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DrainProof

Cost-optimized solar thermal systems with drain-back function

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Summary

The project aimed to demonstrate a standardised concept for a solar thermal system in the field, with significantly reduced costs compared to conventional systems. As preparatory work, a system concept was developed to reduce life cycle costs by standardising the solar thermal system und using the drainback principle, a simple solar buffer tank and low-cost components such as pre-insulated plastic pipes. The system concept was optimised for retrofitting hot water generation in multi-family houses. For this P+D project, findings from previous research projects were implemented and the system concept was brought closer to market maturity. Unfortunately, the project team was unable to find any interested customers and suitable conditions for the proposed drainback concept within the project timeframe. Cancellations were often justified by the fact that photovoltaic systems were currently being offered more favourably. Consequently, the system could not be demonstrated in real installations.

Zusammenfassung

Das Projekt hatte zum Ziel, ein standardisiertes Konzept für eine Solarthermieanlage im Feld zu demonstrieren, das im Vergleich zu herkömmlichen Anlagen deutlich kostengünstiger ist. Als Vorarbeit wurde ein Systemkonzept entwickelt, das die Lebenszykluskosten durch Standardisierung der Solarthermieanlage und Verwendung des Drainback-Prinzips, eines einfachen Solar-Pufferspeichers und kostengünstiger Komponenten wie vorisolierter Kunststoffrohre senkt. Das Systemkonzept wurde für die Nachrüstung der Warmwasserbereitung in Mehrfamilienhäusern optimiert. Für das P+D-Projekt wurden Erkenntnisse aus früheren Forschungsprojekten umgesetzt und das Systemkonzept näher an die Marktreife gebracht. Leider gelang es dem Projektteam nicht, innerhalb des Projektzeitraums interessierte Kunden mit geeigneten Bedingungen für das vorgeschlagene Drainback-Konzept zu finden. Absagen wurden häufig damit begründet, dass Photovoltaikanlagen derzeit günstiger angeboten werden. Folglich konnte das System nicht in realen Anlagen demonstriert werden.

Résumé

Le projet visait à démontrer un concept standardisé pour un système solaire thermique sur le terrain, avec des coûts considérablement réduits par rapport aux systèmes conventionnels. Dans le cadre des travaux préparatoires, un concept de système a été développé afin de réduire les coûts du cycle de vie en standardisant le système solaire thermique et en utilisant le principe du drainback, un simple réservoir tampon solaire et des composants peu coûteux tels que des tuyaux en plastique pré-isolés. Le concept du système a été optimisé pour la modernisation de la production d'eau chaude dans les immeubles collectifs. Pour ce projet P+D, les résultats de projets de recherche antérieurs ont été mis en œuvre et le concept du système a été rapproché de la maturité commerciale. Malheureusement, l'équipe du projet n'a pas réussi à trouver de clients intéressés ni de conditions appropriées pour le concept de drainback proposé dans le délai imparti. Les annulations étaient souvent justifiées par le fait que les systèmes photovoltaïques étaient actuellement proposés à des conditions plus avantageuses. Par conséquent, le système n'a pas pu être démontré dans des installations réelles.

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List of abbreviations

DBS	Drainback system
DHW	Domestic hot water
MuKEn	Mustervorschriften der Kantone im Energiebereich
PV	Photovoltaics
SFOE	Swiss Federal Office of Energy

1 Introduction

1.1 Context and motivation

Although solar thermal heat is expected to play an important role for the supply of buildings with renewable heat, the yearly installed total area of solar thermal collectors is not increasing, as shown in the market figures of recent years (BfS, 2023). Some studies have analysed the market situation in Switzerland for solar thermal and suggest measures to boost the solar thermal market on different levels such as technical, legal, incentive, and communication level (Philippen et al., 2016) (Müller et al., 2014). On the technical level, the studies call for measures that lead to a general cost reduction of solar thermal systems. As important measures, a higher degree of standardisation along with better and cheaper storages are mentioned. Ways to reduce the costs of solar thermal installations were extensively discussed and analysed in IEA SHC Task 54 (IEA, 2019). This Task highlighted various strategies to reduce investment cost and the cost of avoiding fossil fuel by solar systems. Most important strategies are overheating prevention in the systems, use of plastic components, reduction of maintenance costs, “easy to install” components, standardisation, and performance increase.

