Report on Solar Combisystems Modelled in Task 26

Appendix 2: Generic System #3a: Advanced Direct Solar Floor

A Report of IEA SHC - Task 26

Solar Combisystems

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Appendix 2: Generic System #3a: Advanced Direct Solar Floor

by

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A technical report of Subtask C

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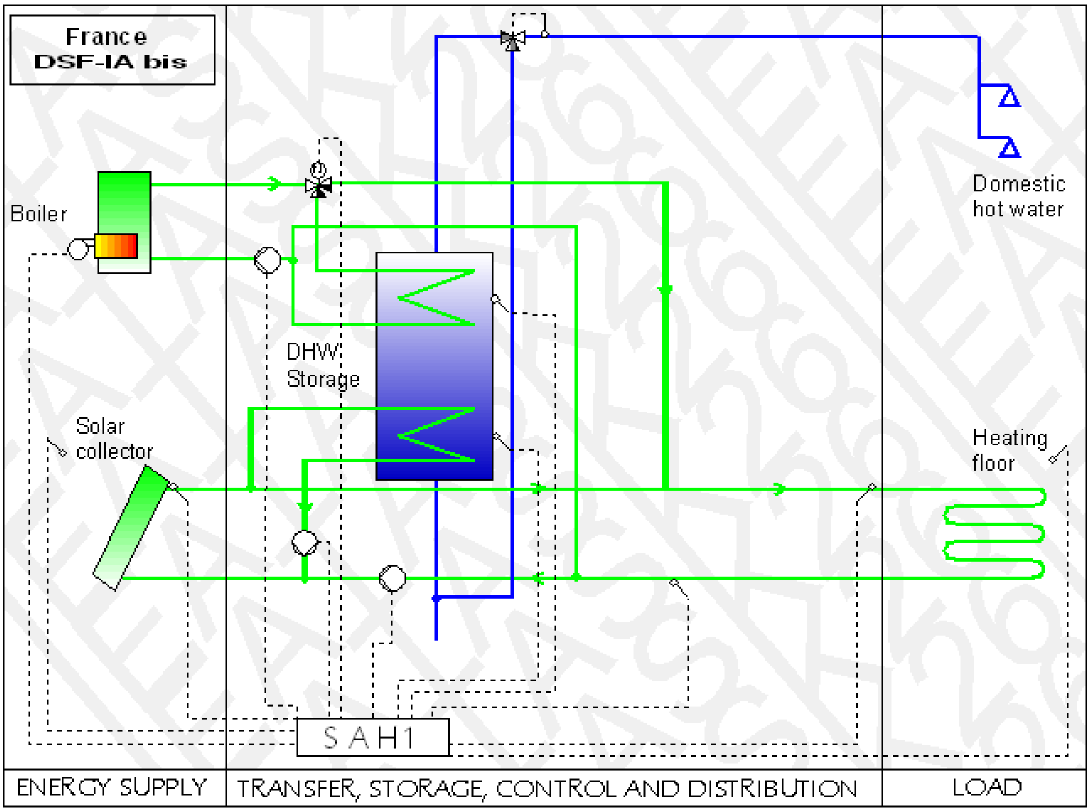
Structure of the Report:

1 General description of System #3a, Direct Solar Floor and Integrated Auxiliary Power

Direct Solar Floor (France)



Main features

Heat management philosophy

Solar loop DHW preparation and space heating by means of a heating floor :
If the temperature at the collector outlet is higher than the one at the bottom of the tank, then the pump of the solar DHW loop is started up. The second solar pump, in the heating floor loop, can be switched on as soon as heating need is detected by the controller. Then the pump will actually be activated only if the solar collector hot temperature reaches a certain level, computed by the controller. If it is not the case, the auxiliary boiler loop will be activated instead.

The DHW and DSF solar loops can run simultaneously if the solar radiation is high enough: it depends also upon the solar DHW temperature in the tank and the inlet set temperature for DSF.

The special feature of the system: the auxiliary power from the boiler can be injected in the heating floor as well as power from the solar collectors, but never simultaneously. The challenge lies in the control strategy so as to optimise solar production with regard to a high level of user's comfort.

Preparation of DHW :
The water on the bottom of the store is heated by solar loop and the complementary energy to reach the DHW set temperature is supplied by the auxiliary system (boiler) in the top area of the store.
The domestic water storage (top of the tank) temperature is controlled by a thermostat with upper and lower dead bands. When the thermostat signal rises, the set temperature of the boiler is fitted to the specific DHW user's set temperature (e.g. 75°C for DHW at 50°C).

Influence of auxiliary energy source on system design and dimensioning
Gas is usually used as auxiliary energy. Oil, wood boiler and other auxiliary systems can also easily be connected to the storage and control unit.

Cost (range)
Usually, the global cost for customers, including collector installation (typical 18 m²), boiler, DHW tank, heating floor and all the hydraulic connections is comprised between 18000€ and 22000€.

Market distribution
The annual production is raising around 400 DSF-IA systems, with typical 18m² solar collector area.
Manufacturer : CLIPSOL.

2 Modelling of the system

2.1 TRNSYS model

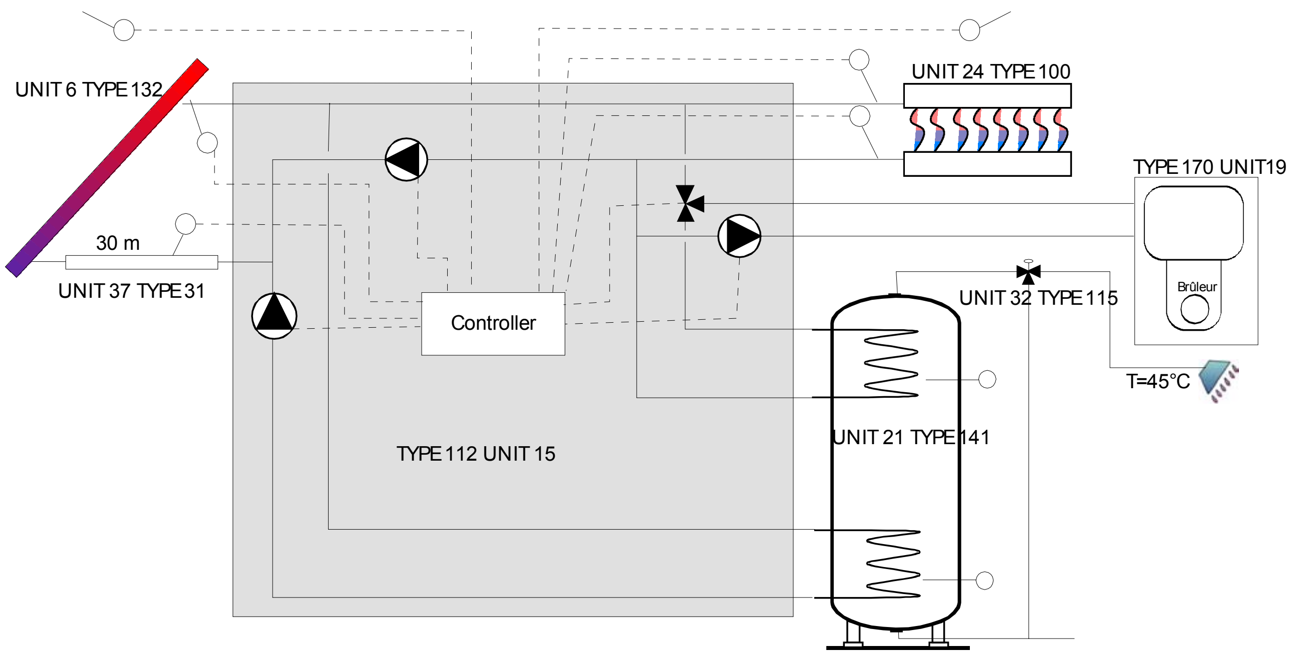


Figure 1: Modelling of System #3a in TRNSYS

2.2 Definition of the components included in the system and standard input data

2.2.1 Collector – model Type 132 v1.02

Collector	η0, a1, a2, inc. angle modifier (50°)	0.8, 3.5, 0.015, 0.9
	Area	20 m²
	Specific mass flow	40 kg/m²h

Data defined in the reference conditions (refer also to [1])

2.2.2 Pipes between collector and storage

Model :	Type 31 on cold collector loop back		
Pipes :	Inner diameter: 2 cm	Total Length : 30	m
Insulation :	Thickness: - mm (2.38 W/m²K)	Thermal Conductivity: 0.042	W/m.K

Data defined in the reference conditions [1].

2.2.3 Solar and auxiliary DHW storage

Type : 141 Version Number : 1.99

Storage tank	Total volume	0.5 m³
	Height	1.7 m
	Store volume for auxiliary	0.17 m³
	Number of nodes	20
	Medium	Water
	Insulation thickness, thermal conductivity	5 cm, 0.042 W/mK
	Heat input system collector	direct
	Position of collector temperature	0.23
	Start / Stop ΔT	5 K / 1 K

Heat Exchanger N°1 (solar): Medium : Glycol (40%) / Water
Type of heat exchanger : serpentine
Heat Transfer Coefficient : 600 W/K

Heat Exchanger N°2 (auxiliary): Medium: Glycol (40%) / Water
Type of heat exchanger: serpentine
Heat Transfer Coefficient: 400 W/K

Heat losses are defined using the geometrical data, and the correction factor defined in the reference conditions [1]: C_{corr}=MAX(1.1,(1.5-V_{store}/10))

Heat transfer coefficients are defined by CLIPSOL using data from manufacturer of serpentine.

2.2.4 Boiler

Type 170 – Specific Type, data defined by Heimrath (in agreement with Task 26)

Aux. Boiler		15 kW
	Mean annual efficiency	90 %
	Energy	Natural gas
	Minimum running time	3 min
	Minimum stand still time	3 min
	Start $\Delta\vartheta$, hysteresis, auxiliary	10 K

2.2.5 Building

Type56 –Data defined in [2]

2.2.6 Heat distribution

Radiators – Heating Floor

Radiator:	*Radiator area (MFH)*	*31 m²*
NOT USED	*Heat capacity (MFH)*	*5 x 1150 kJ/kgK*
	Set flow- and return temperatures (MFH)	*40 / 35 °C*
	Set flow rate	*0,669 kg/s*
Heating Floor	Thickness	
		140 m²
	Specific heat of floor material	920 J/kg.°C
	Heat conduction coefficient of floor material	1.75 W/m.°C
	Density of floor material	2450 kg/m3
	Space between two pipes	10 cm
	Set flow- and return temperatures (MFH)	40 / 35 °C

(Data defined in Reference Conditions [1])

2.2.7 Control strategy

Specific: See appendix for I/O description.

