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Short study into the energy savings potential of using water-saving and efficiency technologies in showers and tap fittings in residential buildings

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Abstract

Status quo: Water/energy-saving taps in standards and legislation relating to saving energy in buildings

Calculation standard *DIN V 18599:2018-09* contains a mathematical approach for taking a design-related flow rate limitation into account (*Section 6.4.9*). This could be used to factor the energy-related impact of water-saving measures into an energy demand calculation. However, the standard does not intend for this option to be used in calculating certificates under public law (energy performance certificate); rather, it is intended solely for producing calculations with free boundary conditions (energy consulting and similar).

However, the approach is proving difficult to apply at the moment in other ways too:

- The approach has not necessarily been implemented in every energy consulting software program.
- The input parameter required for the approach is not self-explanatory and has barely been defined in the standard as of yet. Suitable preset or default values are not available.

Assumptions regarding net energy demand

The contractor has calculated the following potential savings in terms of net energy demand for heating domestic water in residential buildings, which could be achieved through the widespread use of water/energy-saving taps:

- Approx. 30% for an average baseline scenario with a moderately high proportion of showers and a still significant proportion of baths
- Approx. 40% if the proportion of baths is reduced and compensated by greater use of showers and/or lavatory taps

This range seems plausible, including in view of the calculation approach for taking a design-related flow rate limitation into account that is contained in the standard.

Impact on final energy demand and other variables derived from it

The extent of the impact made on the total values by the net energy saving analysed here of up to 30/40% on the hot water side essentially depends on two properties. Measures for saving hot water have a greater effect:

- The higher the proportion of domestic water heating as part of the total energy demand – i.e. they are particularly effective when the heating demand is as low as possible
- The less the final energy demand for heating domestic water is determined by fixed losses (storage, distribution/circulation)

The example calculations shown here result in the following savings in terms of the total primary energy demand or total greenhouse gas emissions:

- Between 2 and 6% with a centralised domestic water heating system with storage tank and distribution with circulation
- Up to 12% in a highly insulated building (Efficiency House 40) with a central heat pump (for heating purposes) and decentralised continuous flow heaters

For context, the energy savings potentials calculated here based on using water/energy-saving taps are juxtaposed with a selection of typical energy-saving measures[1]:

Table 1 Example energy savings potentials of various energy-saving measures (for calculation/source information, see Table 12)

Energy-saving measure			**Saving in terms of thermal final energy**
Comprehensive/predominant use of water/energy-saving taps		Centr. DWH, circulation	2 to 6% [a]
		Dec. elec. DWH	Up to 12% [a]
Heating control	Flow temperature reduction/heating curve optimisation of heat pumps	Low	4%
		High	12%
	Flow temperature reduction/heating curve optimisation otherwise		1 to 4%
	Night setback/shutdown		3 to 10%
	Summer shutdown		0 to 4%
Hydraulic balancing			4 to (15)% [b]
Subsequent insulation of heating and hot water distribution pipes			2 to 5%
Significant improvement in thermal insulation of buildings Example reduction of *H'T* from the reference building value according to GEG to 70% of the reference building value			25%
Solar heating of domestic water			6 to 26% [a]

a The percentage savings were determined based on the total primary energy demand (see 4.2.2). Assuming that the same energy source is used for heating and domestic water heating, the savings can be transferred approximately to the total final energy demand.

b Measure includes some savings effects from peripheral measures (in particular new thermostat valves and flow temperature reduction)

Comparing them with these isolated energy-saving measures illustrates that the total savings calculated here based on using water/energy-saving taps equate to between 2 and 12%, which are significant numbers. If the thermal insulation of buildings were to continue improving over time, that aspect would become more important.

Conceptual considerations on application in terms of standards and energy-saving legislation

Background/problem

Part 8 of DIN V 18599, Section 6.4.9 already contains a calculation approach for reducing the net energy demand for heating domestic water compared to the default value. This approach could be used to represent the net energy saving analysed here. However, as outlined above, so far it is proving difficult to apply in practice.

Possible solution(s)

The following steps would be appropriate to take the example options for saving hot water analysed here into account based on the approach already described in the standard:

- **Update content of the standard**

  In particular, the approach according to Section 6.4.9 DIN V 18599-8 must be supplemented with default or recommended values, which link the numerical value to technical features by means of written selection options. Appendix 2 shows the broad outline of this step and provides suggested text for updating the standard.

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[1] The energy savings that are actually achievable essentially depend on the individual boundary conditions; the values shown here are example ranges.

- **Applicability in terms of energy-saving legislation**

  Discussions must be held with legislators and in the standards committee to decide whether the existing restriction that limits the approach to non-legal energy consulting services can be withdrawn (see also suggested text in Appendix 2).

  Below are just some of the reasons why it would make sense to apply the approach to certification:

  - In the face of pressing environmental issues and environmental policy targets, and with a view to ensuring a secure energy supply for the long term, energy sufficiency needs to be incorporated into energy analyses, or incorporated to a greater extent than previously (in addition to technical efficiency). In the context of evaluating buildings in terms of energy-saving legislation, aspects of usage behaviour could be taken into account more.
  - People who use the standard or the software that implements the standard directly (e.g. energy consultants) and users of buildings are made more aware of the energy-related impact of their usage behaviour if this can be represented on the certificate.

    An appropriate compromise needs to be found between representing the impacts of usage to a suitable degree and not building an (excessively) high potential for abuse into the evaluation process through any options for improving the look of the figures.
  - Representing energy-efficient technical features on energy certificates will likely create incentives for further development in this area.

The assignment

This study assesses the energy savings potentials that can arise from using water-saving and efficiency-increasing technologies in showers and tap fittings in residential buildings. Specifically, it looks at the following key points:

- How water-saving taps are currently taken into account in calculation standard DIN V 18599, which is referenced in the *Gebäudeenergiegesetz* (GEG, the German Buildings Energy Act) and *Bundesförderung für effiziente Gebäude/Klimafreundlicher Neubau* (BEG/KfN, German federal funding for efficient buildings/climate-friendly new builds)
- Example calculations for a model detached house in these example scenarios regarding technical installations and equipment for thermal insulation:
    - Efficiency House 40 with air-to-water heat pump
    - Renovated existing building ($H'_T \approx H'_{T,Ref}$) with district heating
    - Older/partially renovated existing building (from the 1990s) with natural gas condensing boiler

  These examples are each analysed in the following configurations/usage scenarios in terms of water consumption:
    - Standard products and normal usage according to DIN V 18599 (i.e. default value for net energy demand for heating domestic water without interventions/modifications)
    - Water/energy-saving taps according to the current options under consideration in DIN V 18599
    - Water/energy-saving taps according to client specifications
- Comparison of energy and greenhouse gas characteristics plus evaluation of the results in terms of the impact of water/energy-saving taps and/or the ability to represent them:
    - Realisable energy savings potentials
    - Representation in standards and, where applicable, overview of existing need for amendments
    - Representation/impact in the context of the aforementioned energy-saving legislation and funding policy regulations
- Qualitative analyses of the following issues relating to water/energy-saving taps and showers:
    - Are other energy savings potentials available in the supply chain for heating domestic water (e.g. smaller continuous flow heater(s)/circulation system/hot water storage tank) and, if so, do these also have to be taken into account in the calculation?
    - Are there implications for evaluating centralised hot water systems compared to decentralised ones?
    - How can the energy savings potential be assessed compared to other building renovation work?

Unless otherwise stated in context, all the analyses that make up this study relate to residential buildings. Different conditions may prevail in non-residential buildings, which can lead to different results to those depicted here.

1 Digression: Legislation on saving energy in buildings and DIN V 18599

1.1 German Buildings Energy Act (GEG) [1, 2]

Legislation on saving energy in buildings in the form of the German Buildings Energy Act (GEG)[2] sets out requirements for the energy performance of buildings including in relation to new builds and comprehensive renovations.

An "energy performance certificate" must be produced as evidence, particularly in the case of new builds. This document compares, inter alia, the energy demand of the building under evaluation with the energy demand of a reference building that is identical in terms of its usage and size/geometry, but that meets an energy performance level defined by the GEG.

The DIN V 18599 series of standards is used to calculate the energy demand for this type of verification.[3]

1.2 DIN V 18599 [3]

DIN V 18599[4] describes, in 11 parts[5], a comprehensive procedure for calculating a building's energy demand, taking into account its usage, size/geometry, structural-physical properties and technical installations and equipment.

The 11 parts that make up the main procedure of the standard[5] span more than 1,000 pages in total; Table 2 gives an overview of their content. Domestic water heating is covered in Part 8 of the standard.

Table 2 Parts of the DIN V 18599 standard and content of the main procedure

Part	Content (title)
All	Energy efficiency of buildings – calculation of the net, final and primary energy demand for heating, cooling, ventilation, domestic hot water and lighting
1	General balancing procedures, terms and definitions, zoning and evaluation of energy sources
2	Net energy demand for heating and cooling of building zones
3	Net energy demand for air conditioning
4	Net and final energy demand for lighting
5	Final energy demand of heating systems
6	Final energy demand of ventilation systems and air heating systems for residential buildings
7	Final energy demand of air-handling and air-conditioning systems for non-residential buildings
8	Net and final energy demand of domestic hot water systems
9	Final and primary energy demand of power generation plants
10	Boundary conditions of use, climatic data
11	Building automation

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[2] Previously took the form of the *Energieeinsparverordnung* (EnEV, the German Energy Saving Ordinance) in conjunction with the *Erneuerbare-Energien-Wärmegesetz* (EEWärmeG, German Act on the Promotion of Renewable Energies in the Heat Sector)

[3] Previously it was permitted to produce energy demand calculations in uncooled residential buildings using the older DIN V 4108-6/4701-10 duo of standards as an alternative. This option is no longer permissible as of this year, only DIN V 18599 may be used now.

However, Article 22(2) of the latest GEG [11, 12] still refers to the old DIN V 4108-6/4701-10 standards duo – albeit only within the period up to 31/12/2023, which has now elapsed. Sentence 4 of Article 20(2) defines the net energy demand for hot water as 12.5 kWh/m²a, but as this relates solely to the aforementioned calculation option, it no longer has any effect. It is assumed that the reference to the old standards duo (including the specified characteristic) is a remnant of the editorial process.

[4] For organisational reasons, the standard was produced as a *Vornorm* (pre-standard, hence *DIN V*) and updated by the 2018-09 version, which is also referenced by the latest GEG. In the successor version (scheduled for 2024), DIN is set to transfer the series to the *Technical Specification* (*DIN/TS*) format. This short study primarily refers to the latest version (DIN V 18599:2018-09); however, the considerations shall also apply accordingly to the successor version.

