

# HEATING WITH HEAT PUMPS UP TO + 65 °C WITH EVI

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## Abstract

Heat pumps with EVI-cycle (enhanced vapour injection) are able to provide around 10 K higher output temperature: + 65 °C instead of usually + 55 °C. The EVI increases the max. temperature difference of heat pumps remarkably, from around 60 K to around 80 K. The EVI increases also the power of air/water heat pumps then when it is needed: when temperature of the used outside air is low. That makes them much more attractive. These effects are especially welcome for low insulated buildings and for replacement of boilers in existing houses. As side effect the domestic hot water can also be produced at a higher temperature level, depending on the hydraulic connection. Illustration of the EVI-Cycle, effect on COP, performance factor, recommended hydraulic diagrams for space heating and domestic hot water production and best practice examples are given.

**Key words:** Heat pump, high temperature heat pump, enhanced vapour injection (EVI), renewable energy

## Introduction: Why higher temperatures by “injection” respectively EVI?

To enter in this interesting segment of the replacement market, the Swiss Federal Office of Energy arranged a competition for retrofit heat pumps. Together with the Swiss Federal Institute of Technology of Lausanne (EPFL) and Electricité de France (EDF) a new version of the refrigerant cycle for heat pump application was developed. Standard heat pumps produce flow temperatures of max. + 55 °C, which is well accepted for new buildings. To enable heat pumps for replacement in older buildings, this temperature has to be higher: > + 60 °C. The shown concept uses R407C, a well-known refrigerant, contrary to R290, which is flammable and R134, whose power density is poor. An injection within the refrigerant cycle allows increasing from max. + 55 °C to + 65 °C without concessions on the reliability. Hereby approved components are used. EVI, enhanced vapour injection, reinforces the air/water heat pumps by increasing their usefulness. EVI improves the following features of air/water heat pumps, which are most important for their use: lift of the increase of temperature from 60 K to 80 K. That means at – 15 °C outdoor temperature still + 65 °C flow temperature can be reached. The other positive effect of EVI is the increase of the power, when it is needed, i.e. when it is cold (wintertime).

## How works EVI?

In Figure 1 the difference between the standard refrigerant cycle and the refrigerant cycle with enhanced vapour injection is in the right part visible: during the compression a portion of wet vapour gets injected. The main differences are:

- The compressor is also pressure-side cooled with effect of higher end temperature
- 25 – 30 % higher power, comparable to a turbo charger
- Slightly better coefficient of performance (COP), when EVI is activated

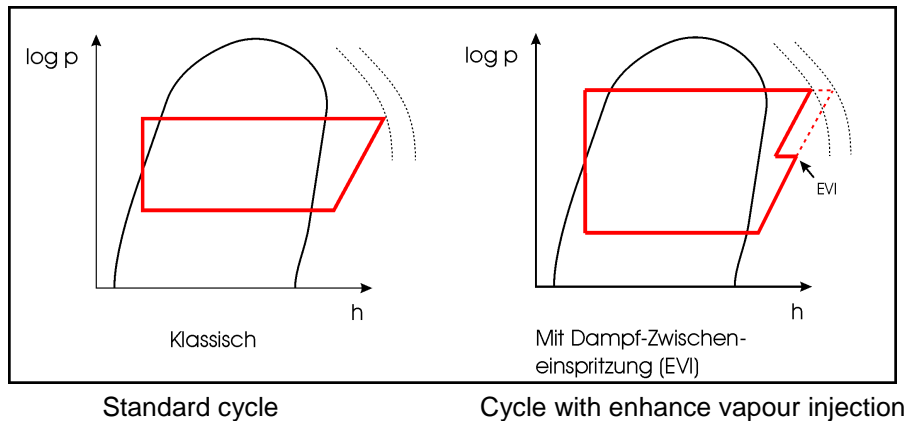


Figure 1. Difference between the cycles standard and EVI

These effects, shown in details in figure 2. have been confirmed at first by independent test institutes and since 2001 by numerous field applications. The working process has quasi a two-stage compression, when the EVI is activated. The bigger surface in figure 2. represents the higher power, the point in the right upper corner shows the same max. vapour temperature.