Switching the boiler loop between HF- and DHW- loop according to the expected heating floor inlet temperature estimated by the controller.

2.3 Difference in simulations induced by the use of heating floor

The use of a heating floor instead of radiators (within the reference system) leads to much lower overheating penalties: this observation is based on simulations performed with all heating resources inhibited, in the reference and in the Clipsol DSFIA system. It can be explained as an inertia effect which will reduce overheating during summer.

Through those results (table containing values for each building type and meteorological station), we estimated both systems basic penalty functions (all heating resources inhibited). It's then been admitted that the difference, which appeared to be in favour of the heating floor, will be added to DSFIA penalty function in order to maintain the reliability of performance comparison between the solar combisystems.

See the table below for numeric values.

This leads us to define a "FSI2" variable, as a corrected FSI value for a house equipped with heating floor.

Heating floor surface = 140 m²

Reference Building Pen Up ($Qp_{enalty,SH,Up}$):

	Zurich			Carpentras			Stockholm		
	SFH 30	SFH 60	SFH 100	SFH 30	SFH 60	SFH 100	SFH 30	SFH 60	SFH 100
JAN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FEB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MAR	0.02	0.00	0.00	2.04	0.00	0.00	0.00	0.00	0.00
APR	0.01	0.00	0.00	0.00	0.00	0.00	5.97	0.00	0.00
MAY	25.57	2.40	0.00	855.30	800.90	538.40	263.50	144.90	33.07
JUN	653.80	237.20	4.91	3931.00	4074.00	2937.00	1344.00	878.10	200.00
JUL	2885.00	2835.00	1957.00	9398.00	11860.00	11730.00	2356.00	2067.00	1070.00
AUG	3078.00	3005.00	1860.00	7648.00	9225.00	8243.00	2333.00	2083.00	1204.00
SEP	544.50	221.50	6.51	5202.00	5927.00	4912.00	12.52	4.98	0.32
OCT	0.00	0.00	0.00	511.40	202.10	34.48	17.90	4.35	0.00
NOV	0.00	0.00	0.00	3.81	0.00	0.00	0.00	0.00	0.00
DEC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUM	**7187.00**	**6301.00**	**3829.00**	**27550.00**	**32080.00**	**28390.00**	**6332.00**	**5182.00**	**2508.00**

Heating Floor Building Pen Up ($Qp_{enalty,SH,Up}$):

	Zurich			Carpentras			Stockholm		
	SFH 30	SFH 60	SFH 100	SFH 30	SFH 60	SFH 100	SFH 30	SFH 60	SFH 100
JAN	0.00	0.00	0.00	0	0	0	0	0	0
FEB	0.00	0.00	0.00	0	0	0	0	0	0
MAR	0.00	0.00	0.00	0	0	0	0	0	0
APR	0.00	0.00	0.00	0	0	0	0	0	0
MAY	1.79	0.00	0.00	301	349	223	52	27	1
JUN	102.80	35.95	0.00	1428	2043	1730	353	311	71
JUL	1007.00	1383.00	1145.00	3925	6742	7918	754	920	571
AUG	996.10	1377.00	1000.00	2996	5002	5348	754	958	669
SEP	81.21	38.44	0.00	1955	3136	3130	1	0	0
OCT	0.00	0.00	0.00	103	54	11	0	0	0
NOV	0.00	0.00	0.00	0	0	0	0	0	0
DEC	0.00	0.00	0.00	0	0	0	0	0	0
SUM	**2188.90**	**2834.39**	**2145.00**	**10708.80**	**17326.06**	**18360.07**	**1914.40**	**2217.10**	**1312.54**

Pen Up: difference Ref-Syst, (added to CLIPSOL DSF-IA space overheating penalties) :

	Zurich			Carpentras			Stockholm		
	SFH 30	**SFH 60**	**SFH 100**	**SFH 30**	**SFH 60**	**SFH 100**	**SFH 30**	**SFH 60**	**SFH 100**
JAN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FEB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MAR	0.02	0.00	0.00	2.04	0.00	0.00	0.00	0.00	0.00
APR	0.01	0.00	0.00	0.00	0.00	0.00	5.97	0.00	0.00
MAY	23.78	2.40	0.00	553.90	451.60	315.00	211.72	117.70	31.60
JUN	551.00	201.25	4.91	2503.00	2031.00	1207.00	990.70	566.90	129.23
JUL	1878.00	1452.00	812.00	5473.00	5118.00	3812.00	1602.20	1146.60	498.90
AUG	2081.90	1628.00	860.00	4652.00	4223.00	2895.00	1579.00	1124.70	534.80
SEP	463.29	183.06	6.51	3247.00	2791.00	1782.00	11.50	4.98	0.32
OCT	0.00	0.00	0.00	408.00	148.34	23.81	17.40	4.35	0.00
NOV	0.00	0.00	0.00	3.81	0.00	0.00	0.00	0.00	0.00
DEC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUM	**4998.00**	**3466.71**	**1683.42**	**16842.75**	**14762.94**	**10034.81**	**4418.49**	**2965.23**	**1194.85**

2.4 Validation of the system model

The previous system studied (#3 DSFIA) was globally validated using in situ monitoring and FSC procedure.

3 Simulations for testing the library and the accuracy

3.1 Result of the TRNLIB.DLL check

Run SCS1a.trd and note your results in the boxes below

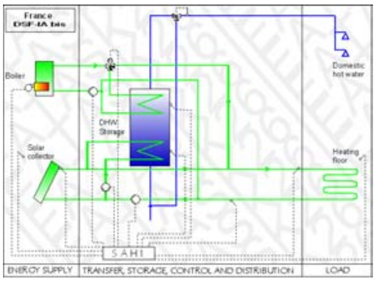
	$F_{sav,therm}$	$F_{sav,ext}$	F_{si}	Q_{boiler}	$Q_{penalty,SH,Low}$	$Q_{penalty,SH,Up}$	$Q_{penalty,DHW}$
Richard's Result	0.7900	0.7406	0.3006	9443	30	26480	0
Your Results	0.7896	0.7400	0.2967	9461	30	26640	0
Difference	0.0004	0.0006	0.0039	18	0	160	0

3.2 Results of the accuracy and the timestep check

Conv tolerance	Int tolerance	Timestep	$F_{sav,therm}$	Epsilon
0.002	0.001	1.5 min	0.4601	-
0.005	0.001	1.5 min	0.4597	-0.0004
0.008	0.001	1.5 min	0.4604	0.0007
0.010	0.001	1.5 min	0.4594	-0.0010
0.050	0.001	1.5 min	0.4527	-0.0067
0.001	*0.002*	1.5 min	0.4602	-
0.001	*0.005*	1.5 min	0.4602	0.0000
0.001	*0.008*	1.5 min	0.4602	0.0000
0.001	*0.010*	1.5 min	0.4602	0.0000
0.001	*0.050*	1.5 min	0.4602	0.0000
0.001	0.001	*1.5 min*	0.4602	-
0.001	0.001	*3 min*	0.4662	0.0060

4 Sensitivity analysis and optimisation

4.1 Presentation of results



Direct Solar Floor Heating (CLIPSOL,France)

Main parameters (optimised Base Case) :			
Building :	*SFH 60*	DHW Tank Volume :	*0.5 m³*
Climate :	*Zurich*	DHW Tank height	*1.72 m*
Collectors area :	*20 m²*	Solar HX inlet rel. height Aux. HX inlet rel. height	*0.23* *0.68*
Collector type :	*Standard Flat Plate*	Solar tank sensor rel. height Aux. Tank sensor rel. height	*0.23* *0.68*
Specific flow rate (Collector)	*40 kg/m²h*	Thermal insulation	*5 cm*
Collector azimuth/tilt angle	*0 / 45°*	nominal Boiler heating rate	*15 kW*
Collector upper dead band	*DHW: 3°C* *HF : 5°C*	Condensation Boiler	
Slab thickness	*10 cm*	Heating Floor surface	*140 m²*
Heating Floor gap between tubes I	*10 cm*	Heating Floor spec. mass flow rate	*600 kg/h*
Heating floor inlet temp.	*23°C*		
Simulation parameter:			
Time step	*1/40h*	Tolerances Integration Convergence	*0.001 /* *0.001*
Controller DHW upper DB	*3*	Controller DSF upper DB	*5*

Summary of Sensitivity Parameters		
Parameter	Variation	Variation (%) in $f_{sav,therm}$
Base Case	-	
Collector size [m^2]	5 – 50	29 – 57
Collector Azimuth [°] (fixed tilt of 45°)	-90 – 90	37.2 – 45.9
Collector Tilt [°] (fixed azimuth of 0°)	5 – 90	39.5 – 46.1
DHW store Size [m3]	0.15 – 0.7	44.9 – 45.5
Insul. Thickness [cm]	2 – 32	48.9 – 38.3
Specific Mass Flow rate in solar DHW-HX (ponderation factor from base case value)	0.5 – 6	44.9 – 45.6
DHW-HX UA [W/K]	300 – 900	44.6 – 45.7
Set temperature for DHW aux. Store [°C]	40 – 80	49.1 – 37.6
Solar DHW Temp. sensor rel. height	0.02 – 0.44	46.6 – 47.1
Aux. DHW Temp. Sensor rel. height	0.58 – 0.88	45.9 – 47.8
Collector inlet rel. height	0.15 – 0.45	45.3 – 47.0
Boiler inlet rel. height	0.48 – 0.78	46.3 – 47.1
Climate (Std)	Carp. / Zur. / Stock.	74.9 / 45.9 / 37.7
Climate - Condensation boiler[On/Off]	Carp. / Zur. / Stock.	-
Condensation boiler perf.	Off/On/Opt	44.0 / 47.0 / 48.8
Climate Collector tilt [15° – 90°]	Carp. / Zur. / Stock.	-
Building type (Std)	SFH 30 / 60 / 100	51.5 / 43.5 / 38.8
Collector Controller dT_{start} for Heating [°C]	1 – 10	45.7 – 46.0
Collector Controller dT_{start} for DHW [°C]	0.5 – 5	45.8 – 46.0
Overheating limit [°C]	1 – 10	43.8 – 45.9
Design Heating floor inlet temperature [°C]	18 – 30	42.7 – 48.5
Slab thickness [cm]	10 – 15	45.8 – 46.1
Gap between heating floor pipes [cm]	10 – 20	45.8 – 46.0
Heating floor specific mass flowrate [kg/h]	300 – 800	45.8 – 46.7

