Test procedure and seasonal performance calculation for residential heat pumps with combined space and domestic hot water heating

Testing procedures

- Experiences with existing standards
- Experiences with proposed procedures

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Reference group: NIBE AB, IVT AB, Thermia Värme AB

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Background for Swedish participation in Annex 28

- A well-established heat pump market – 66 000 units sold during 2004
- Ground-source heat pumps – 40 000 units during 2004
- Exhaust air heat pumps (EAHP) with simultaneous space and domestic hot water heating common in Sweden (totally 15 000 EAHPs sold during 2004)
- Long experience from heat pump testing in general
- Long experience from testing of combined space and domestic hot water heating
- Existing method for simultaneous space and domestic hot water heating for EAHP; SP method 0029 – limited to Swedish circumstances and size of house

Methodology

Swedish contribution – part 2 and 3

- Defining boundaries
- Outlining first draft of test method
- Laboratory testing with GSHP (alternate heating)
  - Evaluation of draft method
  - Comparing previous, existing and proposed standards and methods
- Analysing test results ⇒ basis for proposal of test and calculation method
- IEA HPP Annex 28 working meeting ⇒ agreement on joint proposed test and calculation methods
- Laboratory testing with EAHP with simultaneous space and hot water heating
  - Evaluation of joint proposed test method

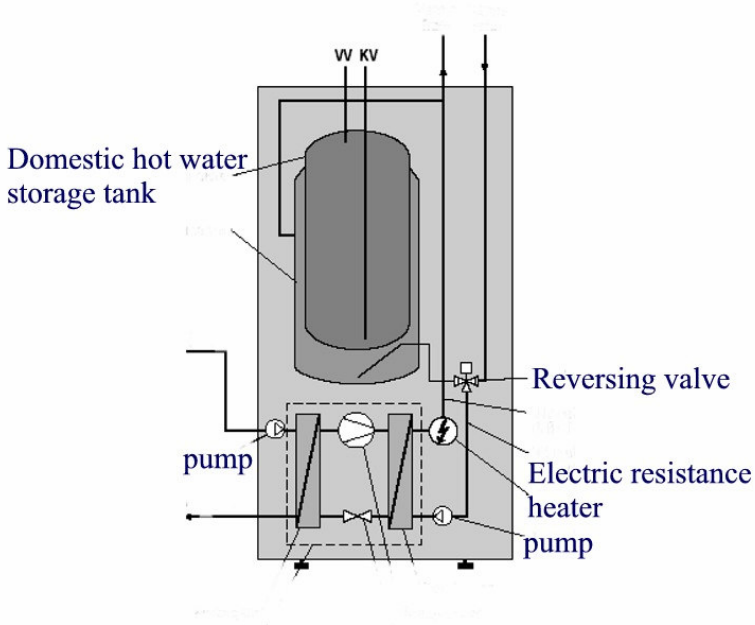
Laboratory testing

Ground-source heat pump

- Test according to EN255 and EN14511
- Mandate M/324 for hot water draw-offs
- Combined test according to EN255-2 and EN255-3

Exhaust-air heat pump

- Combined tests according to SP method 0029
- Steady-state, combined and DHW test according to proposed test method (based on EN14511 and EN255-3)



Typical Swedish manufactured GSHP, nominal thermal power 8.5 kW

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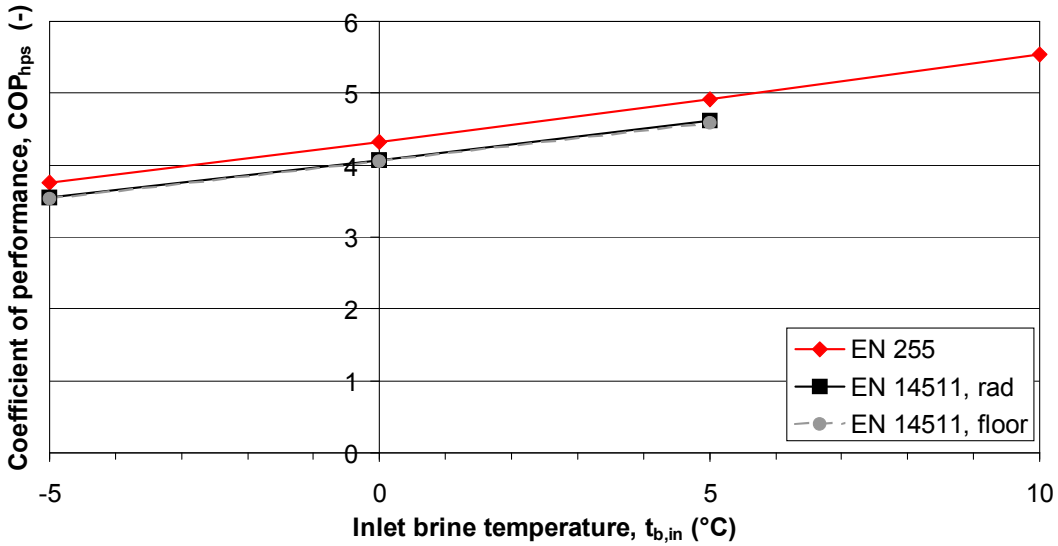
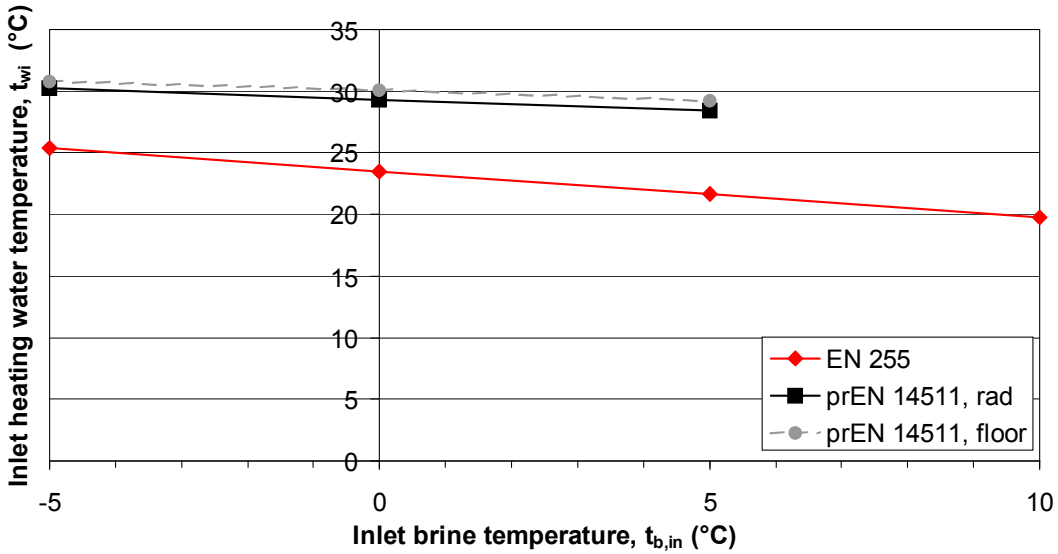
Results GSHP – Comparison of EN 255 and EN 14511

