Bundesanstalt für Materialforschung und -prüfung

Test guideline for dynamic performance testing and calculation of the seasonal coefficient of performance

Heat pumps with electrically driven compressors for space heating

BAM, S.4 Ecodesign and energy labelling

Bundesanstalt für Materialforschung und -prüfung

Contents

1. Scope

This test guideline describes a test method for determining the seasonal performance (SCOP, η_s) of heat pumps with electrically driven compressors as an alternative to EN 14825:2018.

2. Normative references

The methodology for the dynamic testing of heat pumps described in this test guideline is based on assumptions and correlations which can also be found in the current European standards EN14825 and EN14511. Assumptions that are used in these standards are explicitly mentioned in this test guideline.

3. Procedure for the dynamic testing

The procedure of dynamic testing is divided into the steps shown in Figure 1.

3.1.1 Pre-test at T_{biv} and creation of the target heating characteristics

The pre-test at T_{biv} to verify performance P_{biv} should also be used for the preparation steps of the main test described in section 5. If$T_{biv} = T_{design}$, the test described in section 6.2.2 is omitted for T_{design} and the main test on the temperature profile is carried out directly after the pre-test at T_{biv}.

3.1.2 Test at T_{design}

According to the heating characteristics determined according to the procedure described in section 5, a test is carried out at the outdoor temperature T_{design} and the correlating specifications for the sink parameters. The duration of this measurement is two hours.

3.1.3 Temperature Profile

Im Anschluss an die Prüfung bei T_{design} bzw. $T_{biv} = T_{design}$ wird unmittelbar die Prüfung des Temperaturprofils mit den in Abschnitt 3.1 für den Heizfall vorgegebenen Zeiten für jede Temperatursequenz durchgeführt.

3.1.4 Test methods for electric power input during thermostat-off mode, standby mode, crankcase heater mode and off mode

The test methods for electric power input during thermostat-off mode, standby mode, crankcase heater mode and off mode are performed according to the test methods described in EN 14825:2018.

3.1.5 Calculation of the seasonal space heating energy efficiency

By taking into account the BIN weighting of each individual sequence and any subtractions resulting from deviations from the target value (target heating capacity and target supply temperature), the seasonal space heating energy efficiency is calculated as described in Section 7.

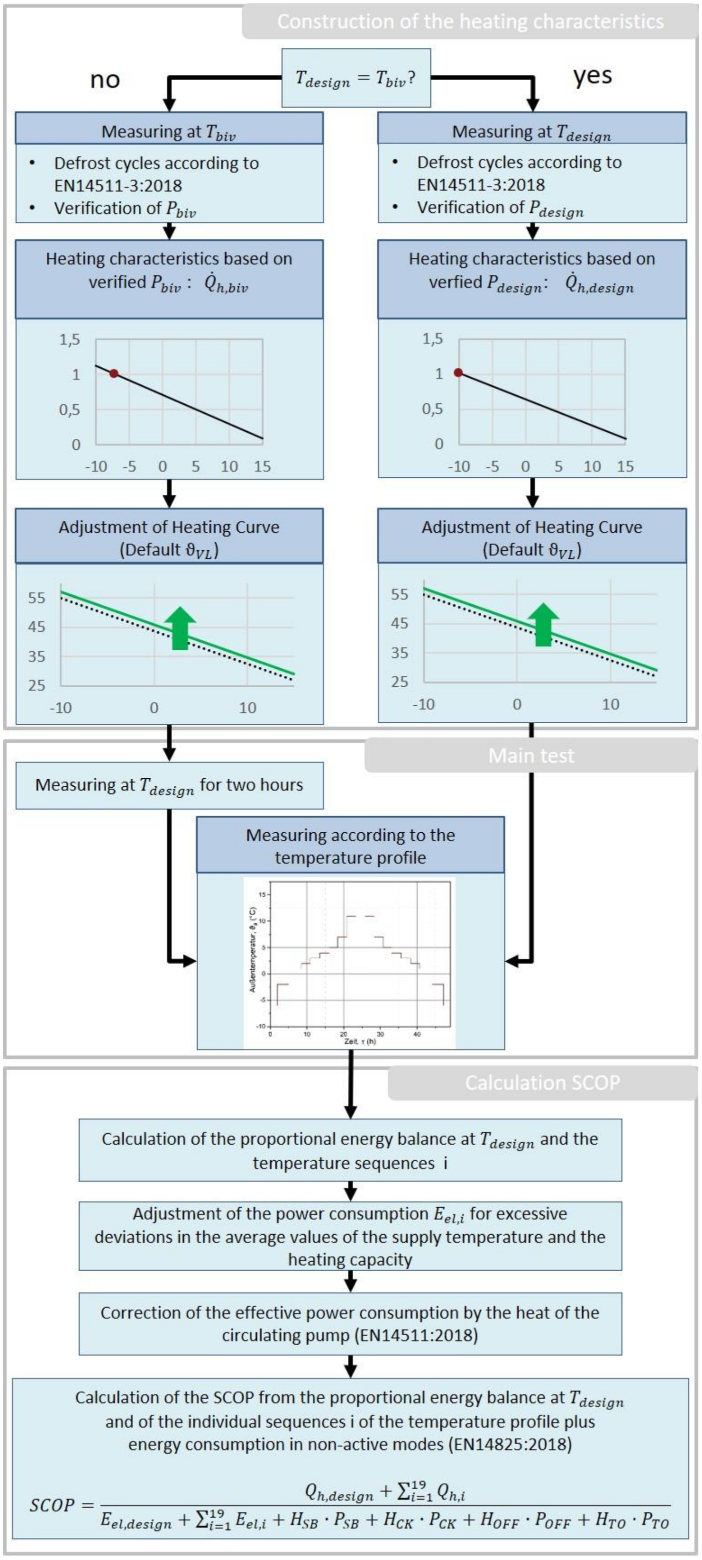

Figure 1: Procedure for the dynamic testing of heat pumps.

4. Basic principle and general conditions of dynamic testing

The dynamic method is based on the requirement that the test specimen has to cover specified building loads and temperatures under various outdoor conditions. The building loads are applied on the test bench to the test specimen by a compensation load. These loads, as well as the test conditions on the source side, are provided by the test bench's conditioning apparatus. The control system of the test specimen is active at all time during the test. By using this test methodology, there is no complete decoupling of compensation load and delivered heat or cooling output. This test guideline describes the necessary general test conditions needed to minimise the interactions and to ensure reproducibility of the results on different test benches.

