

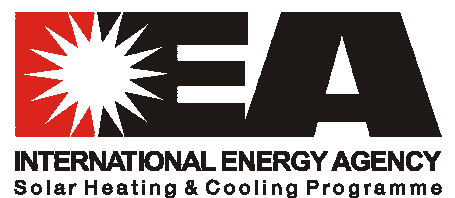
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# The Concise Cycle Test Method A Twelve Day System Test

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**A Report of IEA SHC - Task 26  
Solar Combisystems  
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# The Concise Cycle Test Method A Twelve Day System Test

by

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A technical report of Subtask B



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## 1 Summary

A test cycle for laboratory testing of solar combisystems including auxiliary heat sources was designed. A test facility was built and a small number of systems were tested. Conclusions from theoretical and practical work are:

- The CCT does not provide a direct indication of annual system performance.
- An investigation of the auxiliary heater and controller(s) through measurements is indispensable as most and many problems are associated with these components.
- The emphasis of the test must lie in the investigation of system operation.
- To derive objective figures for annual system performance is a complex task.

## 2 Background and motivation

Laboratory testing of solar thermal systems is justified only if the system to be tested will be produced and installed many times. Otherwise the information gained through testing will not justify the time and money spent. The only kind of solar combisystem that may be produced in sufficient numbers are small units destined for single family homes and produced as fixed sets with a high degree of prefabrication (factory made systems that may be fitted with a variable number of collector modules).

Solar combisystems in Switzerland are most often fitted with an auxiliary heat source other than a simple electrical auxiliary heating element. The auxiliary heater is most often a boiler fired by natural gas, oil or biomass or, alternatively, a heat pump. The auxiliary heater covers the majority of the heat load. It is by far the most important component for the performance of the solar combisystem. In addition, the auxiliary heater's performance (efficiency) is not a constant but depends on the interaction with the other system components. Thus an isolated test of the auxiliary heater is likely not to reveal the boiler's efficiency when integrated into the system. Neither will a test of the system without the auxiliary heater yield a good indication of the overall system performance. For this reason, the auxiliary heat source and its controller should be considered as part of the system when testing solar combisystems.

The CTSS method [1] would be extremely time-consuming and expensive if, for solar combisystems, the auxiliary heater and its controller would be measured and modelled as separate components in order to derive the overall system performance. A faster and less expensive test method for small solar combisystems including auxiliary heater and all controllers was desired. The CCT method is intended to fulfil this requirement. It was inspired by the work conducted at SERC, Sweden [2]. There, a short cycle has been used to compare the performance of a variety of tanks used for solar combisystems. While SERC and other institutes have investigated the possibility of extending the test method to not only compare different tanks against each other, but to be able to determine the performance for standard reference conditions, SPF has developed a longer test cycle to assess the performance of solar combisystems as a whole.

There is a large variety of combisystem designs which tend to be complex and difficult to simulate in detail. In Switzerland, most systems are installed in the same climatic region. Therefore, the primary results of the test should be to:

- gain information about the correct or incorrect functioning of the system and
- permit the derivation of a performance figure for one single set of reference conditions (e.g. one climate, one load).

### 3 Reference conditions for annual calculation

Because the CCT is likely to indicate the system performance for only one single climate and load, it is important to choose a representative set of annual reference conditions. The conditions were evaluated to be as representative as possible for single family homes in Switzerland. Much effort was spent defining these conditions for the hot water load and the mains water temperatures, the building load and its characteristics and the climatic conditions. Once established, the annual conditions were used as a basis to define the conditions of the CCT.

#### 3.1 Climate

There were two reasons not to rely on synthetic weather data, which is readily available from Meteonorm [3]:

- Meteonorm overestimates the fraction of diffuse radiation. An investigation of data produced with the program led to doubts in the reliability of synthetic data in general.
- With verification of the proper functioning of the system being one main objective of the test, it was desirable to use more dynamic radiation data than the standard hourly data.

A set of weather data was assembled by selecting months from 5 recent years of measured data. The time resolution of the source data was 10 minutes. In the source data the solar radiation was provided as global radiation on the horizontal plane. The solar radiation processor of TRNSYS was used to calculate the radiation values on the collector plane which was defined to be at a tilt angle of 45°, oriented south. The data was then stored at intervals of 1/32 h. A comparison verified that it was safe to use the TRNSYS radiation processor at intervals shorter than 1 hour, even though the calculations of the solar radiation processor are based on hourly relations. The weather file includes the quantities global horizontal solar radiation, relative humidity, sky diffuse solar radiation, wind speed and wind direction, even though these quantities are not currently used for system testing or system simulation. Unfortunately the weather data file was completed only long after the start of the simulation work in subtask C and the file could not support this work.