Coefficient of performance, COP_{hps}



Inlet heating water temperature, $t_{w,in}$



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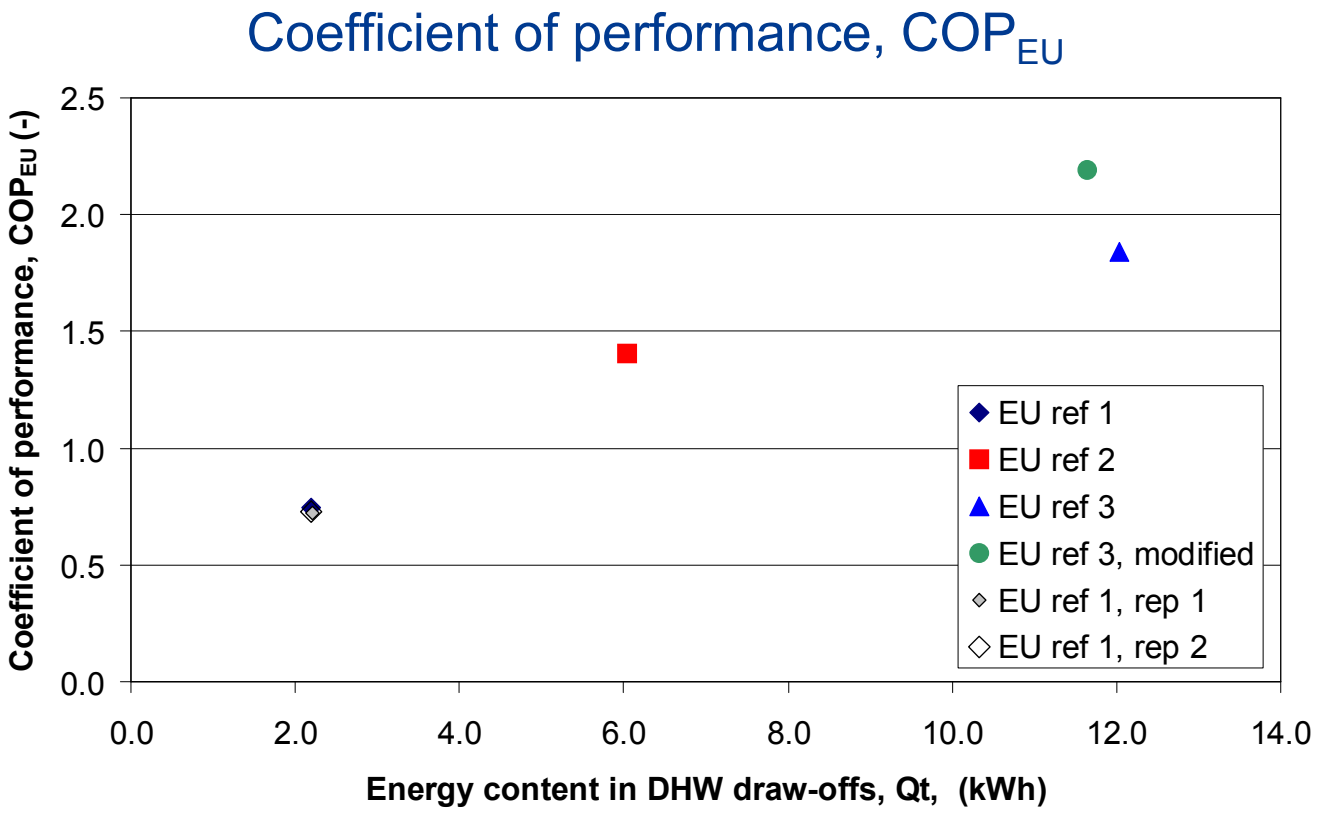
Results – Mandate M/324 test for hot water draw-offs



EU ref 1	11 draw-offs	2.1 kWh
EU ref 2	23 draw-offs	5.8 kWh
EU ref 3	24 draw-offs	11.4 kWh
EU ref 3 mod	3 draw-offs	11.4 kWh

$$COP_{EU} = \frac{Q_t}{\overline{P}_T \cdot \tau_{cycle}}$$

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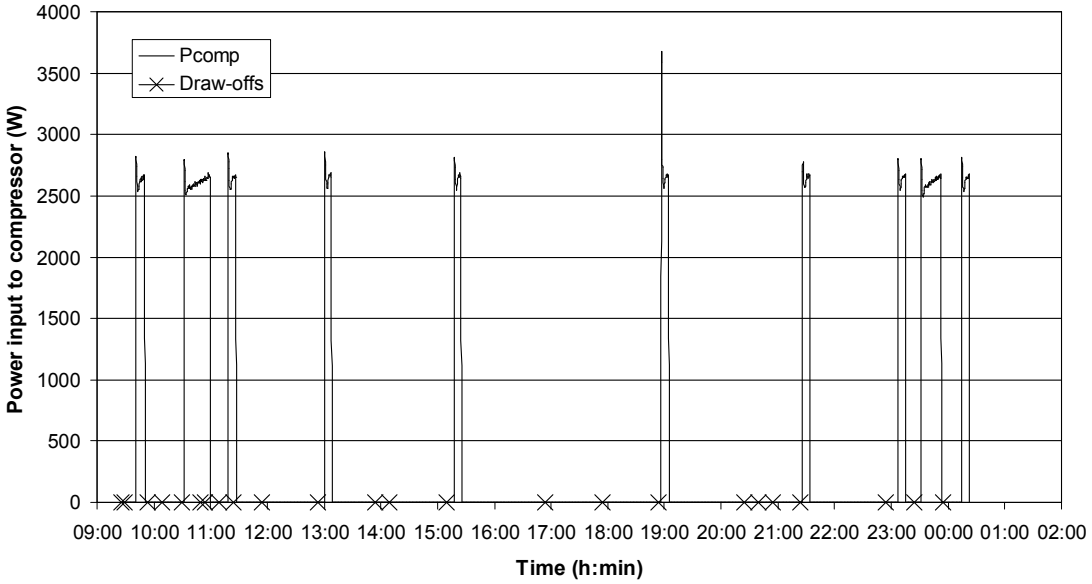
Results – Comparison of draw-off cycle ”EU ref ” and ”EU ref 3, modified”