[5] The series of standards currently comprises 13 parts. However, at present only Parts 1 to 11 – the "main procedure" – are relevant in practice and are referenced by legislation on saving energy in buildings in its current form (GEG) for certificates under public law.

The individual steps involved in an energy demand calculation are executed in the opposite direction to the flow of energy. They usually start with calculating the net energy demand (e.g. the amount of room heat that would be needed to maintain a required room temperature under idealised conditions). The energy-related effects/losses associated with technical installations and equipment are gradually added to this net energy demand. These installations and equipment:

- Transfer energy to the effective space (e.g. radiators including room temperature control)
- Distribute energy in the building (e.g. heating pipes of a certain length, insulation and position in the building)
- Store energy (e.g. heating buffer storage)
- Generate energy (e.g. heating boiler)

Figure 1 depicts a diagram of the workflow, taking space heating as an example, and shows significant interfaces/balancing areas and (energy-related) balancing terminology according to DIN V 18599.

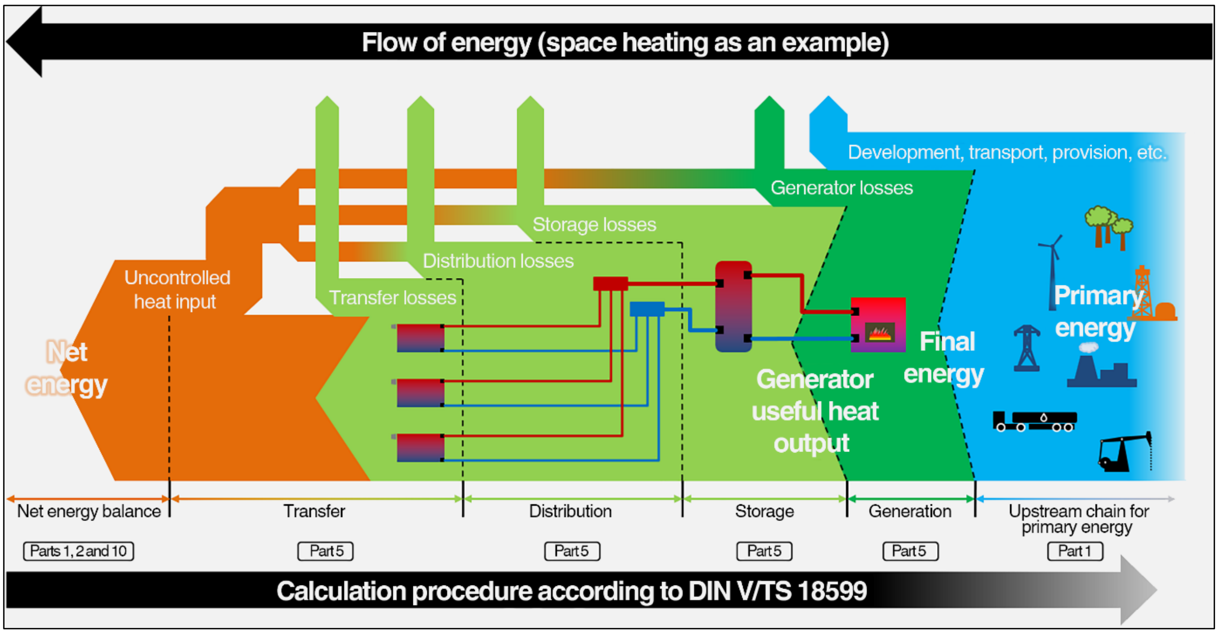

Figure 1 **Directions of flow of energy and calculation workflow according to DIN V/TS 18599, using space heating as an example**

2 Status quo: Water/energy-saving taps in legislation relating to saving energy in buildings and referenced regulations

2.1 Options available in standards for taking water/energy-saving taps into account

2.1.1 Default value for net energy demand for heating domestic water

DIN V 18599-10 (boundary conditions of use) contains specific default values for the net energy demand for heating domestic water in relation to:

- Net building floor area for residential buildings
- Net building/zone floor area and, alternatively, sometimes usage (e.g. number of rooms, beds or workspaces) for non-residential buildings

For residential buildings, the characteristic is specified depending on the size of the residence (see also Figure 2):[6]

$$q_{\mathrm{w,b,a}}\left[\frac{\mathrm{kWh}}{\mathrm{m^2a}}\right] = \underbrace{16{,}5\left[\frac{\mathrm{kWh}}{\mathrm{m^2a}}\right]}_{\text{Basic value}} - \underbrace{0{,}05\left[\frac{\mathrm{kWh}}{\mathrm{m^2a}}\right] * A_{\mathrm{NGF,WE,m}}[\mathrm{m^2}]}_{\text{Reduction depending on the average size of the residence}}$$

Equation 1
Specific net energy demand for heating domestic water in residential buildings

$q_{\mathrm{w,b,a}}$	Net energy demand for heating domestic water related to the net building floor area
$A_{\mathrm{NGF,WE,m}}$	Average net floor area of a residence

This characteristic implicitly already contains energy losses from unused, draining hot water[7] for normal/average conditions.

When interpreting the characteristic, the type of reference area must be taken into account. The relationship above relates to the net floor area as defined by the standard. For residential buildings this figure is greater than the living area.[8]

2.1.2 Explicit correction options

Impact of controlling the draw-off temperature

Section 6.1 DIN V 18599-8 (domestic water heating) allows for a reduction of 2% in the default value for the net energy demand for heating domestic water when certain devices are used to control the draw-off temperature[9]. By contrast, the value increases by 5% when hydraulically controlled continuous flow heaters are used.

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[6] The default value that depends on the size of the residence was calculated by conducting extensive research in reference material and evaluating real consumption data from several billing providers; the associated project report is available (in German) as *BBSR Online Publication 17/2017* [20]. The existing relationship designated equation 1 is found accordingly in the BBSR paper, albeit with slightly different numerical values – these variations are likely due to the different reference areas used in both representations (net floor area versus usable floor area).

[7] e.g. from manually mixing to adjust the draw-off temperature

[8] The net floor area according to DIN V 18599 corresponds to the net floor space as per DIN 277; it is the total of all internal floor areas (inside dimensions, i.e. without footprints for walls/rising structural components). How much it deviates from the living area in residential buildings depends on the proportion of ancillary areas that go beyond the living area. On the one hand, in relatively small residential buildings with a high proportion of warm ancillary areas (e.g. detached houses with a cellar inside the thermal envelope), the difference can be very large (see table 9 for an example). On the other hand, in very large residential buildings with a low proportion of ancillary areas (e.g. relatively small corridor/staircase areas or cold/external stairs, cellars outside the thermal envelope and so on), both values can converge.

[9] Temperature-controlling tap fittings or electronically controlled continuous flow heaters with temperature selection accurate to the nearest degree

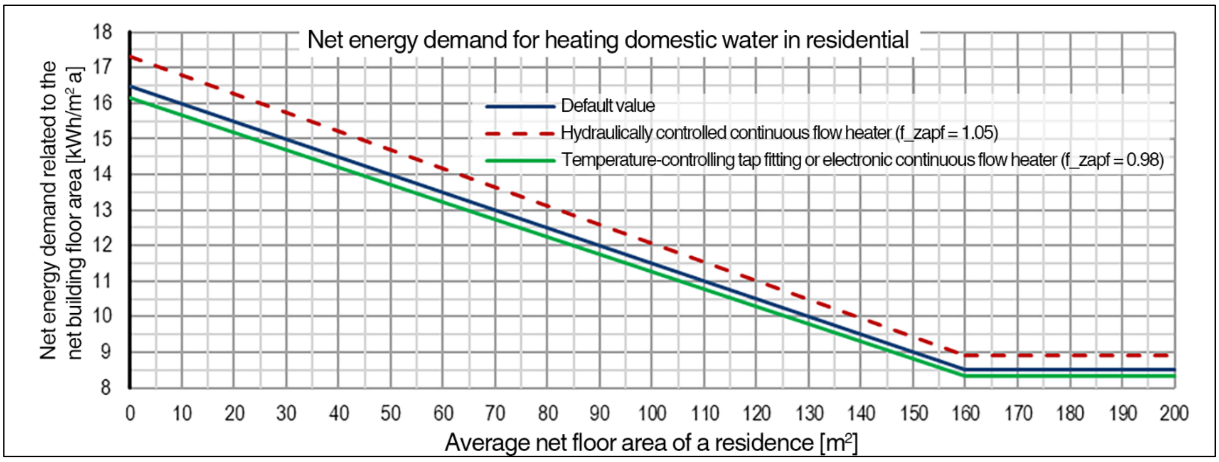

Figure 2 **Net energy demand for heating domestic water (Section 6.1 DIN V 18599-8) based on the default value for residential buildings (Table 4 DIN V 18599-10)**

The possibility of reducing the net energy demand by 2% essentially represents a decrease in energy losses, which are thanks to better temperature control – less hot water is draining away unused. This calculation option does not imply any loss of comfort compared to usage as per the standard.

Design-related flow rate limitation

Section 6.4.9 DIN V 18599-8:2018-09 describes the optional inclusion of a design-related (hot water) flow rate limitation or a limited power output of the domestic water heater.

The standard assumes the following:

- The available hot water flow rate without limitation is 12 l/min.
- A power/flow rate limitation can only be energy-efficient when hot water usage is dominated by the duration of draw-off, not the amount of hot water drawn – this type of usage primarily corresponds to showers.
- The proportion of showers contained in the net energy demand for heating domestic water (without limitation) is approx. 65%[10].
- The maximum available hot water flow rate is used in approx. 75%[10] of showers or showering time. The limitation is effective in this percentage of the draw-off time.

Figure 3 shows the reduced net energy demand as a relative value over the maximum hot water flow rate for domestic water heating.

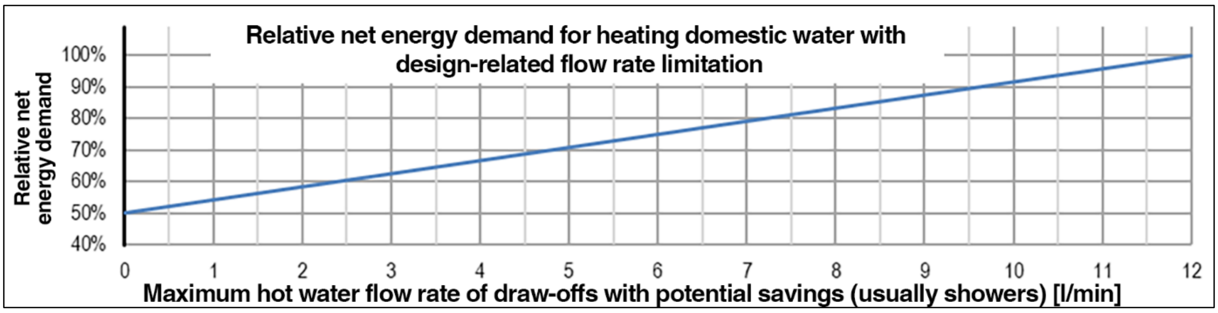

Figure 3 **Relative net energy demand for heating domestic water with design-related flow rate limitation (Section 6.4.9 DIN V 18599-8)**

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[10] Assumptions according to Section 6.4.9 DIN V 18599-8:2018-09: The assumptions made in the standard rest on unpublished drafts in which water consumption values (by reference to several sources, including [15, 16, 21]), inter alia, are converted into energy proportions based on further assumptions.