#### 3.2 Domestic hot water load and mains water temperature

The single family home draw-off file (200 lt/d) which was provided by Ulrike Jordan for use in task 26 [4] served as a basis to define the domestic hot water (dhw) load. The original four categories of the draw-off were treated separately. The category small load volumes was split into two new categories with load volumes smaller than 1.6 litres per occurrence and greater than 1.6 litres per occurrence. The occurrences with less than 1.6 litres load volume are considered as volume-type draw-off. Each occurrence of volume-type is terminated when the specified volume has left the tap, no matter what the temperature at the tap is. All other occurrences are considered as energy-type draw-off. These occurrences are terminated when the specified energy has been removed from the system via the tap. The energy is counted only once a threshold temperature is reached.

As a result of a small survey of the situation in Switzerland, the mains temperatures were defined individually for each category of occurrences with each category having its own annual fluctuation. The lowest mains water temperature is 8°C, the highest mains water temperature is 19°C. Choosing mains water temperatures different from those used for the simulations made in subtask C is the main reason why the dhw-load is not identical with the load assumed in subtask C. Also the duration per category of occurrences was slightly changed from the original values.

### **3.3 Building load and building load characteristics**

A single family house was defined to provide the building heat load. The house has 200 m<sup>2</sup> of floor area on two stories. Its annual heat demand amounts to 12500 kWh/a if it is heated to 20°C by an ideal air heater. However, it is heated via the floor (slab) dividing the two stories and with good settings of the controller to assure 20°C indoor air temperature it consumes about 15500 kWh/a. The heated floor area is 100 m<sup>2</sup> with roughly half of the heat provided to the lower storey via the bottom surface. The two stories, however, are modelled as a single thermal zone.

The building is modelled with TRNSYS type 56, the floor- or slab-heating is modelled by type 160 ("floor or hypocaust heating") [5]. Two circuits are used, one of which covers a floor area of 90 m<sup>2</sup>, the other the remaining 10 m<sup>2</sup>. The first circuit is fitted with thermostatic valves. Optionally the second circuit may also be fitted with a thermostatic valve. If the combisystem controller or the auxiliary boiler does not permit the flow through the building heat distribution lines to be shut off, the second loop may not be fitted (or rather simulated) with a thermostatic valve. With a slab heating area (100 m<sup>2</sup>) being smaller than the total floor area (200 m<sup>2</sup>) the heating characteristic is that of a marginally designed floor heating system and similar to that of a generously designed home with radiators. The design supply temperature to the slab heating is about 39°C at a design ambient temperature of -10°C and a flow rate of 550 lt/hr. With both its mass and its window-areas being moderate, the house benefits moderately from passive solar gains.

## **4 The CCT test conditions**

The core of the CCT consist of 12 days which were composed of days selected from the annual reference conditions. Different days were selected for climate and dhw-load.

### **4.1 Climate**

The days were selected to correspond with the annual conditions in this order:

- solar irradiation on the collector plane
- fluctuation of the daily solar irradiance on the collector plane
- ambient temperature

After selection of the days the ambient temperature was modified at the beginning and end of each day in order to get a gradual transition from one day to the other. Also the temperature was smoothed throughout the test to obtain a very continuous function of time.

### **4.2 Dhw-load**

The days were selected to correspond with the annual conditions in this order:

- Total energy of energy-type occurrences
- Fluctuation of daily sums of energy-type occurrences
- Include at least one day with a rather difficult-to-meet load profile
- Reflect the seasonal fluctuation

No care was taken to assure that the sum of the dhw-volume of volume-type occurrences corresponds to the annual conditions. The CCT-dhw-load file gained through the selection of days from the annual file was not further manipulated for fine-tuning with two exceptions: If

occurrences of different categories were to take place simultaneously, the time of one occurrence was shifted to a time nearby. The minimum flow rate is limited to 250 lt/min.

## **5 Additional and preliminary tests**

A series of tests are useful to adjust the controller settings and the setting of the domestic hot water mixing valve before running the CCT.

