SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

2017 HIGHLIGHTS

Task 55 – Towards the Integration of Large SHC Systems in DHC Networks

Participating Countries

Austria

Canada

China

Denmark

Finland

France

Germany

Spain

United Kingdom

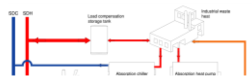
THE ISSUE

In recent years, megawatt-scale solar thermal district heating (SDH) systems have gained increasing attention globally. Several ambitious projects were successfully implemented in countries such as Austria, Germany, Italy, France, Spain, and Norway. Large-scale SDH systems and their large-sized seasonal storages have become attractive options for cost effective and low carbon heat supply. In the next step, large systems will become even bigger and likely grow from MEGA to almost GIGA-sized installations. These systems will be able to meet the increasing energy demand of city districts and of whole cities. Compared to conventional heat generation systems, the effective operation of a SDH network and its seasonal storage can guarantee a primary energy consumption reduction of >70% in thermal needs. However, the actual integration of large solar thermal systems into existing and new networks faces several challenges. Expertise on the integration of large solar thermal systems into district networks is limited. Therefore, SHC Task 55 collects and disseminates technical and economic solutions to leverage large-scale solar thermal district heating and cooling systems worldwide.

OUR WORK

SHC Task 55 aims to provide a platform for practitioners and scientists to present the benefits and challenges of SDH and SDC systems. It collects research results on options and measures to realize sophisticated SDH and SDC systems by focusing on characteristics of solar thermal systems, technical and economic specifications of district heating networks that are relevant for the integration of solar thermal systems and hybrid technologies, analyses of system components and their integration, modular designs of large SDH/SDC systems, and economic requirements of large SDH/SDC systems in different market regions. Finally, SHC Task 55 collaborates with the IEA Technology Collaboration Programme on District Heating and Cooling including Combined Heat and Power (IEA DHC).

Task Period 2016 – 2020
Task Leader Sabine Putz, SOLID, Austria
Email s.putz@solid.at
Website http:task55.iea-shc.org



KEY RESULTS IN 2017

Optimized hydraulics and piping in large solar systems

There are many aspects to consider, to get an optimum pipe system in a large collector array. Normally standard district heating pipes are used but with special design considerations for the much more frequent thermal cycling and larger thermal movements in collector stagnation conditions. The heat losses and pipe volumes should be minimized of course, but are not so large compared to the collector heat losses and volumes in a well-designed large system.

Low total pressure drops and even flow distribution in a wide flow range are more critical for good performance. At DTU this has been addressed in a recent PhD work. This study presents a numerical model to evaluate the flow distribution in a large solar collector field, with solar collectors connected both in series and in parallel. The boundary conditions of the systems, such as flow rate, temperature, fluid type and layout of the collector field can be easily changed in the model. The model was developed in Matlab and the calculated pressure drop and flow distribution were compared with measurements from a solar collector field. A good agreement between model and measurements was found. The model was then used to study the flow distribution in different conditions. Balancing valves proved to be an effective way to achieve uniform flow distribution also in conditions different from those for which the valves were regulated. For small solar collector fields with limited number of collector rows connected in parallel, balancing valves are not strictly necessary if the pressure drop across the collector rows is much higher than the pressure drop along the longest distribution pipe.