4.1 Target outdoor temperature profile and correlation between source and sink side

The temperature range and the temperatures used in the dynamic test are based on the temperature distribution of the average reference heating period from Annex B of EN 14825:2018. The shares of the seasonal heating demand of individual temperatures were grouped into bins, represented by the outdoor temperature profile. The dynamic test, based on the reference building model according to Chapter 6 of EN 14825:2018, also includes the building loads correlating with the outdoor temperature and the requirements for sink temperatures. Figure 2 shows the outdoor temperature profile to be taken during the test in heating mode. During the test, consecutive compensation measurements are performed by applying various compensation loads at different outdoor temperatures. At each outdoor temperature, the target values for the compensation load and the sink temperature change according to the reference building model specified in Chapter 6 of EN 14825:2018. Table 1 summarizes the outdoor temperature with correlating heating load (part load ratio).

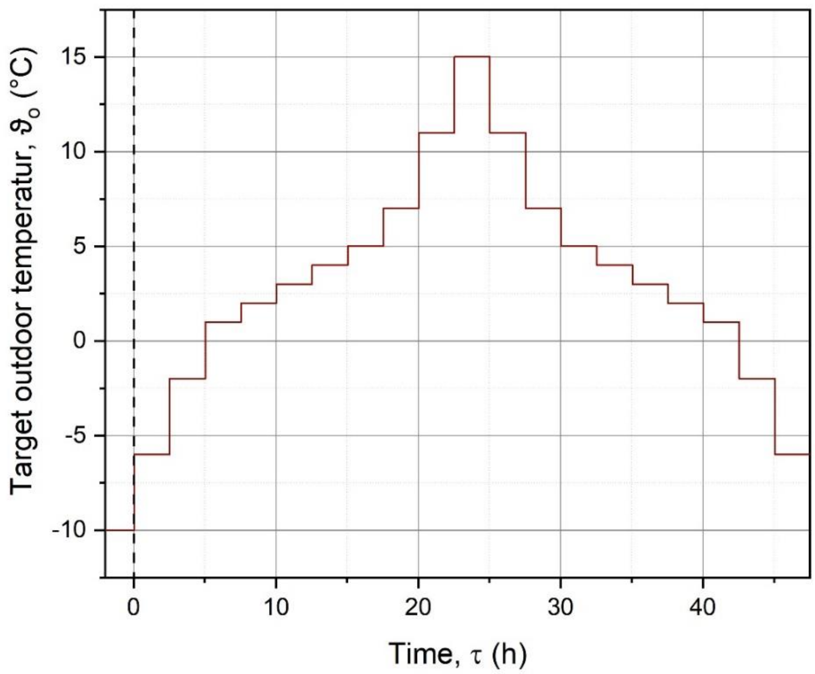

Figure 2: Outdoor temperature profile during the dynamic test for the heat pumps.

Table 1: Length of the individual temperature sequences and correlation between outdoor temperature and heating capacity.

Number i of sequence (-)	Length of sequence (min)	Cumulative test time (h)	Outdoor temperature ϑ_o (°C)	Part load ratio PLR with regard to nominal power (%)	Supply temperature ϑ_s (°C) (High temperature application)	Supply temperature ϑ_s (°C) (Low temperature application)
0	150,00	-	-10	$\frac{-10-16}{(T_{biv}-16)} \cdot \frac{\dot{Q}_{h,biv}}{\dot{Q}_{design}}$	55,00	35,00
1	150,00	2,50	-7	$\frac{-7-16}{(T_{biv}-16)} \cdot \frac{\dot{Q}_{h,biv}}{\dot{Q}_{design}}$	52,00	34,00
2	150,00	5,00	-3	$\frac{-3-16}{(T_{biv}-16)} \cdot \frac{\dot{Q}_{h,biv}}{\dot{Q}_{design}}$	47,00	31,50
3	150,00	7,50	1	$\frac{1-16}{(T_{biv}-16)} \cdot \frac{\dot{Q}_{h,biv}}{\dot{Q}_{design}}$	43,00	29,50
4	150,00	10,00	2	$\frac{2-16}{(T_{biv}-16)} \cdot \frac{\dot{Q}_{h,biv}}{\dot{Q}_{design}}$	42,00	29,00
5	150,00	12,50	3	$\frac{3-16}{(T_{biv}-16)} \cdot \frac{\dot{Q}_{h,biv}}{\dot{Q}_{design}}$	40,00	28,50
6	150,00	15,00	4	$\frac{4-16}{(T_{biv}-16)} \cdot \frac{\dot{Q}_{h,biv}}{\dot{Q}_{design}}$	39,00	28,00
7	150,00	17,50	5	$\frac{5-16}{(T_{biv}-16)} \cdot \frac{\dot{Q}_{h,biv}}{\dot{Q}_{design}}$	38,00	27,50
8	150,00	20,00	7	$\frac{7-16}{(T_{biv}-16)} \cdot \frac{\dot{Q}_{h,biv}}{\dot{Q}_{design}}$	36,00	26,50
9	150,00	22,50	12	$\frac{12-16}{(T_{biv}-16)} \cdot \frac{\dot{Q}_{h,biv}}{\dot{Q}_{design}}$	30,00	24,00
10	150,00	25,00	15	$\frac{15-16}{(T_{biv}-16)} \cdot \frac{\dot{Q}_{h,biv}}{\dot{Q}_{design}}$	27,00	22,50
11	150,00	27,50	12	$\frac{12-16}{(T_{biv}-16)} \cdot \frac{\dot{Q}_{h,biv}}{\dot{Q}_{design}}$	30,00	24,00
12	150,00	30,00	7	$\frac{7-16}{(T_{biv}-16)} \cdot \frac{\dot{Q}_{h,biv}}{\dot{Q}_{design}}$	36,00	26,50
13	150,00	32,50	5	$\frac{5-16}{(T_{biv}-16)} \cdot \frac{\dot{Q}_{h,biv}}{\dot{Q}_{design}}$	38,00	27,50
14	150,00	35,00	4	$\frac{4-16}{(T_{biv}-16)} \cdot \frac{\dot{Q}_{h,biv}}{\dot{Q}_{design}}$	39,00	28,00