This calculation option represents a reduction in the amount of hot water drawn or the hot water flow rate during use, i.e. this option does not imply any loss of comfort compared to usage as per the standard. At the moment, the standard expressly stipulates that this option can only be used for non-legal consulting services, not for producing certificates under public law.

ITG uses up to four different energy consulting programs (18599 software) at present. The aforementioned option is not included or not visible as such in the programs we use.[11]

2.1.3 Other modification options

Alongside use of the default value, the standard also fundamentally permits use of an individual net energy demand for heating domestic water. By modifying this variable accordingly – based on external calculations, for example – a 18599 calculation can represent effects that have not been recorded otherwise in the standard before now.

However, this option may not be available in energy consulting practice, since it will not necessarily be possible to freely input the net energy demand for heating domestic water in the 18599 software being used.[11] Only one of the energy consulting programs used by ITG has an identifiable option for inputting this characteristic.

2.2 References in energy-saving legislation

2.2.1 Default value versus individual specification

For certification cases based on energy demand calculations according to DIN V 18599, the German Energy Saving Ordinance (EnEV) [4] stipulated that the default value as per DIN V 18599-10 must be used for the net energy demand for heating domestic water. However, the German Buildings Energy Act (GEG) [1, 2] has not adopted this stipulation; in this respect it is ambiguous whether the legislators intend that only the default value may be used in certification cases or whether an individual value may be used as well.

It is assumed that this issue was of little relevance in practice until now:

- It is possible that the fact the explicit rule had been omitted was not (really) picked up on and the procedure that applied during the EnEV era was retained in practice.
- Not all 18599 programs provide the option to freely input this characteristic in any case (potentially also due to the previous EnEV rule). In addition, a reduced net energy demand – provided it is permitted in certification cases – would have to be applied to both the building under evaluation and the reference building. In that sense this option is likely to have a low impact as per the variations that are realistically possible.

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[11] The standard allows for alternative approaches for certain sub-problems (e.g. alternative calculation approaches, use of product characteristics instead of default values and so on). Conventional 18599 software is primarily used for producing certificates under public law according to GEG (energy performance certificates) and sometimes, over and above that, for non-legal consulting services. The most common use cases do not necessarily require all the alternative approaches permitted according to the standard for every sub-problem. This means not all alternative options provided in the standard are implemented in every software programs.

2.2.2 Temperature control

The aforementioned options for controlling the draw-off temperature can also be applied when certifying the building under evaluation.

The technical installations and equipment related to domestic water heating and distribution have been defined for the reference building; however, nothing has been defined as regards controlling the draw-off temperature. In cases where a property of the reference building that is needed for the calculations has not been defined, this property must be adopted from the building under evaluation. In this respect what is already the low impact of this option is likely to be barely noticeable in certification cases.

3 Preliminary analysis: Energy savings potential provided by the product features of tap devices

3.1 Digression: Qualitative relationship between draw-off amount, temperature rise, power demand and energy demand

The power input into a flowing medium or the power output out of a flowing medium is linked to the media mass flow and the associated temperature change.

$$\dot{Q} = \dot{V} * \rho * c * \Delta\vartheta$$

Equation 2
Relationship between energy flow, media flow and temperature change

$\dot{Q}$	Energy flow (power) into or out of the medium
$\dot{V}$	Media flow rate
$\rho * c$	Material characteristics (density and specific heat capacity) of the medium
$\Delta\vartheta$	Temperature change of the medium

Figure 4 shows the fundamental[12] relationship for heating water.

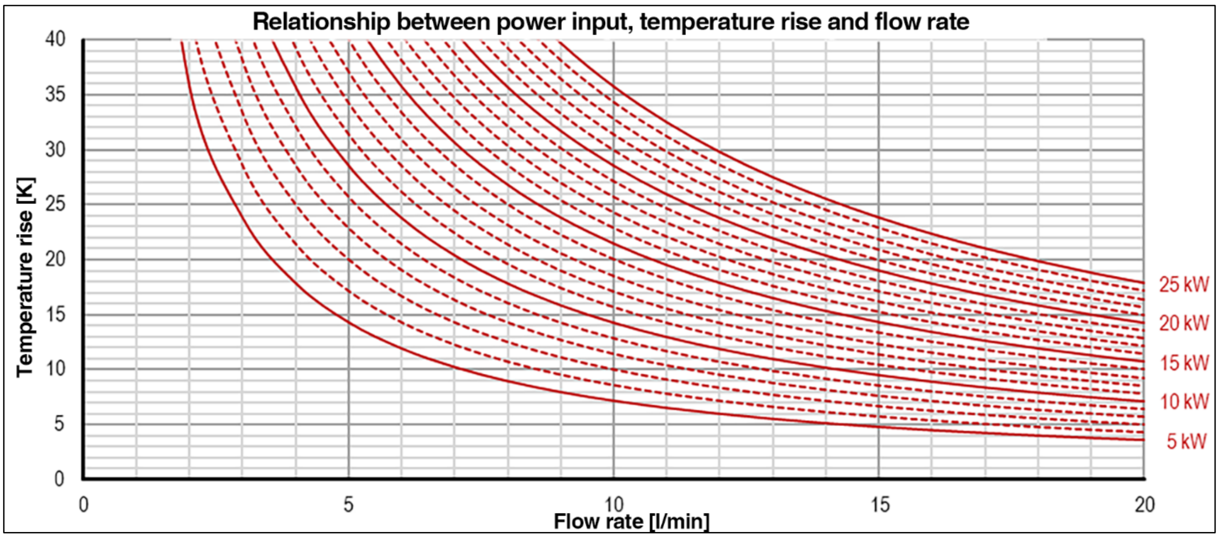

Figure 4 **Relationship between the power input into the water flowing through a water heater, its temperature rise and the flow rate; idealised depiction without heat transfer losses and so on**

The graph illustrates, inter alia, that when the flow rate to be heated is reduced, less power is required to heat it. The relationship applies in the first instance in the idealised analysis; however, operation of one single draw-off point where water is heated using a continuous flow heater[12] can be presented as an illustrative example, which is very close to the idealised analysis.

In view of real buildings, potential planning considerations and conventional technical solutions for heating domestic water, however, the relationship shown above does not allow for a blanket conclusion that using water-saving taps justifies dimensioning the (hot water) heat generator

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[12] The graph shows the idealised relationship simplified for a constant density and without any losses/temperature differences caused by technical implementation (heat exchangers in particular). In view of real devices, the graph must therefore be understood as more qualitative than quantitative – manufacturer data for real water heaters (heat exchangers, continuous flow heaters) may contain different numerical values.

to be smaller. There are other significant (or sometimes even crucial) factors at play here – the impacts and uncertainties below must be interpreted as examples only:

- Measures to limit flow rate affect different water heaters in different ways. With a storage charging system, the impact is likely to be low to non-existent (again depending on the draw-off behaviour, relationship between storage volume and hot water demand, charging control, etc.), whereas with a continuous flow heater without storage volume, it is likely to be clearly visible.
- Dimensioning of the water heater may already include other power deductions (e.g. due to considerations relating to the simultaneity (or otherwise) of hot water draw-offs in centralised systems), which means an implicit power limitation may already be in place and there will be less potential for measures at tap fittings from the outset.
- When it comes to such measures to limit flow rate on the fitting side, which can be deactivated by the user (e.g. by pressing a button to override a range limit), an assessment must be made as to whether deactivating such measures will still allow the required hot water temperature to be achieved or whether a reduction in comfort is acceptable.
- For buildings with many users (e.g. medium to large buildings with several residential units) and/or areas used in different ways (including non-residential usage, where applicable), the extent of the possible savings effect also depends on the case-specific combination of individual usage properties and draw-off behaviours.

Power-related dimensioning is not covered by DIN V 18599. Physically speaking, increasing or decreasing the draw-off amount/power does not necessarily change the energy demand. As far as the option of limiting draw-off amounts analysed here is concerned, the impact on the energy demand depends on whether and to what extent hot water usage is determined by the **duration** of draw-off, rather than the **volume** drawn. Section 3.3 looks into this in more detail regarding residential buildings and estimates the impact with specific numerical values for the example calculations that follow in Section 4.

3.2 Flow limitation

The features of tap devices analysed here primarily aim to reduce the maximum available flow rate during draw-offs, in particular by limiting the flow range. Table 3 shows the potential savings specified by the client and the average flow values derived from that data for use in the subsequent example calculations.

Table 3 Flow rates of tap fittings

Draw-off point	Flow rate [l/min]		
	Standard product [a]	Water/energy-saving product	
		Usual range [a]	Selected (average value)
Shower	16.3	6 to 8	7.0 (43%)
Bath tub	— [b]	— [b]	— (100%) [b]
Lavatory tap	5.0	2 to 4 [c,d]	3.0 [d] (60%)
Kitchen tap	10.1	6	6.0 (59%)

a Data provided by the client

b For bath tubs, the absolute draw-off volume required to fill the tub is key. A flow rate limitation is therefore generally unlikely to save any water and could even – since the water would cool down more as the tub would take longer to fill – tend to cause an increase in energy demand.

c Alongside flow-limiting product versions/features, the *cold start* option (range of the mixer lever rotated, so with the lever in its usual home position it is cold water that flows out, not mixed) has been specified with an energy savings potential of 20%. In terms of energy, this saving is comparable to reducing the average hot water flow rate from 5 to 4 l/min.

d The applicable version of DIN EN 817 [5], *2008-09*, stipulates a minimum flow of 4 l/min (section titled "Determination of flow rate"). This limitation is set to disappear from the upcoming version of the standard (currently draft version *2023-07*). This calculation is based on the planned new version (with no minimum flow limitation).

3.3 Impact on the net energy demand for heating domestic water

The limitation of the maximum available flow rate analysed in 3.2 can lead to a reduction in hot water consumption and in associated energy expenditure. This section estimates these savings as an example.