### **5.1 Conditioning before running the core CCT**

Two phases are used to condition the tank before starting the core phase having a duration of twelve days: the initial conditioning and the cycle conditioning.

#### **5.1.1 Initial conditioning**

During the initial conditioning phase both the auxiliary heated (upper) part and the lower part of the tank should be brought to reasonable temperatures before the cycle conditioning starts. This may be achieved by: a) conditioning the tank at 25 ... 30°C; b) enabling the auxiliary heater to heat the upper part of the tank to its auxiliary set temperature. Alternately a UCT (see below) may be run. Else, if a CCT has been attempted and aborted during the first three days, the cycle conditioning may be started immediately.

#### **5.1.2 Cycle conditioning**

The final 18 hours of the core phase of the CCT is added before the beginning of the core phase. These 18 supplementary hours are called the cycle conditioning phase. Simulations were used to verify that the energy stored in the tank and, more importantly, the energy stored in the virtual building and its slab heating is nearly equivalent at the beginning and at the end of the core phase. Experience has shown that the cycle conditioning phase brings the tank to the wanted temperatures effectively and that the influence of the temperatures after initial conditioning is minor. However, this is true only if, at the start of the cycle conditioning phase, the temperature at any layer in the tank is not much above the auxiliary set point temperature.

### **5.2 UCT: a short preliminary test**

One of the major findings of the practical tests is that solar combisystems tend not to work the way they are meant to. It would be a pity to run a full CCT only to discover that e.g. a valve is not working at all. Therefore it is advisable to run a short preliminary test. The UCT (ultra concise test) runs at high load and radiation (higher mean values than annual cycle or concise cycle). There is a relatively small load and moderate solar radiation at the beginning to allow the auxiliary heater and the solar collectors to bring the tank to normal operating temperatures. Next, there is a high space heating and dhw-load to check extreme conditions like system behaviour at low ambient outdoor temperatures. The final phase of the UCT consists of high solar radiation and a low to moderate space heating load to check the system covering its load by using stored heat and solar input. The UCT is a good method to check the fitness of the test facility, since it, as well as the candidate test system, runs under

high load conditions during the UCT. The UCT is modified for specific needs and for different initial states of the system. It is not at all used to derive a system performance figure.

### **5.3 Hot water temperature test**

As a rule, the hot water mixing valve is installed with the system and needs adjustment. For the series of tests in process at time of writing, it has been prescribed that the hot water temperature shall be between 50°C and 55°C under normal conditions. Repeated testing may be necessary to adjust the valve and verify the correct setting and functioning.

### **5.4 Hot water performance test**

it is advisable to avoid settings that impede the system from covering the dhw-load imposed during the CCT. To do this, another preliminary test is used. After conditioning the tank using the same procedure and criteria described above as initial conditioning before the CCT, a series of draw-offs at different flow rates are scheduled. The energy removed during each draw-off is prescribed. The test resembles the procedure developed by other task 26 participants and described in chapter of this technical report. However the recovery times between draw-off occurrences is longer and the auxiliary heater is normally enabled during part of the test. This hot water performance test may be modified depending on the system's programmed modes of operation. Particularly the enable times of the auxiliary heater may be extended or restricted. For example if, during the CCT, the auxiliary heater shall always be enabled to supply heat for dhw-preparation and -storage then the auxiliary heater may be enabled throughout the hot water performance test too.

### **5.5 Adjusting and testing the space heating controller**

Generally the supply temperature to the space heating is controlled by the system controller as a function of the ambient outdoor temperature (heating curve). Thus the space heating load is determined not only by the test facility but also by the system. For example if the system supplies fluid hotter than expected into the space heating, more heat will be removed by the test facility and the temperature inside the virtual building will be higher than would normally be expected. To minimize the differences in space heating consumption between systems, it is advisable to adjust the space heating controller as carefully as possible. Simulations were used to define a desired heating curve as a function of the fluid flow rate. If possible, the controller is then adjusted accordingly.

### **5.6 Standby-loss test**

After completion of the CCT, the stand-by heat losses, or rather the stand-by energy consumption of the system is determined. Immediately after the CCT, the system's auxiliary heater is left enabled for the dhw-preparation. It was found that the systems reach steady state quickly, often within one day. The auxiliary energy consumption can be used to indicate stand-by losses. During the standby-loss test the CCT data is checked and the disassembly of the system can be prepared.