Sensitivity parameter :	Collector size [m^2]	5 – 50 m^2

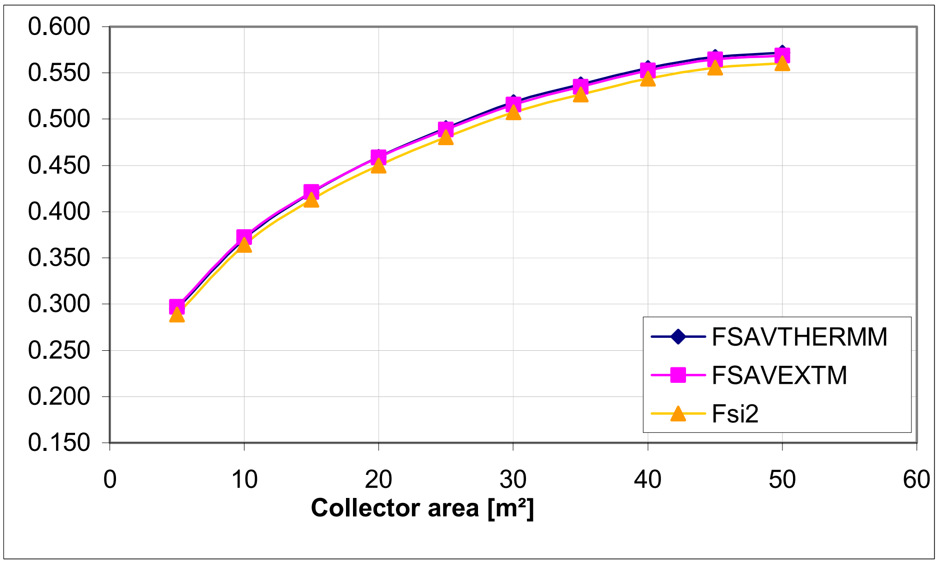


Figure 2: Variation of fractional energy savings with collector size

Differences from Base Case
None

Description of Results
As expected the increase of savings with increasing collector area decreases the larger the area. There are very few penalties incurred for the settings, so that $f_{si} \approx f_{sav,ext}$

Comments

Sensitivity parameter :	Collector Azimuth [°]	-90 – 90

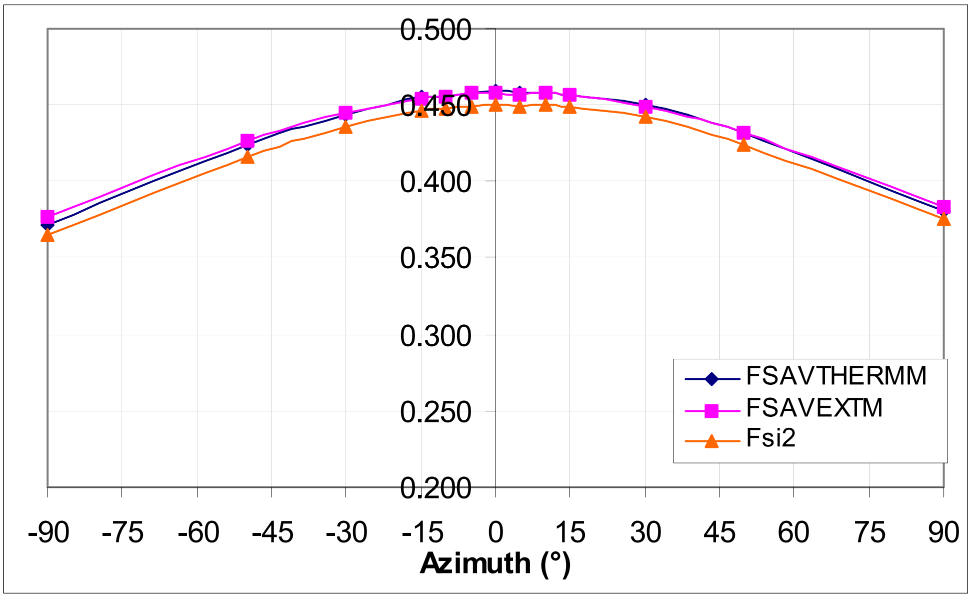


Figure 3::Variation of fractional energy savings with azimuth angle

Differences from Base Case
None

Description of Results
Maximum is around 10° west. Highest savings seem to happen in the afternoon, as the working temperature is at a higher level.

Comments

Sensitivity parameter :	Collector Tilt [°] (fixed azimuth of 0°)	5° - 90°

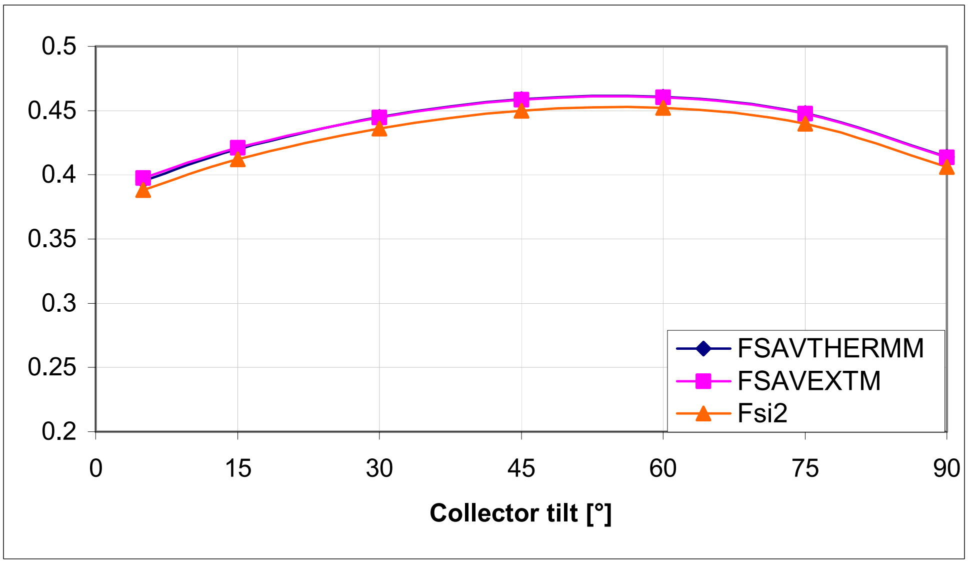


Figure 4: Variation of fractional energy savings with collector tilt, with fixed azimuth angle of 0°.

Differences from Base Case
None

Description of Results
Here the savings show an optimum at around 55° tilt. This is dependent on load data. Generally, the larger the space heating load in relation to the DHW load, the higher the optimum tilt angle.

Comments
None

Sensitivity parameter :	DHW Store Size [m3]	0.15 – 0.7 m^3

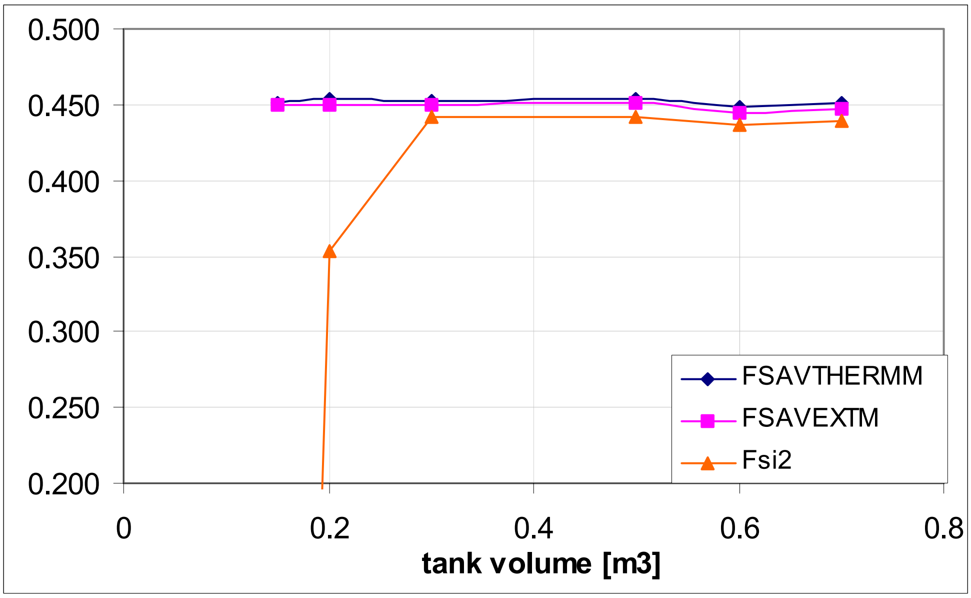


Figure 5: Variation of fractional energy savings with DHW store volume

Differences from Base Case

Description of Results
With small storages (under 0.2 m^3), the system can't reach the comfort level required on DHW production and those configurations are deeply penalised : the Fsi reflects this weakness.

Comments
None.

Sensitivity parameter :	Store Insulation (whole store) [cm]	2 – 34 cm

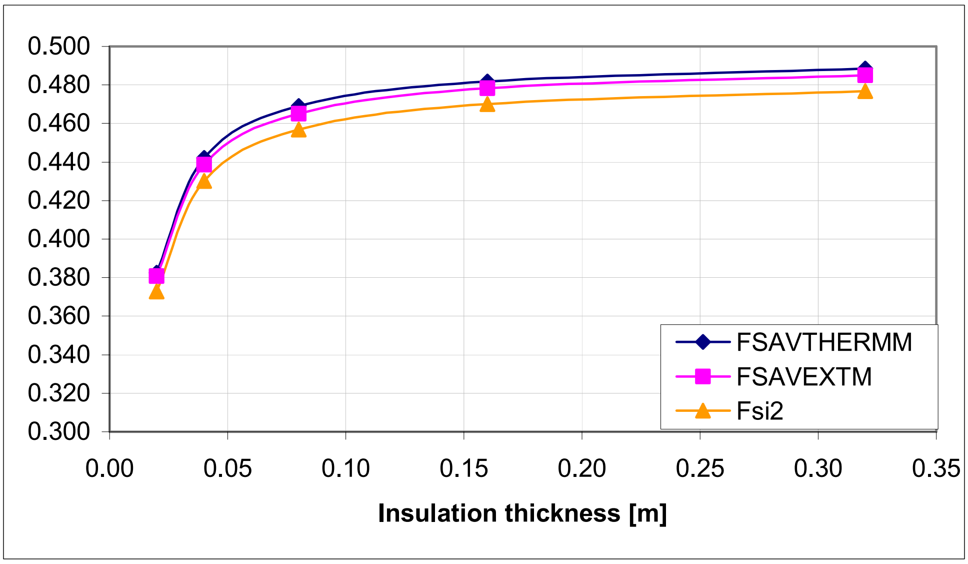


Figure 6: Variation of fractional energy savings with the thickness of insulation

Differences from Base Case
None

Description of Results
The significant threshold for insulation thickness seems to be around 10 cm. Beyond this value, the performances increase very slightly with no significant gain.