15	150,00	37,50	3	$\frac{3-16}{(T_{biv}-16)}\cdot\frac{\dot{Q}_{h,biv}}{\dot{Q}_{design}}$	40,00	28,50
16	150,00	40,00	2	$\frac{2-16}{(T_{biv}-16)}\cdot\frac{\dot{Q}_{h,biv}}{\dot{Q}_{design}}$	42,00	29,00
17	150,00	42,50	1	$\frac{1-16}{(T_{biv}-16)}\cdot\frac{\dot{Q}_{h,biv}}{\dot{Q}_{design}}$	43,00	29,50
18	150,00	45,00	-3	$\frac{-3-16}{(T_{biv}-16)}\cdot\frac{\dot{Q}_{h,biv}}{\dot{Q}_{design}}$	47,00	31,50
19	150,00	47,50	-6	$\frac{-7-16}{(T_{biv}-16)}\cdot\frac{\dot{Q}_{h,biv}}{\dot{Q}_{design}}$	52,00	34,00

4.2 Permissible deviations

Temperatures are subjected to permissible deviations if provided by the test bench (e.g. inlet temperature on the source side). However, they are not subjected to permissible deviations if they are provided by the heat pump (e.g. HP outlet temperature on the heat sink side).

4.2.1 Permissible deviations from target values on the source side

If no defrost cycles occur or the heat pump is not in standby mode, the permissible deviations listed in Table 2 apply to the test bench side. Defrost cycles are defined according to the criteria defined in EN14511. In any case, the test bench must ensure that the deviations listed in Table 2 for the parameters at the heat pump inlet are not exceeded. The measurement data should be recorded at least every 10 seconds.

Table 2: Permissible deviations from the test bench-dependent target values *(HP-Inlet on the source side)*

Measurand	Permissible deviation of the arithmetic mean values from target values of sequence i	Permissible deviations of the individual measured values from the target values of sequence i
Liquid Inlet		
Temperature	± 0,2K	± 0,5K
Air Inlet		
Temperature (dry bulb)	± 0,3K	± 1K
Temperature (wet bulb)	± 0,4K	± 1K

4.2.2 Permissible deviations on the heat sink side (to be verified by round robin test!)

The return flow temperature influences the heat output of the heat pump and should hence remain within a defined fluctuation range. We differentiate between test benches with and without intermediate circuit (see section 5). For test benches without intermediate circuit, the return flow temperature must be within the permissible deviations of the individual measured values of sequence i as described in Table 3. For test benches with intermediate circuit, the cooling temperature (see Section 6.7) shall be within the permissible deviations of the individual measured values of sequence i as described in Table 3.

Tabelle 3: Permissible deviations *(HP-Inlet on the heat sink side)*

Measurand	Permissible deviations of the individual measured values of sequence i
Liquid Inlet Temperature	± 1K

4.2.3 Quality of heat pump sensors

Table 4 shows the permissible deviations between the temperatures measured by the heat pump and the reference temperatures of the test bench.

Table 4: Permissible deviations between the test bench reference temperatures and those measured by the heat pump.

Measurand	Permissible deviation of the arithmetic mean values from target values of sequence i
Liquid Inlet Temperature	± 0,5K
Air Inlet Temperature	± 0,5K

4.2.4 Maximum acceptable deviation of indoor temperature

The supply temperature at the heat pump outlet and the heating output are primarily dependent on the control quality of the control unit under test. Table 5 shows the permissible deviations for the supply temperature and for the heating output. If these are exceeded or undercut, the measured value of the electric energy consumption of sequence i is adjusted in accordance to the procedure explained in section 7.3.

Table 5: Permissible deviations from the target supply temperature (HP outlet) and the target heating output.

Measurand	Permissible deviation of the arithmetic mean values from target values of sequence i
Temperature	± 2K
Heating output	± 5 %

5. Test setup

5.1 Brine- and water/water

Brine and water/water heat pumps are measured on the sink and source side using the enthalpy method in accordance with EN 14511-3:2018, either with or without an intermediate circuit (Figure 3a and b).