## 6 The indoor test facility at SPF

### 6.1 Principles

- The test facility should allow for the installation and operation of the candidate test system as completely as possible.

Therefore the system is installed completely with the exception of the collector array and the building. All controllers including their sensors are installed. The auxiliary heater may use either natural gas or fuel oil as its energy source. It is intended to expand the test facility to also allow automatic biomass boilers. In principle, it would be possible to let the system operate with ground source heat pumps as an auxiliary heater. However, the ground source would have to be emulated.

- The design of the test facility should be such that there is no or only minimal interference with the system and its operation.

The system controllers are set-up to operate as under normal in-field conditions. Under normal circumstances there are only two exceptions: Because there are no collectors, the temperature sensor of the collector-loop controller may not be installed in the collector. It is installed in the collector-emulator instead. The output of the collector-loop controller, normally connected to the collector-loop pump is instead received by the test facility. The test facility then controls the collector-loop pump.

- It must be possible to simulate the test.

In order to be able to simulate the CCT and to finally derive a system performance metric for annual reference conditions it must be possible to simulate a system which is similar to the candidate test system for both the CCT-conditions and the annual reference conditions. This is one of the reasons why TRNSYS is used to control the collector- and building load emulators.

### 6.2 Installation of the system

The system is installed in a designated area in the indoor test facility by the manufacturer or a designated installer. The backside and the left hand limit of the installation area consists of an inner wall. Except for the collector loop piping, the components of the system may be fitted to the inner wall or are set on the concrete floor. For the collector loop piping a special rig may be used. A number of rules have been set up to make sure that the installation of the system is realistic. Experience with solar domestic hot water systems has shown that if no such rules exist, most installations and particularly the pipe work are specially tuned for testing. The rules (in German) are available from SPF on request. The most important rules are:

- There may be no bend downwards on any pipe connecting the system to the test facility, unless this piece of pipe (bend down) is prefabricated and delivered with the system.
- The hot water pipe that connects the system to the test facility may not be insulated.
- No insulation may be added to the system or any pipe. Excluded from that rule is the piping that supplies and returns water to and from the test facility for space heating.

### 6.3 Collector emulation

The collector array is emulated using an electrical heating element and a plate heat exchanger for cooling. The matched flow collector model [6] is used to model the collector power. However, the component model may be replaced with any other collector model

suitable and compatible with TRNSYS. TRNSYS predicts the power for one simulation time-step based on the inlet temperature and flow rate from measurements and the ambient temperature and radiation from a file. The calculated collector output power is then transferred to the test facility and used as set-value. Special TRNSYS-components have been programmed to exchange information between TRNSYS and the computer program which controls the test facility. The simulation time-step is 1/32 h which is equivalent with the time interval at which data is provided from a file. A glycol-water mixture is used in the collector loop. It is always of the same brand, quality and concentration. It is identical to the fluid used for collector testing at SPF.

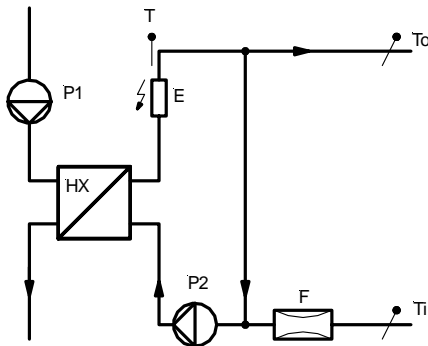


Figure 1: Simplified schematic of the collector emulator. P1 is a pump on the cold side of heat exchanger HX; P2 assures a high and constant flow rate through the heat exchanger HX and the electrical heater E; F: flow-meter; Ti, To: inlet and outlet temperature sensors. T is the system temperature sensor. In a real installation it would normally be located at the outlet of the collector array. At the same position there is another temperature sensor of the test facility to control the temperature at T.

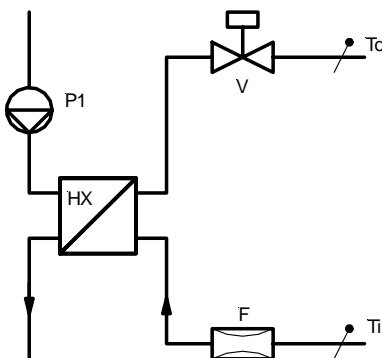


Figure 2: Simplified schematic of the building load emulator. The basic design is similar to the collector emulator (see Figure 1). V is a motorised variable valve. Its purpose is to simulate a thermostatic valve. The position of the valve is a function of the (virtual) indoor air temperature.

