HEAT PUMPS

NET4ENERGY

17th March 2021

Partners

Hungary Slovakia Romania Ukraine

NET4SENERGY

Heat pumps

History of heat pumps

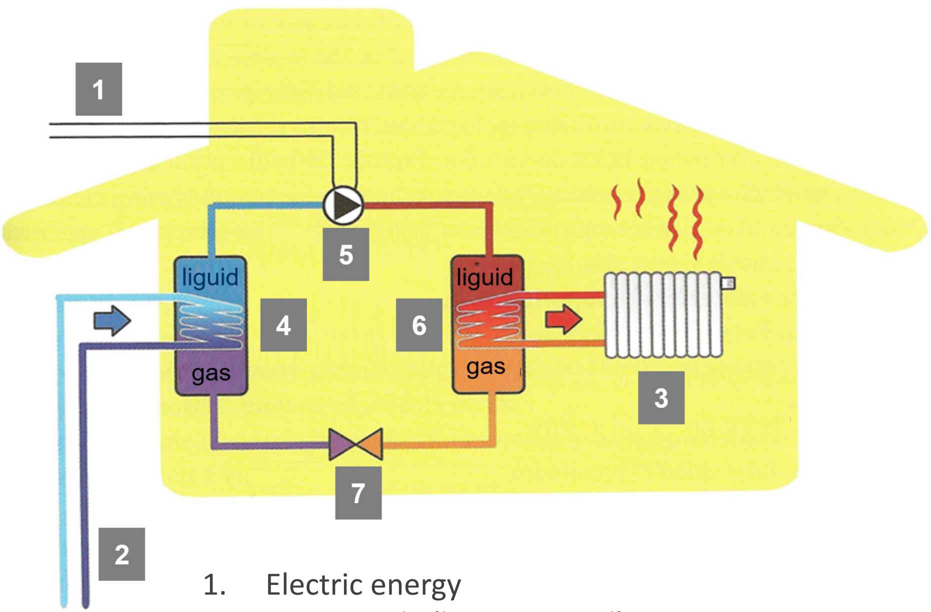
prof. Ing. **Aurel Stodola**, Dr. h. c.

(* 11th May 1859, Liptovský Mikuláš – SLOVAKIA
† 25th December 1942, Zürich, Switzerland)

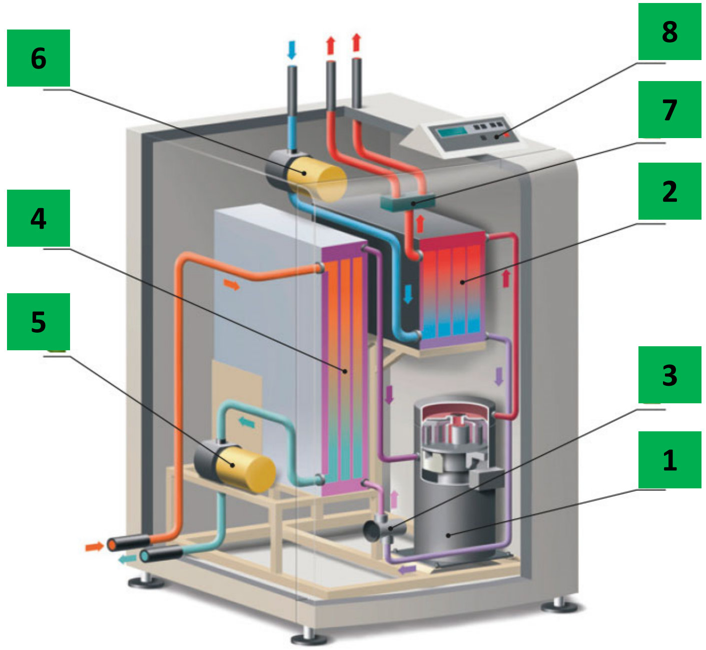
He was the designer of the first heat pump. His heat pump from 1928 still works in Switzerland and heats the town hall in Geneva with heat removal from the lake water (it is a closed circuit).

Heat pumps

Principle of heat pump operation



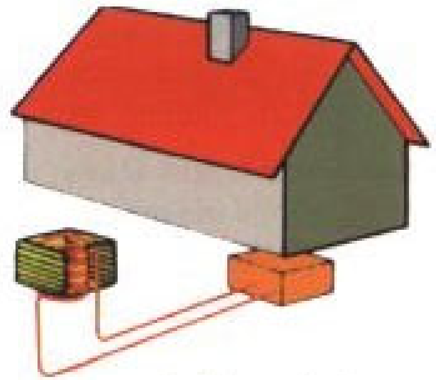
1. Electric energy
2. Heat supply (low potential)
3. Heat transfer (high potential)
4. Evaporator (source circuit plate heat exchanger)
5. Compressor
6. Capacitor (plate heat exchanger heating circuit)
7. Expansion valve