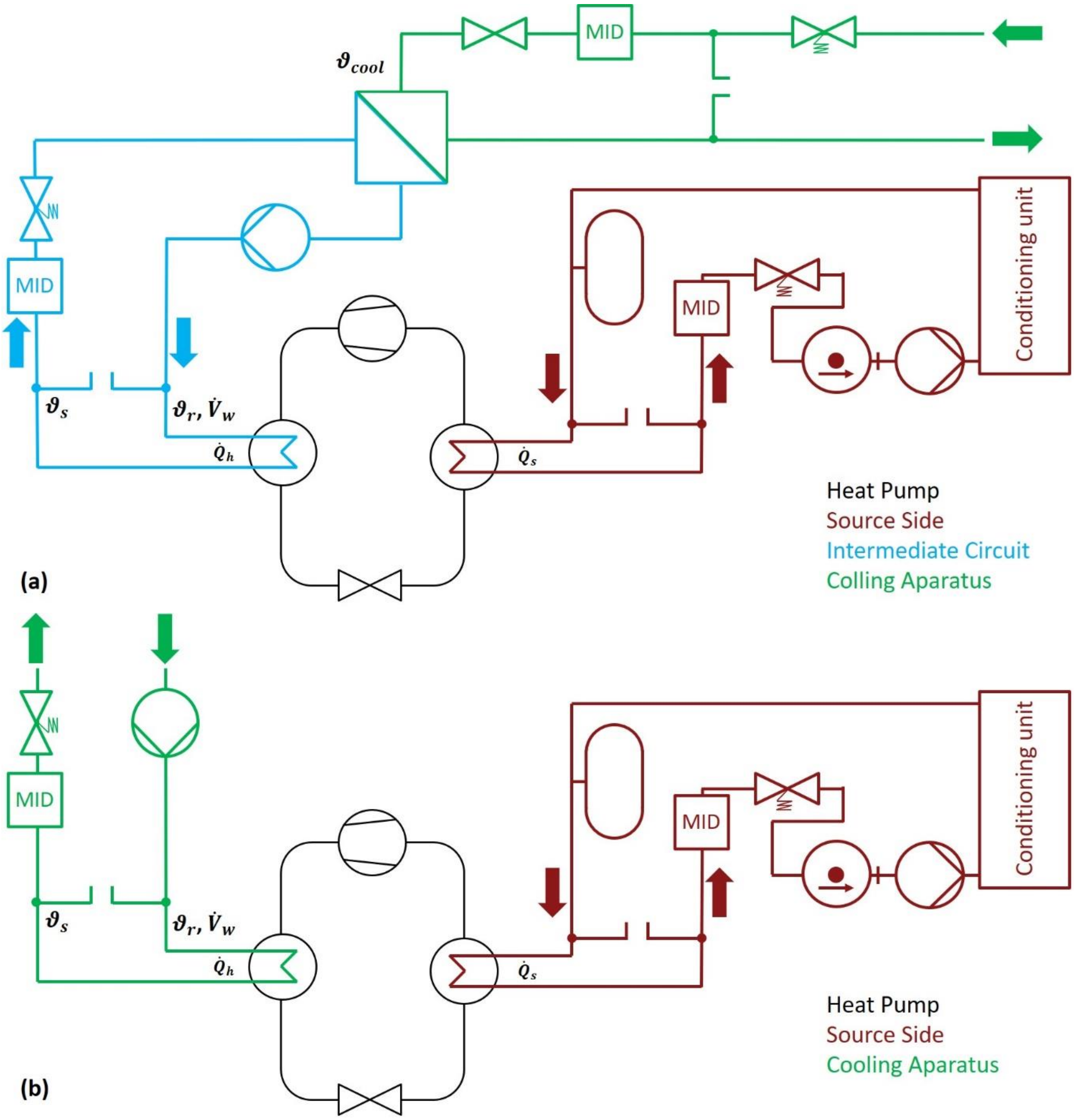

Figure 3: Test setup for testing brine and water/water heat pumps with (a) and without (b) an intermediate circuit.

5.2 Air/water

Air/water heat pumps are measured on the sink side using the water enthalpy method according to EN 14511-3:2018, either with or without an intermediate circuit (Figure 4a and b).

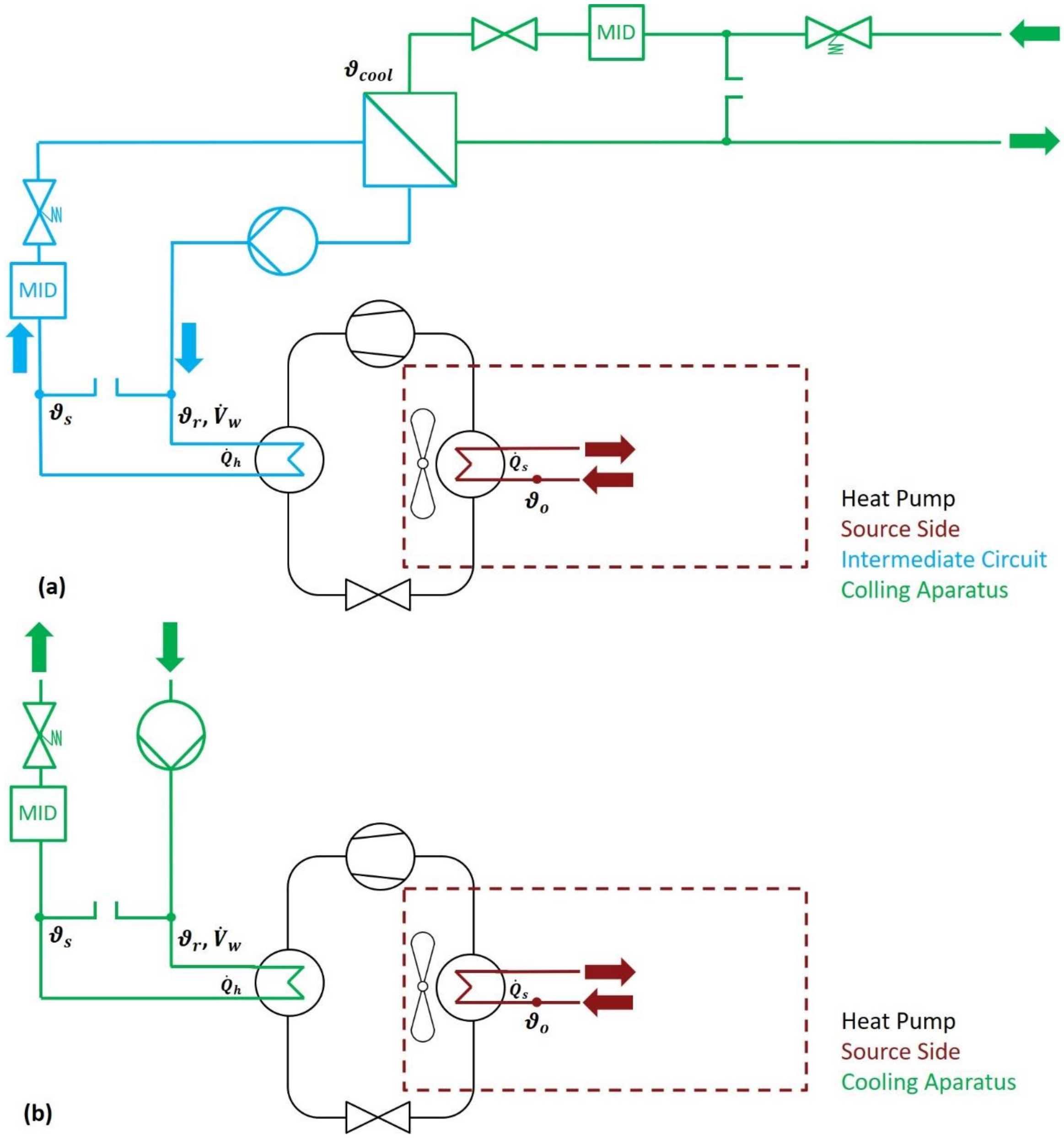

Figure 4: Test setup for testing air/water heat pumps with (a) and without (b) an intermediate circuit.

6. Test preparation and test procedure

Depending on the design of the test specimen, specific preparations have to be made prior to the measurement.

In order to ensure a comparable test, the correct adjustment of the controller of the heat pump must be verified in advance. This can be done during verification of the manufacturer's data at the bivalence point (see section 3). In order to enable reproducible measurements, at least the parameters the following preparations have to be made before starting the actual test and measurements:

- Basic settings on the heat pump (section 6.1)
- Selection of temperature level (section 6.2)
- Consideration of electrical supplementary heater (section 6.3)
- Methods for setting the outdoor temperature (section 6.4)
- Creating of the heating characteristic (section 6.5)
- Adjustment of the heating characteristic if necessary (section 6.6)
- Further settings (section 6.7)

6.1 Basic settings

Generally the heat pumps shall be tested in the settings in which they are delivered by the manufacturer or available on the market (factory settings). Exceptional settings to be modified are those listed in this section. Instructions for setting up on the test bench and on the heat pump controller are given in Annex A.