The calculation approach used for these estimates corresponds to the procedure in DIN V 18599-8:2018-09 in terms of content. However, it expands the analysis by adding more tap types besides showers that have the potential to make savings (see also the suggested text for updating the standard with the typographical conventions for formulae written out in the *Appendix*). It models, in simplified form, a limitation of the available hot water flow rate with the tap fittings fully open as far as they will go/until resistance is met compared to a reference value. According to this model, the net energy demand for providing hot water decreases when the following conditions are met simultaneously:

- It is not the absolute draw-off amount (e.g. filling a bath tub) or the draw-off flow rate that is key for the usage scenario; rather, it is the draw-off duration (e.g. showers, hand washing).
- In the usage scenario, the tap is opened as far as it will go/until resistance is met and the resulting flow rate applies.

Thus, every type of hot water usage or tap is identified for calculation purposes by

- their proportion of the net energy demand for hot water,
- of that, the proportion at maximum flow rate (i.e. with fitting open as far as it will go/until resistance is met) in which a limitation is effective, and
- the relative flow rate reduction achieved by the limitation measure (see 3.2).

Data from reference material relating to the proportions (water or energy) for different tap types does show similar trends overall, but the details sometimes vary quite considerably. To cover a certain scope of potential draw-off scenarios, the following factors are analysed:

- A basic scenario that is geared towards the characteristics already available in the standard in terms of shower usage, but that also includes other tap types
- Three other draw-off scenarios (high proportion of showers, high proportion of lavatory taps, high proportion of baths)

Table 4 summarises the presumed boundary conditions.

Table 4 **Example usage scenarios regarding draw-off behaviour; modifications from the basic scenario highlighted in red**

Draw-off point	**Basic scenario**		**High proportion of showers**		**High proportion of lavatory taps**		**High proportion of baths**	
	• Assumptions regarding proportion of showers according to DIN V 18599-8:2018-09: • Analysis expanded to include *bath tub*, *lavatory* and *kitchen tap types*		• Increased proportion of showers and proportion at maximum flow rate • Corresponding reduction in proportion of baths		• Increased proportion of lavatory taps and proportion at maximum flow rate • Corresponding reduction in proportion of baths		• Uniform distribution of net energy across shower/bath tub	
	Proportion of net energy without flow rate limitation	**Factor for draw-off proportion at maximum flow rate**	**Proportion of net energy without flow rate limitation**	**Factor for draw-off proportion at maximum flow rate**	**Proportion of net energy without flow rate limitation**	**Factor for draw-off proportion at maximum flow rate**	**Proportion of net energy without flow rate limitation**	**Factor for draw-off proportion at maximum flow rate**
Shower	65% [a]	0.75 [a]	**85%**	**0.80**	65%	0.75	**45%**	0.75
Bath tub	25% [b]	1.00	**5%**	1.00	**5%**	1.00	**45%**	1.00
Lavatory tap	5% [c]	0.75 [d]	5%	0.75	**25%**	**0.80**	5%	0.75
Kitchen tap	5% [c]	0.50 [e]	5%	0.50	5%	0.50	5%	0.50
Total	**100%**		**100%**		**100%**		**100%**	

a Assumptions according to Section 6.4.9 DIN V 18599-8:2018-09: The assumptions made in the standard rest on unpublished drafts in which water consumption values (by reference to several sources, including [6, 7, 8]), inter alia, are converted into energy proportions based on further assumptions.

b This proportion would result for the detached house analysed as an example (4.1) with approx. 70 fillings of bath tubs (180 to 200 l) per year at a draw-off temperature of 35 K above the cold water level.

c For the sake of simplicity, the rest is split 50/50 across lavatory taps and kitchen taps.

d Assumption: Medium to high proportion of time-dominant draw-offs (e.g. hand washing); low proportion of volume-dominant draw-offs

e Assumption: Split approximately 50/50 across time and volume-dominant draw-offs

Tables 5 to 8 show estimates of possible net energy savings based on the data on flow rate limitation given in 3.2 and on the assumptions relating to the energy-related weighting of the draw-off points and to draw-off behaviour mentioned above. All percentages relate to the net energy demand for heating domestic water without or before water-saving measures (*Column1*).

Table 5 **Estimate of (net) energy savings from limiting the maximum available flow rate at the tap device: Basic scenario**

Draw-off point	**Proportion of net energy without flow rate limitation [a]**	**Factor for draw-off proportion at maximum flow rate [a]**	**Proportion of net energy at**		**Factor for flow rate limitation [d]**	**Proportion of net energy with flow rate limitation**
			Maximum flow rate [b]	**Lower flow rate [c]**		
	Column1	*Column2*	*Column3 = column1 * column2*	*Column4 = 1 – column3*	*Column5*	*Column6 = column3 * column5 + column4 (* 1)*
Shower	65%	0.75	48.75%	16.25%	0.43	37.19%
Bath tub	25% [e]	1.00	25.00%	0.00%	1.00 [e]	25.00% [e]
Lavatory tap [f]	5%	0.75	3.75%	1.25%	0.60	3.50%
Kitchen tap	5%	0.50	2.50%	2.50%	0.59	3.99%
Total	**100%**		**80%**	**20%**		**70%**

a See Table 4

b Proportion of energy which a limitation of the maximum available flow rate can affect (provided that the absolute draw-off volume is not key)

c Proportion of energy that does not depend on a limitation of the maximum available flow rate

d See 3.2/Table 3

e For bath tubs, the absolute draw-off volume required to fill the tub is key. A flow rate limitation would not save any water and could even – since the water would cool down more as the tub would take longer to fill – tend to cause an increase in energy demand.

f For lavatory taps, alongside flow-rate-limiting features, the *cold start* product feature (range of the mixer lever rotated, so with the lever in its usual home position it is cold water that flows out, not mixed) is available, for which the client specifies an energy savings potential of 20%. In light of the low energy-related weighting of lavatory taps in the example analysis performed here (5% before energy-saving measures), they have not been listed separately for different energy-saving features; the calculation is simply performed with the flow rate limitation outlined above.

Table 6 **Estimate of (net) energy savings from limiting the maximum available flow rate at the tap device: High proportion of showers; modified input variables compared to basic scenario highlighted in red**

Draw-off point	Proportion of net energy without flow rate limitation[a]	Factor for draw-off proportion at maximum flow rate[a]	Proportion of net energy at		Factor for flow rate limitation[d]	Proportion of net energy with flow rate limitation
			Maximum flow rate[b]	Lower flow rate[c]		
	Column1	*Column2*	*Column3 = column1 * column2*	*Column4 = 1 – column3*	*Column5*	*Column6 = column3 * column5 + column4 (* 1)*
Shower	**85%**	**0.80**	68.00%	17.00%	0.43	46.20%
Bath tub	**5%**[e]	1.00	5.00%	0.00%	1.00[e]	5.00%[e]
Lavatory tap[f]	5%	0.75	3.75%	1.25%	0.60	3.50%
Kitchen tap	5%	0.50	2.50%	2.50%	0.59	3.99%
Total	**100%**		**79%**	**21%**		**59%**

Table footnotes same as for Table 5

Table 7 **Estimate of (net) energy savings from limiting the maximum available flow rate at the tap device: High proportion of lavatory taps; modified input variables compared to basic scenario highlighted in red**

Draw-off point	Proportion of net energy without flow rate limitation[a]	Factor for draw-off proportion at maximum flow rate[a]	Proportion of net energy at		Factor for flow rate limitation[d]	Proportion of net energy with flow rate limitation
			Maximum flow rate[b]	Lower flow rate[c]		
	Column1	*Column2*	*Column3 = column1 * column2*	*Column4 = 1 – column3*	*Column5*	*Column6 = column3 * column5 + column4 (* 1)*
Shower	65%	0.75	48.75%	16.25%	0.43	37.19%
Bath tub	**5%**[e]	1.00	5.00%	0.00%	1.00[e]	5.00%[e]
Lavatory tap[f]	**25%**	**0.80**	20.00%	5.00%	0.60	17.00%
Kitchen tap	5%	0.50	2.50%	2.50%	0.59	3.99%
Total	**100%**		**76%**	**24%**		**63%**

Table footnotes same as for Table 5

Table 8 **Estimate of (net) energy savings from limiting the maximum available flow rate at the tap device: High proportion of baths; modified input variables compared to basic scenario highlighted in red**

Draw-off point	Proportion of net energy without flow rate limitation[a]	Factor for draw-off proportion at maximum flow rate[a]	Proportion of net energy at		Factor for flow rate limitation[d]	Proportion of net energy with flow rate limitation
			Maximum flow rate[b]	Lower flow rate[c]		
	Column1	*Column2*	*Column3 = column1 * column2*	*Column4 = 1 – column3*	*Column5*	*Column6 = column3 * column5 + column4 (* 1)*
Shower	**45%**	0.75	33.75%	11.25%	0.43	25.74%
Bath tub	**45%**[e]	1.00	45.00%	0.00%	1.00[e]	45.00%[e]
Lavatory tap[f]	5%	0.75	3.75%	1.25%	0.60	3.50%
Kitchen tap	5%	0.50	2.50%	2.50%	0.59	3.99%
Total	**100%**		**85%**	**15%**		**78%**

Table footnotes same as for Table 5

By using the features for limiting flow rate that are analysed here and working on the aforementioned assumptions, a 30% reduction in the net energy demand for heating domestic water can be estimated in the **basic scenario**. The same value would result by including a design-related flow rate limitation according to Section 6.4.9 DIN V 18599-8:2018-09 for reducing the hot water flow rate applied there to approx. 4.8 l/min (see also Section *Design-related flow* rate limitation/Figure 3).

This estimate is significantly affected by the high proportion of energy used for showering – logically, this is also where there is the greatest potential to make savings. The assumptions regarding proportion of showers and the related proportion at maximum flow rate have been adopted from DIN V 18599-8 for the basic scenario; the ranges seem plausible for residential use. For usage scenarios where the usage/weighting of draw-off points differs significantly, such as in non-residential buildings, other conditions may prevail (e.g. plumbing systems with a large number of (hot water) washing stations, but with no or only a few shower stations) – trends can be derived from these variations (Table 6 to 8).

Of the scenarios analysed, the example with a **high proportion of baths** and a correspondingly reduced proportion of showers indicates a net energy saving of just 22% compared to the basic scenario.

By contrast, every variation where there is a reduced proportion of baths compared to the basic scenario tends towards a larger net energy saving. The examples shown here with an **increased proportion of showers** and an **increased proportion of lavatory taps** result in net energy savings of 41 and 37%.

4 Example energy demand calculations

4.1 Boundary conditions

4.1.1 Methodology/calculation procedure

Example energy demand calculations are performed using commercial energy consulting software according to DIN V 18599:2018-09. The hot water usage scenarios to be analysed (default value, maximum saving according to client specifications) are represented by modifying the net energy demand for heating domestic water accordingly.