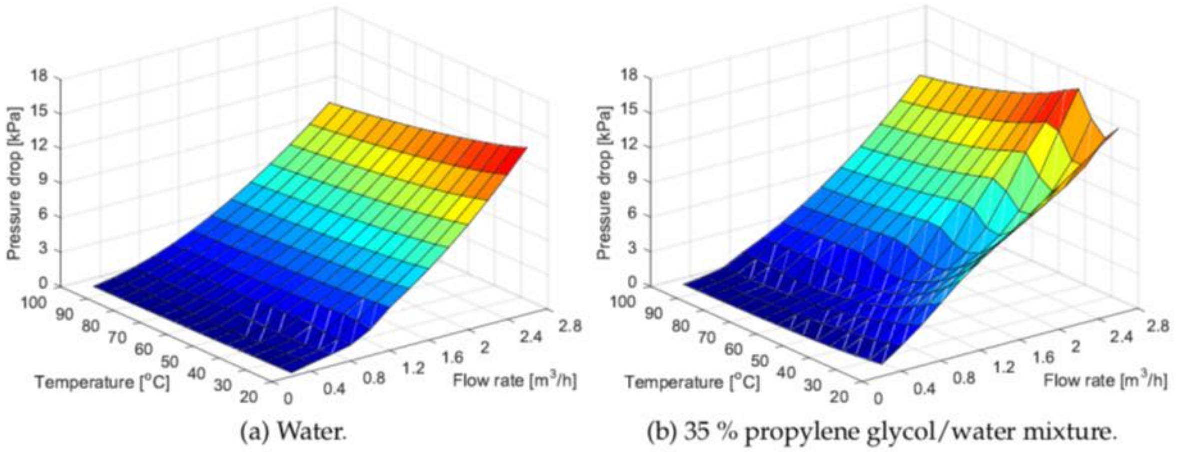


Figure 3.2: Pressure drop in Arcon-Sunmark HTHEATstore 35/08 collector.

Figure 1: Ref: F. Bava et al. Modelling of Solar Collector Fields for District heating plants in District Heating Systems. DTU 2017. Byg DTU. Report no: R-365.

Simulation and design of collector array units within large systems

For a lage collector array even small changes of design can give large marginal energy cost savings. In a PhD work experiments and detailed collector field simulation modelling were used to study the variation collector of array performance, due to changes in hydraulic design, working fluid mixture and for example fraction of collectors in each row, with and without convection suppressing foil. The models were first carefully validated against experiments. The following figure illustrate the optimization of number of collectors with different glazing designs in a collector field. In this case 5 collectors without foil and 9 with foil were found to be optimal.

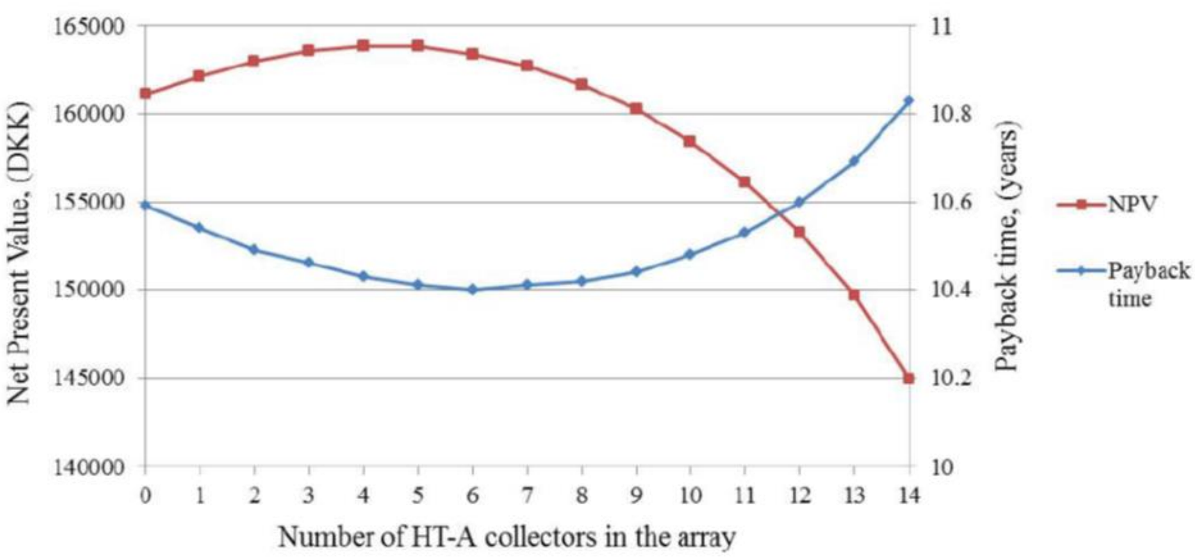


Fig. 6. Net Present Value (NPV) of the row at 20 years (left axis) and payback time of the investment (right axis).

Figure 2: Ref: F. Bava et al. Modelling of Solar Collector Fields for District heating plants in District Heating Systems. DTU 2017. Byg DTU. Report no: R-365.

Taars-Analysis and validation of a quasi-dynamic model for a solar collector field with flat plate collectors and parabolic trough collectors in series for district heating