6.2 Selection of temperature level

For some heat pumps the temperature level of the heat sink has to be defined. The application temperature levels known from EN 14511/14825 (low, intermediate, medium, high) have to be specified here. If possible, these specifications should be set on the heat pump.

6.3 Consideration of electrical supplementary heater

The supplementary electrical heater in the heat sink circuit (if present) is not deactivated, allowing the unit to be switched on at temperatures below the bivalence temperature.

6.4 Methods for setting the outdoor temperature

For the test specimen to react to changes of the outdoor temperature during the measurement and to be able to adjust the sink parameters according to the heating characteristic to be set in the next step, the outdoor temperature must be preset at any time during the test. This can be done in various ways, depending on the type of test specimen:

1) Outdoor temperature sensor

One possibility is to set the outdoor temperature for the test specimen directly via its outdoor temperature sensor, which in the case of air/water units must be placed directly in the conditioned test room of the outdoor unit and in the case of brine and water/water units in a separate (outdoor temperature) climate box, which is also to be conditioned according to Table 1. If defects in the sensors of the tested heat pump are detected during the pre-test at T_{biv} (Section 3.1.1), the test engineer is entitled to replace them with calibrated sensors.

2) **Electrical resistance**

Another possibility is the use of an electrical resistance, which simulates the outside temperature on the test specimen by adjusting its electrical resistance. In this case, the temperature sensors of the test object must be replaced by the resistance cascade.

No matter which method is chosen here, it cannot replace the physical conditioning of the test chamber for air/water heat pumps.

6.5 Creating of the heating characteristic

For a correct determination of the heating characteristic to be created, the performance data of the manufacturer must at first be verified.

a) If there is no bivalence point and/or if $T_{design} = T_{biv}$, the heating output $\dot{Q}_{design}$ is measured at the design temperature T_{design} (manufacturer's declaration) and used as the basis for the heating characteristic curve..
b) If a bivalence point exists, the heating output $\dot{Q}_{biv}$ is determined at the bivalence temperature T_{biv} (manufacturer's declaration).

If possible, measurement data is recorded in accordance with EN14511, with the exception that the control of the heat pump is active during the measurement. This means that manual defrosting is forced before data recording is started.

When $\dot{Q}_{biv}$ or $\dot{Q}_{design}$ is determined, the heating characteristic correlations between the source and sink sides result from section 6 of EN 14825:2018. The measured heating output values $\dot{Q}_{biv}(T_{biv})$ or $\dot{Q}_{design}(T_{design})$ are used as the basis. The values for the target supply temperature and the target heating output at further outdoor temperatures result from the correlations defined in Section 4.1 of this document. It may be advisable to verify the determined heating characteristic under further conditions (e.g. at ϑ_o = 12°C).

Figure 5 gives two examples of target heating characteristic curve for a heat pump with 10 kW of nominal heating output. The heating characteristics result from the verified heating output at a) T_{design} or b) T_{biv} and the part load ratios according to Table 1.:

$$a)\ \dot{Q}_H = PLR \cdot \dot{Q}_{design}\ bzw.\ \ b)\ \dot{Q}_H = PLR \cdot \dot{Q}_{biv}$$

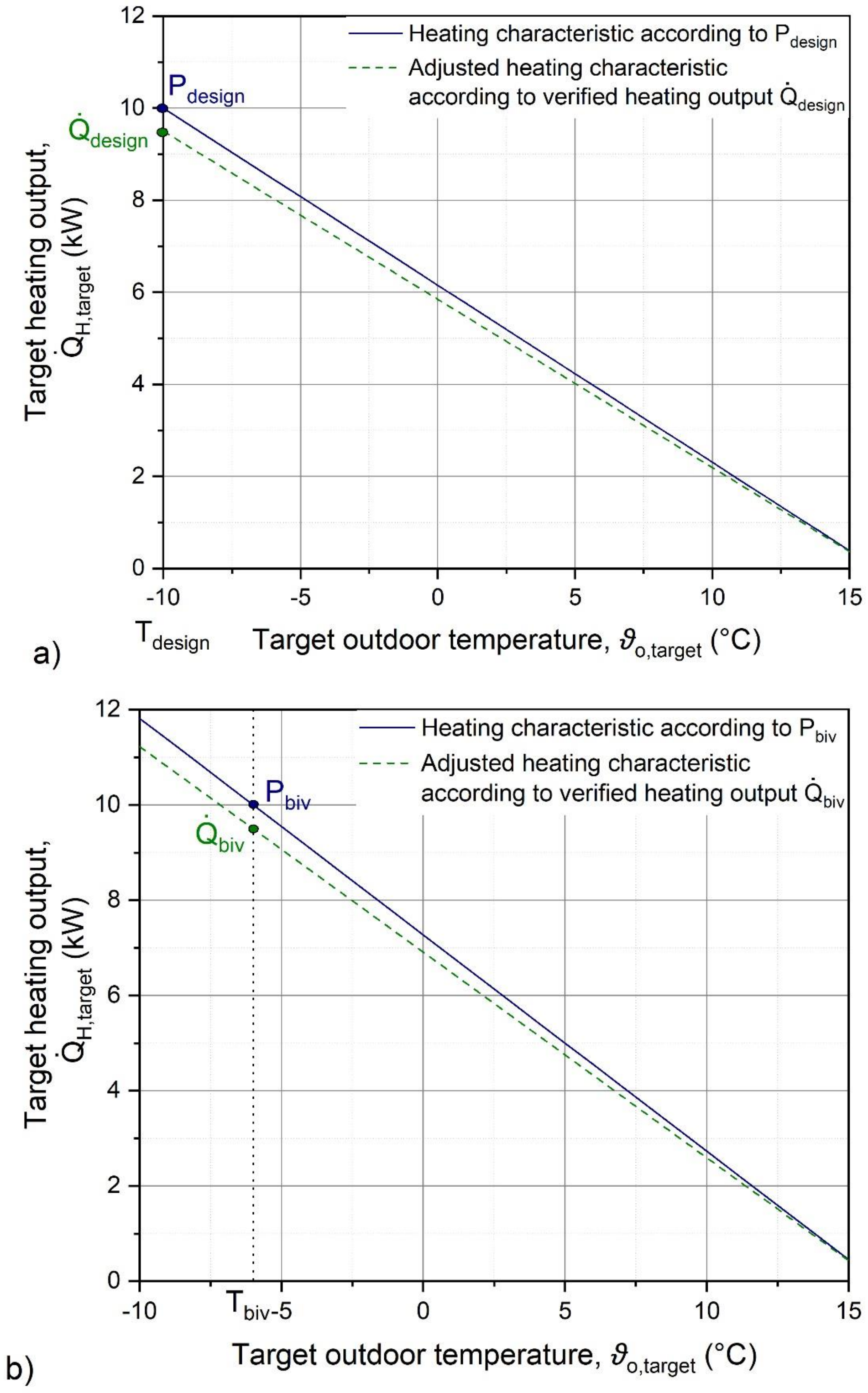

Figure 5: Determination of the heating characteristic curve on the basis of the verified heating capacity at a) T_{design} or b) T_{biv}.