EU ref 3

24 draw-offs

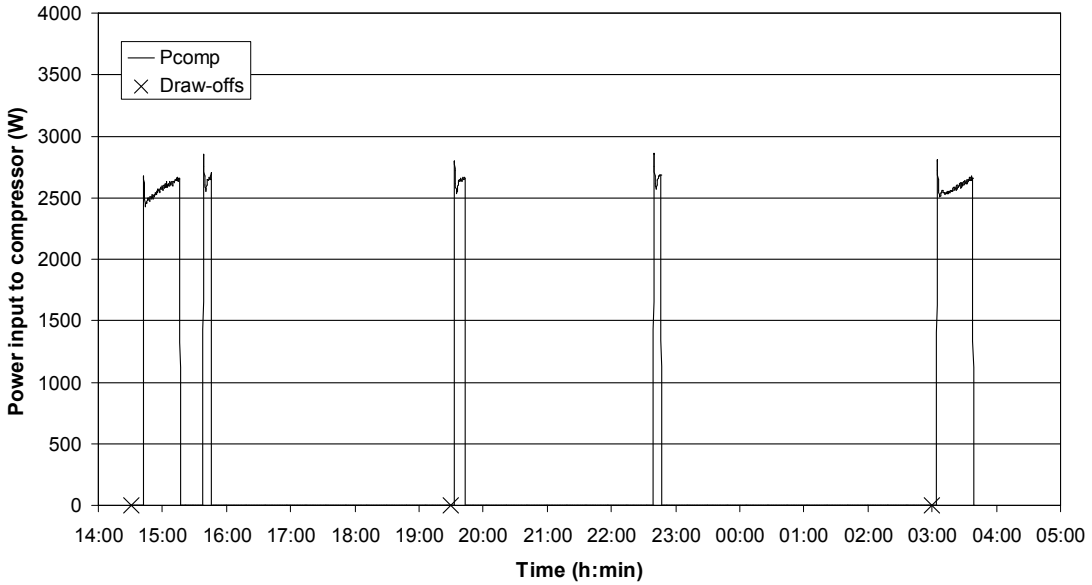
11.4 kWh



EU ref 3, modified

3 draw-offs

11.4 kWh



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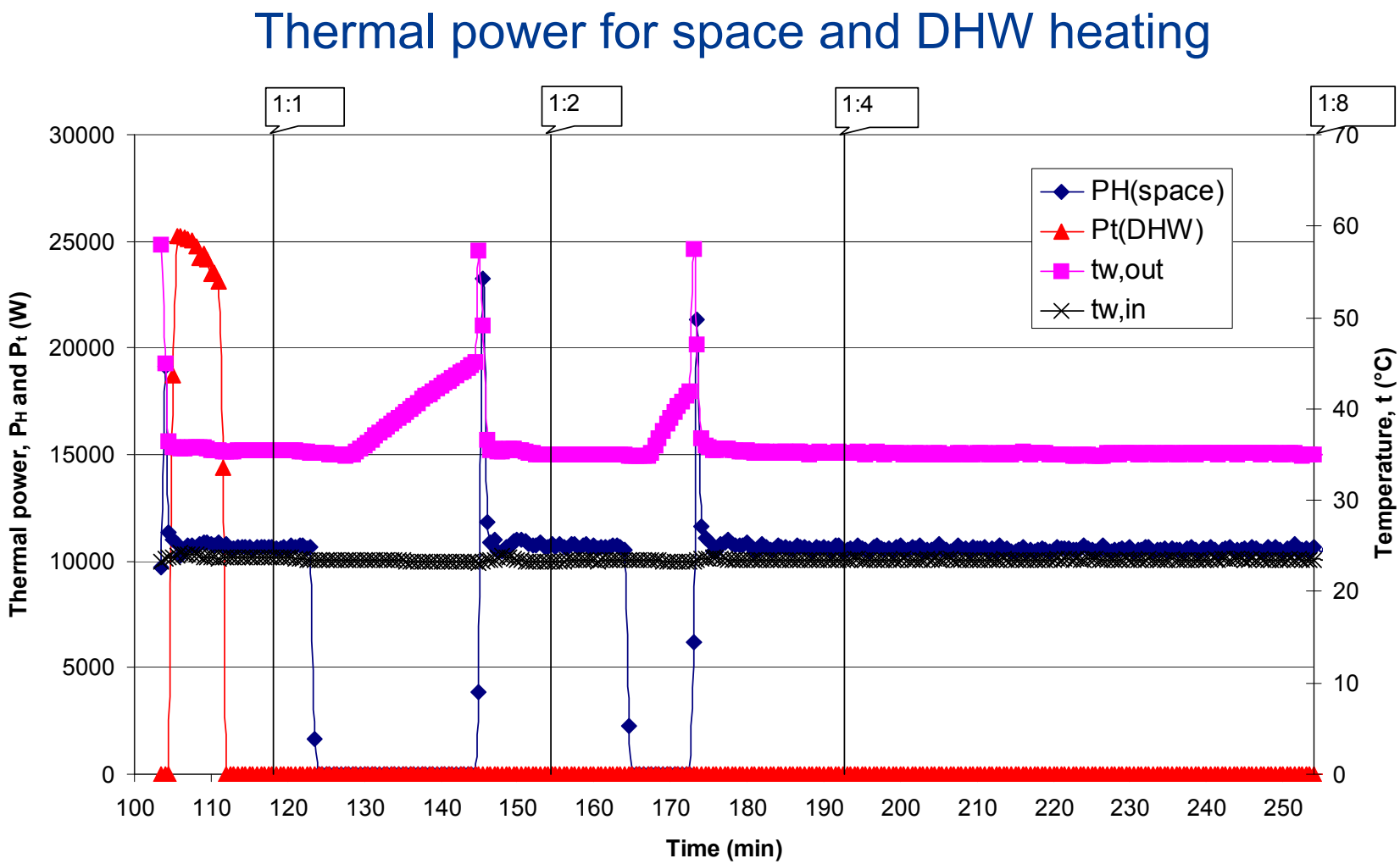
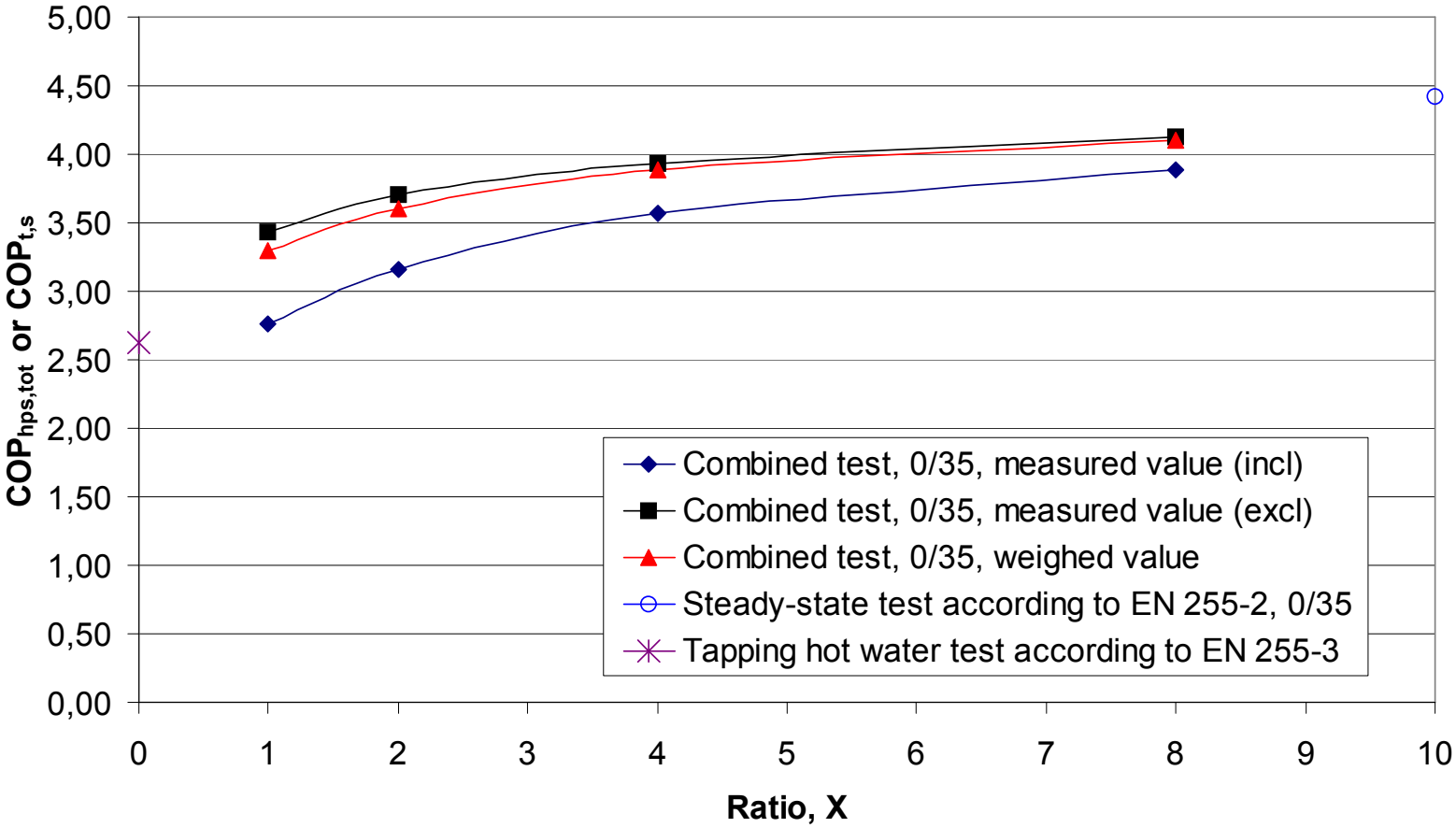
Results – Combined test according to EN 255-2 and EN 255-3



