STORAGE TANKS OR HEAT EXCHANGERS IN ONE-FAMILY HOUSES SUPPLIED WITH DISTRICT HEATING?

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In Denmark two systems are commonly used for preparing domestic hot water in one-family houses with district heating: a storage tank system or a heat exchanger system.

In a storage tank system the domestic hot water is stored in the tank and heated by the district heating water through a helical coil heat exchanger. This reduces the maximum hydraulic load of the district heating supply as a flow rate of 50-100 l/h is necessary.

In a heat exchanger system the domestic hot water is heated instantaneously by the district heating water through a plate exchanger. This gives a high maximum hydraulic load of the district heating supply as a flow rate of 700-800 l/h is necessary.

In recent years the district heating companies in Denmark have been very focused on reducing the cost of district heating supply to dwellings in order to keep district heating cost-effective compared to other alternatives of heat supply. Therefore, there is a conflict between some district heating companies and consumers as the companies want the consumers to install heat storage tanks in order to reduce their costs. The companies' costs will be reduced as they can use smaller dimensions of the service pipes and in some of the distribution networks due to the lower maximum hydraulic load. On the other hand: most of the consumers want to install heat exchangers because they require less space, are cheaper to install and do not "run out" of hot water.

R&D PROJECT

However, a new R&D project, which is financially supported by the Danish District Heating Association, shows that it is not possible to offer a clear conclusion of which type of installation gives the most cost-effective district heating supply.

The Danish district heating company "Roskilde Distribution" (Roskilde Forsyning) and consulting engineers Ramboll recently finished the R&D project. The project consists of a cost comparison of district heating supply to houses with heat exchanger versus houses with storage tank. Furthermore, the project consists of an investigation of the consumers' satisfaction with heat exchangers, measurements on district heating supply to one-family houses with heat exchanger for domestic hot water, as well as theoretical calculations concerning temperature loss and pressure loss in service pipes. This article concentrates on the cost comparison.

COST COMPARISON

The cost comparison is carried out by comparing district heating supply to the following 3 alternatives:

1. One-family house with heat exchanger system for domestic hot water
2. One-family house with storage tank system for domestic hot water
3. One-family house with heat exchanger system for domestic hot water combined with a small pump on the district heating side of the heat exchanger

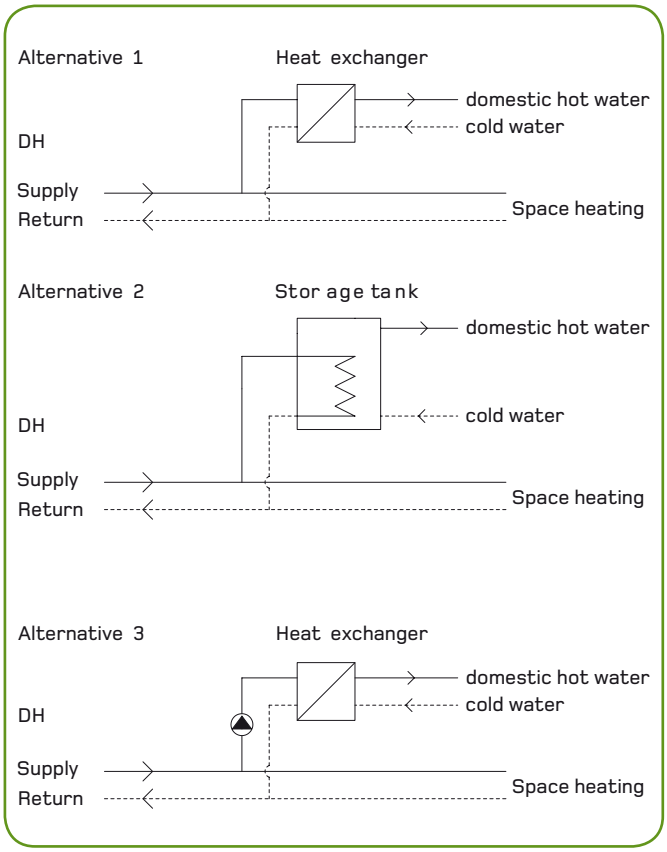

Figure 1 illustrates the principles of the 3 alternatives. Alternative 3 with the small pump on the service pipe just before the heat exchanger makes it possible to reduce the dimension on the service pipe compared to alternative 1. The service pipe pump is in operation when there is a load on the heat exchanger for domestic hot water (typically less than 1 hour per day).