In Switzerland, the market of domestic hot water (DHW) preparation in multi-family buildings (MFH) is seen as an important market section by Swiss solar thermal companies (Philippen et al., 2016). Especially for this market section, the costs of the solar thermal systems have to be reduced, as owners of MFH tent to be more cost-sensitive (Lehmann et al., 2017). For MFH it can be expected that retrofitting of fossil burners used for DHW preparation (or for room heating) will be a relevant field of application for solar thermal systems. The reason for this is that the legal framework is changing in many cantons with taking over the MuKEn 2014 regulations (EnDK, 2021). According to an estimation of the city of Zürich (Lehmann et al., 2017), the regulations of MuKEn 2014, in particular Part F, can have a major importance for all renewables as their use is one of a few measures that have to be realised when retrofitting old heating systems in MFH. One of the measures accepted by MuKEn 2014 Part F is the installation of a solar thermal system, which supports the DHW preparation. In addition, there are cantons that are requiring solar thermal system for DHW on new buildings and do not accept a 100 % PV roof anymore. For instance, the canton de Neuchâtel, request to have a solar thermal system (STS) for 3 over 4 of the proposed standards heating production systems. And if a wood heating system is used, a STS is mandatory (Canton de Neuchâtel, 2021).

However, also with the MuKEn regulations, using solar thermal is only one of several solutions. Hence, the solar thermal systems still have to persist the competition with other renewables and efficiency measures. To foster the diffusion of solar thermal systems, the above-mentioned cost reduction especially for applications in MFH should be implemented.

1.2 Project objectives

The pilot and demonstration project has the following objectives:

- Demonstration of five large, cost-effective standard drainback systems in the field
- Providing detailed design (product selection) based on cost and lifetime optimisation
- Proof of safe operation (venting and draining of solar circuit)
- Solar gains better or at least the same as for conventional solar systems
- Confirmation of expected cost reductions based on field experience (compared to conventional solar thermal systems: investment costs -18 %)

2 Approach

As the proposed DBS concept includes several relevant changes compared to today's standard solar thermal systems, there is a strong need to install and test several variations of the proposed DBS. Especially the companies need experience and trust in the new concept with respect to the typical situations in the field before a market launch. Important variations of characteristics of the location and of the system size that have an impact in the system design are:

- Collector field size and in the follow, the number of parallel collector rows. A large number of parallel paths for the fluid can lead to negative effects for venting/draining and to an unstable or inefficient operation of the solar circuit.
- Designing the solar circuit open to the atmosphere (on storage level) will lead to anticipated strongest cost reductions, as some system components can be less robust due to the low system pressure. However, for systems with large height differences and also to reduce possible chemical impact of solved oxygen on hydraulic components, a system variation that is closed to atmosphere might be advantageous for some situations in the field.
- The difference in height between storage (normally in the cellar) and the collector field. Here, large differences in height (multi-family buildings) lead to large pressures resp. pump power and pump head. To reduce the effect, the drainback-vessel might be separated from the storage (if the system is closed) and placed on a higher level.
- The shape of the roof – flat or pitched – has an important impact for the design of the solar circuit. Pitched roofs will in many situations allow the connection pipes of the solar circuit to have larger slopes which is advantageous for the draining. Analysing safe solutions for the design of the water-filled solar circuit on flat roofs (including roof penetration) needs to be considered.
- The connection of the solar part to the existing DHW storage tank can be a challenge as well, as in many old DHW-tanks no free connections are available that can be used for the heat transfer from the solar puffer storage. Here, an innovative way via the inspection flange will be developed and tested in some of the field DBS.

System concept

The system concept to be demonstrated in the field was developed within the SFOE-research project SimplyDrain2.[1] In the project SimplyDrain2, a solar thermal drainback system was developed, installed and tested in the lab. Figure 1 shows a simplified hydraulic scheme of the system.

The system's special features are:

- Atmospheric open solar buffer storage that contains the drainback volume (no expansion vessel needed)
- Water as heat transfer fluid in the solar circuit
- Pressure maintenance valve in the solar circuit flow pipe for keeping approx. atmospheric pressure in the collectors during solar circuit operation (securing boiling temperature of approx. 100 °C)
- Use of plastic piping and pipe fittings with tool-free mounting
- Flat plate collectors with inclined absorber piping (for the drainability)
- Creation of a new connection to the DHW storage tank via its maintenance flange (by water jet cutting of a hole through the enamel coated blind flange)