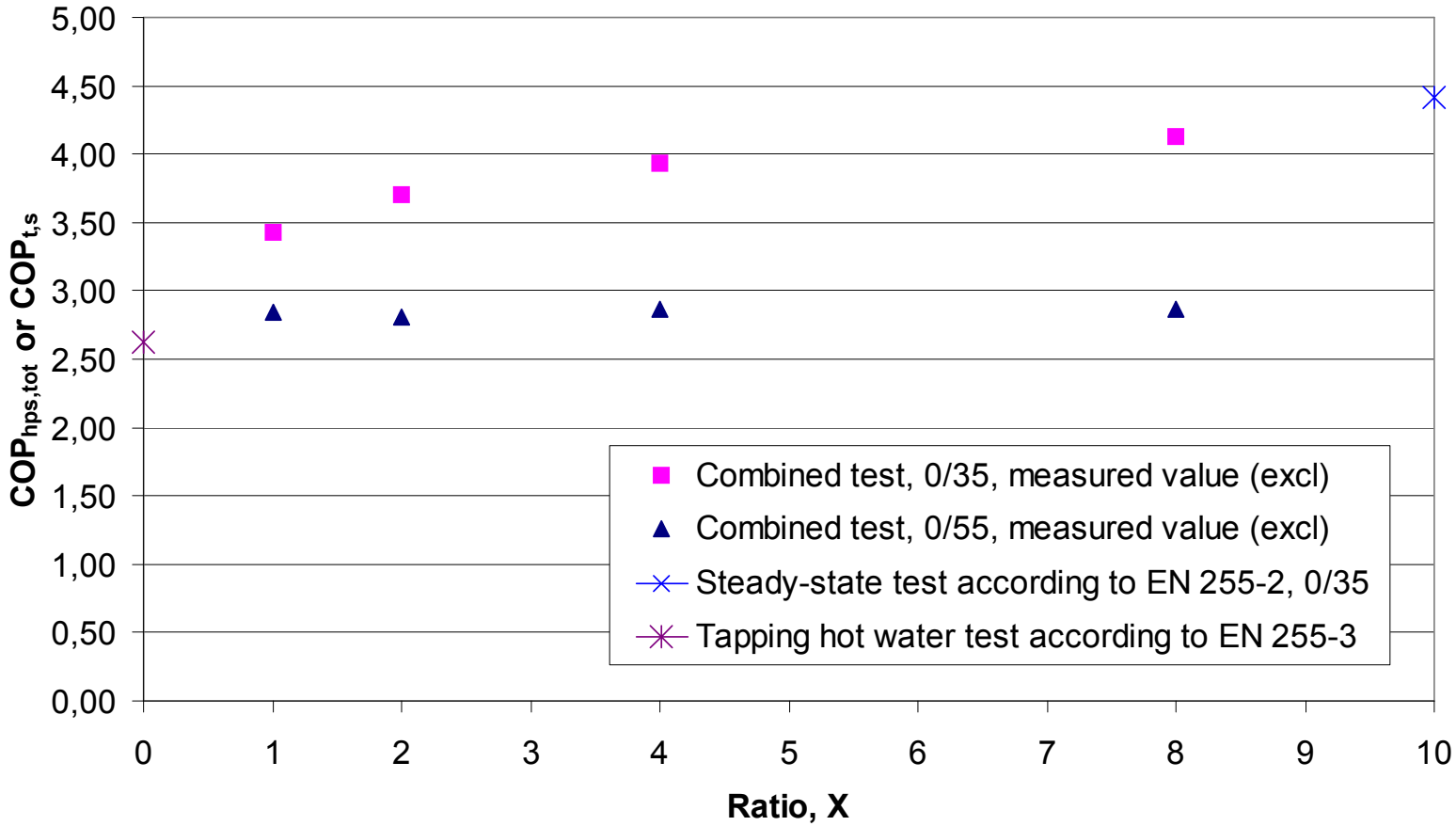
Results – Combined test according to EN 255-2 and EN 255-3