The results take the form of final and primary energy demand values as well as greenhouse gas emissions.

4.1.2 Model building

The analysis looks at a detached house with a living area of approx. 150 m², a cellar, two (residential) storeys above ground and a cold attic.

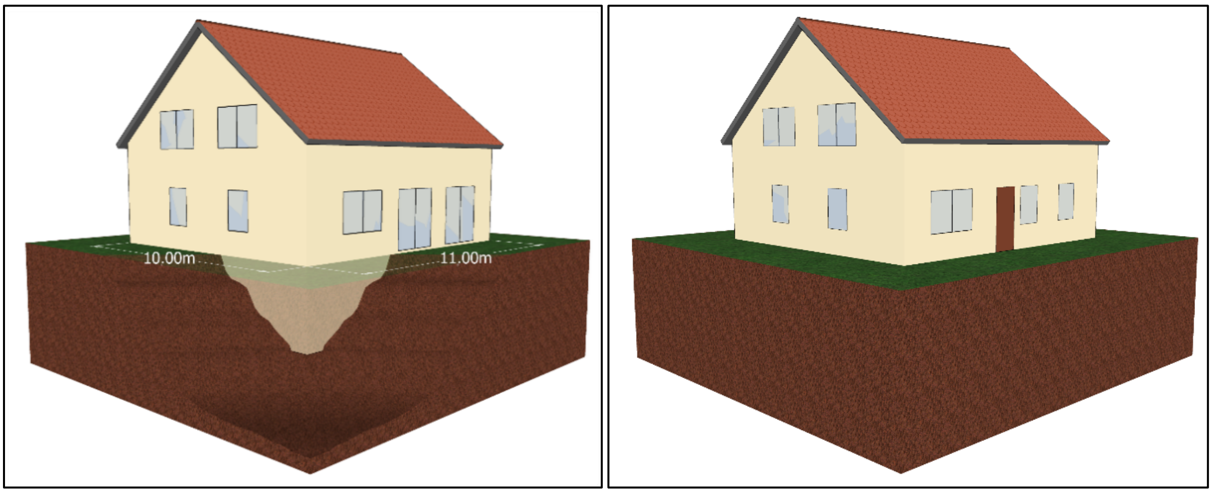

Figure 5 Model building of a detached house, south-west elevation (left) and north-east elevation (right)

The model building's thermal envelope in terms of the energy balance according to DIN V 18599 and GEG constitutes the floor slab, cellar walls that are in contact with the earth, above-ground external walls, the bottom half of the pitched roof areas and the top storey ceiling in the attic.

Table 9 Size parameters for the model building, rounded values

Living area	m²	150
Net floor area[a]	m²	252
Usable floor area[a] **acc. to GEG**	m²	288
Gross volume[a]	m³	900
Net volume[a] **(air volume)**	m³	660

a Including cellar (cellar inside the thermal envelope)

Three different combinations of thermal insulation level and technical installations and equipment are analysed:

- Efficiency House 40 thermal insulation[13], electric air-to-water heat pump

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[13] The key criterion applied is the *specific transmission heat loss related to the heat-transferring exterior surface* as defined in GEG/BEG ($H'_{T,Act} \approx 0.55 * H'_{T,RefGEG}$).

- Reference building thermal insulation[14] according to GEG, district heating connection
- Existing 1990s building[15], gas condensing boiler

Table 10 summarises the key parameters relating to structural physics and technical installations and equipment.

Table 10 Properties of the building envelope and conditioning by technical installations and equipment

Property			Value		
			EH 40 thermal insulation, heat pump	**Reference thermal insulation GEG, district heating**	**Existing building, gas condensing boiler**
Thermal transmittance U [W/m²K]	Floor slab		0.20	0.35	0.50
	Cellar wall		0.14	0.35	0.50
	External wall		0.14	0.28	0.50
	Roof, top storey ceiling		0.10	0.20	0.30
	Window		0.70	1.30	1.30
	Door		1.00	1.80	2.40
	Thermal bridges		0.030	0.050	0.100
Airtightness	Category according to Section 6.3.1.2 DIN V 18599-2		I	I	III
Space heating	Transfer		Underfloor heating, PI controller	Radiator, P controller	Radiator, P controller
	Distribution	Design temperatures	35/28 °C	55/45 °C	55/45 °C
		Pipe lengths	Default values according to DIN V 18599-5:2018-09		
		Pipe insulation	Up-to-date pipe insulation (EnEV/GEG)		
		Pump	Δp-c, designed to suit requirements		
	Generation		Air-to-water heat pump	District heating	Gas condensing boiler
Domestic water heating	Distribution	Pipe lengths and insulation	Distribution with circulation, default values same as for heating system		
		Recirculating pump	Controlled		
	Generation		Indirectly heated storage tank/heat generator for heating system		

Three different levels of net energy demand for heating domestic water ($Q_{w,b}$) are analysed for each of the three building/equipment configurations outlined above:

a Default value for net energy demand according to DIN V 18599 without interventions/modifications (see 2.1.1): $Q_{w,b}$ = 2,143 kWh/a[16]

b Combination of energy-saving options in shower fittings, lavatory taps and kitchen taps with a reduction in net energy demand of 30% compared to the default value as per the basic scenario according to 3.3: $Q_{w,b}$ = 1500 kWh/a

c Combination of energy-saving options in shower fittings, lavatory taps and kitchen taps with a reduction in net energy demand of 40% compared to the default value based on variations with a lower proportion of baths according to 3.3: $Q_{w,b}$ = 1285 kWh/a

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[14] The calculation is performed using the structural-physical properties (including U-values) for the reference building according to GEG. A building that has been (partially) modernised to the level of the reference building or an "old new build" from the EnEV 2014 era is a possible practical example.

[15] With more or less extensive standard modernisation work (e.g. windows replaced, roof/floor insulation added), depending on the age of the building

[16] This equates to an area-specific value of 8.5 kWh/m²a in relation to the net floor area of 252 m² or of 14 kWh/m²a in relation to the living area of 150 m².

4.1.3 Characteristics of energy sources

The following specific characteristics of energy sources according to GEG/DIN V 18599-1:2018-09 are applied:

Table 11 Specific characteristics of energy sources

Energy source	Primary energy factor [$kWh_{Prim,Hl}/kWh_{End,Hl}$]	Specific greenhouse gas emissions [$g_{CO2eq}/kWh_{End,Hl}$]
Natural gas	1.10	240
Power, grid mix	1.80	560
District heating from oil/gas with minimum 70% from combined heat and power plant	0.70	180

4.2 Results

4.2.1 Final energy balance

Figure 6 shows the final energy demand of the model building:

- In the aforementioned analysis cases (4.1.2)
- In the proportions for heating and domestic water heating, with those then subdivided into heat and auxiliary energy

The heat proportion of the final energy demand for heating domestic water is also specified as a relative value based on the initial/comparison state in each case.

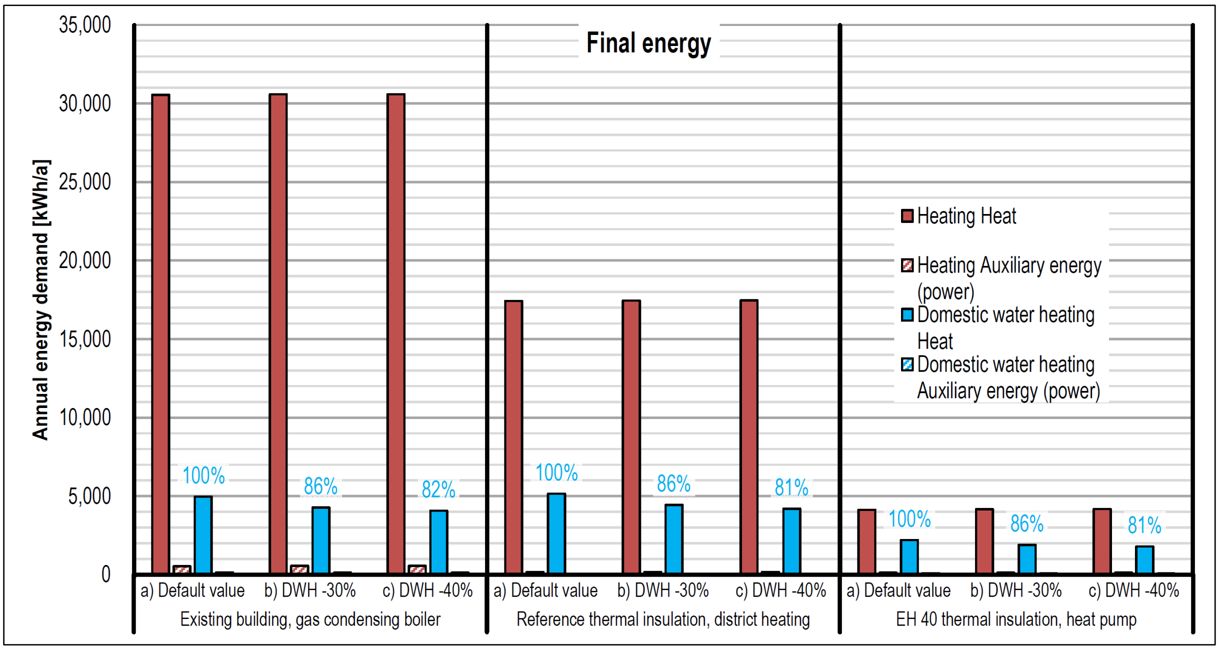

Figure 6 Annual final energy demand (related to heat value); results shown in tables in Appendix 2

The 30 or 40% saving in the net energy demand for hot water that is achieved by using water/energy-saving tap devices (see 4.1.2) leads to a saving of 14 or 18 to 19% in the final energy demand on the hot water side as seen in the example calculation.

The fact that the percentage savings are much less noticeable in the transition from net energy to final energy can be traced back to losses associated with technical installations and equipment that do not change in proportion to the net energy demand (i.e. the amount of hot water drawn). For the centralised systems analysed here, these are the significant, largely fixed losses arising from storage and distribution with circulation. For systems without a hot water storage tank and/or without distinct distribution pipes with circulation, the percentage final energy saving would be closer to the percentage net energy saving; in the analyses looking at primary energy/greenhouse gas emissions (4.2.2), this is again shown in an additional calculation example using electric continuous flow heaters.

Furthermore, the results already suggest that the impact which the hot water demand has on the total energy demand depends on the split between heating and domestic water heating. The sub-section below looks into this again briefly.