Comments
None

Sensitivity parameter :	Mass flowrate ponderation factor in solar HX	0.5 - 6

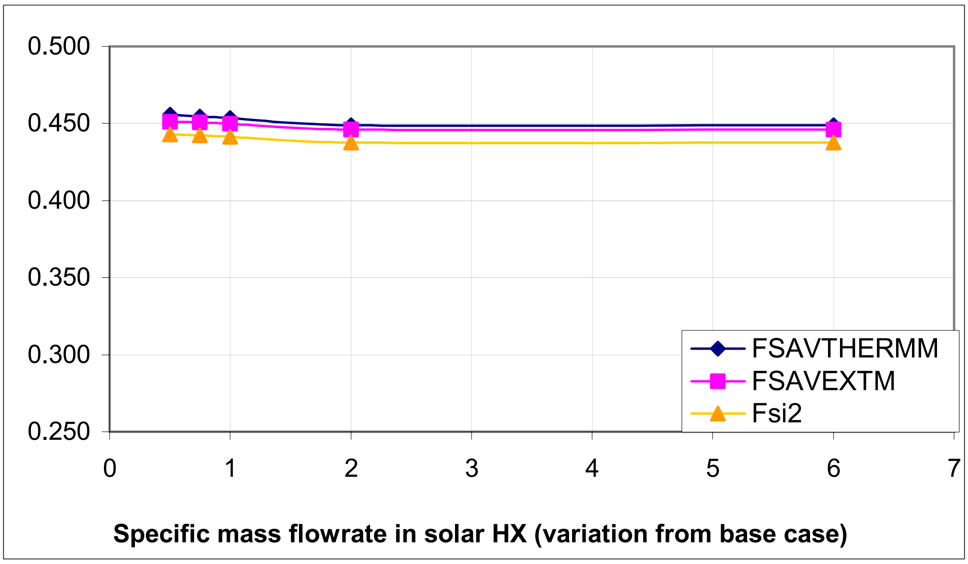


Figure 7: Variation of fractional energy savings with variation of specific flowrate in the solar heat exchanger

Differences from Base Case
None

Description of Results
The performance tends to sink slightly from very low flowrate until the twice the base case value. Beyond this value, there ‘s no more relevant gain.

Comments
The flowrate in solar heat exchanger depends on the running mode of the system: is the DSF activated or not, will decrease or increase respectively the flowrate. The pump actuators are the same at the moment: the pressure drop in the loops is different and generally in favour of the heating floor.

We actually set this pressure drop (as a ponderation factor for base case value) in the DHW solar loop to vary the mass flowrate.

Sensitivity parameter :	Transfer efficiency in solar HX	300 – 900 W/K

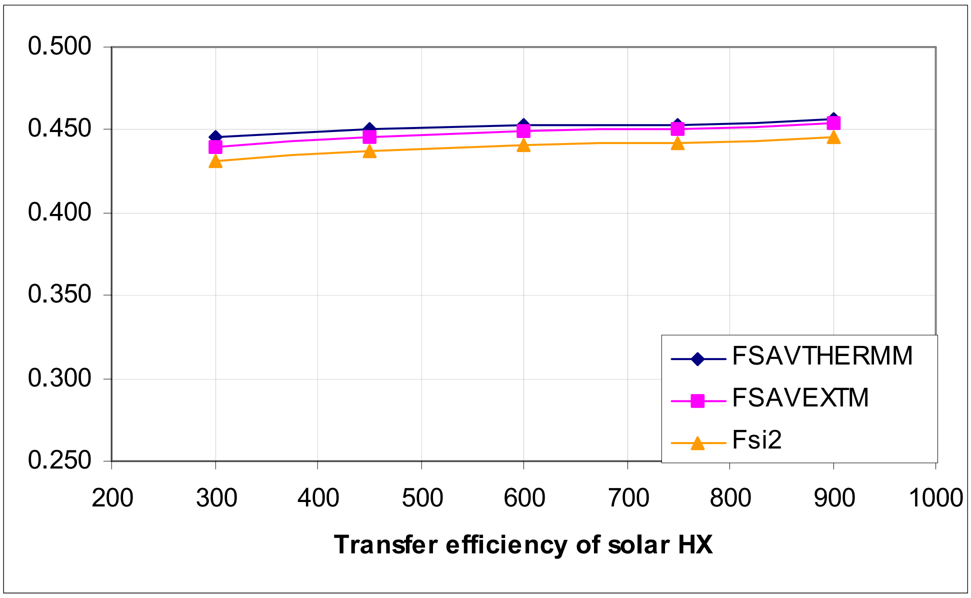


Figure 8: Variation of fractional energy savings with variation of transfer efficiency in the solar heat exchanger

Differences from Base Case
None

Description of Results
Performance are smoothly increasing with HX transfer efficiency.

Comments
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Sensitivity parameter :	DHW temperature set point	40 – 80 °C

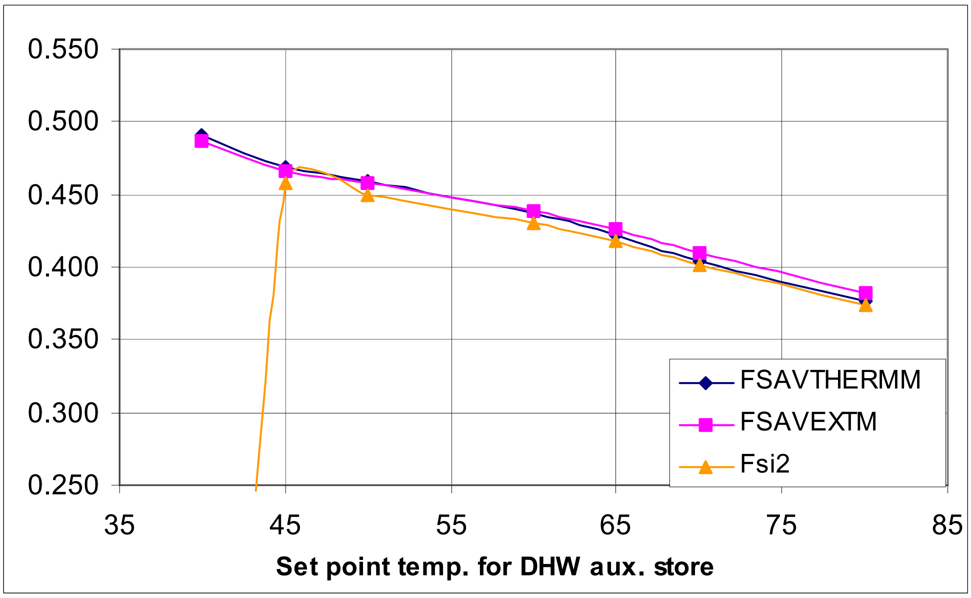

Figure 9: Variation of fractional energy savings with variation of DHW set point in aux. area

Differences from Base Case
None

Description of Results
The savings clearly increase as the set point decreases but it drops below 45°C, the F_{si} criterion will dramatically drop too: it shows the limit of auxiliary system which has been designed for a minimum energy buffer.

Comments

Sensitivity parameter :	Rel. height of solar temp. sensor	0.02 – 0.44

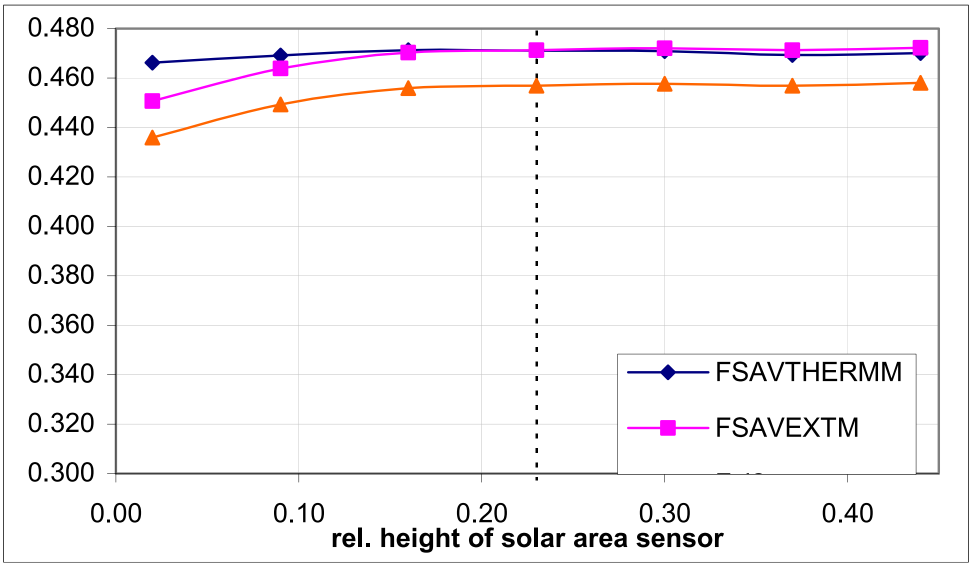

Figure 10: Variation of fractional energy savings with variation of solar temp. sensor rel. height

Differences from Base Case

Base case: rel. Height solar temp. sensor = 0.23
rel. height of collector inlet = 0.23

Description of Results

The highest performance values are obtained at collector inlet level.