Coefficient of performance for combined, steady-state and tapping hot water tests



Results – Combined test according to EN 255-2 and EN 255-3

Coefficient of performance for combined, steady-state and tapping hot water tests – summation GSHP



Summary of results from laboratory testing

- COP for EN 255 higher than for EN 14511 – sometimes unrealistic values of inlet temperatures
- COP for combined operation can be predicted by weighting if alternate heating is applied – verification necessary?
- Important to guarantee that the energy content of the storage tank is equal at start and stop of evaluation cycle in tests involving draw-offs
- Extent of temperature stratification influences performance

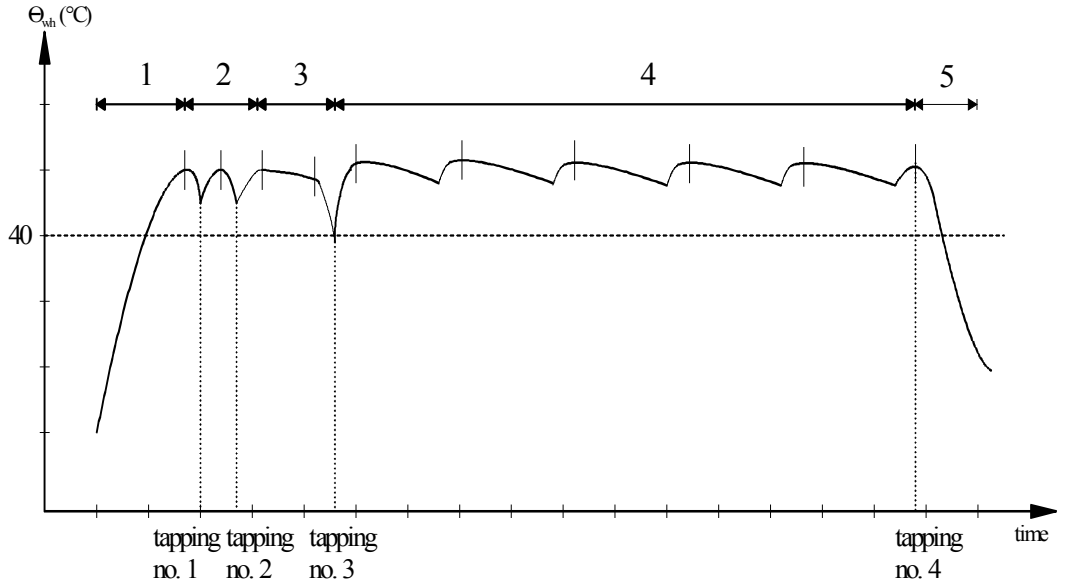
Proposed test method

- The test method should deliver input data to a calculation method and calculations of specific cases should be possible

  - ✓ Stay with existing standards to a large extent
  - ✓ Flow rates are defined by temperature intervals
  - ✓ No specified draw-off profiles, but four subsequent draw-offs
  - ✓ Test points for steady-state single space heating, single DHW heating and combined space and DHW heating
    - Steady-state test points for evaluation of influence of different parameters

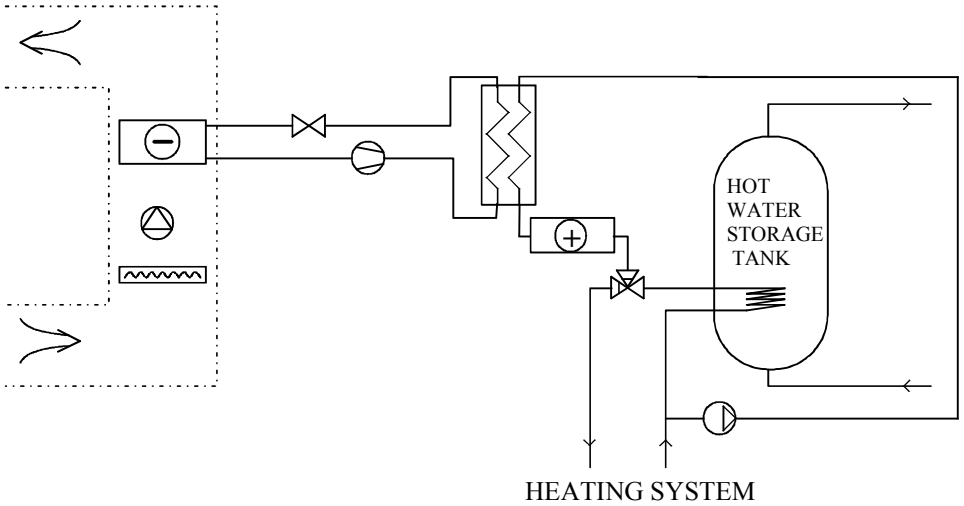
Proposed modification of EN 255-3

- Cold water temp. 10°C and flow rate 0.167 m^3/s
  - More realistic values and in accordance with other standards for DHW heating
- Replacing 2 draw-offs of half the volume by 4 draw-offs of a fourth of the volume
  - A repeating process – equal energy content of storage tank at start and stop of evaluation period
  - Smaller more realistic draw-offs (affects stratification in tank).
  - Maximum allowed deviation of the two last draw-offs is 5 %

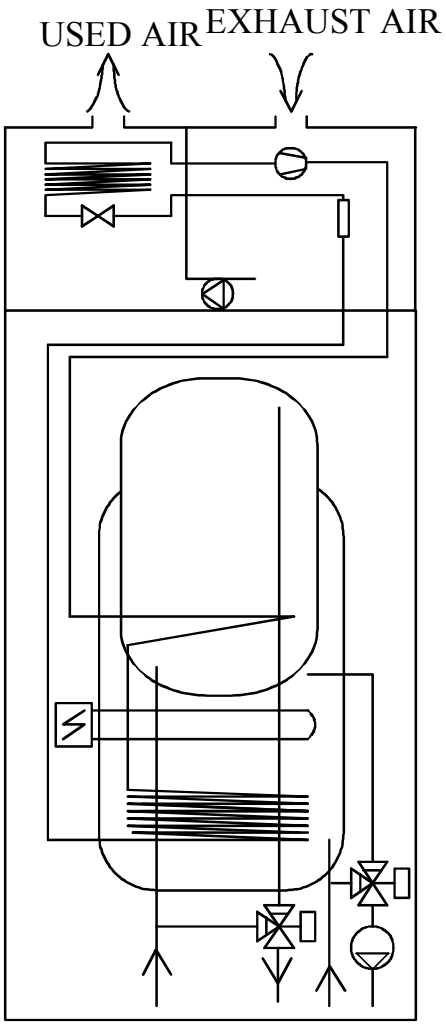


Different types of exhaust air heat pumps

"Type 1"