4.2.2 Primary energy and greenhouse gas emissions

The primary energy demand and greenhouse gas emissions are shown below:

- In the aforementioned analysis cases (4.1.2)
- In the proportions for heating and domestic water heating, with those then subdivided into heat and auxiliary energy

. To illustrate the impact that the measures on the hot water side analysed here have on the relevant total value, both relative values are also specified based on the initial/comparison state in each case.

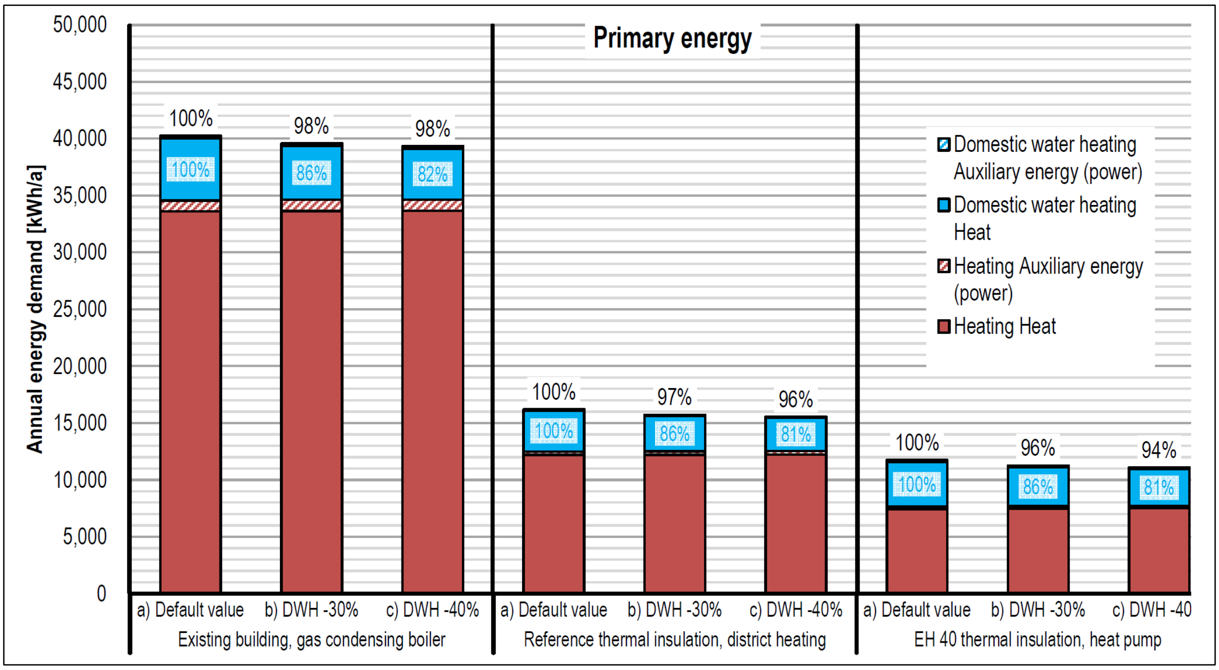

Figure 7 **Annual primary energy demand; results shown in tables in Appendix 2**

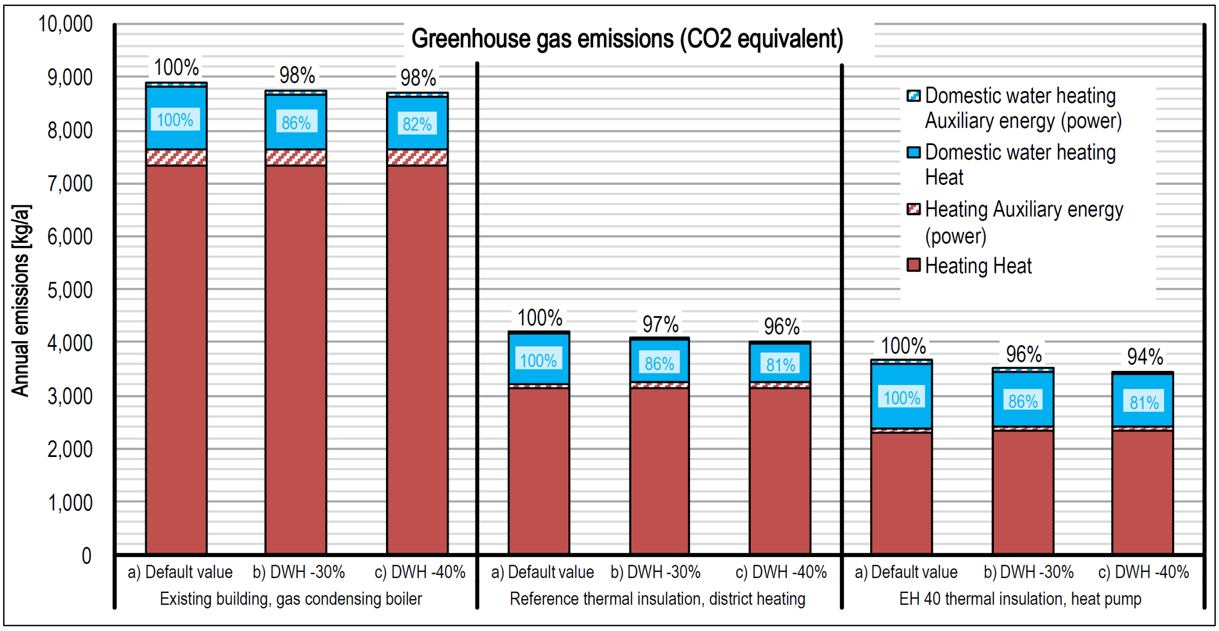

Figure 8 Annual greenhouse gas emissions; results shown in tables in Appendix 2

The (final energy) savings on the hot water side calculated in 4.2.1 are at the same level for primary energy and greenhouse gas emissions.[17] If the saving is related to the total value (heating + domestic water heating), the percentage change will be smaller by definition: for the water/energy-saving measures analysed here, the "Net energy DWH -30%" or "Net energy DWH -40%" levels result in total savings of 2% in the existing building or 4 to 6% in the Efficiency House 40.

By definition, changes in the energy demand for a conditioning type (in this case, domestic water heating) have a larger impact in relation to the total energy demand the greater the energy-related weighting of said conditioning type is (and vice versa). In other words, potential savings on the hot water side will be more noticeable as part of the overall picture the lower the energy demand for heating is (e.g. thanks to better thermal insulation).

Furthermore, as has already been touched on in 4.2.1, there would also be a greater impact on the total values if the saving in net energy were curbed less by considerable, largely fixed storage and circulation losses and could therefore have more of an effect on the final energy level.

Figure 9 is an extract of a graph showing the figures for an Efficiency House 40 with domestic water heating by decentralised continuous flow heaters. The net energy saving of 30 or 40% in relation to domestic water heating is at almost the same level for primary energy (percentage values are

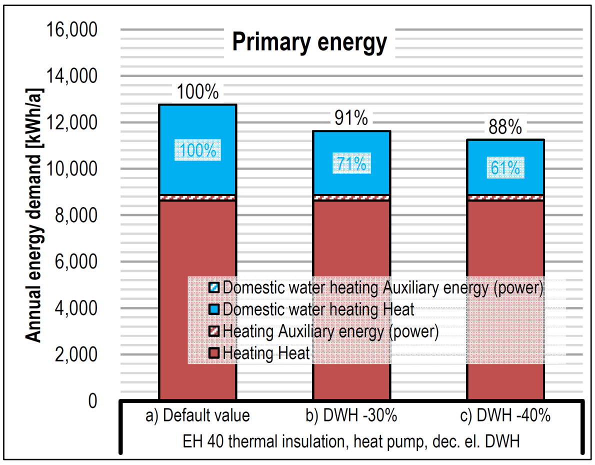

Figure 9 Annual primary energy demand, extract for EH 40 with domestic water heating by decentralised continuous flow heaters; results shown in tables in Appendix 1

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[17] Final and primary energy or final energy and greenhouse gas emissions are linked by a constant factor for one and the same energy source (4.1.3) and are therefore proportional to one another.

identical for final energy, primary energy and greenhouse gas emissions[17]). In relation to the total value, this now results in savings of between 8 and 12% (compared to 4 to 6% with a centralised domestic water heating system, see Figure 7 on the right).

5 Key results and potential courses of action

5.1 Assumptions regarding net energy demand

Based on data provided by the contractor, a potential saving has been estimated of 30 to 40% in terms of net energy demand for heating domestic water in residential buildings, which could be achieved through the widespread use of water/energy-saving taps. This range seems plausible, including in view of the calculation approach for taking a design-related flow rate limitation into account that is contained in the standard.[18]

5.2 Impact on final energy demand and other variables derived from it

The extent of the impact made on the total values by the net energy saving analysed here of up to 30 or 40% on the hot water side essentially depends on two properties. Measures for saving hot water have a greater effect:

- The higher the proportion of domestic water heating as part of the total energy demand – i.e. they are particularly effective when the heating demand is as low as possible
- The less the final energy demand for heating domestic water is determined by fixed losses (storage, distribution/circulation)

The example calculations shown here result in the following savings in terms of the total primary energy demand or total greenhouse gas emissions:

- Between 2 and 6% with a centralised domestic water heating system with storage tank and distribution with circulation
- Up to 12% in a highly insulated building (Efficiency House 40) with a central heat pump (for heating purposes) and decentralised continuous flow heaters

For context, Table 12 again juxtaposes the energy savings potentials calculated here based on using water/energy-saving taps with a selection of typical energy-saving measures[19].

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[18] The optional approach in the standard allows for a reduction in the default value for the net energy demand for heating domestic water. The largest reduction that is mathematically possible according to this approach is 50%, although this does not represent a realistic use case, it is merely the mathematical limit of the results range – it basically equates to an assumption that the flow rate would be reduced to 0% when showering. For example, a saving of 30% would harness a little over half of the maximum savings potential that is theoretically possible at present according to the standard.

The suggested text for the standard found in Appendix 2 writes out the basic equation so that values can be assigned to all the key parameters; default values are also suggested for some analysis cases.

[19] The energy savings that are actually achievable essentially depend on the individual boundary conditions; the values shown here are example ranges.