The cost comparison is carried out by comparing the total costs defined as the sum of the costs for the consumer and the cost for the district heating company. The cost for the consumer consists of the investment cost (heat exchanger, storage tank or heat exchanger with service pipe pump), the cost of heat loss from the installation and the costs for the electricity for the service pipe pump in alternative 3. The costs for the district heating company consists of installation costs for the service pipe and cost of heat loss from the service pipe. Furthermore, the extra installation costs and heat loss cost by designing the distribution network for heat exchangers instead of storage tanks are included.

The cost comparison is carried out for new and existing houses on 120 m² and 180 m² and for 3 different lengths of the service pipes: 5 m, 15 m and 50 m. The comparison is also carried out for 3 marginal heat production prices: 5.38 €/GJ, 8.06 €/GJ and 13.43 €/GJ. The marginal heat production prices correspond to production based on straws/wood chips (5.38 €/GJ), large transmission network based on combined heat and power (8.06 €/GJ) and a small distribution network based on combined heat and power (13.43 €/GJ).

The cost comparison for existing houses is carried out to help making the right decisions when renovating service pipes.

The cost comparison is based on calculating the net present value (NPV) over a time horizon of 30 years and with a real interest rate on 3%.

RESULTS

Table 1 shows as an example of the result of the cost comparison for new houses of 180 m² with a service pipe of 15 m and at a heat production price of 8.06 €/GJ. Table 1 shows that alternative 2 (storage tank system) in the actual case has the lowest costs in terms of NPV. However, it also appears that the differences are relatively small. The total costs for alternative 1 (heat exchanger system) are 6% higher and for alternative 3 (heat exchanger system with service pipe pump) the total costs are 2-3% higher.

The cost comparison also shows the contradiction between the consumer and the district heating company as alternative 1 has the lowest cost for the consumer and the highest cost for the district heating company. However, the costs for the consumers does not take into account that higher costs for the district heating company will also lead to higher costs for the consumer.

	NPV pr. house over 30 years			Extra costs pr. house compared to alt. 1		
Type	Consumer	Company	Total	Consumer	Company	Total
	€	€	€	€	€	€
Alt. 1	2521	6823	9344	-308	859	551
Alt. 2	2829	5964	8793			
Alt. 3	2958	6070	9028	129	106	235

	NPV pr. house over 1 year			Extra costs pr. house pr. year compared to alt. 1		
	Consumer	Company	Total	Consumer	Company	Total
	€	€	€	€	€	€
Alt. 1	84	227	311	-10	28	18
Alt. 2	94	199	293			
Alt. 3	99	202	301	5	3	8

Table 1: NPV per. house for new houses on 180 m² with a service pipe of 15m and at a heat production price 8.06 €/GJ.

In general the cost comparison showed the following tendencies:

- Alternative 1 had the lowest costs for short service pipe lengths of 5m
- Alternative 2 had the lowest costs for 'normal' service pipe lengths of 15m
- Alternative 2 or 3 had the lowest costs for long service pipe lengths of 50m depending on the heat production price

The cost comparison also showed that the heat loss cost from the pipes only has a minor influence on the results. Instead it is the construction costs of the pipes that have the major influence on the results. One of the reasons why the heat loss only has a small influence on the results is that the investigation is based on the usage of twin pipes.

Based on the cost comparison it is not possible to give a clear conclusion of what type of installation gives the most cost effective district heating supply to one-family houses as the results depend on the length of the service pipe, location in district heating network, and long service pipe length also depends of the actual heat production price.

As a very general rule the following can be proposed for supply of one-family houses:

- Heat exchanger systems should be used for short service pipes
- Storage tank systems should be used for service pipes of middle length
- Storage tank systems or heat exchanger systems with a small pump on the service pipe should be used in case of long service pipes

However, it should be mentioned that the total costs between the different installations are relatively small.

Furthermore, measurements in the project on the hydraulic load on service pipes to two houses with heat exchanger for domestic hot water showed a maximum flow rate of around 300 l/h. This is lower than the design flow of 700-800 l/h. It is therefore recommended to investigate this further, because if the design flows in service pipes for heat exchangers can be reduced to 300-400 l/h, then the cost comparison will be changed in the favour of heat exchangers.

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