ANALYSE OF FUNCTIONALITY AND QUALITY OF 120 SOLAR THERMAL SYSTEMS IN RESIDENTIAL BUILDINGS AND COMMERCIAL APPLICATIONS

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1. Introduction

Large solar thermal systems in residential buildings and commercial applications (tourism services, sports facilities, wood drying, operation buildings of hair dressers, butchers, etc.) launched successfully in the Austrian solar thermal market in the last few years. This fact motivated the solar branch and a few subsidy departments (on federal level and in the provinces) to initiate a broadly based analysis of the systems' functionality and quality.

Fig. 1: 120 plants between 20 und 400 m² in different applications have been evaluated

Within the frame of a research project assigned from Klima- und Energiefonds as well as the provinces Styria, the Tyrol, Vorarlberg and Lower Austria 120 solar thermal systems (with a collector area between 20 m² and 400 m²) will be analyzed. The aim of this research project is to deliver the basics for the improvement of the functionality and quality of the system on the one hand and to define a consistent quality standard in cooperation with subsidy departments on the other hand.

The non university research Institute AEE INTEC is the leader of this project assisted by the regional Institutes Energie Tirol, Energieinstitut Vorarlberg and AEE Wien/Niederösterreich.

2. On site plant visits and temperature records

With the help of a structured tool kit an expert rates all solar supported heating networks on site in two categories. Category 1 includes a total of 148 different assessment criteria of qualitative and quantitative aspects for example suitability of components, dimensioning of components, safety device, shade effects, thickness of insulation, working up quality, etc.. Category 2 evaluates the plant functionality in general and includes 60 different assessment criteria. Typical examples are the check of the pressure ratios, the actual switching status of pumps or valves, the actual temperature values. A key aspect in rating the plant's functionality is a temperature recording at each hydraulic loop (flow pipe and return pipe) based on a mini temperature logging system. These mini temperature loggers remain in the plant for about two or three weeks. Then the data loggers are uploaded and the measured data are illustrated as temperature profiles and checked for plausibility. The results from the temperature data logging are then compared and overlaid with the results from the on site visits. The advantage of the mini data loggers is the low price of approximately €20 per logger and the achievable precision in order to identify the respective rate of the system function (for example operation time, temperature differences between flow and return pipe, gravity driven circulations, fault flow, etc.).

3. Data evaluation and plant assessment tool

The assessment of all plants was based on 12 different rated categories of energy efficiency (for example plant functionality, selection of dimensions and components, choice of system concept, details of installation, plant management, etc.). In addition to the category of "energy efficiency" a second main category "plant safety" was defined. This category includes for example working up details for safety devices, lightning connection, implementation of the Austrian hygiene standard B 5019 for domestic hot water preparation, etc.

It has to be taken into consideration that the whole plant assessment was done with a holistic approach, that is a detailed evaluation of the solar plant but also an evaluation of specific aspects from other chapters of the entire heat supply system with a great influence on the operation of the solar plant. This includes for example important things like the hydraulic involvement and the operation mode of the conventional heat supply system as well as the heat distribution system.

The rating of the 12 energy efficiency categories as well as the reached results of all 120 plants in these categories are diagrammed in figure 2. It is easy to identify that in practically in all efficiency categories there is room for improvement. Based on the rating the most room for improvement lies in the categories "Functionality" and "Choice of system concept". At a relative consideration the categories "dimensioning and component selection", "plant management", "hydraulic regulation", "pipe insulation" as well as "stagnation behaviour" show extensive potential for optimization.