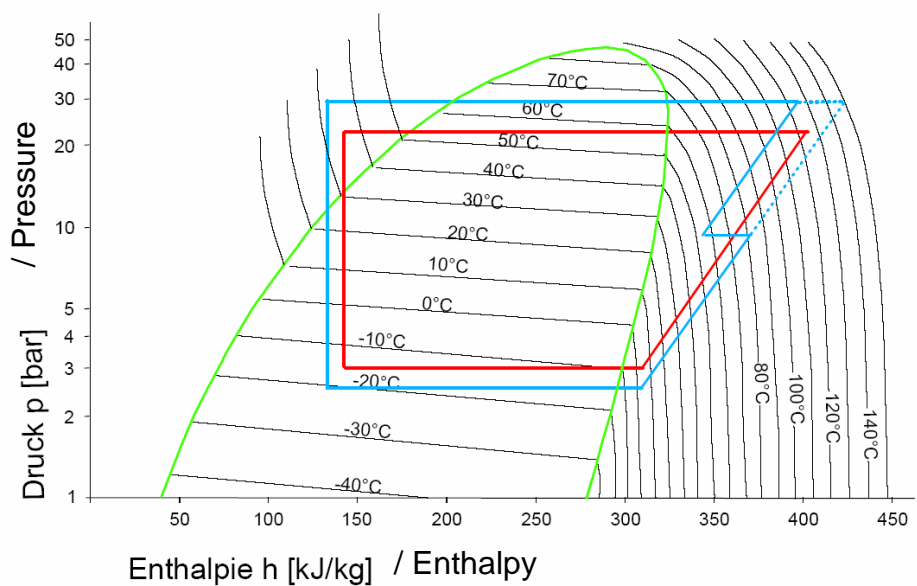


Figure 2. Detailed log p/h –diagram of the refrigerant process with and without EVI.

### Effect on air/water and brine/water heat pumps

The power-characteristic of a classic air/water heat pump has the feature to generate less power with increasing frostiness. That's why the heat pump, chosen at the dimensioning temperature - 12 °C is normally over-dimensioned for the early and post-season. In figure 3. is the new, nearby constant power-characteristic of an air/water heat pump with EVI visible. Beside the higher power is significant, that the classic version can produce at - 15 °C outdoor temperature a flow temperature of max. + 45 °C, meanwhile the EVI-version produces at - 15 °C a flow temperature of max. + 65 °C, see figure 4. With this difference the EVI-cycle gives an impression of its capability.