"Type 2"



- **Laboratory tests with an exhaust air heat pumps of "type 2" according to the proposed test method**

Results EAHP – Coefficient of performance

Influence of wet bulb temperature

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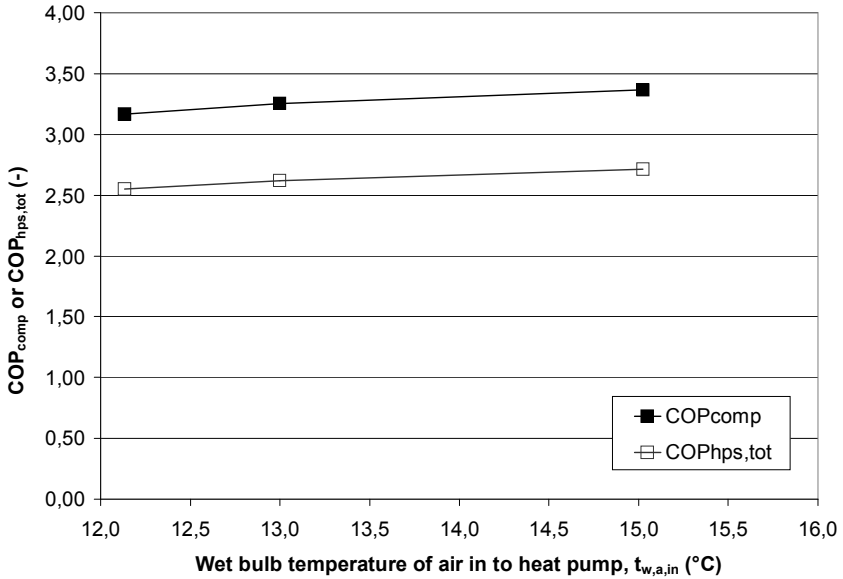
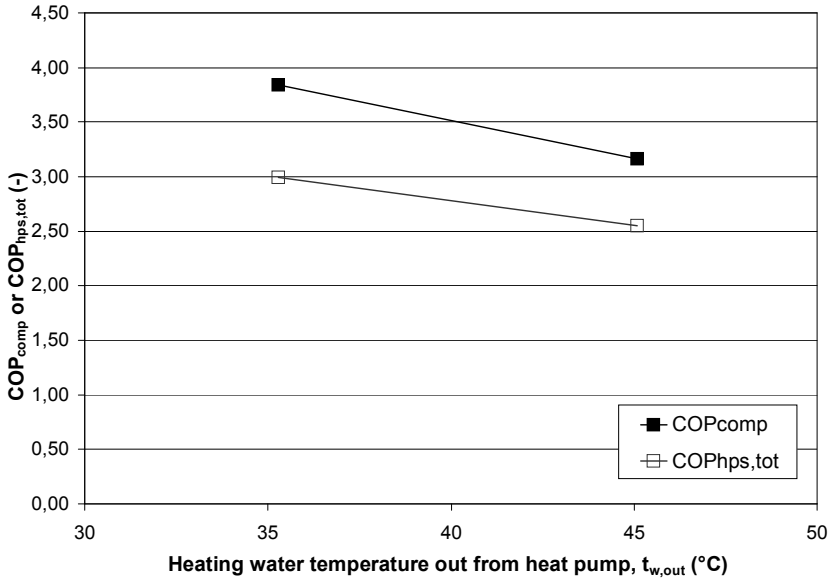


Influence of heating water temperature

$$COP_{comp} = \frac{P_{H,tot}}{P_{comp}}$$

$$COP_{hps,tot} = \frac{P_{H,tot}}{\left(P_T - P_{\sup p}\right)}$$



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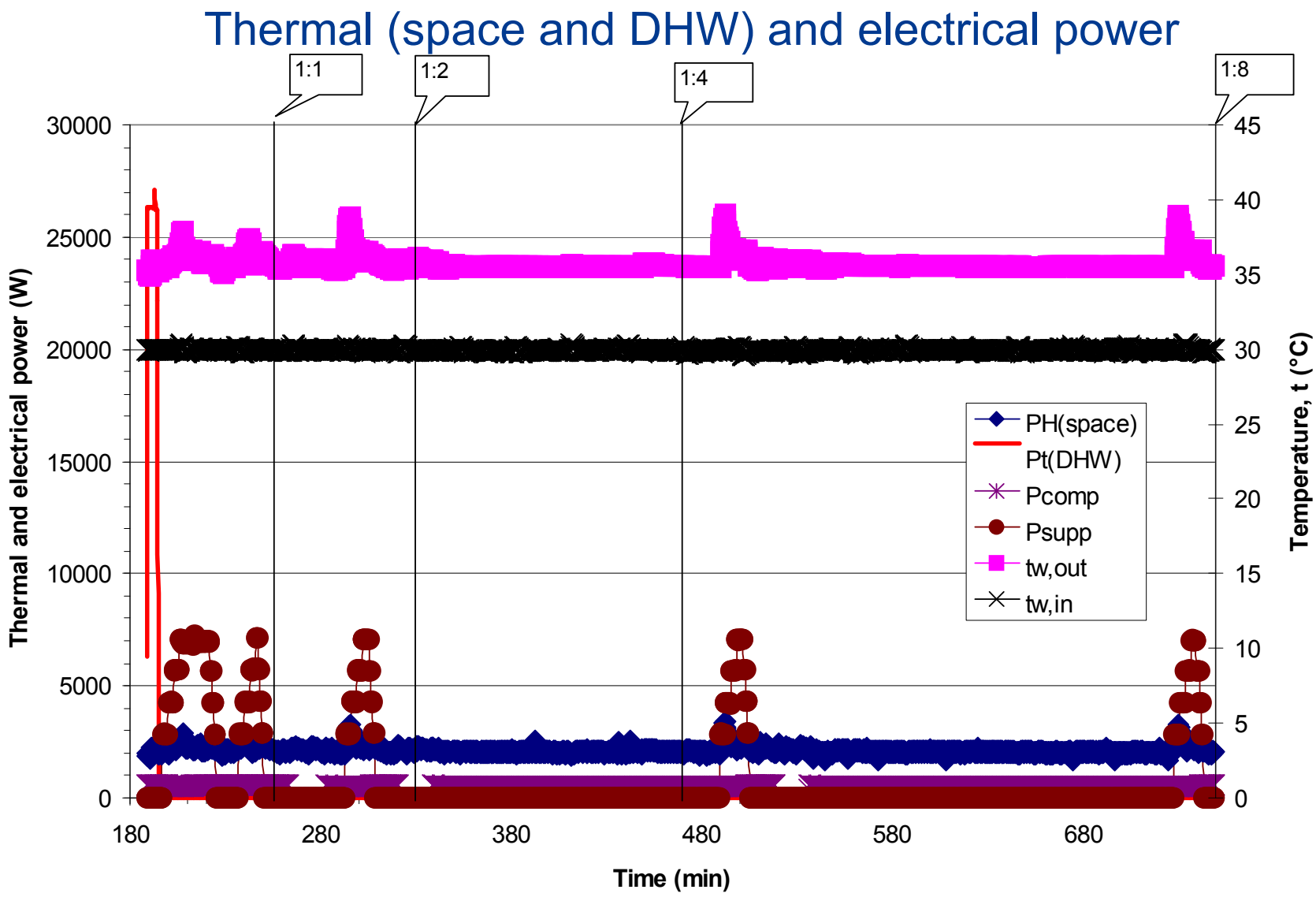
Results – Combined test according to proposed test method (EN 14511 and EN 255-3, modified)