6.6 Adjustment of the heating characteristic

The conditions on the source and sink side must be correctly recorded by the heat pump and the correlation between source and sink side shown in section 4.1 must be maintained. Therefore, the temperature sensors of the heat pump shall be verified and compared with the laboratory measurement equipment. The verification can also be done, for example, during the preliminary test at T_{biv}. If there are too large deviations between the temperatures measured by the heat pump and those determined by the test bench (see Table 4), an adjustment of the heating characteristic has to be made via an offset at the heat pump controller. If this is not possible, the heating characteristic can be indirectly adjusted by setting an offset of the (outdoor temperature) climate box or resistors (see section 6.4). If the permissible deviations listed in Table 4 cannot be maintained even with an offset shift of the heating characteristic, the offset closest to the tolerance band from Table 4 must be selected which at the same time ensures a supply temperature higher than the set supply temperature given in Table 1. For the selection of the suitable offset, a maximum of 1K steps should be used. To determine a suitable offset, at least two different test points on the heating characteristic should be approached. In addition to the bivalence point, the test points at 2°C and/or 12°C outside temperature are recommended for this.

Similar to a boiler, heat pumps can be equipped with a control parameter that considers the storage behaviour of the building. This factor damps changes in outdoor temperature and thus leads to a time delay in the target value specification in the heat pump controller. If this parameter is present, it should be set to "zero" or as low as possible. This ensures that the set point of the supply temperature is set by the heat pump controller as quickly as possible after the outdoor temperature has changed.

Figure 6 shows two examples of the adjustment of the heating characteristic. The dashed line represents both the target supply temperature and the default setting on the heat pump. In Figure 6a, an offset of +1K is sufficient to obtain supply temperatures within the tolerance band. In Figure 6b, the measured supply temperature ϑ_s (HK_(+1K)) with an HK offset of +1K is below the set supply temperature and outside of the tolerance band. A further increase of the offset (in this case +2K) leads to an increase of the measured supply temperature (ϑ_s (HK_(+2K)), which is now above the tolerance band. If, as in this case, the adjustments within the tolerance band are not possible, the next higher value shall always be used to ensure that the target temperatures are not undercut. In this case, the adaptation HK_(+2K) shall be selected for the test.

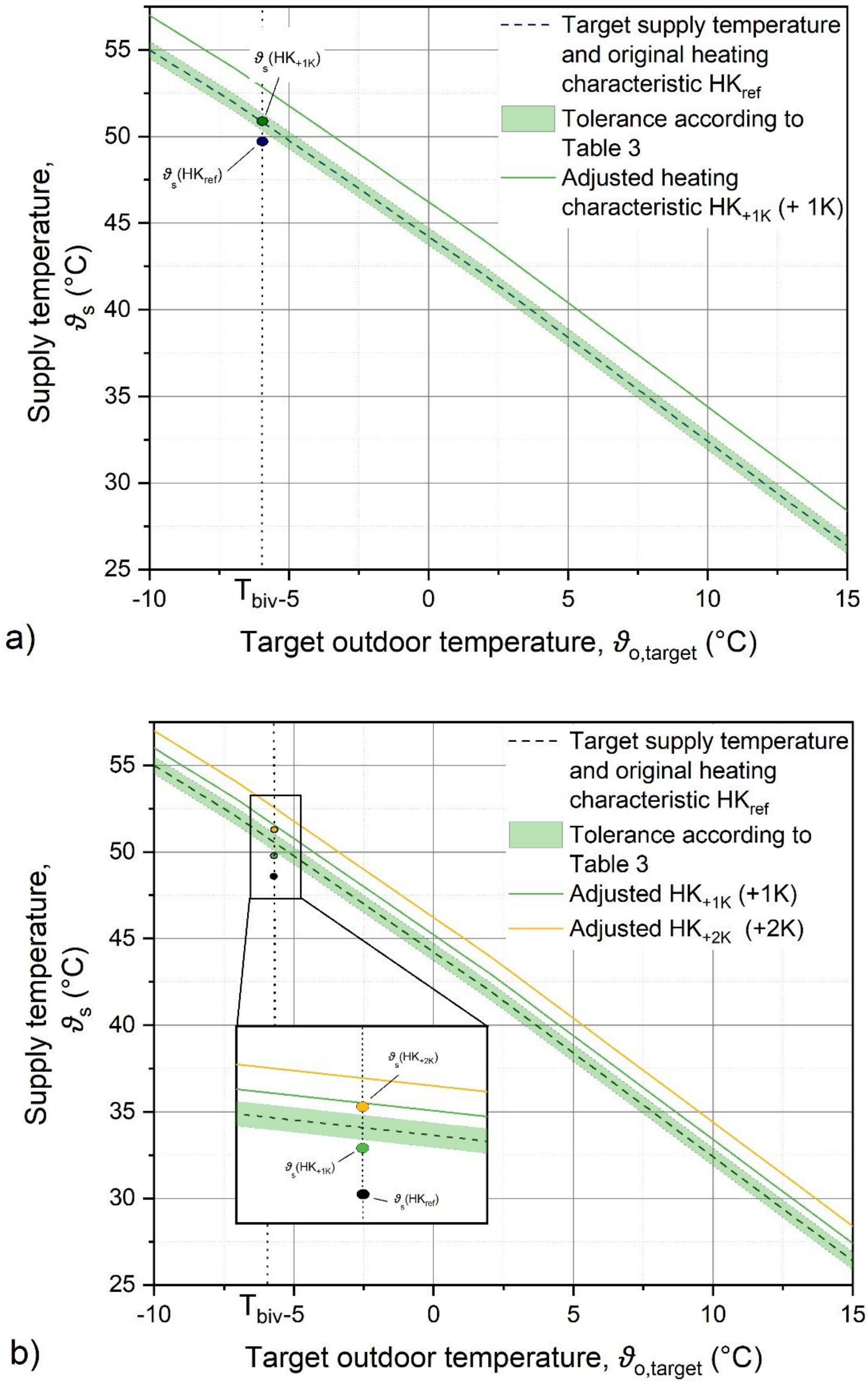

Figure 6: Adjustment of the heating characteristic (HK) and measured supply temperatures (points) before and after adjustment.

