



CONNECT AND PROTECT

HWAT Energy Efficiency Study

Total Energy Analysis of Domestic Hot Water Generation and Distribution
Systems Hot Water Generator: Condensing Boiler System & Condensing Boiler
with a Storage Charging System



RAYCHEM

Technical Information

Total energy analysis of domestic hot water generation and distribution systems Hot water generator: Condensing boiler system & condensing boiler with a storage charging system

There are two options to compensate for the heat loss in hot water distribution pipes: using a temperature maintenance tape or using a recirculation pipe.

What is more sensible from an energy point of view when using a condensing boiler for hot water generation? A study by TU Dresden dealt with the question of which measure is more energy-efficient when using condenser boiler systems. The results presented show that a hot water distribution system which compensates for heat losses in the pipes with an electrical temperature maintenance tape is a better solution both in terms of energy efficiency and economy when compared to a conventional recirculation system. A single-pipe hot water system including a temperature maintenance tape inherently allows fewer losses from the smaller distribution system.

INTRODUCTION

Measures to reduce CO₂ emissions decided at EU level relate to a large extent to buildings too. Country-specific energy guidelines for new builds and renovated properties were introduced in EU member states as part of the EU Energy Performance of Buildings Directive. These are reflected in Germany in the EnEV (Energy Saving Regulations) and the subsequent standards and directives [e.g. DIN V 18599 1]. Apart from space heating the energy expended for providing domestic hot water is particularly significant. With increasing construction and energy standards more and more attention is being paid to the energy required for domestic water heating. Existing water heating systems must be co-ordinated with the hot water distribution system or vice versa in order to guarantee the lowest possible primary energy consumption in buildings to comply with the EnEV.

The primary energy factor for the power mix will reduce further in view of the increasing proportion of renewable energies involved in power generation. From a primary energy point of view therefore, compensating for heat loss using a temperature maintenance tape on hot water pipes is becoming increasingly important.

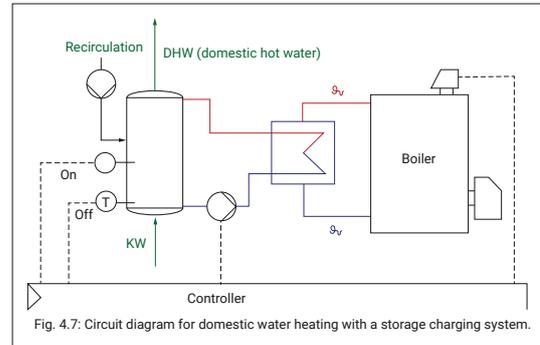
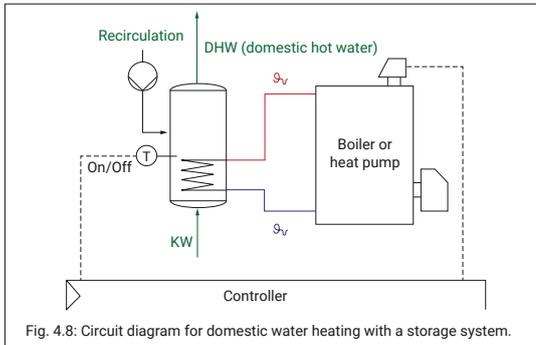
This Technical information provides up-to-date results on the primary and final energy behavior of condensing boiler heat generators with and without storage charging systems in a combination of hot water distribution in a single pipe system with a temperature maintenance tape compared with a hot water recirculation system. These results were determined based on a scientific investigation by the Institute for Energy Technology at the Technical University of Dresden using a digital building simulation program [TRNSYS -TUD]. This results has been incorporated into a TU Dresden research report and are shown in detail in that report.

THE PROBLEM

The system components for supplying hot water in a building are examined only from an energy point of view in the relevant literature and standard (e.g. Current DIN V 18599/DIN V 4701-T10). Therefore an actual analysis of the energy flows is only partially achieved. The interaction between heat generators and domestic water heating and distribution has not played a part up till now. The result of the TU Dresden study clearly shows that the boundaries of the assessment must be extended to cover the whole hot water system in order to achieve a sensible primary energy design for all system components (depending on the type of building).