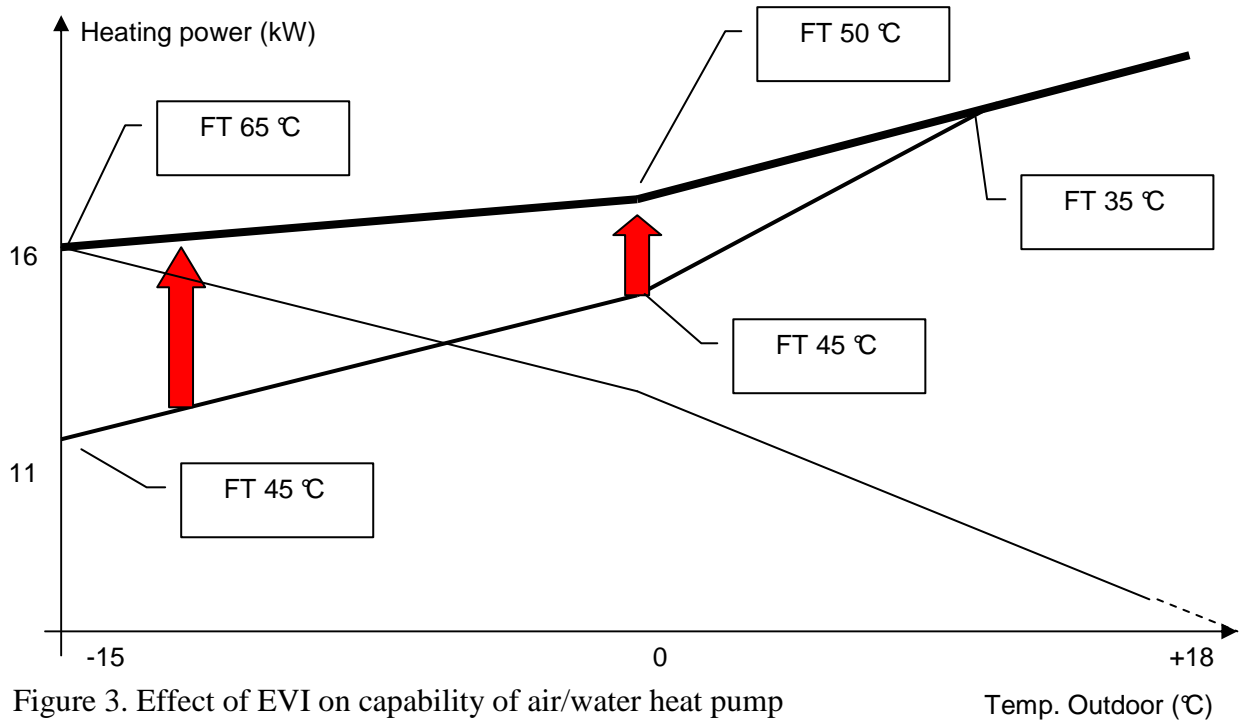


Figure 3. Effect of EVI on capability of air/water heat pump (FT=flow temperature)