## 6.4 Building load emulation

The emulation of the building load is to a high degree identical with the emulation of the collector. Here an outlet temperature (not power) is transferred from the TRNSYS simulation to the test facility controller and used as a set value. The system controller normally determines the supply temperature to the building heat distribution based on the ambient (outdoor) air temperature. Optionally, the indoor air temperature may be used too. The

outdoor air temperature which the system shall assume, is generated in a small box. The system's sensor is located in that box during the test. Another box serves to optionally accommodate a sensor for the indoor air temperature. However, no system has been tested using the indoor air temperature for space heating control yet.

## **6.5 DHW-conditioning and control**

The mains water is conditioned to the temperature specified in the file. The flow rate is also controlled.

## **6.6 Measurements**

### **6.6.1 Auxiliary energy consumption (natural gas or fuel oil)**

The measurement of the auxiliary energy consumption is the primary quantity used to characterise the system performance. The auxiliary heater will most often cover between 65% and 95 % of the heat load, but the purpose of the testing is to obtain information on the remaining 5% to 35% which is covered by the solar collectors! For there shall be a reasonably accurate judgement of the solar performance, the assessment of the auxiliary energy consumption must be accurate to within  $\pm 1\%$ .

In the case of a gas boiler as auxiliary heater, natural gas from the line is used. It is difficult to meet the required accuracy. The measurement is complex and expensive. The volume flow is measured by a drum-type flow-meter. The assessment of the calorific value of the fuels cannot be done in-house which tends to increase the inaccuracies and uncertainties. (An unpleasant thing about the measurements you take yourself is that you too often find out they are wrong. The unpleasant thing about relying on measurements taken by others, is that they may be worse but you do not find it out.)

Two alternatives to using natural gas from the line were evaluated but rejected:

- Liquefied propane/butane from bottles (not the same properties as natural gas; some boilers can not be operated on this type of fuel)
- Pure pressurized methane from bottles (too expensive).

An alternative to the drum-type gas meter would be to compress natural gas from the line alternating into two or more bottles and use scales to determine the amount of gas used. Fuel oil consumption is measured by means of a scale.

### **6.6.2 Temperatures**

The points at which the system has to be hydraulically connected to the test facility are clearly defined and are identical for each system to be tested. Thus they are not necessarily as close as possible to the system. (E.g.: The manufacturer installs the pipe that connects the cold water supply to the tank. The pipe is considered to be part of the system. The temperature is measured at the facility near the point where the system is joined to the facility.) This is also true for the temperature measurements used to determine the collector gain and the building load. It is slightly different for the measurement of the hot water outlet temperature: The test facility uses a pipe to mimic the hot water distribution piping. The pipe has a defined geometry. The hot water temperature for dhw-energy calculation is measured at the outlet of this pipe.

### 6.6.3 Flow rates

Fluid flow rates are measured within each loop (building, collector, draw-off). Because the TRNSYS models use constant fluid properties (specific heat, density), the capacitance rate is calculated by the data acquisition system and passed on to the TRNSYS simulations.

### 6.6.4 Parasitic energy

Parasitic energy consumption is measured. If the system permits, the measurement is split up between the type of usage (auxiliary heater, building load distribution, collector loop operation).

## 7 Theoretical investigations

Simulations of the test and annual simulations of the same system have shown, that the performance assessed during the CCT is not directly representative for the systems annual performance. There is a few percent difference of a few percent in mean auxiliary power. There is a difference of about 15% (depending on the system type and sizing) in mean collector power. The CCT overestimates the energy gained by the collectors. This is due to the share of the collector loop in operation being longer during the simulation of the CCT compared to the simulation of an annual cycle. During the annual cycle the collector loop is out of operation during much of the summer period, because there is excessive solar energy provided. The concise cycle is too short to heat up the tank and leave the collector loop out of operation for a long time. Depending on the system and its controller settings the stage of solar overheating will not be reached at all. However, a relatively high temperature will be reached and throughout the 12 days the tank will go from fully discharged at the beginning to (nearly) fully charged and be discharged again. This means that it will be used more intensively and contribute more to the system performance than it would be in a real year. Thus a direct characterisation based on a CCT is not possible. This is one reason why the name AC/DC (annual calculation / direct characterization) is replaced by the more appropriate name concise cycle test (CCT). The other reason is to make sure that the CCT is not mistaken for the other short test method examined in Task 26, referred to as AC/DC in Task 26 and this technical report, which might be used for the testing of tanks used for solar combisystems.