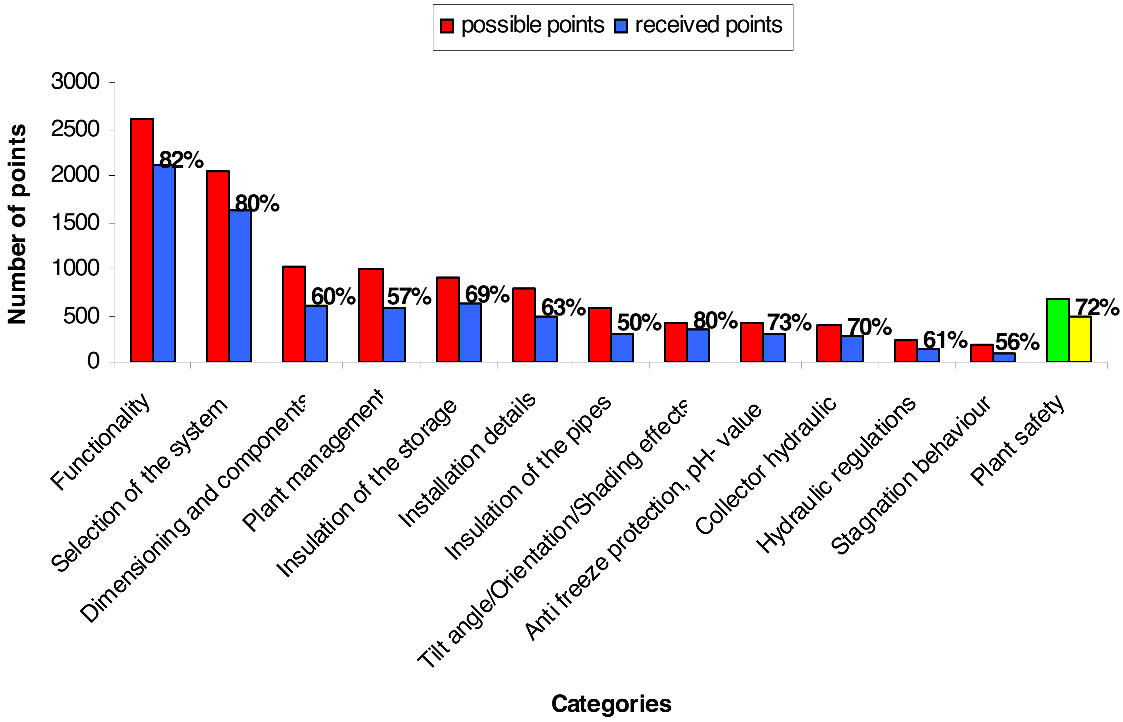

Fig. 2: Comparison of the theoretically achievable points in all 120 plants with the effectively reached (in 12 energy efficiency categories and one category in plant safety)

4. Definition of an energy efficiency label

For a clear illustration of the particular plant quality an energy efficiency label based on this 12 main categories was created. Concerning the illustration and the information the energy efficiency label for solar supported heating systems is based on the energy certificate for buildings. Following a respective code the label consists of 7 stages (from A to G). The energy efficiency label "A" represents a solar system with highest energy efficiency and the energy efficiency label "G" stands for a quasi malfunction of the solar system. On the one hand all the noticed deficits were considered in the assessment of the plants. Otherwise all deficits which could be corrected with some effort are listed in a separate column of the label. This allows a direct feedback to the plant operator or to the investor. Noticeable deficits in the category "plant safety" (safety devices, statics aspects, implementation of the Austrian hygiene standard B 5019 for domestic hot water preparation, etc.) are noted on the label but not considered in the energy efficiency assessment.

The numbers of the respectively given labels for the overall 120 evaluated plants are illustrated in figure 3. For one plant the energy efficiency label "A" was given from the project team. Label "C" was with 48 plants the most frequently given label. All in all 97 of the 120 plants are ranked in the band "A" to "D". Considering the very critical assessment process this is an excellent result.

The remaining 23 evaluated plants (label "E" to "G") show failings in functionality. Some of this failings concerned the solar plant directly but in a lot of cases also indirectly from the common heat supply system with negative effects on the solar plant. Six plants were awarded the energy efficiency label "G". This means 6 solar systems with quasi malfunctioning.