Comments

Sensitivity parameter :	Rel. height of aux. temp. sensor	0.58 – 0.88

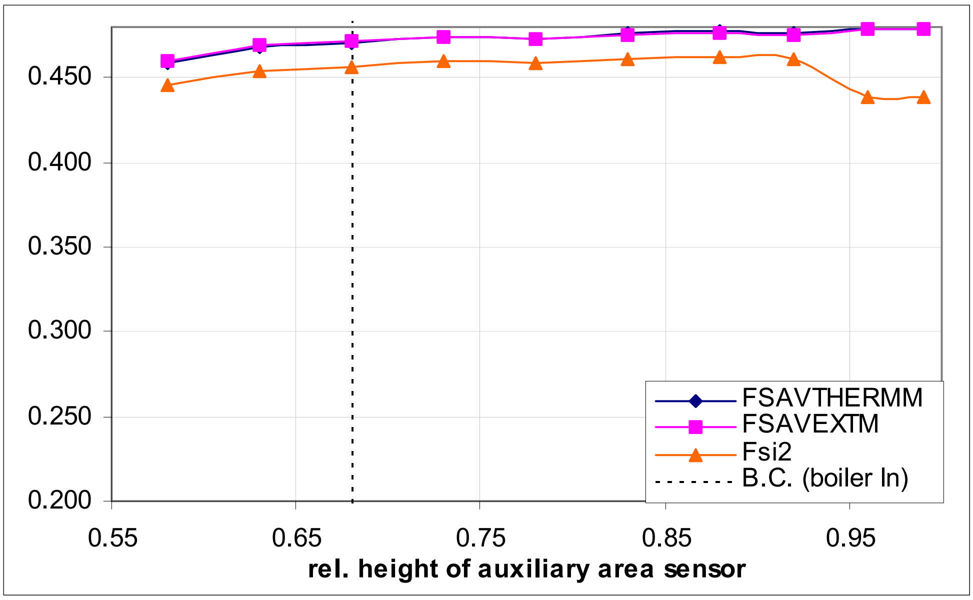

Figure 11: Variation of fractional energy savings with variation of auxiliary temp. sensor rel. height

Differences from Base Case

Base Case: rel. height aux. Temp sensor: 0.68
rel. height boiler inlet : 0.68

Description of Results

In this case, the performances are rising as the sensor height is increasing until it reaches the 0.95: at this level, the system is producing hot water just in time, there is nearly no more storage. The DHW penalties are not as high we could have assumed at first look: the height's difference between HX and sensor has got a buffer behaviour.

Comments

Sensitivity parameter :	Rel. height of collector inlet	0.15 – 0.45

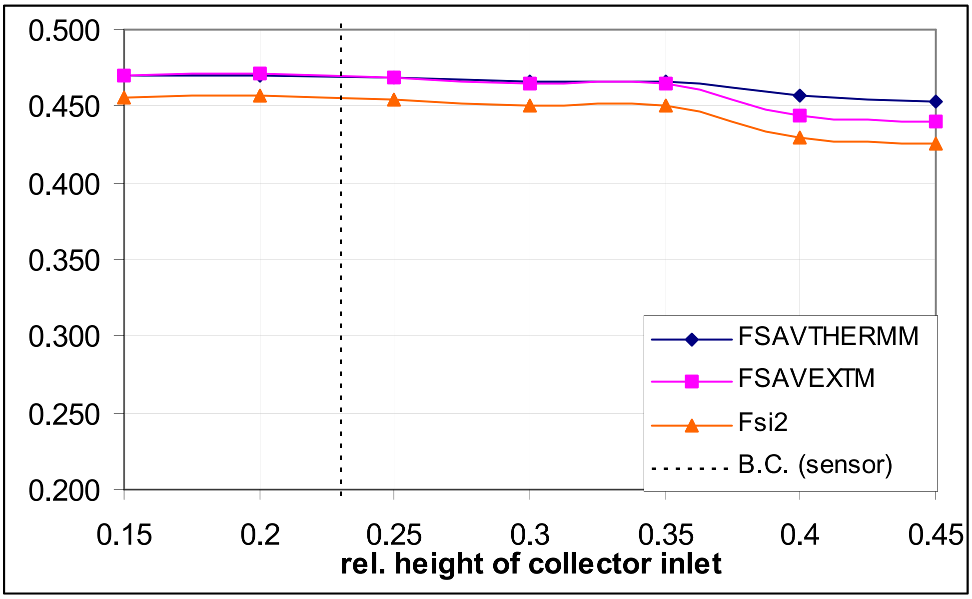

Figure 12: Variation of fractional energy savings with variation of collector inlet rel. height

Differences from Base Case

Base case: rel. Height solar temp. sensor = 0.23
rel. height of collector inlet = 0.23

Description of Results

Optimal conditions : when the inlet is just below the sensor, around 0.2 .

Comments

Sensitivity parameter :	Rel. height of boiler inlet	0.48 – 0.78

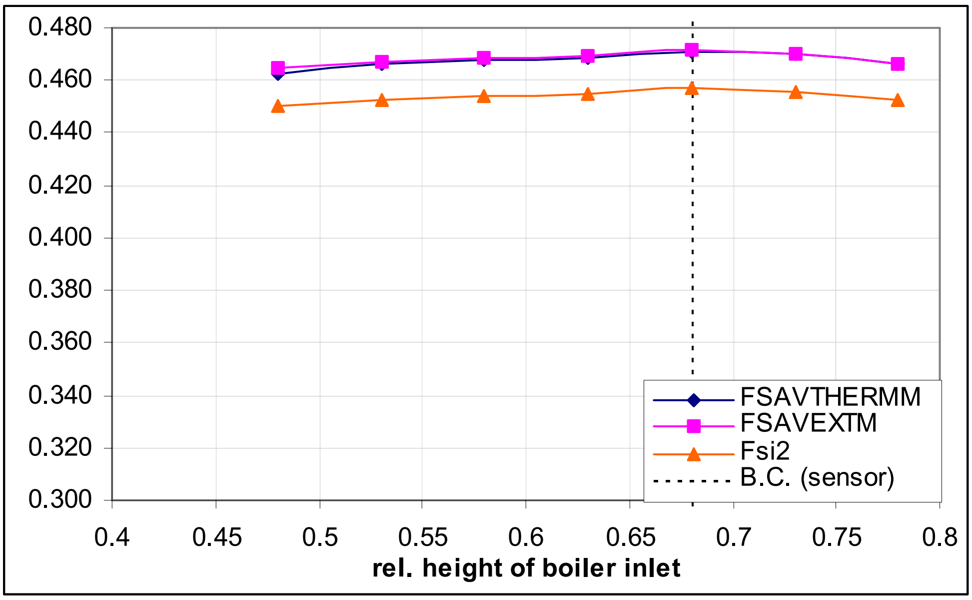

Figure 13: Variation of fractional energy savings with variation of auxiliary inlet rel. height

Differences from Base Case

Base Case: rel. height aux. Temp sensor: 0.68
rel. height boiler inlet : 0.68

Description of Results

Performances are rising smoothly as the inlet is rising towards the temp. sensor height. The maximum is reached as both are at the same level. Performances start to decrease beyond this value.

Comments

Sensitivity parameter :	Climate	Zur – Carp – Stock

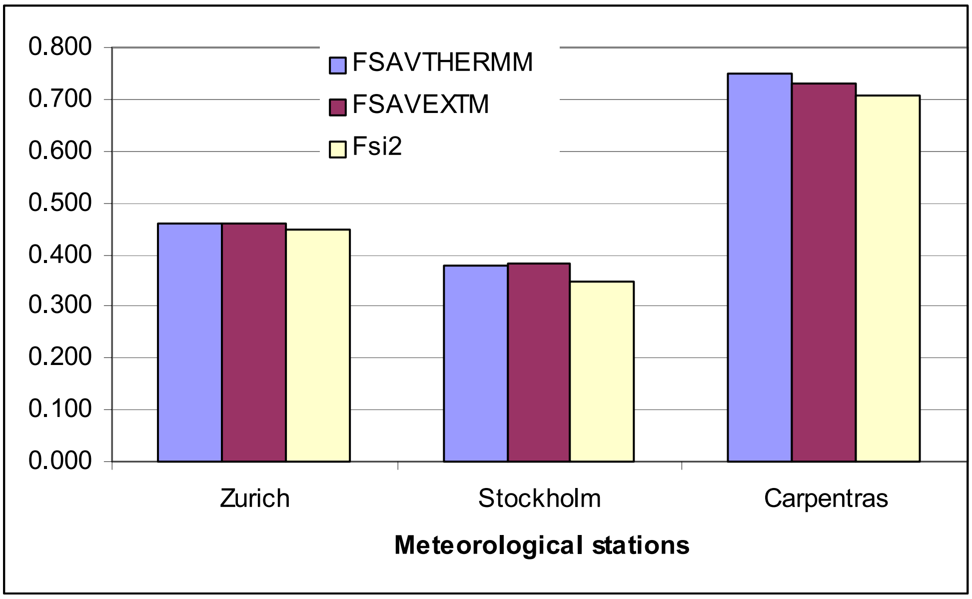

Figure 14: Variation of fractional energy savings with climate.

Differences from Base Case

Description of Results

Comments

Sensitivity parameter :	Climate – Condensation's mode	Zur – Carp – Stock

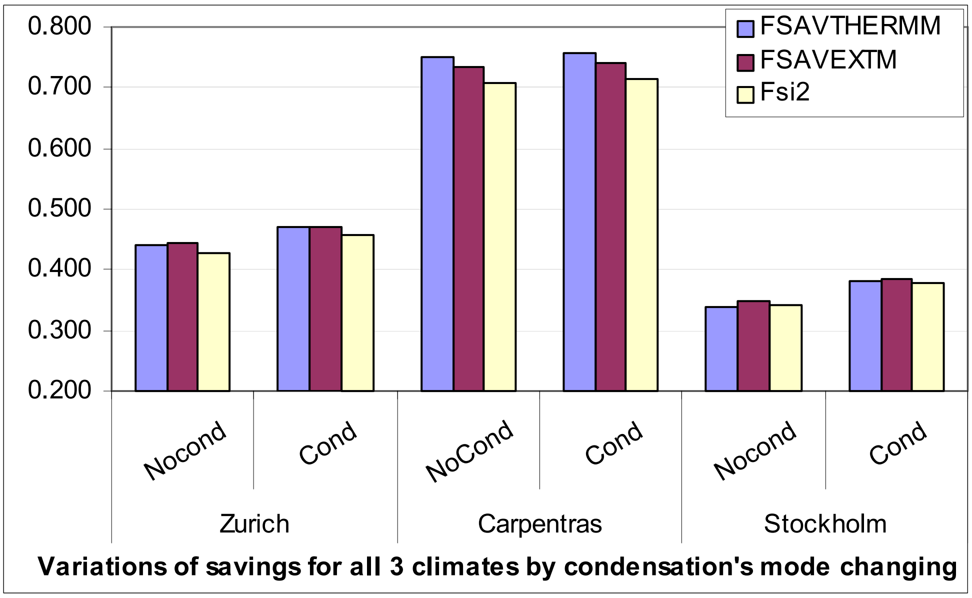

Figure 15: Variation of fractional energy savings with climate and condensation's mode of the boiler.