The simulations show that the CCT-result is not representative for the annual performance (e.g. the solar fraction is not the same). The results (e.g. the auxiliary consumption) may not be calculated by multiplying the CCT results with a factor as simple as 365/12. This is true for both the auxiliary and the parasitic energy consumption. A more complex treatment of the CCT results is required to determine the annual performance. There are two obvious options to do this:

- Determine a set of functions to convert CCT performance into annual performance by means of preliminary simulations.

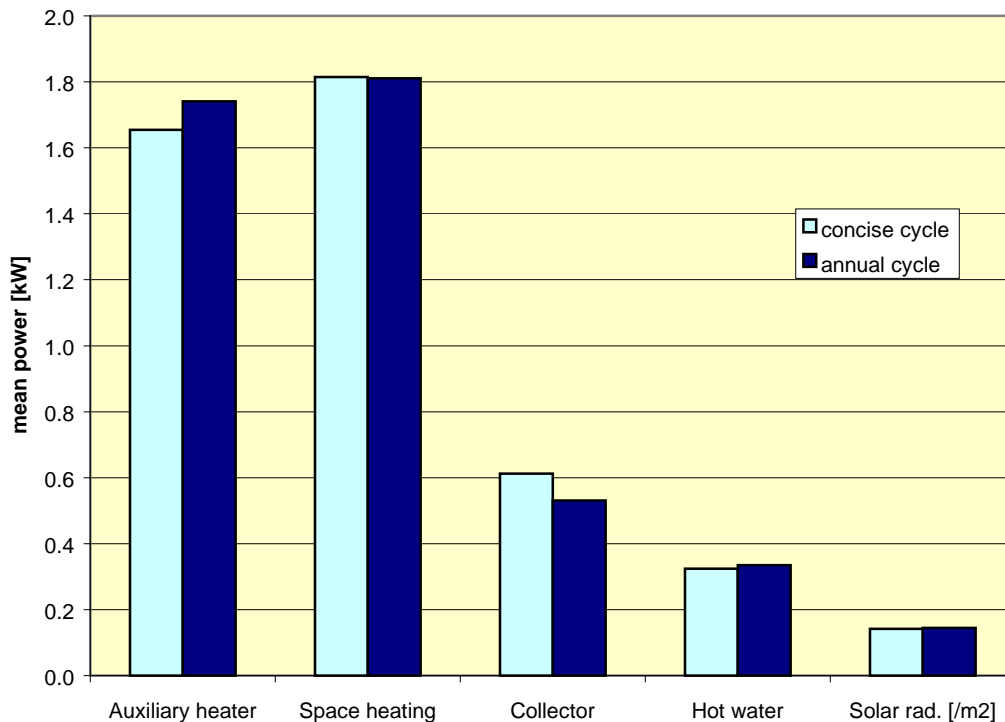
The obvious disadvantages of this option are that a lot of preliminary work has to be done and that there is still no certainty that this work covers properly all the system types and system sizes necessary.

- Make a computer model that is able to predict the CCT performance and use this model to predict the systems annual performance.

The obvious disadvantage of this option is that there will be extensive treatment of the measured data (modelling, parameter identification, etc.) before the annual performance is found. If the model needs to be precise, the CCT is certainly not the best possible

measurement because in this case the CTSS method comes very close and there is enough experience with that method to know that there are better test sequences than the CCT to determine the system parameters.

The best solution lies in using a CCT that is representative enough that the annual performance can be derived from the test. It should be possible to use either correlations or only a few simulations (or a combination of the two) to find the annual performance.



*Figure figchap.3(?): A comparison of the concise cycle and annual cycle mean power, based on simulations. The system simulated is a typical combisystem with 12 m<sup>2</sup> of flat plate collectors and 800 lt of tank volume. There are non-negligible differences for the collector (80 W, 15.3%) and the auxiliary heater (85 W, 5%). The differences of the space heating consumption, hot water load and solar radiation per square metre on the collector plane are negligible and mostly due to the design of the concise cycle.*

## 8 Practical experiences

At time of writing three systems have been tested (measurements completed). The systems were selected from applications. This initial set of measurements of solar combisystems at SPF is partially sponsored by the Swiss Confederation (Bundesamt für Energie). The participation is restricted to systems that are to a very high degree factory made. They are fixed combinations of tanks, solar collectors, auxiliary heat source (oil or gas) and controllers. The most important restriction is that there may only be one or two subassemblies. (E.g. a tank and a subassembly which includes the auxiliary heater and all valves, controllers, etc.). Most systems will be fitted with tanks of around 700 litres in volume and will be tested as being equipped with between 10 and 15 m<sup>2</sup> of (gross) collector area.