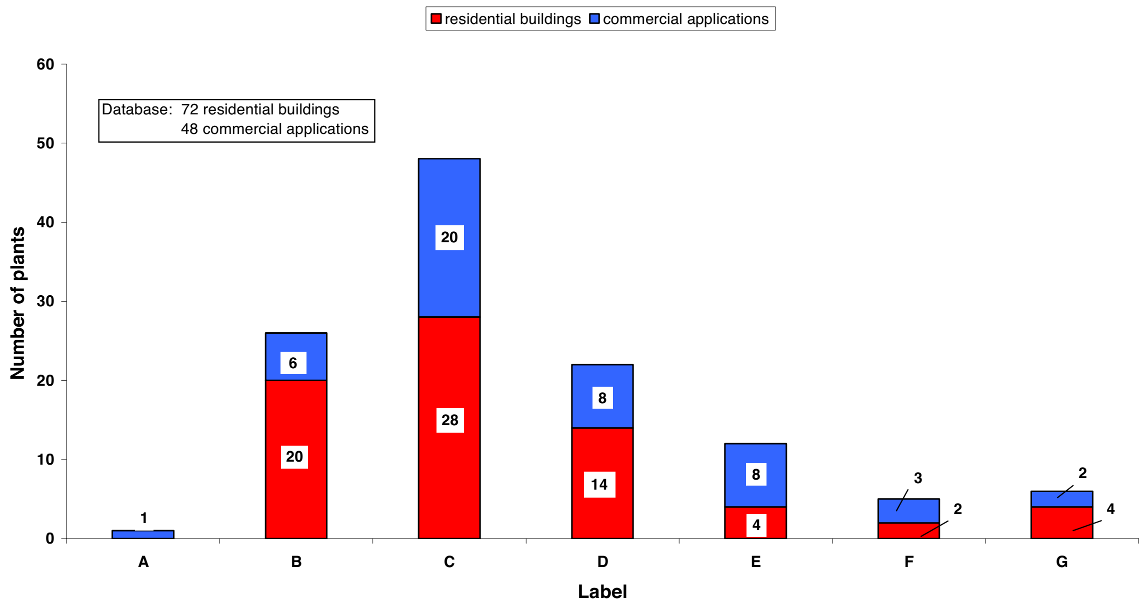

Fig. 3: Frequency scale of all 120 evaluated plants related to the 7 possible quality label

Plants with virtually no functionality were rated as a „quasi malfunctioning". For example plants with no mass flow in the solar loop in a regular operation point or when the integration of the conventional heat supply system (boiler) was blocking, label "G" was given.

5. Frequency scale of different assessment indicators and plant parameters

The extensive data volume of the respective plants were transferred into a data bank and then submitted to a specially created analysing tool. The analysing tool allows the statistic interpretation of each individual point noted during the on site plant visits and thus enabled the comparison with all 120 plants. This data base allows the preparation of frequency scale diagrams for example to the specific storage volume, to specific flow rates, to specific pipe dimensions, dimensions of expansion vessels, insulation thickness of storage tanks, number of storages, concentration of glycol, type of the general hydraulic concept, number of leakages, deficits in the plant management and quality assurance, etc. An exemplary frequency evaluation from the three plant realization chapters "planning", "up working" and "plant management" is given in figure 4, 5 and 7. Figure 4 shows as an example the specific storage volume over the collector area of all 120 evaluated plants.

According to figure 4 the most common used specific storage volume lies in the suggested band between 40 and 100 l/m² gross collector area. It shows that also numerous specific storage volumes are less than 40 l/m² gross collector area amounts and are thus in a sub optimal array.

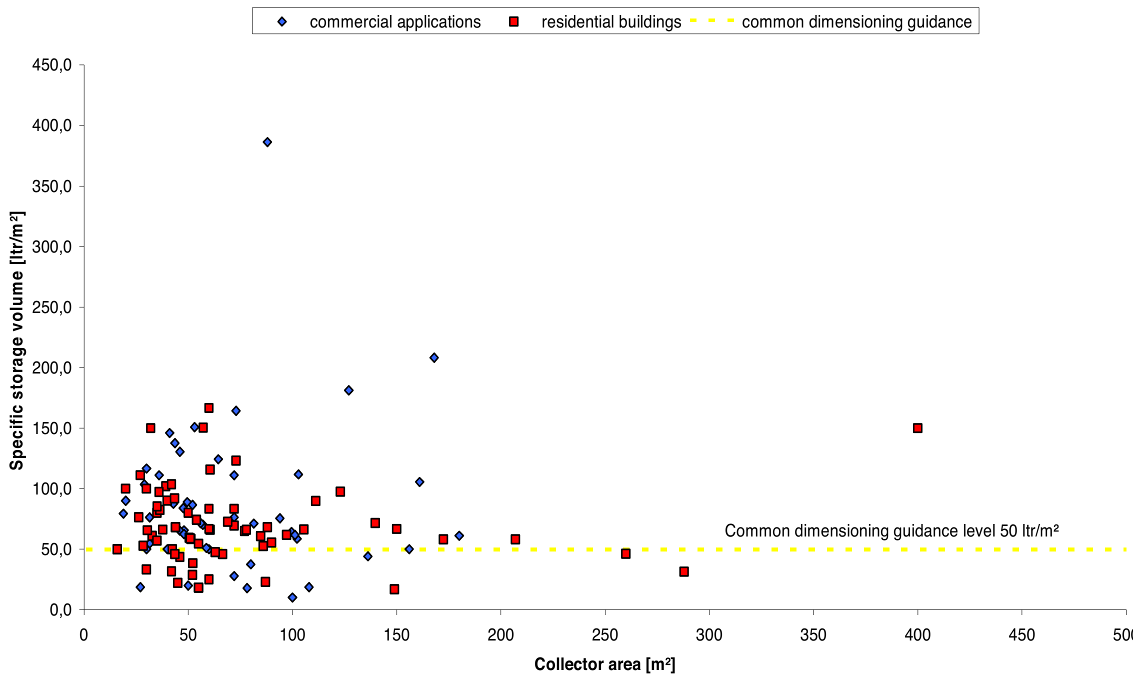

Fig. 4: Distribution of the specific storage volume over the gross collector area