Differences from Base Case

Description of Results

Performance's improvement by use of condensation boiler is especially striking in Stockholm's case: Indeed, condensation's interest appears as the system works at low temperature's level, that is , when the system is rather in heating mode than DHW preparation mode. Consequently, the specific gain must be higher in the stations which have got high heating needs towards DHW needs.

Comments

Sensitivity parameter :	Performance of condensation boiler	Off – On – Opt

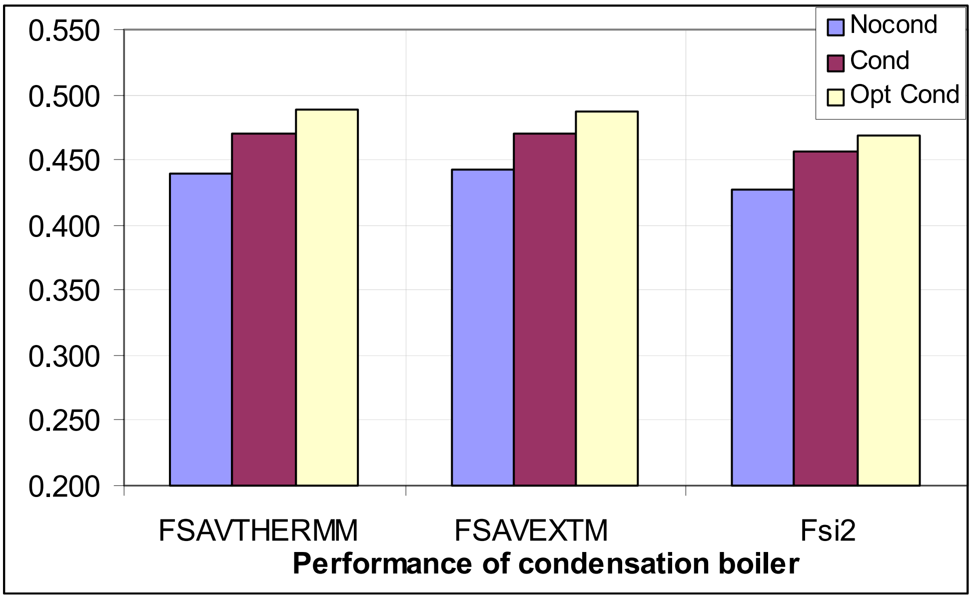

Figure 16: Variation of fractional energy savings with performance of condensation boiler

Description of Results
The component is TYPE 170 in all three simulations.
We used a kind of bypass to force the boiler to work at high temperature level so that it can't condense: first case, Off.
Second case, On: we used the type 170 without any additional system.
Third case, Opt: we used modified parameters with regard to reference. The aim was to use a boiler model which performances would be closer of existing boiler than the reference one's.

	efficiency	
Model	30/40 °C	75/60 °C
WEISHAUPT	110 %	107 %
VAILLANT	109 %	
VIESSMANN	108 %	
Type 170 ref. param.	**103.8 %**	**95 %**
Type 170 optimal param.	**106.7 %**	**98.9 %**

Modifications : reference → optimal parameters
Air surplus (parameter 8) :1.2 → 1.1
Temperature difference between flue gas and return (parameter 11) : 10 → 5°C
Radiat. losses (parameter 12) : 3.5 → 0.5% (75 W instead of 525 W)
Air temp. (input 3) 15°C → 15+0.8*(Tout-15) Ventilation shaft is a kind of heat exchanger at 80% efficiency

The optimal parameters for condensation clearly improve performance of the global installation (nearly 2 points)

Sensitivity parameter :	Building type	SFH 30 – 60 – 100

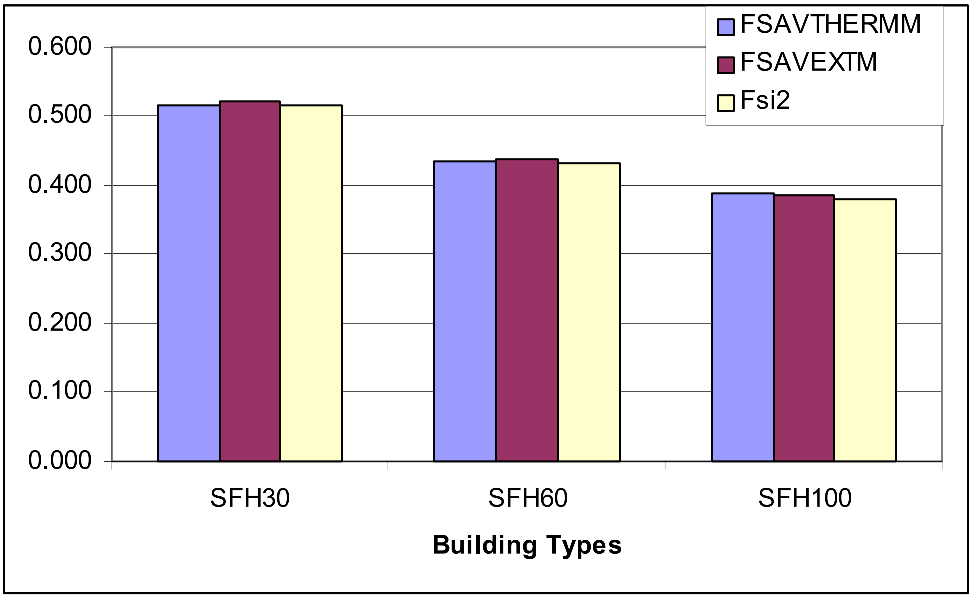

Figure 17: Variation of fractional energy savings with variation of building

Differences from Base Case
Zurich meteorological station

Description of Results
As expected, the basic performances are increasing with building's insulation.
The more the insulation shrinks, the more the low-penalties rise and drop FSI level.

Comments

Sensitivity parameter :	Collector control DT_{start} for DSF	1 – 10 °C

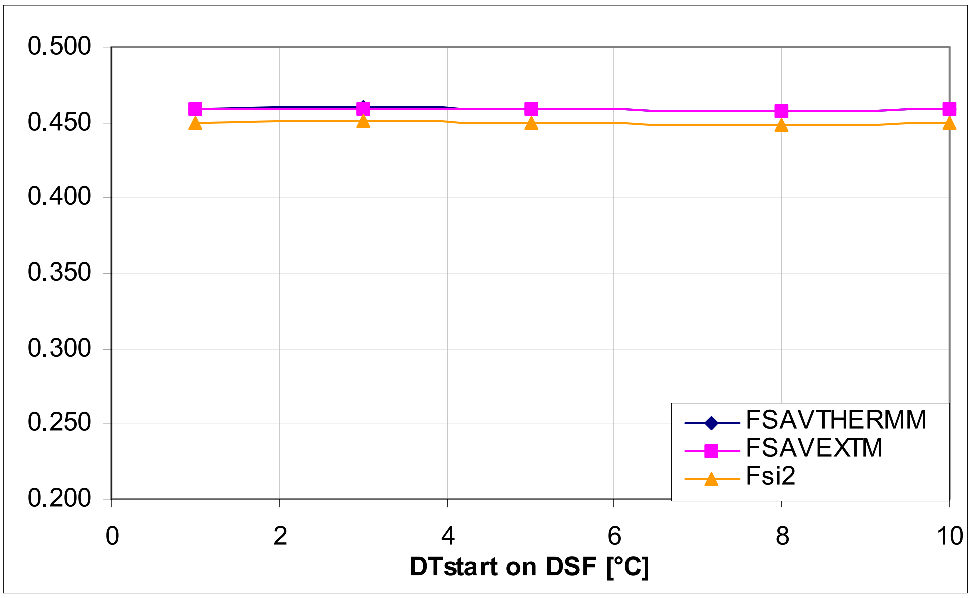

Figure 18: Variation of fractional energy savings with variation of DT_{start} on solar DSF

Differences from Base Case

Description of Results
No significant variation.

Comments

Sensitivity parameter :	Collector control DT_{start} for DHW	0.5 – 5 °C

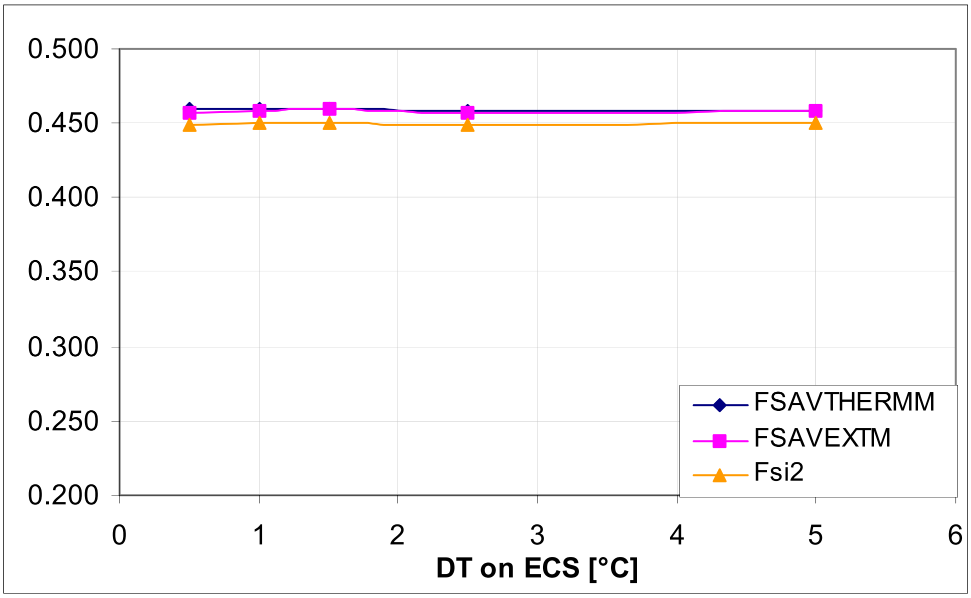

Figure 19: Variation of fractional energy savings with variation of DT_{start} on solar DHW

Differences from Base Case

Description of Results
No significant variation.