Table 12 Example energy savings potentials of various energy-saving measures

Energy-saving measure			Saving in terms of thermal final energy	Source
Comprehensive/predominant use of water/energy-saving taps		Centr. DWH, circulation	2 to 6% [a]	Example calculations in this short study: Detached house in three different thermal insulation levels and example configurations of technical installations and equipment
		Dec. elec. DWH	Up to 12% [a]	
Heating control	Flow temperature reduction/heating curve optimisation of heat pumps	Low	4%	Own assessment based on external sources of the impact of design temperature on the seasonal energy efficiency ratio (measurements/field tests in Switzerland [9] and Germany [10])
		High	12%	
	Flow temperature reduction/heating curve optimisation otherwise		1 to 4%	Unpublished study [11] partially by reference to other (primary) sources [12, 13, 14, 15, 16, 17, 18] and with project-specific assumptions/estimates (including by ITG)
	Night setback/shutdown		3 to 10%	
	Summer shutdown		0 to 4%	
Hydraulic balancing			4 to (15)% [b]	
Subsequent insulation of heating and hot water distribution pipes			2 to 5%	
Significant improvement in thermal insulation of buildings Example reduction of H'_T from the reference building value according to GEG to 70% of the reference building value			25%	Example value taken from the BDEW heating costs comparison for *new builds 2021* [19]: detached house with gas condensing boiler, solar heating of domestic water and a supply/exhaust system with heat recovery
Solar heating of domestic water			6 to 26% [a]	Variation of this example calculation: calculation of the potential savings in terms of final energy on the hot water side based on the *existing* model building (4.1.2) with 7 m² solar collector area; estimated transfer to other model buildings

a The percentage savings were determined based on the total primary energy demand (see 4.2.2). Assuming that the same energy source is used for heating and domestic water heating, the savings can be transferred approximately to the total final energy demand.

b Measure includes some savings effects from peripheral measures (in particular new thermostat valves and flow temperature reduction)

Comparing them with these isolated energy-saving measures illustrates that the total savings calculated here based on using water/energy-saving taps equate to between 2 and 12%, which are significant numbers. By definition, the savings correlate inversely with the heating demand – as the thermal insulation of buildings improves, energy-saving measures on the hot water side become more important.

5.3 Conceptual considerations on application in terms of standards and energy-saving legislation

5.3.1 Background/problem

Part 8 of DIN V 18599, Section 6.4.9 already contains a calculation approach for reducing the net energy demand for heating domestic water compared to the default value. This approach could be used to represent the net energy saving analysed here.

However, so far it is proving difficult to apply the approach outlined above in practice:

- Users find it hard to understand the required input variable (maximum available hot water flow rate at the domestic water heater). There is a lack of any default or recommended values and assigned categories or written descriptions that would allow an association to be made between numerical values and equipment levels or technical features.
- Until now the approach has only been permitted for use in non-legal consulting services as intended by the standard, not in calculations pertaining to GEG certifications (energy performance certificates) and funding derived therefrom.
- The standard does intend for the approach to be used in non-legal consulting services; however, it is not necessarily implemented in the calculation software used. This lack of implementation could be due, at least partly, to the fact that there has so far been

little demand for this input option, given that the approach cannot be applied in certification cases.

5.3.2 Possible solution(s)

The following steps would be appropriate to take the example options for saving hot water analysed here into account based on the approach already described in the standard:

- **Update content of the standard**

  In particular, the approach according to Section 6.4.9 DIN V 18599-8 must be supplemented with default or recommended values, which link the numerical value to technical features by means of written selection options, e.g.

  - "No water-saving measures"
  - "Comprehensive use of flow-rate-limiting shower fittings, lavatory taps and kitchen taps"[20]
  - Other interim level(s), where applicable
  - Differentiation by building/usage types, where application

  Appendix 2 broadly explains these thoughts and provides suggested text for updating the standard.

- **Applicability in terms of energy-saving legislation**

  Discussions must be held with legislators and in the standards committee to decide whether the existing restriction that limits the approach to non-legal energy consulting services can be withdrawn.

  Below are just some of the reasons why it would make sense to apply the approach to certification:

  - In the face of pressing environmental issues and environmental policy targets, and with a view to ensuring a secure energy supply for the long term, energy sufficiency needs to be incorporated into energy analyses, or incorporated to a greater extent than previously (in addition to technical efficiency). In the context of evaluating buildings in terms of energy-saving legislation, aspects of usage behaviour could be taken into account more.
  - People who use the standard or the software that implements the standard directly (e.g. energy consultants) and users of buildings are made more aware of the energy-related impact of their usage behaviour if this can be represented on the certificate.

    An appropriate compromise needs to be found between representing the impacts of usage to a suitable degree and not building an (excessively) high potential for abuse into the evaluation process through any options for improving the look of the figures.
  - Representing energy-efficient technical features on energy certificates will likely create incentives for further development in this area.

  Consideration should also be given to removing what is now an obsolete reference to the old DIN V 4108-6/4701-10 standards duo and the related definition of the net

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[20] With additional comments to clearly describe the water-saving features, where applicable

energy demand value 12.5 kWh/m²a. Since the term stated in the regulation has already elapsed – that is, the regulation is no longer valid – this would be a purely editorial update.

Sources and further reading

[1] *GEG 2023 | Gesetz zur Einsparung von Energie und zur Nutzung erneuerbarer Energien zur Wärme- und Kälteerzeugung in Gebäuden (Gebäudeenergiegesetz - GEG) | [vom 8.8.20 (BGBl. I S. 1728), zuletzt geändert durch Art 18a G v. 20.7.2022 (BGBl. I S. 1237)],* 01.01.2023 (Inkrafttreten).

[2] GEG 2024 Gesetz zur Änderung des Gebäudeenergiegesetzes [und weiterer]; Vom 16. Oktober 2023; Veröffentlicht im Bundesgesetzblatt Jahrgang 2023 Teil I Nr. 280 vom 19.10.2023, 10/2023.

[3] DIN Deutsches Institut für Normung e.V., *DIN V 18599:2018-09 Energetische Bewertung von Gebäuden -- Berechnung des Nutz-, End- und Primärenergiebedarfs für Heizung, Kühlung, Lüftung, Trinkwasser und Beleuchtung -- Teile 1 bis 11,* 09/2018.

[4] *EnEV 2014: Verordnung über energiesparenden Wärmeschutz und energiesparende Anlagentechnik bei Gebäuden (...) vom 27. Juli 2007 (...), zuletzt geändert durch Artikel 1 der Verordnung vom 18. November 2013 (BGBl. I S. 3951).*

[5] DIN Deutsches Institut für Normung e.V., DIN EN 817:2008-09 | Sanitärarmaturen - Mechanisch einstellbare Mischer (PN 10) - Allgemeine technische Spezifikation; Deutsche Fassung EN 817:2008, 09/2008.

[6] BDEW Bundesverband der Energie- und Wasserwirtschaft e.V., [Grafik] Trinkwasserverwendung im Haushalt, Aktuelle Version (2022): https://www.bdew.de/service/daten-und-grafiken/trinkwasserverwendung-im-haushalt/, 2014.

[7] Mauro Cordella, Elena Garbarino, Maria Calero, Fabrice Mathieux, Oliver Wolf, JRC SCIENCE AND POLICY REPORTS MEErP Preparatory Study on Taps and Showers; Final Report EUR 26939 EN, 2014.

[8] Aquaterra for Environmental Agency UK, Water and the environment | International comparison of domestic per capita consumption, 12/2008.

[9] Stefan Bertsch, Matthias Berthold, Manuel Prinzig, Michael Eschmann, *[ONLINEARTIKEL] Wie gut sind aktuelle Wärmepumpen im Feld?,* Bei Seitenaufruf 01/2023 verfügbar unter: https://www.gebaeudetechnik.ch/branche/marktnews/wie-gut-sind-aktuelle-waermepumpen-im-feld/, 01/2021.

[10] Marek Miara, *[PRÄSENTATIONSFOLIEN] Wärmepumpen in der Praxis (+Best-Practice); 2. Netzwerktagung Klimaneutrales Bauen & Sanieren,* Berlin, 09/2022.

[11] DENA Deutsche Energieagentur, ITG Institut für Technische Gebäudeausrüstung Dresden, Guidehouse, ifeu, Becker Büttner Held, Öko-Institut e.V. u.a. im Auftrag des BMWK, *[NICHT VERÖFFENTLICHTE STUDIE] Analyse und Ausarbeitung von Handlungsempfehlungen zur Optimierung des energieeffizienten und klimaschonenden Betriebs von Heizungen; Arbeitstitel: Heizsparcheck; Gesamtbericht,* Dresden, Berlin, Müchen, Heidelberg, 2022.

[12] ITG Institut für Technische Gebäudeausrüstung Dresden GmbH im Auftrag des BDH Bundesverband der Deutschen Heizungsindustrie, Kurzstudie Energieeinsparung Digitale Heizung, 01/2017.

[13] Ecofys, Waide, “Optimising the energy use of technical building systems,” 2017.

[14] ITG Dresden, „Energetische Einsparpotentiale und wirtschaftliche Bewertung des hydraulischen Abgleiches für Anlagen der Gebäudeenergietechnik,“ 2019.

[15] IWU, „Berücksichtigung des Nutzerverhaltens bei energetischen Verbesserungen,“ BBSR, Bonn, 2019.

[16] Ostfalia, „Effizienz und Erneuerbare Energien: Akzeptanz- und Motivationskampagne - Hydraulischer Abgleich,“ 2014.

[17] B. Scheithauer, “Mein Energiesparkorridor - Das Einsparpotential,” 2022. [Online]. Available: https://www.hydraulischer-abgleich.de/wissensbox/energie-sparen/einsparpotential/.

[18] P. D. D. Müller, „Alarmstufe Notfallplan Gas – Wie lässt sich im kommenden Winter Erdgas sparen?,“ 24 06 2022. [Online]. Available: https://www.sciencemediacenter.de/alle-angebote/rapid-reaction/details/news/alarmstufe-notfallplan-gas-wie-laesst-sich-im-kommenden-winter-erdgas-sparen/ .

[19] ITG Institut für Technische Gebäudeausrüstung Dresden GmbH im Auftrag des BDEW, *BDEW-Heizkostenvergleich Neubau 2021,* 04/2021.

[20] *EnEV 2009: Verordnung zur Änderung der Energieeinsparverordnung vom 29. April 2009,* 2009.

[21] Ecofys Germany GmbH, co2online gGmbH und ista SE im Auftrag des BBSR/BBR, BBSR-Online-Publikation Nr. 17/2017 | Nutzenergiebedarf für Warmwasser in Wohngebäuden, Bonn, 09/2017.