6.7 Further settings

Depending on the heat pump, the tests can be carried out with constant volume flow or constant temperature difference between supply and return flow. If settable on the heat pump, it should control to a fixed volume flow. The volume flow rate to be set can be found on the type label or in the manufacturer's specifications (data sheet or operating instructions). In any case, data on the type label have priority over data sheets. If the heat pump does not have a circulating pump, the volume flow can be provided by the test bench.

For test benches with intermediate circuit only:
The target cooling temperature ϑ_{cool} is determined by the target heating output, the volume flow in the heating circuit (type label) and the target supply temperature and has to be continuously adjusted. The temperature difference between the return temperature (heat pump inlet) and the cooling temperature should be kept at 2K if possible. Using a temperature difference of 2K, the supply temperature and the heating output should be verified at the during the measurement at the bivalence point and ϑ_{cool}, if necessary, adapted. The temperature difference between the return temperature (heat pump inlet) and the cooling temperature can therefore be greater than 2K for certain heat pumps.

$$\dot{Q}_h = \dot{V}_w \cdot \rho_w \cdot c_{p,w} \cdot (\vartheta_s - \vartheta_r)$$

$$\vartheta_{cool} = \vartheta_r - 2K$$

6.8 Setting the compensation load and outdoor temperature for brine, water and air/water heat pumps

The required compensation load is set by comparing the nominal and measured heating output and adjusting the return temperature ϑ_r. The return temperature is adjusted directly on a test stand without intermediate circuit and indirectly on a test stand with intermediate circuit by adjusting the cooling temperature ϑ_{cool} (the correlation between cooling and return temperature $\Delta\vartheta_{r-cool}$ is defined in Section 5.7). The return temperature ϑ_r should never be lower than the target indoor temperature set on the heat pump during the test.

7. Evaluation and calculation of the seasonal space heating energy efficiency η_s

The determined amount of energy for the heating energy $Q_{h,i,exp}$ measured at the condenser as well as the measured electricity consumption $E_{el,i,exp}$ of each individual temperature sequence i are the basis for the calculation of the seasonal space heating energy efficiency η_s.

7.1 Calculation of the proportional energy balance at T_{design}

In order to adjust the length of the sequence at T_{design} to the share of the heating energy at T_{design} to the total seasonal heating demand as given in Annex B of EN14825:2018, the proportional energies at T_{design} are calculated from the energies determined.

$$Q_{h,design} = Q_{h,design,exp} \cdot 0{,}01394$$

$$E_{el,design^*} = E_{el,design^*,exp} \cdot 0{,}01394$$

7.2 Calculation of the proportional energy balance of the temperature sequence i

The length of each individual temperature sequence must be adjusted for the heating energy weighting of the temperature distribution given in Annex B of EN14825:2018. The amounts of energy measured are therefore corrected for some sequences i as follows. Table 6 displays the values to be used for the weighting factor K_i.

$$Q_{h,i} = Q_{h,i,exp} \cdot K_i$$

$$E_{el,i} = E_{el,i,exp} \cdot K_i$$

Example:

Sequence: $i = 10$

Target outdoor temperature: $\vartheta_{o,10,target} = 15°C$

Target supply temperature: $\vartheta_{s,10,target} = 27°C$

Weihting factor: $K_{10} = 0{,}3952$

Measured heat amount: $Q_{h,10,exp} = 10\ kWh$

Measured power consumption: $E_{el,10,exp} = 4\ kWh$

$$Q_{h,10} = Q_{h,10,exp} \cdot K_{10} = 10\ kWh \cdot 0{,}3952 = 3{,}9520\ kWh$$

$$E_{el,10} = E_{el,10,exp} \cdot K_{10} = 4\ kWh \cdot 0{,}3952 = 1{,}5808\ kWh$$

Table 6: Length of the temperature sequences based on the heating demand distribution given in Annex B of EN14825:2018

Nummer i der Sequenz	Gewichtungsfaktor K_i
1	1,4937
2	2,0383
3	2,1557
4	1,2012
5	1,2444
6	1,1454
7	0,8947
8	2,4180
9	1,6050
10	0,3952
11	1,6050
12	2,4180
13	0,8947
14	1,1454
15	1,2444
16	1,2012
17	2,1557
18	2,0383
19	1,4937

7.3 Adjustment of the power consumption $E_{el,i}$ for excessive deviations in the average values of the supply temperature and the heat output

If, in a sequence i, the average values of the supply temperature or heating output exceed the permissible deviations from the target values specified in section 4.2.2, the affected sequence is subjected to an additional power input. Figure 6 shows an example of the adjustment in the case of impermissibly high deviations of the average supply temperature values in the sequences 9-11.

$$E_{el,i,kor} = E_{el,i} \cdot F_{VL,i} \cdot F_{h,i}$$

If $\vartheta_{s,Ist} < \vartheta_{s,target}$: $F_{s,i} = \frac{\vartheta_{s,i,target} - 2K}{\vartheta_{s,i,exp}}$

If $\vartheta_{s,Ist} > \vartheta_{s,target}$: $F_{s,i} = \frac{\vartheta_{s,i,exp}}{\vartheta_{s,i,target} + 2K}$

If $\dot{Q}_{h,exp} < \dot{Q}_{h,target}$: $F_{h,i} = \frac{\dot{Q}_{h,i,target} - 0{,}05 * \dot{Q}_{h,i,target}}{\dot{Q}_{h,i,exp}}$

If $\dot{Q}_{h,exp} > \dot{Q}_{h,target}$: $F_{h,i} = \frac{\dot{Q}_{h,i,exp}}{\dot{Q}_{h,i,target} + 0{,}05 * \dot{Q}_{h,i,target}}$