Comments

Sensitivity parameter :	Controller allowed overheating parameter	1 – 10 °C

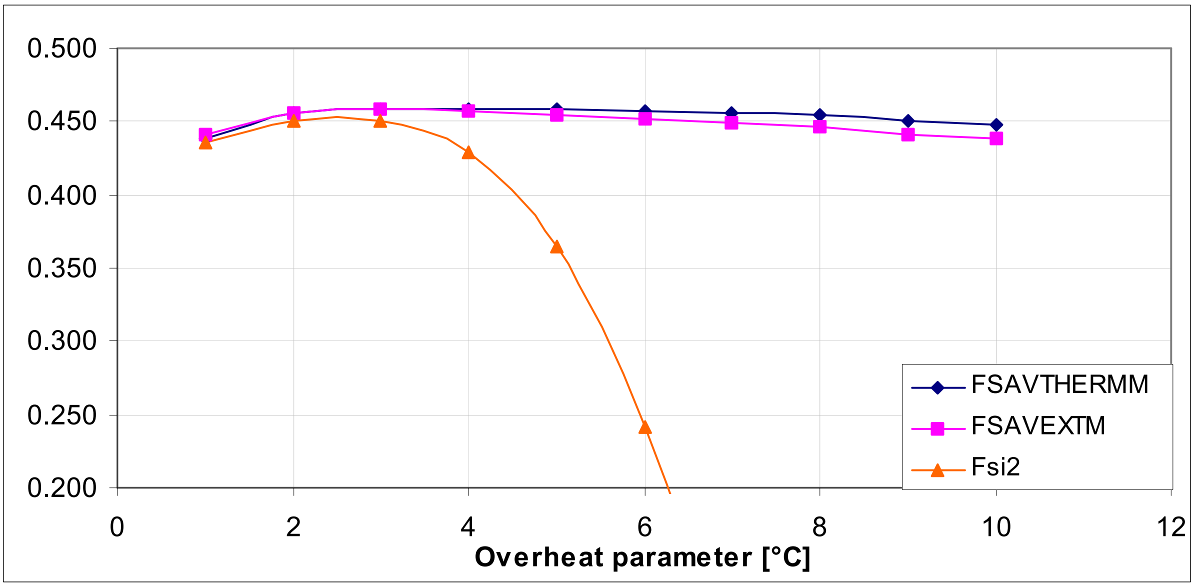

Figure 20: Variation of fractional energy savings with variation of heating floor allowed overheating

Differences from Base Case

Description of Results

Slab's overheat by large solar radiation during the day is used as energy storage strategy. While the system throws energy from collector through the heating floor, even though it is in overheat mode, it can not necessary provide enough high temperature level to produce solar hot water. In this case, the energy may not be redirected to the way it would be optimally used: during summer time, as the space heating needs are nearly null and the DHW needs keep constant (or higher) value, such a running mode is obviously not desirable.
That's why the Fsav indicators are dropping whereas the energy storage is increased.

Fsi's behaviour looks like the overheating penalties's behaviour used to compute it.

Comments

Sensitivity parameter :	Design HF inlet temperature	18 – 30 °C

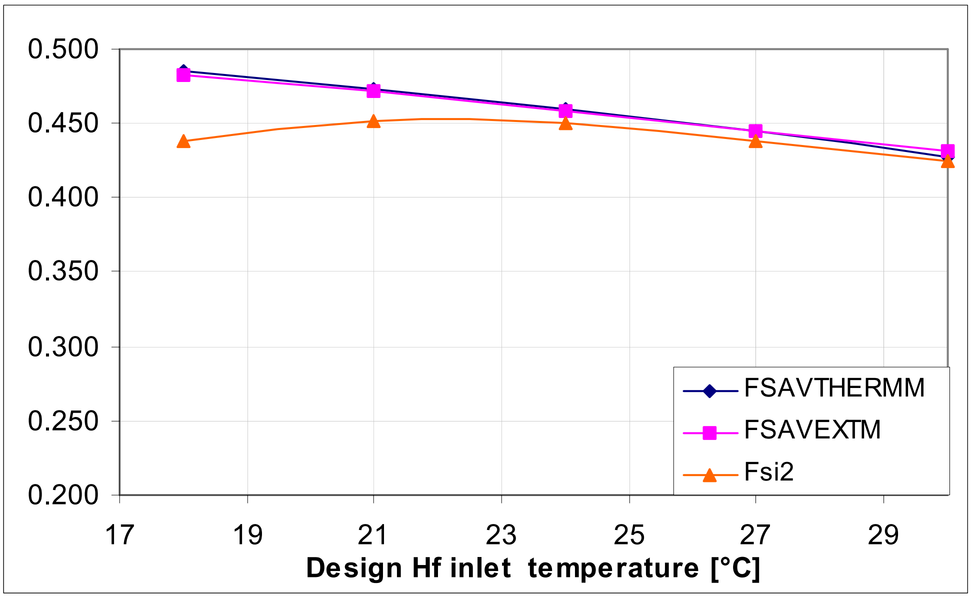

Figure 21: Variation of fractional energy savings with variation of design heating floor inlet temperature

Differences from Base Case

Description of Results

We can reach the optimal value of FSI by 22°C as design HF inlet temperature.

Comments

Sensitivity parameter :	Slab thickness	10 – 15 cm

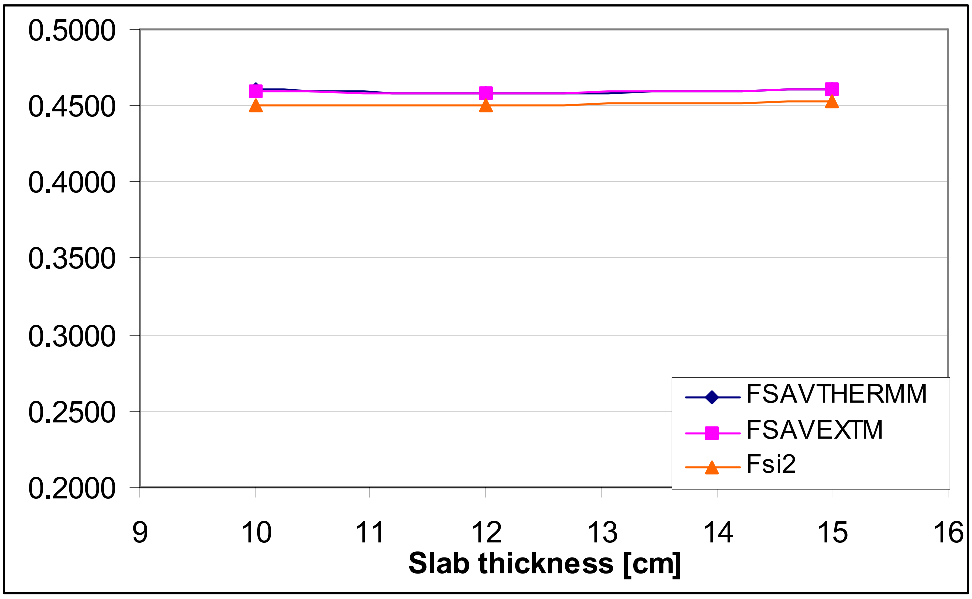

Figure 22: Variation of fractional energy savings with variation of slab thickness

Differences from Base Case

Description of Results
No significant variation.

Comments

Sensitivity parameter :	Gap between tubes	10 – 20 cm

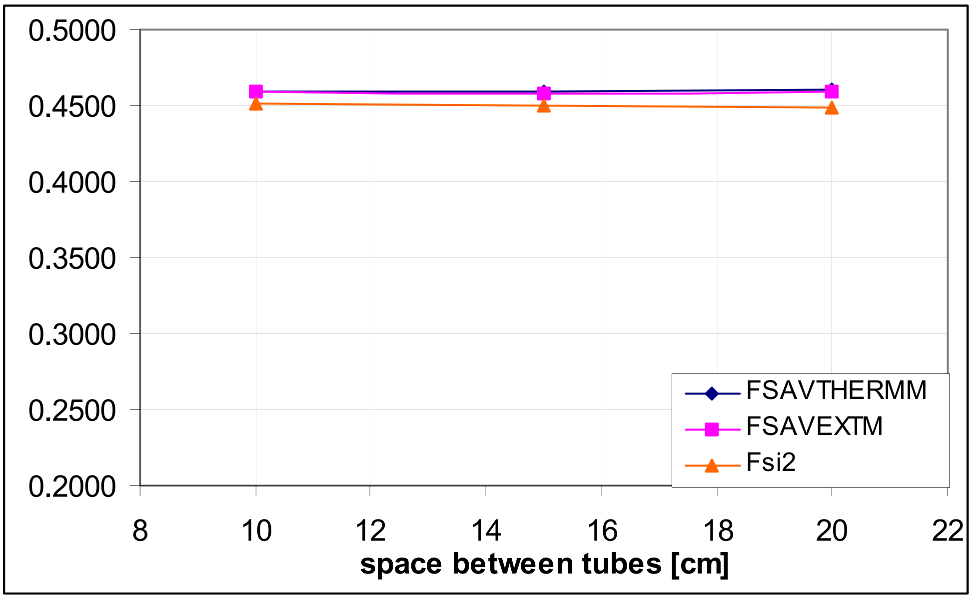

Figure 23: Variation of fractional energy savings with variation of gap size between tubes

Differences from Base Case

Description of Results

No significant variation except very slight decrease of Fsi caused by low-penalties with relative big gap between the tubes.

Comments

Sensitivity parameter :	HF specific mass flowrate	300 – 800 kg/h

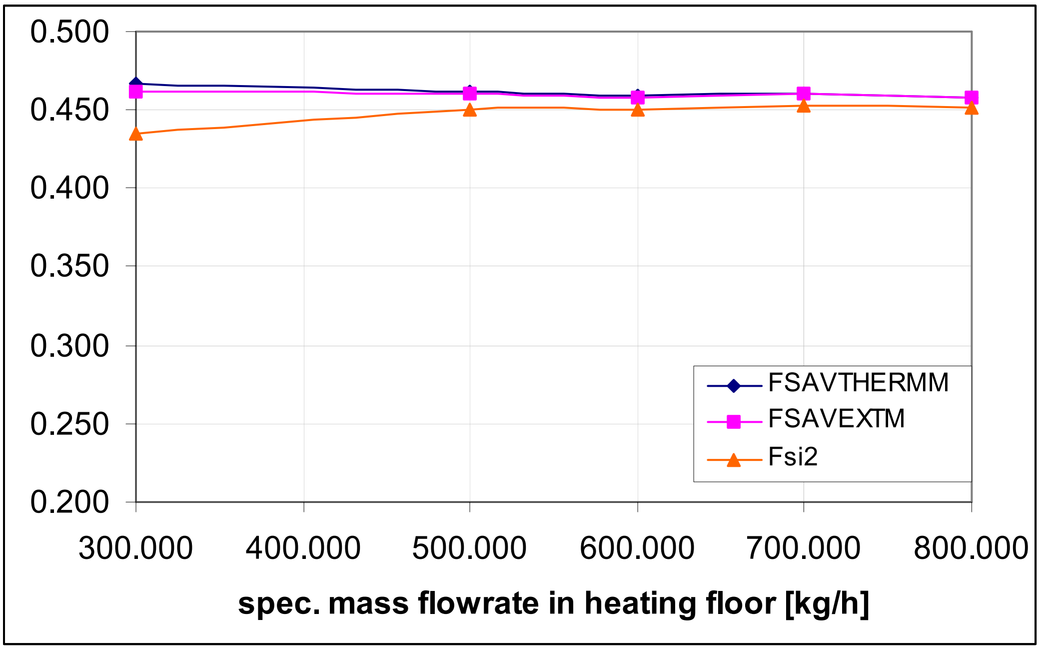

Figure 24: Variation of fractional energy savings with variation of HF specific mass flowrate

Differences from Base Case

Description of Results

Use of small mass flowrate in the heating floor means heating power reduction. This weakness is revealed by HF-low-penalties who are dropping the FSI.