Appendix

Appendix 1 Calculation results

Table 13 Calculation results for analysis variants according to 4.1.2

Calculation variant		Final energy HI [kWh/a]				Primary energy [kWh/a]				Greenhouse gas [kg/a]			
Model building	Net energy demand for domestic water	Heating		Domestic water heating		Heating		Domestic water heating		Heating		Domestic water heating	
		Heat	Auxiliary energy	Heat	Auxiliary energy	Heat	Auxiliary energy	Heat	Auxiliary energy	Heat	Auxiliary energy	Heat	Auxiliary energy
Existing building, gas condensing boiler	a Default value	30,554	531	4,958	131	33,610	957	5,454	235	7,333	298	1,190	73
	b DWH -30%	30,581	558	4,276	129	33,639	1,004	4,704	233	7,340	312	1,026	72
	c DWH -40%	30,599	558	4,061	126	33,658	1,004	4,467	227	7,344	312	975	71
Reference thermal insulation, district heating	a Default value	17,427	167	5,149	55	12,199	301	3,604	98	3,137	94	927	31
	b DWH -30%	17,458	168	4,433	55	12,221	302	3,103	99	3,142	94	798	31
	c DWH -40%	17,468	168	4,194	56	12,228	302	2,936	100	3,144	94	755	31
EH 40 thermal insulation, heat pump	a Default value	4,123	119	2,197	90	7,422	214	3,955	162	2,309	67	1,230	51
	b DWH -30%	4,160	119	1,892	82	7,487	214	3,405	147	2,329	67	1,059	46
	c DWH -40%	4,172	119	1,789	79	7,509	215	3,221	142	2,336	67	1,002	44

Table 14 Calculation results for additional analysis variants with electric continuous flow heaters (page 25)

Calculation variant		Final energy HI [kWh/a]				Primary energy [kWh/a]				Greenhouse gas [kg/a]			
Model building	Net energy demand for domestic water	Heating		Domestic water heating		Heating		Domestic water heating		Heating		Domestic water heating	
		Heat	Auxiliary energy	Heat	Auxiliary energy	Heat	Auxiliary energy	Heat	Auxiliary energy	Heat	Auxiliary energy	Heat	Auxiliary energy
EH 40 thermal insulation, heat pump, dec. el. DWH	a Default value	4,794	131	2,161	0	8,629	236	3,889	0	2,685	73	1,210	0
	b DWH -30%	4,794	131	1,531	0	8,629	236	2,756	0	2,685	73	857	0
	c DWH -40%	4,794	131	1,320	0	8,629	236	2,376	0	2,685	73	739	0

Appendix 2 Example of suggested text for Section 6.4.9 DIN V/TS 18599-8

The conceptual suggestions for updating the standard that were drafted previously are presented below as examples of suggested text for the standard. The text of the 2018-09 version of the standard is used as a basis – to make the amendments clear, the original text (Figure 10, dark blue text) is given immediately before the suggested text (Figure 11 (over several pages), dark red text).

The calculation approach presented here corresponds to the procedure in the *2018-09* version of the standard in terms of content, although it is written with variable symbols (rather than fixed numerical values) for key influencing variables so that

- they can be explained using entries in a legend as per the standard's usual format and
- case-specific values can be assigned to them, where applicable (see also *Table X* and *XX* in the suggested text).

The suggested text gives a broad outline of the amendments that have been considered; however, further deliberations will need to be made and details fleshed out as appropriate to produce the final wording for inclusion in the standard, in particular:

- Research/market analysis into whether or to what extent the existing default values in the standard for the hot water net energy demand have already been influenced by water-saving measures (modification of the parameters given below, where applicable)

- Specification of whether only the default values in the standard or also individual values/product characteristics can be used for the hot water flow rate (suggested text recommends differentiating between a certification case and free calculations)
- Clarification of the reference for the maximum available hot water flow rate $\dot{V}_{\mathrm{max(,ref)}}$
    - e.g. "per draw-off point"
    - Specification of the corresponding temperature level
- Optional:
    - Identical characteristics for non-residential buildings (see Table X below)
    - Interim level(s) of the flow rate default value (see Table XX below)
- Consequential amendments, where applicable

The numerical values contained in the suggested text are based on the example savings potentials calculated for different draw-off scenarios in Section 3.3. They must be interpreted as an initial suggestion subject to any further research into the characteristics in the standard and/or their updating. They equate to a relative reduction in the hot water net energy demand as follows:

- 0% with no measures
- Approx. 30% with comprehensive water-saving measures in detached houses
- Approx. 37% with comprehensive water-saving measures in buildings with multiple residential units

The different characteristics for detached houses and buildings with multiple residential units are based on the assumption that there tends to be a lower expectation of comfort in buildings with multiple residential units (higher proportion of showers with somewhat less frequent usage of the maximum flow rate, although the energy-related impact of the higher proportion of showers (≙ energy saving) prevails).

6.4.9 Domestic hot water systems with design-related flow rate limitation

The net energy demand for hot water may only be modified in the context of an energy consultation. The modification of the net energy demand for hot water specified below is not permitted for producing certificates under public law.

In the case of a design-related hot water flow rate limitation due to a limited power output, the net energy demand for hot water must be corrected as follows[2]:

$$Q_{\mathrm{w,b,red}} = 0{,}5 * \frac{\dot{V}_{\mathrm{max}}}{12\ [\mathrm{l/min}]} * Q_{\mathrm{w,b}} + (1 - 0{,}5) * Q_{\mathrm{w,b}} \quad (97)$$

Where

$Q_{\mathrm{w,b,red}}$	is the corrected net energy demand for domestic hot water (for a month), in kWh;
$Q_{\mathrm{w,b}}$	is the net energy demand for domestic hot water (for a month), in kWh;
$\dot{V}_{\mathrm{max}}$	is the maximum available flow rate, in l/min (product characteristic).

[…]

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[2] The value 0.5 is based on a 65% proportion of showers relative to the total hot water demand and on the assumption that 75% of showers use the maximum flow rate

Figure 10 **Section 6.4.9 DIN V 18599-8:2018-09 [3]**

6.4.9 Domestic hot water systems with design-related flow rate limitation

In the case of a design-related hot water flow rate limitation effective during draw-offs that are usually dominated by the duration of the draw-off (showers, hand washing, etc.), the default value for the net energy demand for heating domestic water can be corrected using the following calculation approach.

The approach models, in simplified form, a limitation of the available hot water flow rate with the tap fittings fully open as far as they will go/until resistance is met compared to a reference value. It can also be applied approximately to

- other power limitations relating to domestic water heating and/or
- flow resistances that influence the flow across the taps' entire range

provided that at least an equivalent effect has been calculated for these aspects.

If a reduction in the hot water net energy demand according to this section must be applied in a certification case, it is recommended to only use default values as per Tables X and XX. These represent normal conditions, averaged over a complete hot water supply area – i.e. no distinction is made between the different draw-off points/tap types (e.g. shower fittings, bath tub taps, lavatory taps and kitchen taps) in a supply area.

If required (free calculation in the context of an energy consultation or similar), the approach can be used with parameters calculated for a specific project. An analysis differentiated by tap type (index ZA) is possible here too.

$$Q_{\mathrm{w,b,red}} = \textstyle\sum_{\mathrm{ZA}} \left\langle f_{\mathrm{w,b,red},\dot{\mathrm{V}},\mathrm{ZA}} \right\rangle * Q_{\mathrm{w,b}} \qquad (97)$$

$$f_{\mathrm{w,b,red},\dot{\mathrm{V}},\mathrm{ZA}} = a_{\dot{\mathrm{V}}_{\mathrm{max,ZA}}} * \frac{\dot{V}_{\mathrm{max,ZA}}}{\dot{V}_{\mathrm{max,ref}}} + \left(1 - a_{\dot{\mathrm{V}}_{\mathrm{max,ZA}}}\right) \qquad (98)$$

$$a_{\dot{\mathrm{V}}_{\mathrm{max,ZA}}} = a_{\dot{\mathrm{V}}_{\mathrm{max}},1,\mathrm{ZA}} * a_{\dot{\mathrm{V}}_{\mathrm{max}},2,\mathrm{ZA}} \qquad (99)$$

Where

$Q_{\mathrm{w,b,red}}$	is the (reduced) net energy demand for domestic hot water taking a design-related flow rate limitation into account (for a month), in kWh;
$f_{\mathrm{w,b,red},\dot{\mathrm{V}},\mathrm{ZA}}$	is the relative reduction in the net energy demand for domestic hot water due to a design-related flow rate limitation for average conditions in the hot water supply area or (project-) specifically for each tap type (index ZA);
$a_{\dot{\mathrm{V}}_{\mathrm{max,ZA}}}$	is the proportion of the net energy demand (related to the value without limitation) in which a design-related flow rate limitation can take effect, for average conditions in the hot water supply area or (project-)specifically for each tap type (index ZA);
$a_{\dot{\mathrm{V}}_{\mathrm{max}},1,\mathrm{ZA}}$	is the proportion of the net energy demand (related to the value without limitation) for draw-off scenarios where it is not the amount of water (absolute draw-off volume or flow rate) that is key, but only the draw-off duration (e.g. showers or hand washing, not filling a bath tub or sink), according to Table X or on a project-specific basis;
$a_{\dot{\mathrm{V}}_{\mathrm{max}},2,\mathrm{ZA}}$	is the proportion of $a_{\dot{\mathrm{V}}_{\mathrm{max}},1}$ in which hot water is drawn at the maximum available flow rate (tap fitting open as far as it will go/until resistance is met) according to Table X or on a project-specific basis;
$Q_{\mathrm{w,b}}$	is the default value for the net energy demand for domestic hot water without design-related flow rate limitation (for a month), in kWh;

$\dot{V}_{\mathrm{max,ZA}}$ is the maximum available hot water flow rate according to Table XX for average conditions in the hot water supply area or (project-) specifically for each tap type (index ZA), in l/min;

$\dot{V}_{\mathrm{max,ref}}$ is the reference value for the maximum available hot water flow rate according to Table XX, in l/min.

Table X — Default values for the draw-off proportions of the net energy demand

Type of building/usage	Draw-off proportion dominated by duration of draw-off [a] $a_{\dot{V}_{\mathrm{max}},1}$	Proportion of $a_{\dot{V}_{\mathrm{max}},1}$ at maximum flow rate [a] $a_{\dot{V}_{\mathrm{max}},2}$
Detached house	0.65	0.80
Building with multiple residential units	0.80	0.75
etc.	etc.	etc.

a The specified characteristics represent standard averaged conditions throughout the complete hot water supply area.

Table XX — Default values and reference value for the maximum available hot water flow rate

Design-related flow rate limitation	Maximum available hot water flow rate [a] $\dot{V}_{\mathrm{max}}$ [l/min]
No flow rate limitation	12
etc.	etc.
Only/predominantly water-saving shower fittings, lavatory taps and kitchen taps	5
Reference value $\dot{V}_{\mathrm{max,ref}}$	12

a The specified characteristics represent standard averaged conditions throughout the complete hot water supply area.

Figure 11 Suggested text for updating Section 6.4.9

As an alternative to the procedure in Section 6.4.9 DIN V 18599-8, the contents provided regarding flow rate limitation could be incorporated in full into the related Section 6.1 (see *Impact of* controlling the draw-off temperature); Section 6.4.9 would then be obsolete and should be removed.