Executive Report

Domestic Hot Water Generation and Distribution in Redeveloped Low Energy Dwelling Houses

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1. Research Objective

The importance of domestic hot water generation and distribution increases proportionally to its increasing share of overall energy use due to the decreasing heating demand.
This does not only supply to new buildings but equally to redevelopments. It has to be taken into consideration that sanitation equipment is build in for a long term, mostly several decades, and therefore should offer a future oriented solution.
The research objective was to analyze and compare the different possibilities of domestic hot water generation and distribution in redeveloped low energy dwelling houses with regard to their energetic efficiency.

2. Research Procedure

Against this background redeveloped domestic buildings, especially those of the „EnSan"-program, were analyzed. It turned out, that overall consumption and energy data of domestic hot water supply were collected, but that no more detailed data could be obtained, e. g. regarding circulation losses. The collected consumption data are interesting; they show an average of 30 – 35 liters per capita per day at a water temperature of 50°C. However, a wide range of deviation from 15 to 80 liters per capita per day was diagnosed.

Four types of residential buildings which are statistically representative for the dwelling stock of the Federal Republic of Germany were selected for this model research:

- **Detached house (EFH):** a very spacious version with 235 m² living space and 2 bathrooms was selected to obtain a clear differentiation from the terraced house.
- **Terraced house (RH):** the popular economical version of a single family house is represented by a 2½-floor-version and 125 m² living space. Generally the terraced house also represents a semi-detached house concerning the domestic hot water system.
- **Apartment building 1 (MFH 1)** : a version with 4 floors, two apartments per floor and 8 two-room apartments, each with 63 m² living space was selected.
- **Apartment building 2 (MFH 2)**: a similar version was selected but with 8 floors and 16 apartments, each with 118 m² living space.

There are different systems for both the domestic hot water generation and the domestic hot water distribution of the diverse types of residential buildings.

The following stipulations were made for the basic research model:

- central hot-water-generation with a circulation system (hot-water distribution pipe and circulation pipe)
- water heating using a central gas-fired condensing boiler and a central tank
- thermal insulation of the pipes according to EnEV
- circulation system with a side-by-side installation of pipes (hot-water distribution and circulation pipes with common insulation and resulting 30% energy savings compared with separate installation of pipes).
- consideration of heat gains caused by hot water generation and distribution during the 185 days heating period at a threshold heating temperature of 10 °C.

The tapping requirements i.e. the daily sequence of hot water consumption are very important for the research. To account for the great variance in reality different tapping requirements for single-, two-, three- and four-person-households were determined for the research. The allocation of tapping requirements to the building types resulted from plausibility considerations (e. g. tapping requirements regarding single- and two-person-households were allocated to MFH 1 with apartments of 62 m² living space but not those of three- or four-person-households).

To obtain a meaningful comparison of hot water generation and distribution the primary energy effort and CO_2-emissions have to be included into the considerations. This happens by determining the cumulated energy demand (CED) as well as the CO_2-equivalents in which the emissions CO_2, CH_4, CO, NMFOC, NO_x and N_2O effecting the climate are combined.

3. Summary of Results

The analysis of the basic model with a central gas-fired condensing boiler and a circulation system indicates that an interruption of the circulation is absolutely advisable for single family houses (EFH and RH), but for apartment buildings only in a very restricted way. For apartment buildings it has to be checked using benchmarks if consumption during the interruption period equalizes potential savings or even increases consumption.

Circulation losses can be avoided completely not using circulation lines. Due to hygienic regulations this can only be realized for pipe sections with less than 3 liters of water volume and therefore can only be realized in single family houses (EFH and terraced houses RH). Despite considerably increased heating efforts for branch pipes a 30 % reduction of hot water distribution efforts can be achieved. However, increased water consumption as well as reductions in comfort have to be accepted as considerably longer waiting times to reach a constant temperature consumption are the result.
The comparison of distributed systems (electrical flow heaters, electrical storage water-heaters and local heating and condensing boilers) demonstrates that flow heaters show better values if there are large heating efforts needed for circulation or lower consumption volumes (EFH with two- and three-person-households and RH with single-person-

households). All other types of residential buildings show substantially higher values of cumulated energy demand as well as CO_2-equivalents of flow heater versions compared with the values of the basic model. Electrical storage water-heaters show higher values for all types of residential buildings as well as household sizes regarding cumulated energy demand and CO_2-equivalents.