Figure 7 shows the frequency scale of noticed leakages in the primary and secondary solar loop. In this picture there is a difference between actual leakages and marks of previous leakages. Actual leakages were noticed in 16 primary loops and 7 secondary loops.

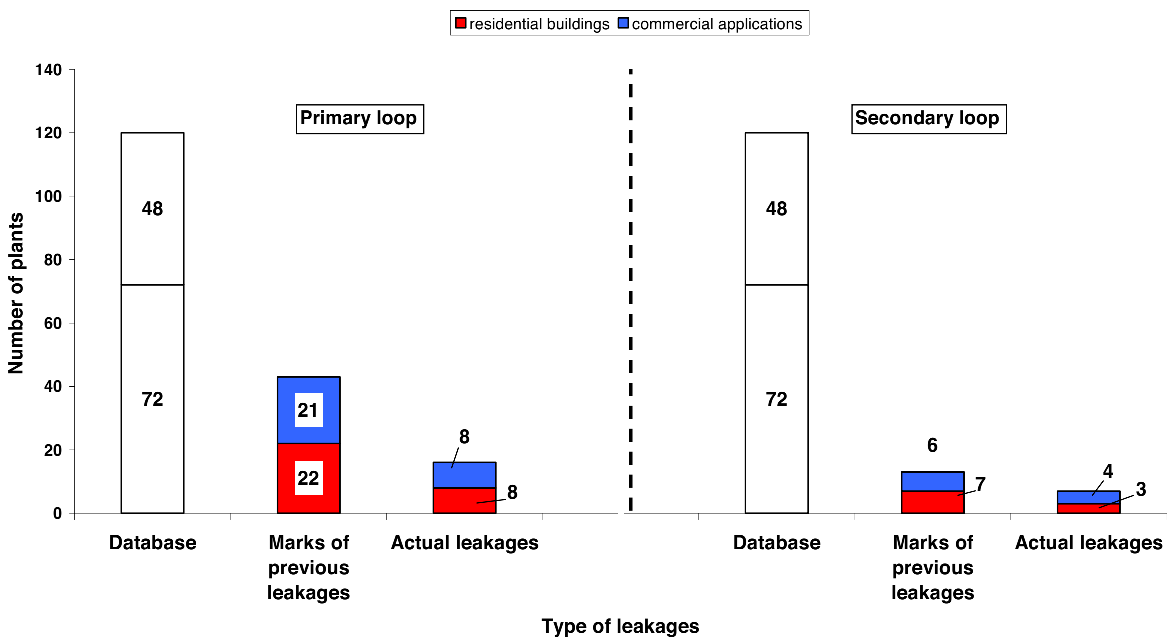

Fig. 5: Exemplesfor a frequency scale noticed leakages in the primary and the secondary solar loop

As illustrated in figure 6 the most frequent leakages were located in the primary loop as well as in the secondary loop at assembled hydraulic stations or pump groups. It is assumed that the reason for the frequency of the leakages in the assembled hydraulic stations lies in not controlled - respectively not retightened - screw connections. If the plant is in normal operation mode the insulation jacket of the hydraulic stations avoid an immediate visual control. But it is also to consider that the located leakages are minor in dimensions.

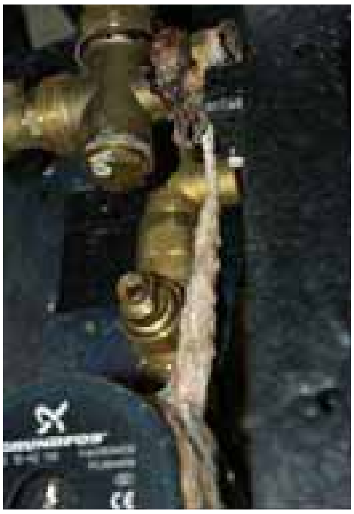

Fig. 6: Exemplarily illustration of located leakages in assembled hydraulic stations and pump groups

Figure 7 shows the frequency scale of aspects in the field of plant management and quality assurance. 92 out of all 120 plants a hydraulic scheme was available as drawing or as a draft version. Only at 63 plants (less more than 50%) the hydraulic scheme was also arranged on site.

