PRECISE MEASUREMENT OF LARGE COLLECTOR ARRAYS FOR THE DEVELOPMENT OF IN-SITU TEST METHODS

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Abstract – The calculation of the expected energy yield of SDH-systems depends heavily on collector efficiency values that are usually derived from laboratory tests of single collectors. The operating conditions of large-scale collector arrays may differ substantially from laboratory conditions. Because of that, the expected solar yield remains highly uncertain, which is an obstacle for further market penetration. To increase the planning reliability of SDH-applications, the research project MeQuSo aims to extend the quasi-dynamic test method of single collectors to arrays.
To develop and validate this test method, it is a prerequisite to acquire precise data of all physical quantities, which are influencing the solar yield of collector arrays. In an Austrian SDH pilot plant, six different collector arrays, each consisting of identical high temperature collectors, was equipped with high precision measurement equipment. The observation will last for a two year period to allow evaluation of monthly, seasonal and yearlong dependencies of collector parameters.

Keywords: In-situ dynamic test, large collector array, Solar Keymark

1. INTRODUCTION

According to a study published by the Austrian Federal Ministry for Transport, Innovation and Technology a market growth in the segments of solar district heating and solar industrial process heat, is being observed recently[1]. Since the heat demand of these applications is substantially higher than for conventional solar installations, large scale collector arrays are needed. Large systems have a substantial prize advantage, due to the cost per square meter of installed collector area decreases with increasing collector area (economies of scale).

For further market penetration of large scale solar thermal systems, several challenges have to be addressed. One of them is the reliability of collector test results. The thereby derived collector efficiency values are the basis for simulations of the yearly energy yield as well as for investment appraisals.

The testing of solar collectors is standardized in the standard EN ISO 9806:2013. Evaluating the thermal performance of a collector according to this standard requires specified test conditions, i.e. defined solar radiation, incidence angle, wind speed etc. The standard also includes outdoor test procedures at specified weather conditions.

Operational conditions of collectors in large solar thermal plants usually differ from the conditions under which the collectors were tested. Secondly, plant-specific characteristics as the azimuth, the inclination, hydraulic effects as variable volume flow caused by speed-controlled pumps, differentiated flow rates of parallel collector arrays and characteristics of the heat transfer medium are not considered in the current test approaches. In Europe solar thermal products are usually certified by Solar Keymark, which is a voluntary third-party certification mark, demonstrating to end-users that a product conforms to the relevant European standards and fulfils additional requirements. The Solar Keymark Certificate is increasingly recognized worldwide.
However, there have been some discussions recently about the credibility of test results of specific collectors for which Solar Keymark Certificates had been issued, following several complaints[2].
The Solar Keymark Scheme Rules allow a high degree of variability of test results – they specify that if the integral of the measured instantaneous efficiency at the special test is more than 90% of the already registered integral the test is considered to be valid[3]. This can lead to a distortion of competition and is increasing the risks for solar thermal plant operators and potential investors.

To reduce the uncertainty of the thermal performance of solar thermal collectors and to increase the planning reliability, current test methods have to be scrutinized and the actual operating conditions have to be put into consideration. A major goal of the research project MeQuSo is to develop an In-situ test of the power output for large collector arrays to assess the thermal performance of the deployed collectors under real operating conditions in the field.

2. The solar thermal test plant “Fernheizwerk Graz”

To develop this In-situ test method, the behaviour of solar thermal plants in operation has to be investigated. In the research project MeQuSo a test plant, located in close proximity of a gas-fired district heating plant in Graz, Austria will be evaluated in detail. The plant, shown in Figure1, has a gross collector area of about 2.500m² whereby seven different collector types of six leading European manufacturers have been installed. The installed collectors represent the highest quality products in the market for high-temperature flat-plate collectors.

Regarding the hydraulics of the absorbers there are harp, meander as well as direct-flow absorbers employed, with both aluminium and copper absorbers. Two hydraulically separated collector fields with two different heat transfer mediums are examined.

The test plant, planned and operated by S.O.L.I.D., offers a unique opportunity to study the behaviour of large scale solar thermal systems in order to develop In-situ test methods.

Figure 1. High angle shot of the solar thermal plant “Fernheizwerk”

3. High precision measurement of the test plant

Existing measurement data of solar thermal plants are not sufficient to improve current collector test approaches, since the needed quantities might not be measured and the accuracy might not be adequate. This is certainly true for radiation, since precise measurement of radiation is not always mandatory for control systems of solar thermal plants. Therefore plant manufacturers are often refraining to install expensive radiation sensors that would deliver high precision data in order to offer competitive prices.