THE SOLUTION

A condensing boiler with a thermal storage heater & a condensing boiler with a storage charging system were selected by TU Dresden as domestic hot water generators for a building model of an apartment block with 12 living units (in accordance with energy standard EnEv 2009)



Source: TU Dresden

The temperature maintenance tape is fitted under the heat insulation and compensates for the heat losses from the hot water pipes so that the temperature of the pipe does not drop below 55°C. As a result of the self-regulating effects of the temperature maintenance tape the power output adjusts to the local pipe temperature as required and thus delivering constantly high temperatures throughout the whole distribution system.

The traditionally used recirculation system compensates for the heat loss by recirculating water in the system. The recirculation system is designed in accordance with DVGW work sheet W553.

The domestic water heating was tested in the first case with a condensing boiler with the storage charging system. In addition a hot water storage system with an integrated heat exchanger was used in combination with a condensing boiler. The heating circuit which served the thermal storage unit was regulated by a temperature gauge (also taking the switching hysteresis into account).

DIN 4708-2 was used for the design of the hot water cylinder and reproduced in the TRNSYS-TUD simulation program.

User behaviour plays an important role in achieving effective use of the hot water provided. Tapping times and the volumes of water drawn were taken into consideration here. When defining the tapping profile reference was made to the international standard for European Countries in ANNEX 42. This tapping profile is also reflected in the HWAT-ECO control unit for the temperature maintenance tape.

The temperature maintenance tape is operated by a control unit that enables the draw-down and switch-off times as well as other functions to be specified depending on the time. The holding temperature is reduced to 50°C at night. Statistical analyses showed higher tapping mass flow times depending on usage. The temperature maintenance tape was switched off for these times because hot water at 60°C was flowing through the hot water pipe anyway.

With recirculation systems 'hygienically perfect' systems may be switched off for no more than 8 hours a day in accordance with DVGW work-sheet W551. It is possible to switch the system off during the night when there will be less water drawn off but the whole distribution system begins cool down to lower temperatures, with greater requirement for reheating later.

RESULTS

The energy expended to maintain the temperature of domestic hot water is determined by several parameters of the whole heat generation and consumption process, including the domestic hot water distribution system and domestic hot water use [which influence each other].

In a recirculated system the stored hot water cools down due to the standing heat loss from the pipe network, and the resultant cooling effect of the lower temperature "return" water that is continually recirculated back to the storage vessel. However, the recirculating water only has a slight cooling effect on the stored water (ΔT is -10K). The unfortunate outcome of 'only' a slight cooling effect is that the heat generator switches on more frequently and during recirculation the cylinder receives higher flow temperature from the primary circuit. Both effects combine to increase the annual use of the condensing boiler when using a recirculation system.

Conversely, with a temperature-maintenance tape a consequent self-adjusting lower average recirculation temperature in the primary circuit, together with a reduction in the amount the system is switched on, leads to reduced levels of use of the condensing boiler.

The resultant, primary energy expenditure for the temperature maintenance tape with a thermal storage heater is up to 5% lower than that of a constantly operating recirculation system. This energy reduction is further enhanced in the case of a temperature maintenance tape combined with a storage charging system which requires up to 8% lower primary energy expenditure.

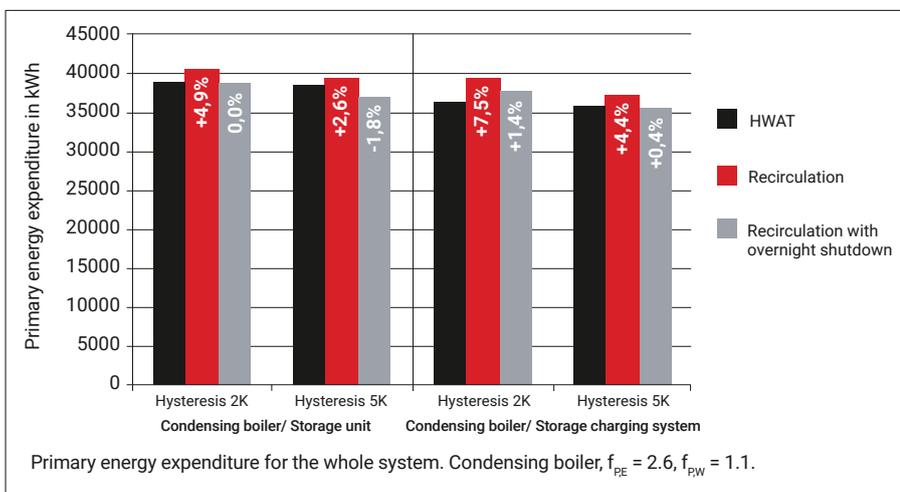


Fig: 1 Primary energy comparison of the whole system temperature maintenance tape <-> Recirculation system with different switching hysteresis for the temperature sensor.