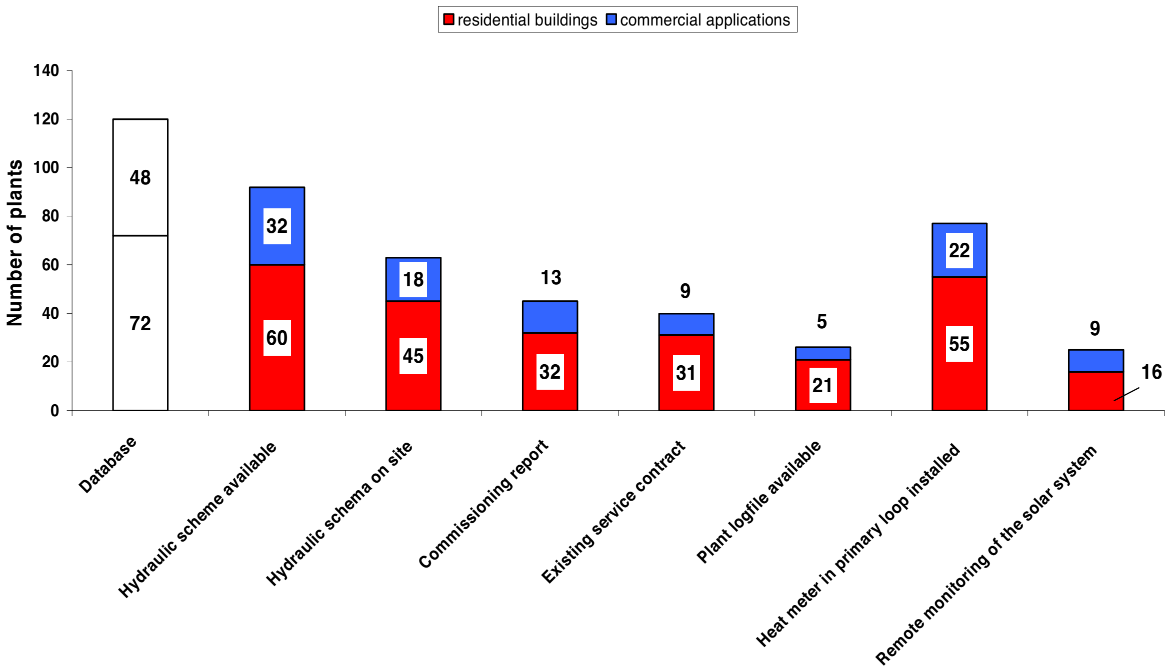

Figure 7: Examples for frequency scale of several aspects in the field of plant management and quality assurance

A heat meter in the solar loop was located in 77 plants. Only in 40 plants a professional service contract was concluded. Figure 7 clearly shows the optimization potential in this kind of assessment category.

In an analogical way a lot of additional interesting data from all 12 i.e. 13 assessment categories were analysed and illustrated in comparable frequency scale diagrams.

6. Summarisation of the results and look out

In summary it can be said that 97 plants in the label categories “A” to “G” of all evaluated 120 plants demonstrate excellent functionality and quality of large solar systems. Considering the very critical assessment process this fact shows a very good result of the broad focused plant evaluation. 23 plants were evaluated with labels from “E” to “G” and this means, that there are really problems in plant operation.

However, in all 12 categories of “energy efficiency” as well as in the category “plant safety“ could be improved. This requirement of improvement refers to all three main areas of responsibility “planning”, “working up” and “plant management”. The evaluating results showed very clearly that the plants with continuous controlling of functionality and solar yield have better energy efficiencies.

Basically the application in residential buildings showed a better functionality and plant quality than the commercial applications. The reason for that can be explained on the one hand with a higher level of system concept standardisation and on the other hand with first basic approaches of professional plant management.

Based on this evaluation results in the objective project a guideline to implement solar supported heat supply systems was created and submitted to the target group. In special workshops with subsidy departments as well as with the HVAC- and solar sector first steps to implement the project results were discussed and worked out. In addition the project results will be integrated in relevant training courses for example the Austrian “Zertifizierte Solarwärme Ausbildung’’.