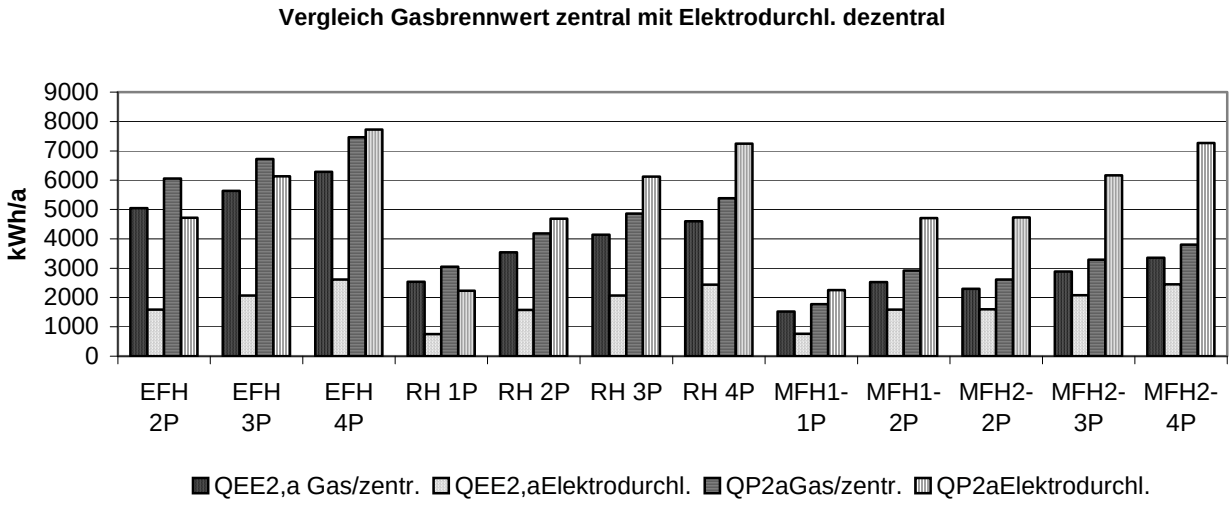

Fig.1: comparison of the final energy effort $Q_{EE2,a}$ and the CED (Q_{P2a}) between basic model and distributed version with electrical flow heaters. Basic model with gas-fired central heating and condensing boiler and circulation system

To avoid electrical hot water generation being ecologically critical distributed solutions using gas-fired condensing boilers can be installed near the location of consumption. This results in partly considerably lower final energy efforts in all kinds of residential buildings, mainly, however, in EFH and RH. Distributed systems in apartment buildings are economically disadvantageous compared with central solutions due to higher investment costs and additional maintenance and chimney sweeper costs.