## **8.1 Building and operating the test facility**

The main lesson learnt is that building the test facility is time-consuming and expensive. The facility should operate without major malfunction during a relatively long period. To achieve this, a high degree of reliability is required. Much more time and money than anticipated was spent in three fields:

- Software of the test facility
- Measurement of natural gas consumption
- Boxes for simulated outdoor and indoor temperatures

## **8.2 Running tests**

Out of the four combisystems for which measurements were taken to date, none worked precisely as it was intended by the manufacturer. This is even more surprising as the participation is explicitly restricted to systems that were (or rather should have been) beyond the prototyping stage of development. A typical problem is that the desired controller setting can not be determined by the manufacturer or his designated installer. In many cases the manufacturer of the solar system had to call on the manufacturer of the controller or boiler to identify the setting that assured correct operation. In one case a logic board of the auxiliary heater had to be reprogrammed by the boiler manufacturer and sent to the test institute for replacement. All problems were associated with boiler operation or with controller functions being inappropriate in conjunction with other controllers or in conjunction with the system design and schematics. None of these problems would have been identified if the boiler (and its controller) were not installed and tested together with the other components! Conclusion:

- It can hardly be overemphasized at this point that the primary objective of a combisystem test should be to verify the correct operation of the system. To evaluate system performance is a second order priority.

Even though much care was taken to make sure that the heating curve was adjusted correctly, there are great differences in space heat consumption between the systems. The relative difference is nearly 20% which is much more than had been expected. Of the three systems, all had the space heating enabled at all times, no nightly reduction of the supply temperature was programmed.

- Space heating controls tend not to work predictably. There is an important problem for fair comparison of system performance because there are important differences in the "load".

It had been anticipated that there will have to be a correction for different systems supplying more or less energy for space heating. There is little doubt, that a correlation can be established based on simulations of the test. However, the difficulty is to decide whether or not such a correction is useful. For example assume the space heating controller of a system performs well at the design temperature. It supplies 35°C at an ambient outdoor temperature of -10°C. According to the heating curve programmed in the system controller it should supply 30°C at 0°C ambient temperature. But measurements show that the supply temperature is then much lower, barely above 25°C, whenever the system supplies (solar) heat from the tank to the space heating. Thus the system heats the building to a lower temperature than it would if the controller performed according to the expectations. The (virtual) building indoor temperature may still be within acceptable comfort limits mainly because the low supply temperatures occur simultaneously with passive solar gains. On the one hand, the system does not perform the way it is meant to. On the other hand, due to the load being low, it will have a low auxiliary consumption. In a simplified view one would say it is a well performing system. It is possible (but far from sure) that the system performs well in

many practical applications. If the house is well suited to the system (or rather its controller) in terms of passive gains, thermal inertia and thermal zoning, good performance is highly probable. In other applications, however, it might be an under-performing system: If there are a few days of the year with insufficient heating, the user will be inclined to lift the heating curve. By doing this the energy consumption will increase throughout the heating season. It is difficult to make an objective judgement of the system. It is not simple to decide about the principles to use for calculation of the annual performance. Because the findings of the testing are complex there is also the problem of their presentation. It might be possible to tell the manufacturer that his system had been energy-efficient did not perform well. However, it is useless to make such a statement to the public e.g. to a potential buyer of the system.

## 9 Outlook

There will be a series of at least ten tests within this and the next year (2003). Throughout these tests the CCT is likely to remain unmodified. The tests will reveal more problems, requirements, positive and negative aspects of the CCT method. Decisions will have to be taken regarding the derivation of an annual performances figure from the CCT and the presentation of test results. Publication of the test results is subject to the manufacturer's consent. Therefore, no prediction may be made about the number and release dates of publications.

Test institutes are encouraged to explore the field of solar system testing following the principles outlined above. SPF will readily support such work.

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