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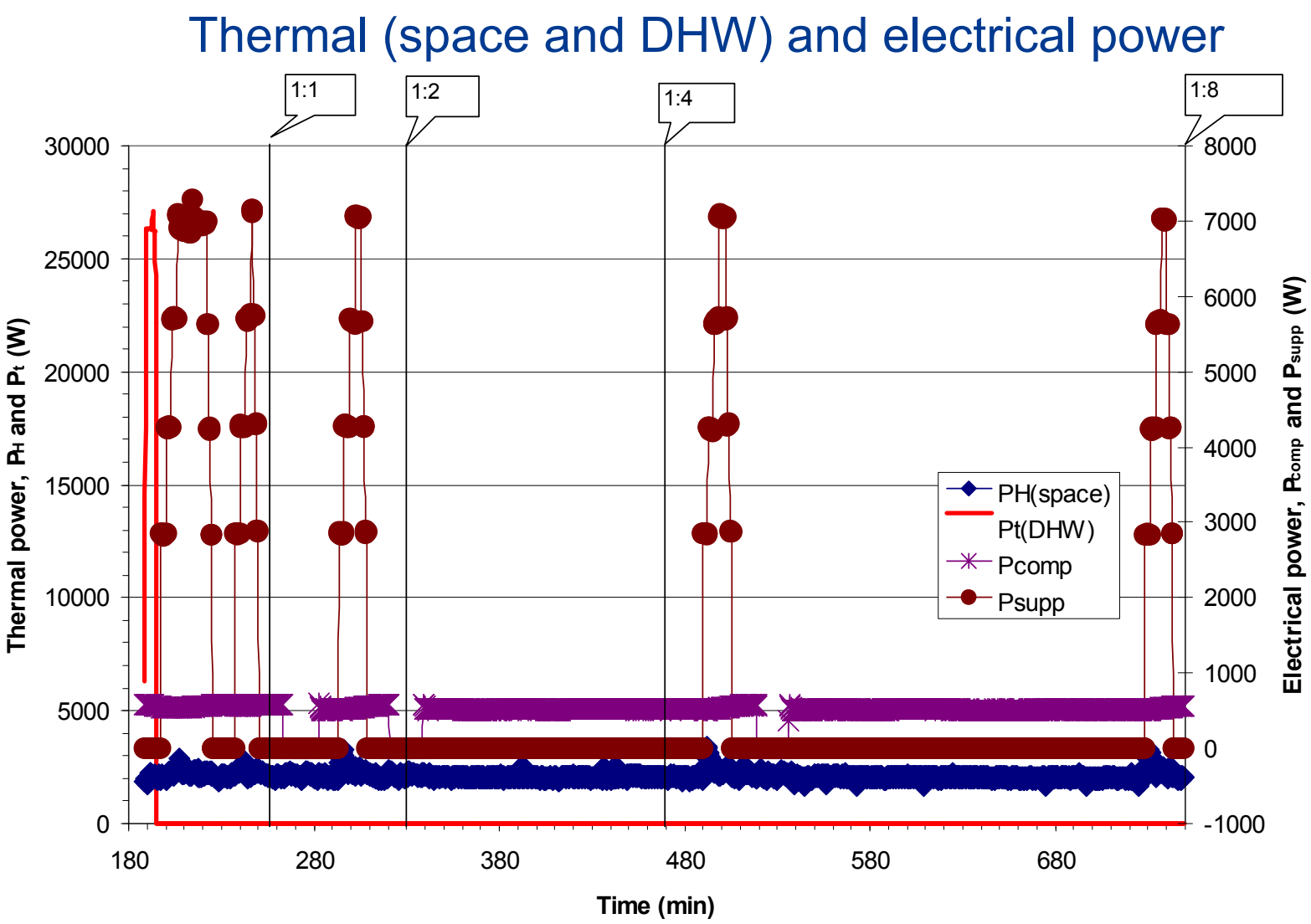