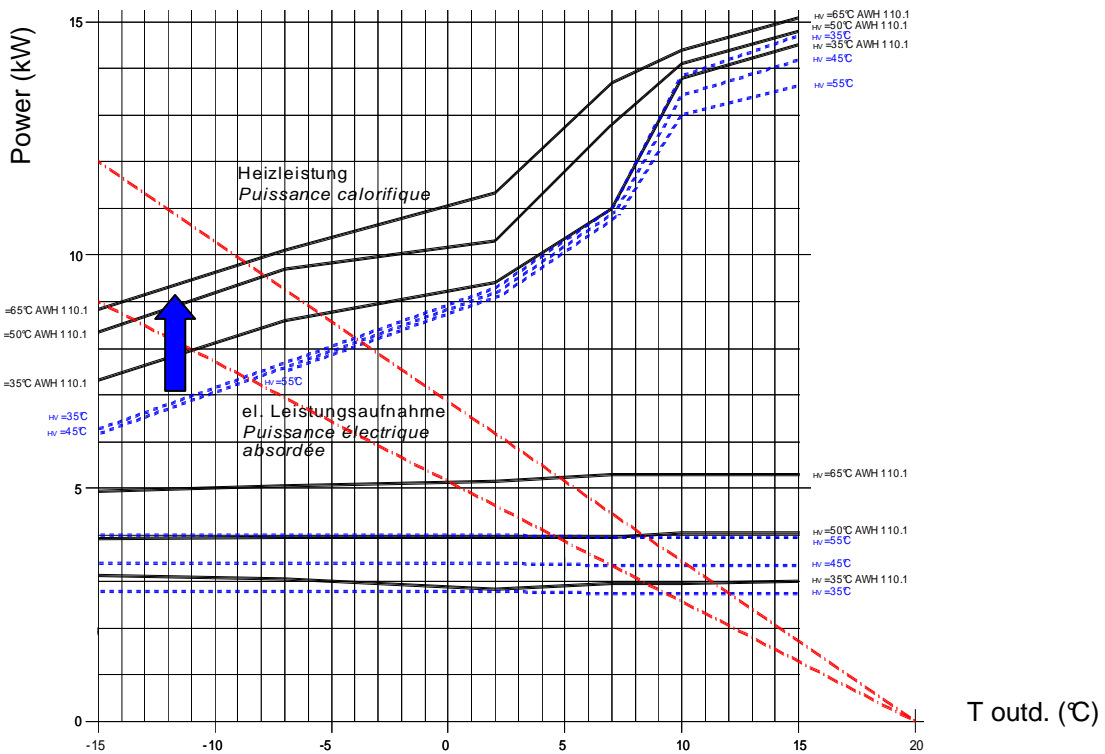


Figure 4. Power-feature of a classic (blue, dashed) and EVI-version (black line) of an air water heat pump AW 110 versus AWH 110

The effect on brine/water heat pumps: no power reduction in high wintertime, when higher flow temperatures are required. For some sizes are in table 1 different situations of brine and flow temperatures with the status of the EVI-activation (turbo on/off) illustrated.

Table 1. Effect of injection on brine/water heat pumps.

Temperature BT/FT (°C) BT=brine temperature, FT=flow temperature	0/35	2/55	0/65
Heating power BWH 110 (kW)	11.0	13.2	12.8
Heating power BWH 120 (kW)	22.9	23.9	22.9
Heating power BWH 240 (kW)	45.8	47.8	45.8
EVI (Turbo)	off	on	On

### Application of EVI-heat pumps

Applying such heat pumps in the replacement market needs some basic rules to follow.

- The power of the heat pump must not be those of the standard point (e.g. + 2/+ 35 °C according to EN 255 / 14511) but of the point of application, for example - 10/ + 65 °C. Looking at figure 4, it makes a difference of 0.4 kW.
- For heating with radiators a buffer tank is mandatory (25 – 50 Liters/kW<sub>th</sub>).
- For hot water production the heat exchanger must be well calculated to reach the highest possible temperature of domestic hot water.
- If the lowest temperature goes in wintertime under - 15 °C, a direct electric heating cartridge must be applied for air/water heat pumps in the buffer tank. Reason: - 15 °C is normally the lowest usable outdoor temperature for air water heat pumps.

More details are visible in the hydraulic systems for air/water and brine/water heat pumps.