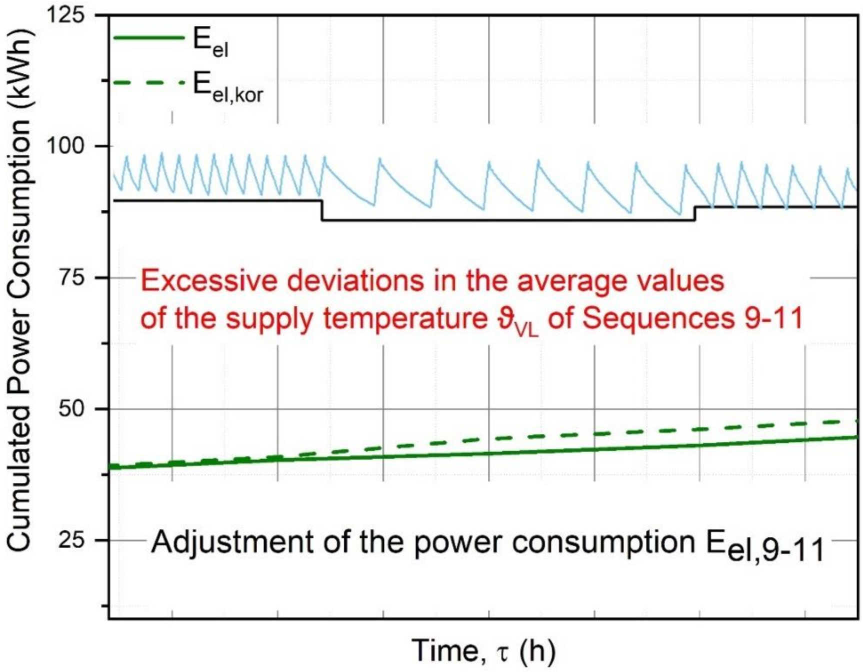

Figure 7: Example for the adjustment of $E_{el,9-11}$ for excessive high deviations of the average supply temperature values in the sequences 9-11..

Example:

Sequence: $i = 4$

Target outdoor temperature: $\vartheta_{o,4,target} = 2°C$

Target supply temperature: $\vartheta_{s,4,target} = 42°C$

Target heating output: $\dot{Q}_{h,4,soll} = 10\ kW$

Arithmetic measured supply temperature: $\vartheta_{s,4,exp} = 38°C$

Arithmetic measured heating output: $\dot{Q}_{h,4,exp} = 8\ kW$

$\vartheta_{s,exp} < \vartheta_{s,target}$ und $\dot{Q}_{h,exp} < \dot{Q}_{h,target}$

Measured power consumption: $E_{el,4} = 1\ kWh$

$$E_{el,4,kor} = E_{el,4} \cdot \frac{\vartheta_{s,4,target} - 3K}{\vartheta_{s,4,exp}} \cdot \frac{\dot{Q}_{h,4,target} - 0{,}05 * \dot{Q}_{h,4,target}}{\dot{Q}_{h,4,exp}}$$
$$= 1\ kWh \cdot \frac{42-2}{38} \cdot \frac{10-0{,}5}{8} = 1{,}25\ kWh$$

7.4 Correction of the effective power consumption by the heat of the circulating pump

he measured heating energy $Q_{h,i,measured}$ shall be corrected for the heat of the circulation pump according to EN 14511-3. The effective amount of electrical energy shall be determined from the measured amount of electrical energy $E_{el,i,measured}$ and the corrections for heat made by the circulating pump(s) and/or the fan, if any..

7.5 Calculation of SCOP und η_s

If for a sequence i the electrical energy $E_{el,i}$ has been adjusted in accordance with section 7.3, the adjusted value $E_{el,i,kor}$ must be used instead of the measured electrical energy $E_{h,i}$ for this sequence in the SCOP calculation. Figure 8 shows examples of the cumulated energies for the heating energy Q_h, the cumulated measured electrical energy consumption E_{el} and the cumulated adjusted electrical energy energy consumption $E_{el,kor}$ according to section 7.3.

$$SCOP = \frac{Q_{h,design} + \sum_{i=1}^{19} Q_{h,i}}{E_{el,design} + \sum_{i=1}^{19} E_{el,i,kor} + H_{SB} \cdot P_{SB} + H_{CK} \cdot P_{CK} + H_{off} \cdot P_{off} + H_{TO} \cdot P_{TO}}$$

$$\eta_s = \frac{SCOP}{CC} - \sum F(i)$$

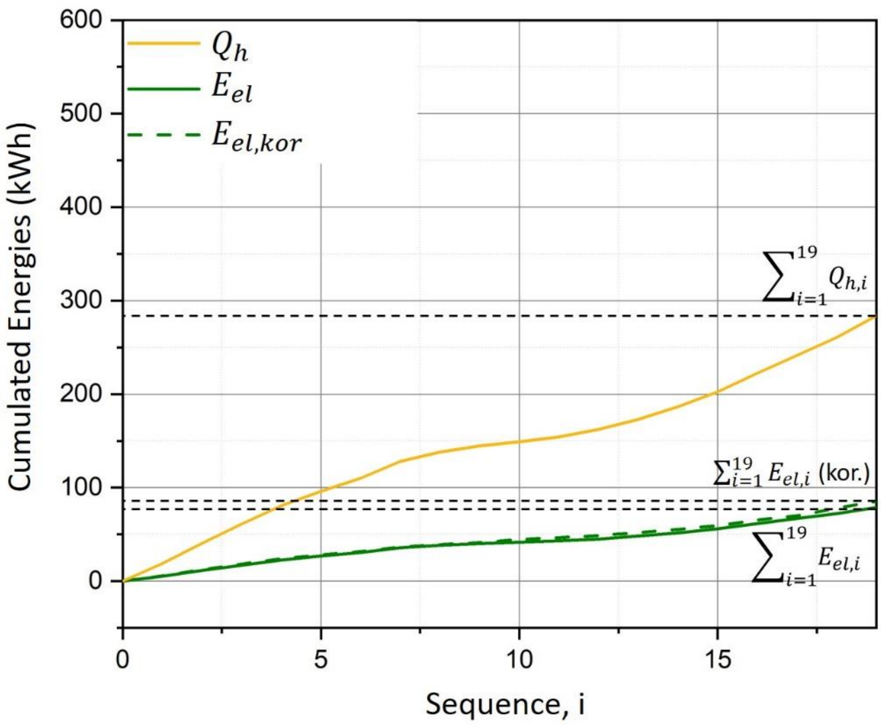

Figure 8: Example for the cumulated heating energy Q_h, the cumulated measured electricity consumption E_{el} and the cumulated corrected electricity consumption $E_{el,kor}$.