On the other hand, increasing the mass flowrate beyond 600 kg/h does not clearly improve the performance.

Comments

4.2 Definition of the optimised system

As described in section 4.1

5 Analysis using FSC

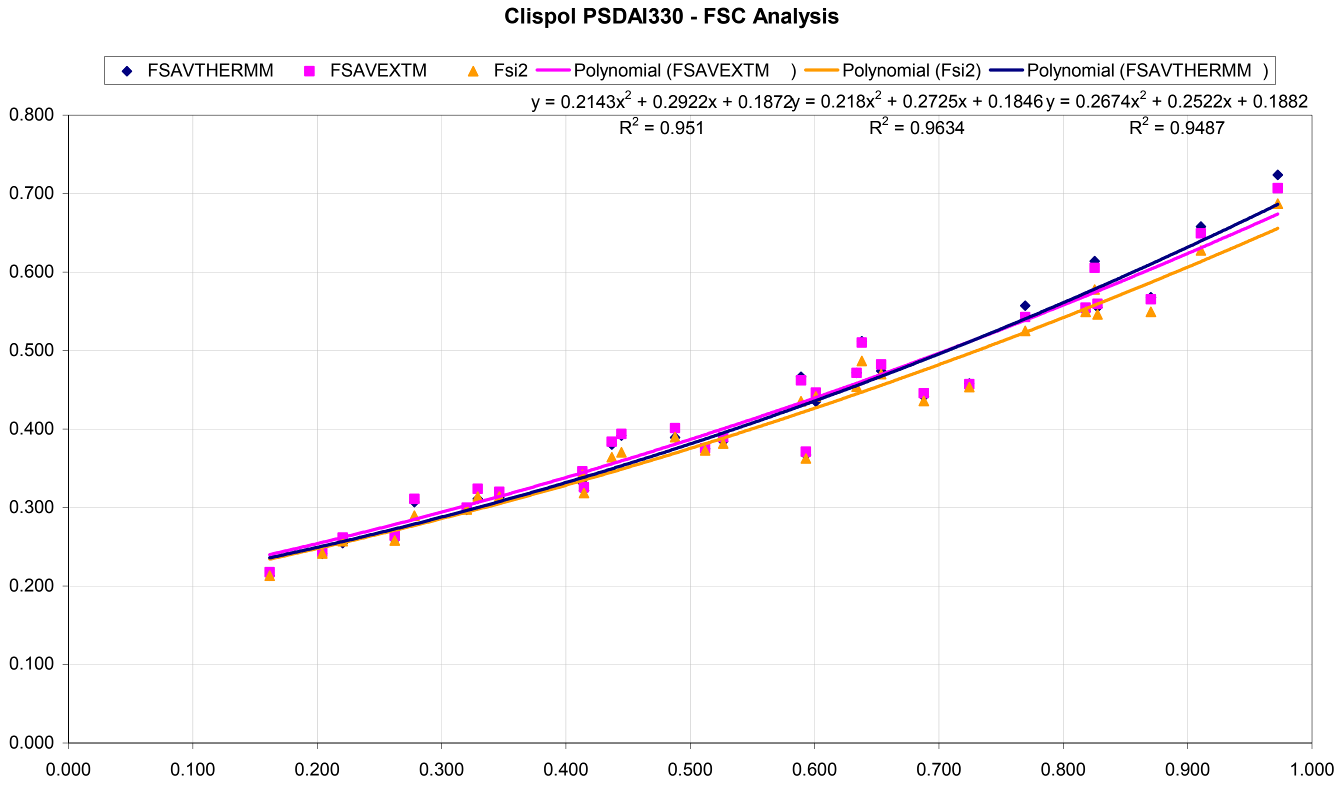

Figure 25: FSC for 3 climates (Carpentras, Zurich, Stockholm) and 3 loads (30, 60, 100 kWh/m²a single-family buildings) and 5 to 40 m² collector area.

6 Lessons learned

- No specific difficulties encountered in models elaboration.
- High auxiliary area sensor, relax of critical recommendations as collector's orientation or slab thickness.

7 References

[1] Weiss, W. (ed.), Solar heated houses – A design handbook for solar combisystems, IEA SHC Task 26, Solar Combisystems, James & James Science Publishers, 2003.

[2] Streicher, W., Structure of the Reference Buildings of Task 26, Technical Report, IEA SHC Task 26 Solar Combisystems, http://www.iea-shc.org, 2003.

8 Appendix 1: Description of components specific to this system

These are components that are

a) not part of the TRNSYS standard library AND
b) not part of the types used as "standard" by Task 26.

8.1 Type 11 : Specific controller for System #3a

Inputs 11:

1:	TColl_hot	Température d'ARRIVÉE du CAPTEUR CHAUD
2:	Tboil_hot	Température d'ARRIVÉE du circuit CHAUDIÈRE CHAUD
3:	THX_ECSOL_cold	Température de RETOUR de l'ÉCHANGEUR SOLAIRE du ballon
4:	THX_ECSAUX_cold	Température de RETOUR de l'ÉCHANGEUR APPOINT du ballon
5:	THF_cold	Température de RETOUR du PLANCHER
6:	Toutside	Température extérieure
7:	Tinside	Température intérieure
8:	TBal_ECSol	Température de la sonde du ballon partie solaire
9:	TBal_ECAux	Température de la sonde du ballon partie appoint
10:	heating	Signal d'AUTORISATION du CHAUFFAGE par le plancher
11:	boiler	Signal d'AUTORISATION du fonctionnement de la CHAUDIÈRE

Outputs 24:

1:	TColl_cold	Température de retour au CAPTEUR
2:	Coll_deb	Débit dans le capteur
3:	TBoil_cold	Température de retour à la CHAUDIERE
4:	Boil_deb	Débit dans la chaudière
5:	THF_hot	Température de départ dans le PLANCHER
6:	HF_deb	Débit dans le plancher
7:	THX_ECSOL_hot	Température de départ ÉCHANGEUR SOLAIRE DU BALLON
8:	ECSol_deb	Débit dans l'échangeur solaire du ballon
9:	THX_ECSAux_hot	Température de départ ÉCHANGEUR APPOINT DU BALLON
10:	ECSAux_deb	Débit dans l'échangeur appoint du ballon
11:	ECSol_loop	Etat de circulation échangeur solaire du ballon
12:	SolHF_loop	Etat de circulation du plancher solaire
13:	HFAux_loop	Etat de circulation du plancher d'appoint
14:	ECSAux_loop	Etat de circulation dans l'échangeur d'appoint du ballon
15:	Boil_loop	Etat de circulation dans la chaudière
16:	EtatBruleur	Etat de fonctionnement du brûleur
17:	THF_hot_aux	Température de consigne pour le plancher en appoint
18:	non utilisé	(double THF_hot_aux)
19:	Coll_loop	Etat de circulation dans le capteur
20:	TconsBoiler	Température de consigne de la chaudière (selon plancher ou ECS)
21:	Boiler_ene	Puissance fournie au SSC par la chaudière
22:	HFSol_ene	Puissance dissipée dans le plancher par le SSC en Solaire
23:	HFAux_ene	Puissance dissipée dans le plancher par le SSC en Appoint
24:	Sol_ene	Puissance fournie par le capteur au SSC

Parameters 19:

1:	THF_base	Température d'entrée nominale pour le plancher chauffant
2:	TExt_base	Température extérieure nominale
3:	THF_mini	Température d'entrée minimale nominale pour le plancher chauffant
4:	HF_deb_spe	Débit nominal dans le plancher
5:	DT_sol_overheat	Surchauffe autorisée en solaire
6:	DT_aux_HF	Différentiel marche/arrêt de l'appoint sur le plancher
7:	DT_aux_ECS	Différentiel marche/arrêt de l'appoint sur l'ECS
8:	DT_ECSSol_on	Différentiel d'enclenchement de l'ECS solaire
9:	DT_ECSSol_off	Différentiel d'arrêt de l'ECS solaire
10:	DT_PSD_on	Différentiel d'enclenchement du plancher solaire
11:	DT_PSD_off	Différentiel d'arrêt du plancher solaire
12:	TconsECS	Température de consigne pour l'ECS d'appoint
13	Tinside_S	Température de consigne pour la température intérieure
14:	Nmax_oscil	Nombre maximum d'oscillations
15:	TBal_ECSolMax	Température de consigne du ballon solaire
16:	ModeCondens	Indication fonctionnement en condensation max ou min 1->condens. max ou 0->condens. min
17:	FactMelange	Taux de mélange entre arrivée chaudière et retour utilisation Intervalle [0;1]
18:	IncrTcons	Increment sur la température de consigne ECS pour définir la température de consigne chaudière en production d'ecs
19:	FactDebECSol	facteur de pondération du débit dans l'échangeur solaire du ballon

8.2 Type 115: Temperature control tap

PARAMETER
1: Tset : Température de consigne du mitigeur

INPUTS

1: Mconso	: Débit de consommation en ECS	kg/h
2: Tsba	: Température de sortie du ballon d'appoint	
3: Tef	: Température de l'eau du réseau	

OUTPUTS

1: Ts	: Température de sortie du mitigeur vers distribution	
2: Ms	: Débit de sortie du mitigeur vers distribution	kg/h
3: T1	: Température de sortie vers le circuit de chauff.	
4: M1	: Débit de sortie vers le circuit de chauffage	kg/h
5: T2	: Température d'ECS passant en eau froide pour mitiger	
6: M2	: Débit d'ECS passant en eau froide pour mitiger	kg/h
7: gamma	: fonction de controle du mitigeur	%