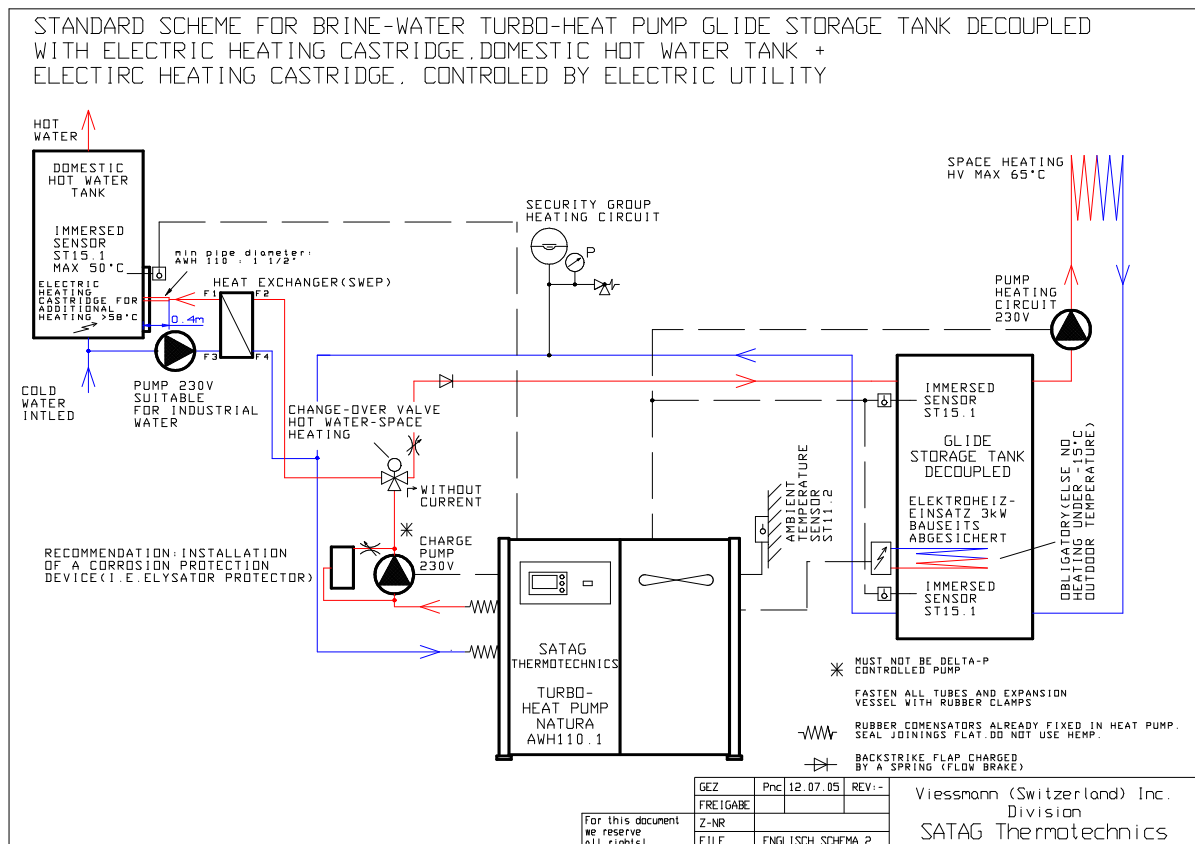


Figure 5. Basic hydraulic scheme for an air/water heat pump with EVI

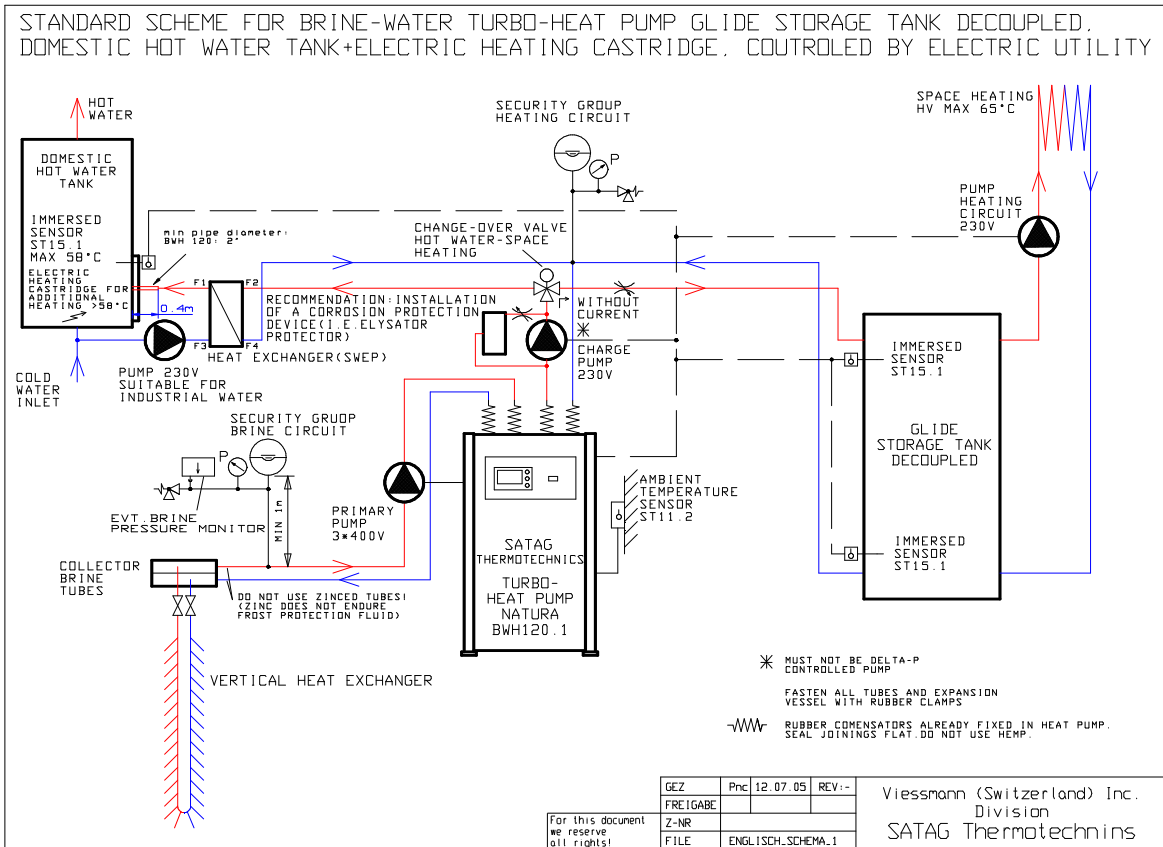


Figure 6. Basic hydraulic scheme for a brine/water heat pump with EVI

### Best practice: examples

Since end of 2001 heat pumps with EVI-cycles are in operation. In the following four examples are given.

1. Farmhouse, 17th century, replacement of single room wood stoves by air/water EVI-heat pump AWH 110. New heating system: radiators with max. flow temperature + 60 °C. Heating power demand ca. 6.5 kW.
2. Private home, year of construction 1958, replacement of direct electric heating by air/water EVI-heat pump AWH 110. Heating demand 9.2 kW. New heating system with radiators, max. flow temperature + 60 °C.



- Private home: Year of construction 1981. Heating system: radiators, replacement of oil boiler by ground coupled EVI-heat pump, heating power 11.0 kW. Max. flow temperature + 60 °C for heating, + 65 °C for domestic hot water.