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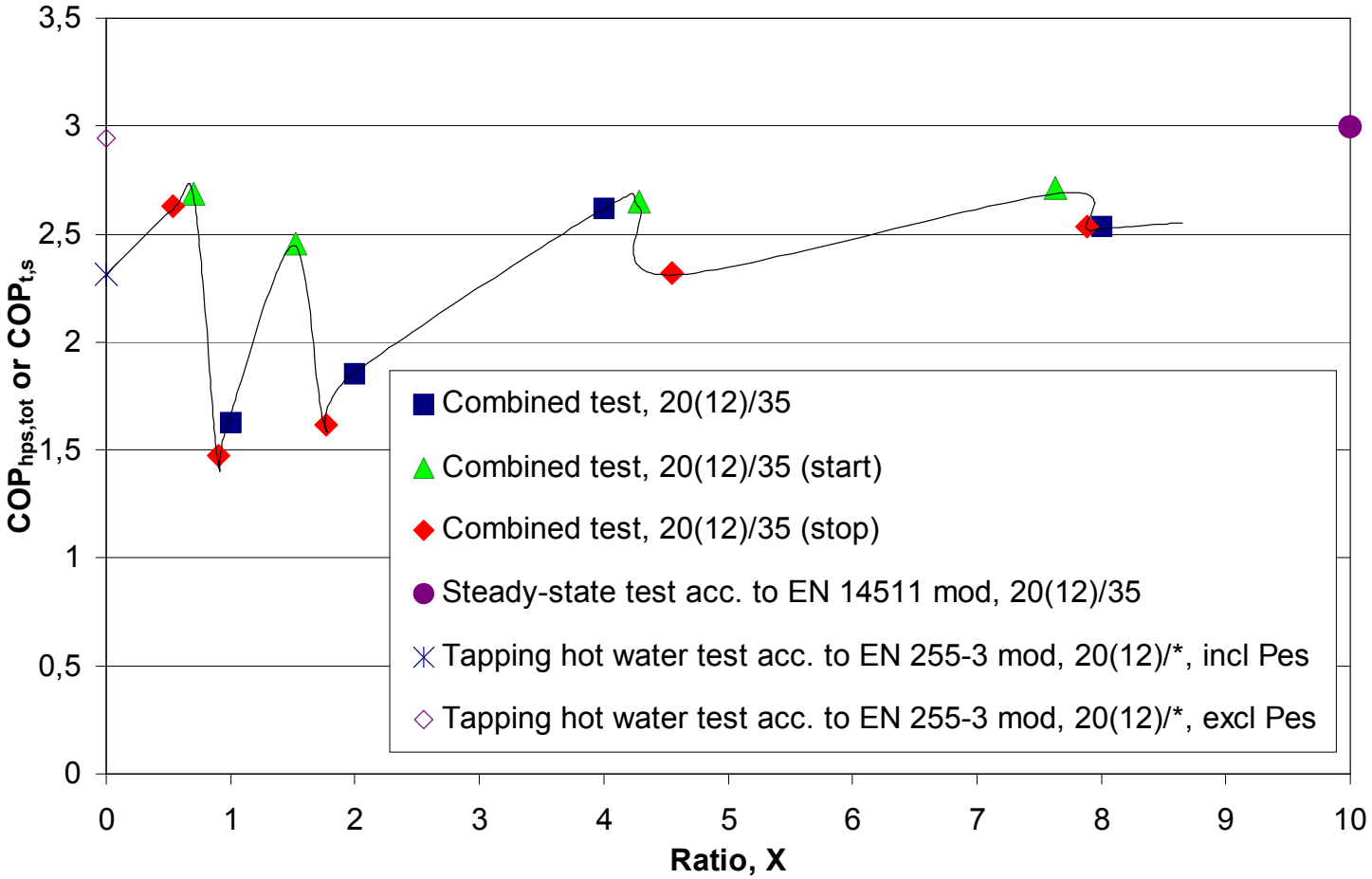
Results – Combined test according to proposed test method (EN 14511 and EN 255-3, modified)

Coefficient of performance for combined, steady-state and tapping hot water tests



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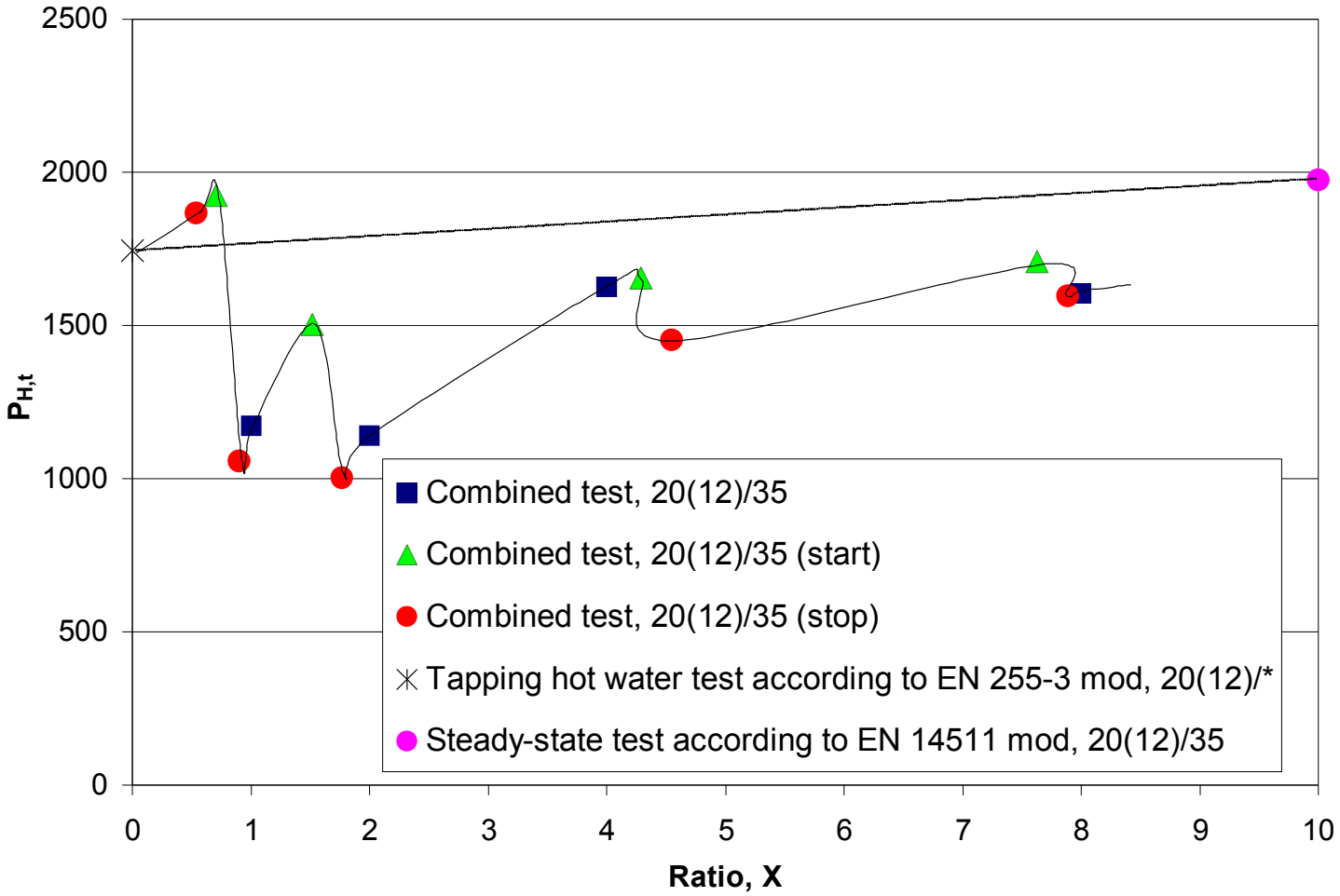
Results – Combined test according to proposed test method (EN 14511 and EN 255-3, modified)

Heating capacity for combined, steady-state and tapping hot water tests



Conclusions

- The proposed test method will deliver results that can be used as input data for calculation of SPF
- Combined testing is necessary for simultaneously heating heat pumps
  - The test procedure must be adapted to different heat pump types and design solutions

  ➢ The results from the test method shall enable fair comparison of heat pumps of different type, design solution and size

- Stand-by losses can influence the performance of the heat pump to a large extent – especially if the heating demand and/or the capacity of the heat pump is low
- Some of the test points are relatively time consuming - this is inevitable, since a long test period is necessary for guaranteeing reliable and representative test values