Source: TU Dresden

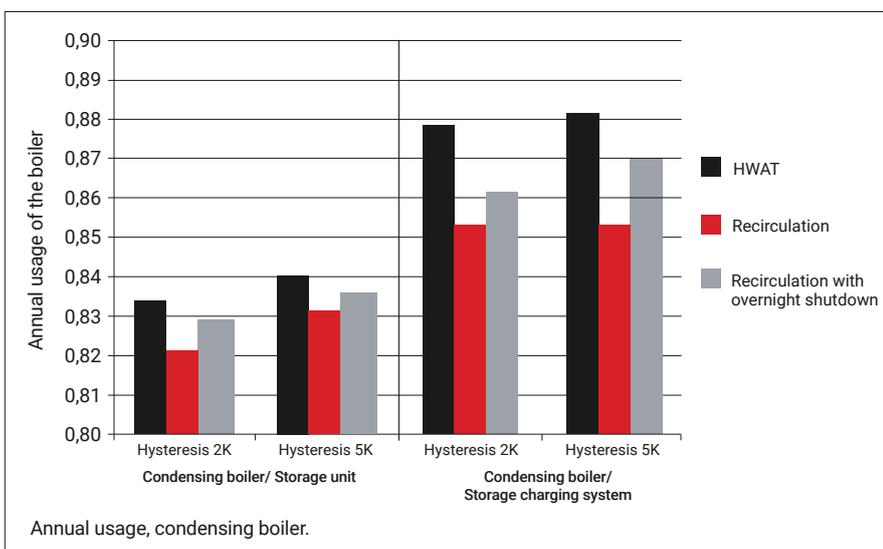


Fig: 2 Annual level of use the condensing boiler.

Source: TU Dresden

It is interesting to look at the primary energy trend in the next few years. An analysis of the primary energy expenditure (with the lower primary energy factors for power) demonstrate that with a lower primary energy factor the primary expenditure with the temperature maintenance tape falls significantly below the value of a recirculation system that is switched off at night.

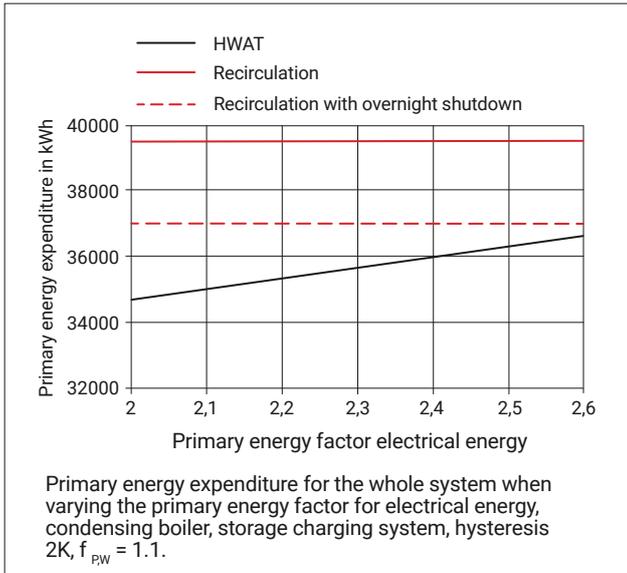


Fig: 3 Primary energy expenditure for the whole system when varying the primary energy factor.

Source: TU Dresden

ECONOMIC COMPARISON

The actual useful energy consumed is crucial for the economic evaluation of the sample project tested. First of all it has been demonstrated that when using the temperature maintenance tape the useful energy requirement just for maintaining the temperature can be almost halved because there is no recirculation pipe. The tests show that to cover the heat losses from recirculation the effectiveness of the primary heat generation may not be disregarded. On the other hand the temperature maintenance tape produces heat exactly where it is needed, under the heat insulation directly on the hot water pipe. The storage unit outlet temperature is monitored by programmed control unit functions and thus ensures in operation that the temperature maintenance tape compensate for the heat losses and the pipe holding temperature always remains below that of the heat generator. Using preconfigured programs the temperature maintenance tape can also be switched off at peak draw-down times when hot water flows directly from the heat generator to the withdrawal points. During the night, when normally no water is drawn, the maintenance tape or the pipe temperature can once more be reduced somewhat to the pre-set energy saving temperature.