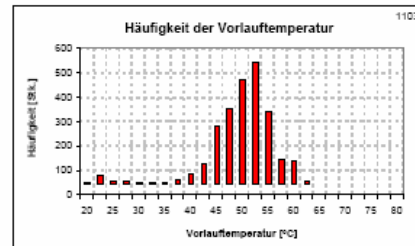
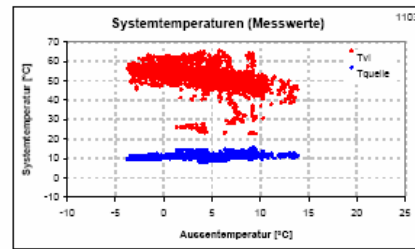
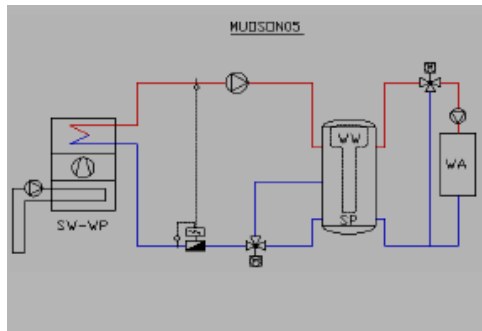


Figure 7. System temperatures, frequency of flow temperatures (source FAWA)

- Trade building: Replacement of oil boilers by two ground coupled EVI-heat pumps. Heating system: radiators and floor heating with max. flow temperature + 60 °C, heating power 45.8 kW, two BWH 210 (right photo).



## Conclusions

EVI, enhanced vapour injection, works like a “Turbo” in a car. It increases the heating power, when it is needed: in wintertime and for domestic hot water production, when high flow temperatures are required. EVI-cycles widen the application of heat pumps from new constructions to the replacement market. Furthermore, EVI-cycle heat pumps allow changing to heating with renewable energy from the environment also in existing buildings.

## References

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