Throughout the last month the solar thermal plant “Fernheizwerk” was equipped with high precision measurement equipment to meet the data quality requirements of the project MeQuSo. Among others, the following equipment was installed, illustrated in Figure 2:

- Precise heat metering of six collector arrays: measurement of the volume flow and the inlet and outlet temperature of the collector arrays
- High precision pyrheliometer to measure direct beam solar radiation. Global radiation in the slope of the collectors is measured with a pyranometer.
- Temperature sensors at selected junctions between single collectors to bring insights of the heating-up behaviour of the selected array.
- Ultrasonic Anemometer to measure the wind speed.
- Video surveillance of the collector arrays to acquire information on shading, dirt and damages.

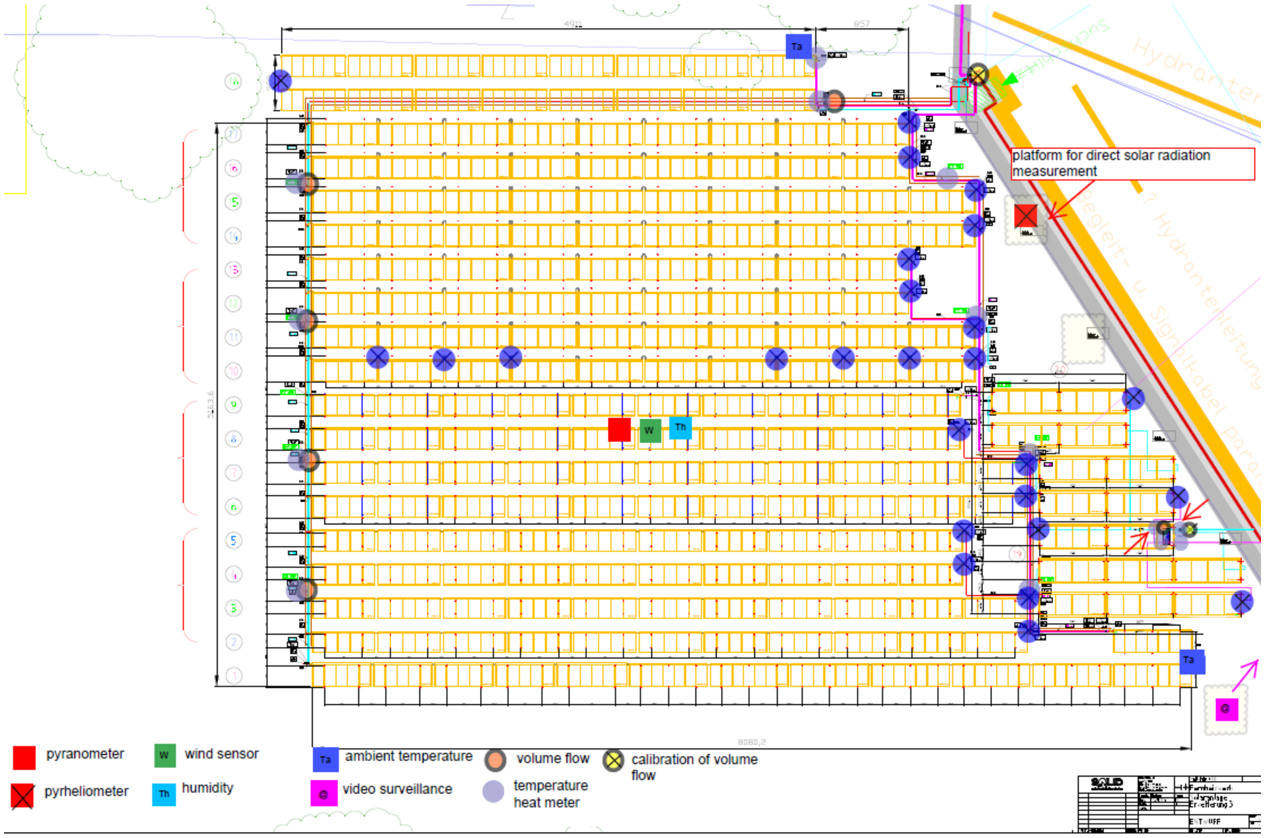

Figure 2. Hydraulic scheme of the solar thermal plant “Fernheizwerk” including the position of the installed sensors

4. Summary

The research project MeQuSo will use the acquired high quality measurement data of the test plant to develop an in-situ quasi-dynamic test methods for collector arrays in the style of EN ISO 9806:2013, extending the quasi-dynamic test method from single collectors to collector arrays.

By having these new methods, several positive benefits for the SDH-community will be generated. Firstly, having a method to gain more accurate efficiency values, will lead to a higher reliability of the expected solar yield, which reduces the risk for future installations.

Furthermore the data and evaluations will increase the knowledge of the behaviour of collector arrays, which will be a source for performance improvements of future collectors as well as the design of collector arrays.

References

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