Apartment block:

Condenser with primary cylinder +distribution system with temperature maintenance tape or recirculation.

Useful energy - amount consumed in kWh

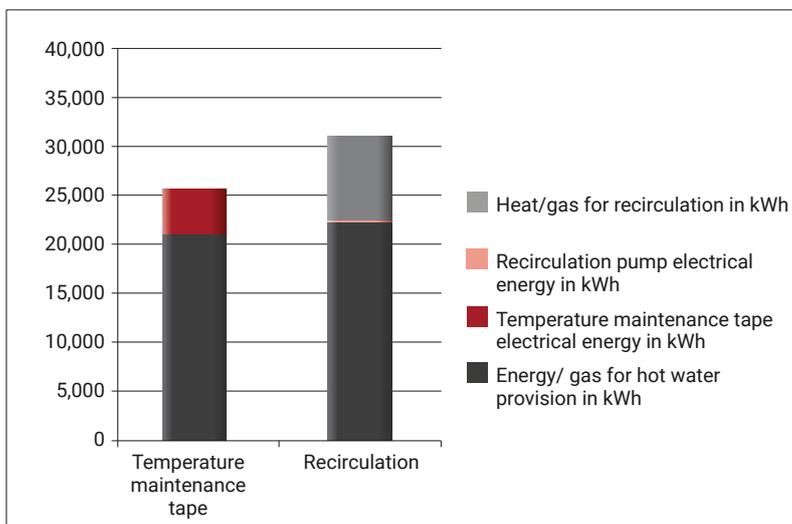


Fig. 4: Useful energy consumption of the condensing heat generator with primary cylinder for hot water provision and heat loss compensation of the pipes with temperature maintenance tape or recirculation pipe.

OPERATING COSTS

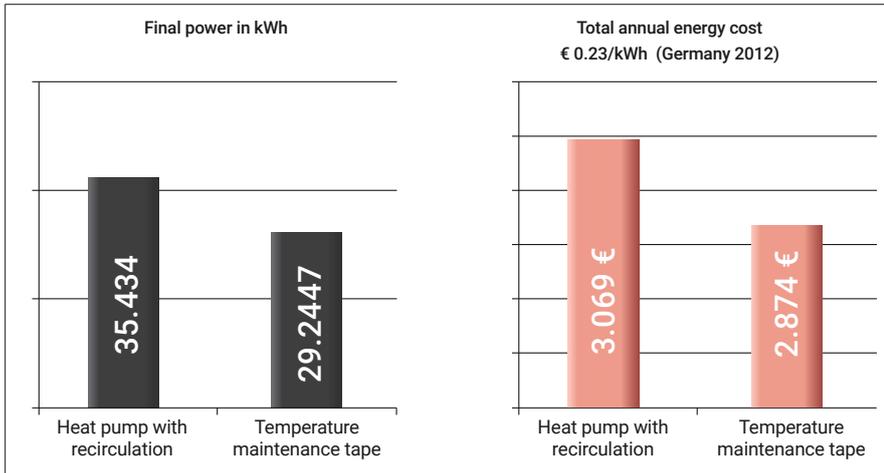


Fig. 5: Useful energy total and annual operating costs comparison of the two distribution systems; electricity price €0.23/kWh (Germany 2012)

Fig. 4 shows that when using a temperature maintenance tape the necessary useful energy for the apartment block examined is 17% less compared with a recirculation pipe both for hot water provision and temperature maintenance. This difference continues to apply with costs too. When taking into consideration the different prices per kilowatt-hour of the energy sources used—electrical energy and natural gas, the annual operating costs in the sample project with the temperature maintenance tape solution are approximately 6% lower than the solution using a recirculation pipe. See Fig. 6.

It must be pointed out that each project has its own system design. The incorporation of renewable energies, such as solar heating or photovoltaic systems may shift the proportions of primary and final energy within certain limits which will result in the operating costs changing for the two distribution systems.

SUMMARY

By extending the assessment limit to the whole hot water generator [including condensing unit, hot water storage & hot water distribution system] the interaction between these system components will be incorporated into the energy assessment.

It becomes clear that a hot water distribution system with a temperature maintenance tape has both primary & secondary energy benefits as well as economic benefits when compared to the traditional recirculation method.

If more renewable energies are used for power production the primary energy factor for power (not the renewable part) will reduce further so that from a primary energy point of view maintaining the temperature with a temperature maintenance tape will tend to be a cheaper solution for designing certain hot water generation systems.

CONTACTS

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