[1] https://www.aramis.admin.ch/Grunddaten/?ProjectID=51630

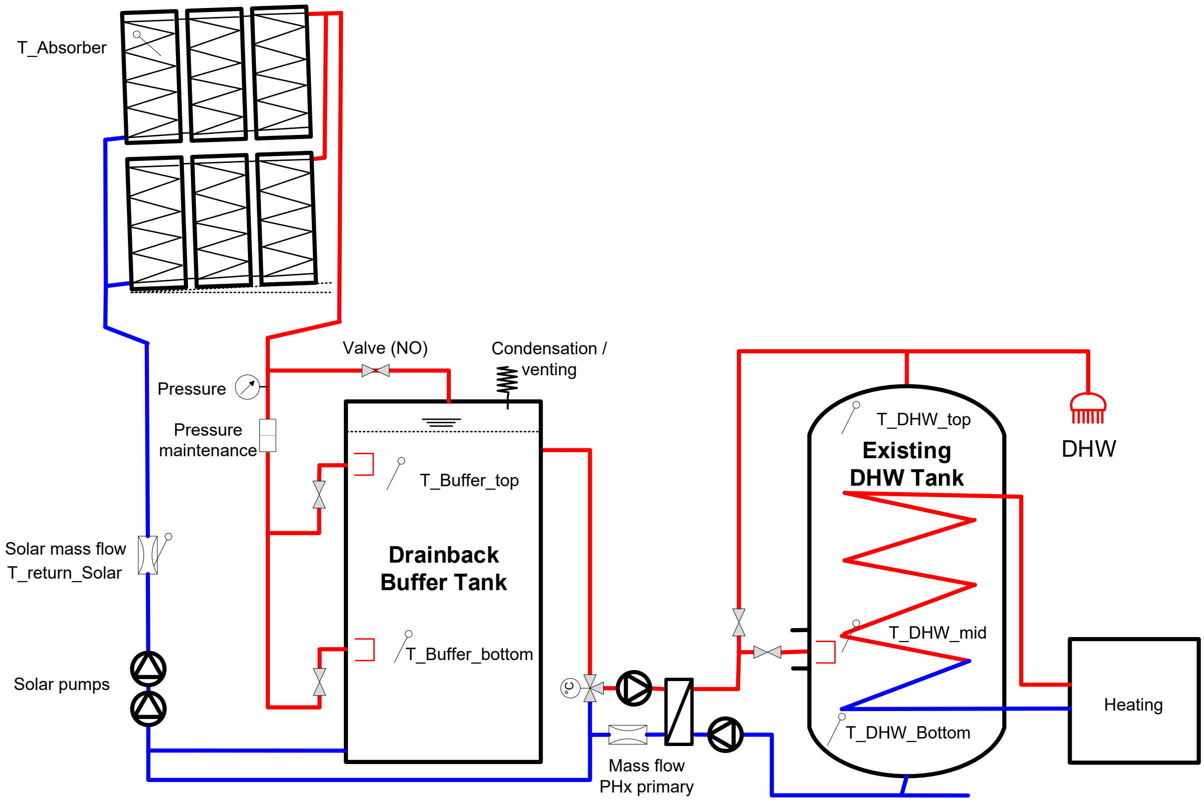

Figure 1: Scheme of the solar thermal drainback system.

Lab test of the heat transfer unit

As part of the system design process, it was decided to test the storage transfer using a prefabricated unit from Equans. The unit was tested in the SPF laboratory as part of a solar thermal drainback system. The aim was to check the practicality of converting an existing hot water storage tank and to assess the cost-effectiveness of the transfer unit's design in terms of material selection and of construction by Equans. The transfer station used replaced an existing one that had previously been used in the SPF laboratory (as part of the solar thermal system of the project SimplyDrain2).

The central component of the transfer unit is a plate heat exchanger that separates the technical water of the solar primary circuit from the drinking water of the secondary circuit. The plate heat exchanger transfers the solar-generated heat to the drinking water. In addition, two circulation pumps, mixing and switching valves and measurement technology for regulating the transfer are installed as hydraulic components.

Installation and operation were successfully demonstrated in laboratory tests. The selected components are suitable for use in field installations.

Figure 2: Storage transfer station with plate heat exchanger (PWT), circulation pumps (P) and valves (orange).

3 Conclusions and outlook

Despite an intensive two-year search, the project team, which includes a major Swiss heating company, was unsuccessful in finding customers who wanted to install an initial demonstration system at their premises. Basically, our offer has obviously met with little interest, which fits in with the generally very low demand for solar thermal systems in Switzerland in recent years, including a significant decline in market volume (see e.g. Swisssolar[2]). In the case of some cancellations, it was mentioned that the customers had decided in favour of a PV system. It should be noted here that the immense price reductions for PV modules, which have been enforced in recent years by Chinese industrial policy, have drastically reduced the competitiveness of solar thermal energy for hot water systems. This applies in particular to thermal collectors that are produced in Switzerland. In addition, a significant increase in the market for the combination of PV and heat pumps has been seen in recent years. Many customers wanted to convert to this system, which is why a solar thermal solution was ruled out.

Despite intensive efforts, the project had to be cancelled due to the unsuccessful acquisition of demonstrators.

[2]

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