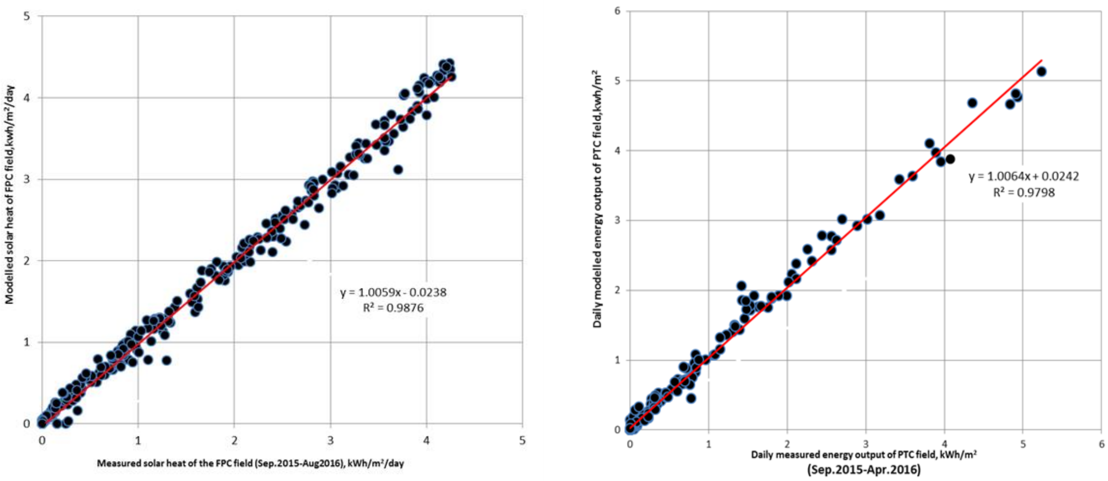


Figure 3: Daily modelled solar energy output as a function of measured solar energy output of the FPC and PTC field1.

Daily modelled and measured energy outputs of the flat plate collector (FPC) field and PTC field in a Danish solar heating plant are shown in Fig.3. The modelled energy outputs of both the FPC and PTC fields are based on the quasi-dynamic model. There is a strong linear correlation between the measured daily thermal performance and the modelled daily thermal performance, which shows the modelled values have good agreement with the measured values.

[1] *Z. Tian, B. Perers, S. Furbo, and J. Fan, "Analysis and validation of a quasi-dynamic model for a solar collector field with flat plate collectors and parabolic trough collectors in series for district heating," Energy, vol. 142, pp. 130–138, 2018.*

The Langkazi Project

Langkazi project has now been officially signed for contract by the government. Price, design and installation are now guaranteed. The project is located at an altitude of 4,441m. The first phase of investments costs about 120million RMB (19 Million USD). And covers an area of 100,000m^2. The collector field area covers 22,200m^2, with a heat storage of 15,000 tons. Space heating will be provided for an area: of 82,600m^2. The land for the collector and for the pit storage have already been confirmed. The detailed engineering design for the solar plant is carried by Arcon-Sunmark, City pipe and the indoor equipment is designing by Chinese Heating Design Institute. It is planned to start the construction phase between the end of March and the beginning of April 2018.

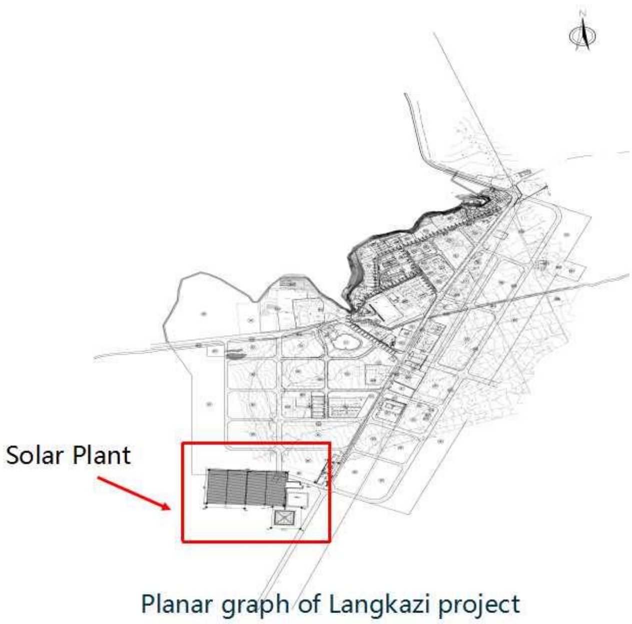


Figure 4: Planar graph of Langkazi project

IEA DHC Cooperation

The international cooperation between the IEA SHC Task 55, Subtask A and the IEA DHC TCP is leading to a more holistic understanding of integrated systems with a clear focus on achieving a high share of solar thermal supply in DH networks. Based on the past work performed in both TCPs, an additional literature review and stakeholder interviews, following analyses of the strengths, weaknesses, opportunities and threats (i.e. SWOT analyses) for the integration of solar energy into DH networks was drafted and will be published in 2018.