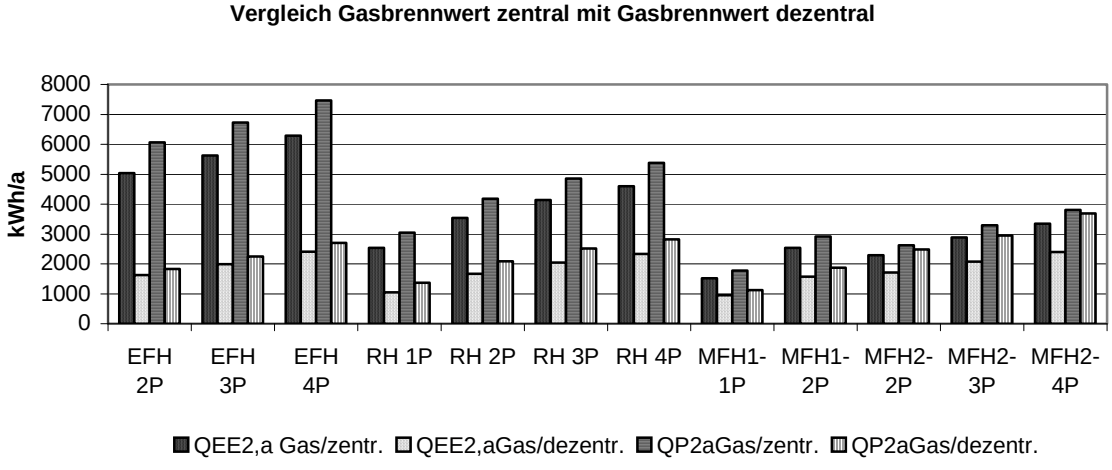

Fig.2: comparison of the final energy effort $Q_{EE2,a}$ and the CED (Q_{P2a}) between the basic model with gas-fired central heating and condensing boiler and the version with gas-fired distributed heating and condensing boiler

A sole-water-heat pump in combination with residential hot water distribution in EFH building types is analyzed. Taking into account the prior efforts for energy production the result is a strongly reduced energy effort of this system versus a gas fired and condensing boiler, whereas the CED is reduced by only 4-5 % solely taking into account hot water production and by 34 % including heating. The analysis of investment and operating costs indicates that a heat pump is only more favorable at a heating supply temperature of 35 °C.

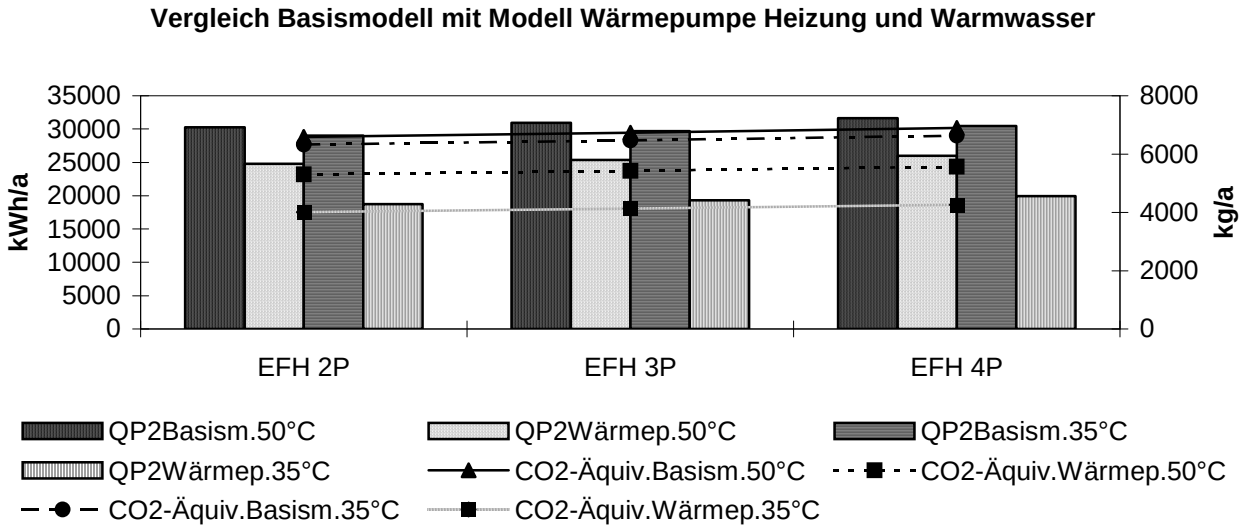

Fig.3: comparison of the CED (Q_{P2a}) and the CO_2-equivalents between the basic model with gas-fired central heating and condensing boiler and the sole-water heat pump version

A thermal solar system with 30 m² flat plate collector surface used as preheating system is analyzed in combination with the apartment building MFH 2. At a solar energy contribution of 12.500 kWh/a (reduction of the CED: by approx.17.100 kWh or 28 %) the cost reduction of 1.100.-€ per year - related to the gas fired and condensing boiler - is possible which results in a payback period of 15 years using a dynamic economic calculation.