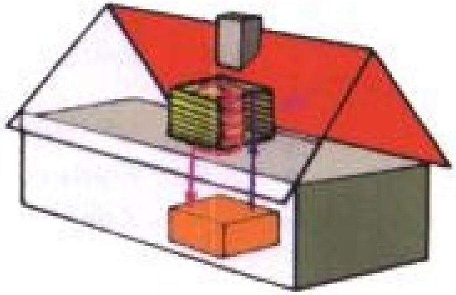
1. Compressor
2. Capacitor (plate heat exchanger heating circuit)
3. Expansion valve
4. Evaporator (source circuit plate heat exchanger)
5. Circulation pump (source circuit)
6. Heating circuit pump
7. Switching valve (heating/domestic hot water)
8. Control panel

Heat pumps

Possibilities of obtaining low-potential heat

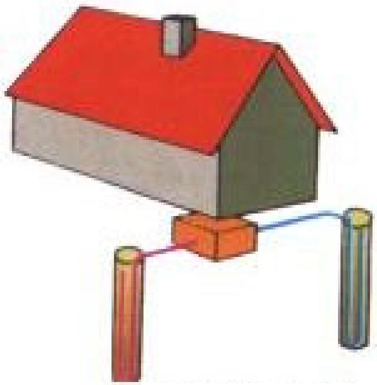


AMBIENT AIR

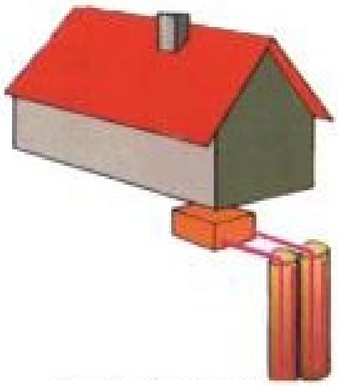


EXHAUST AIR

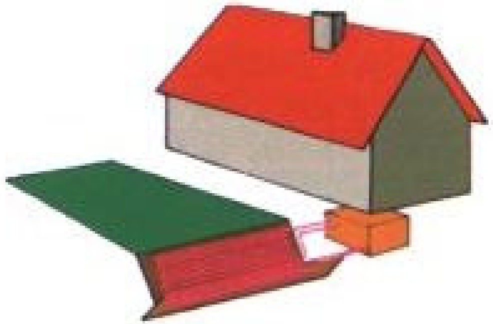
SOIL



TWO WELLS



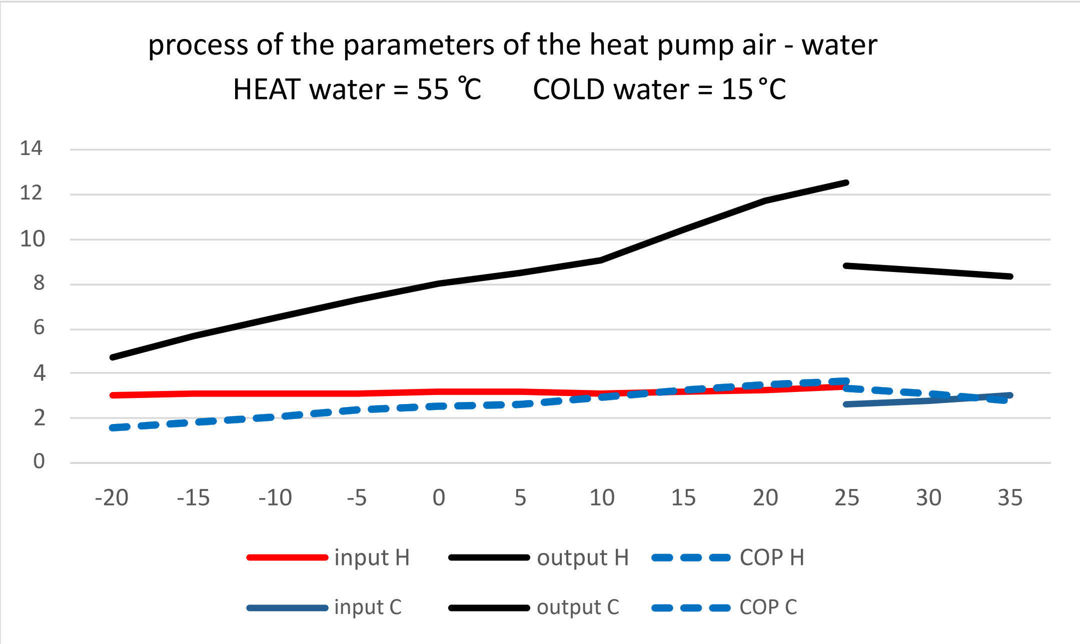
DRY WELL



SURFACE WATER

Heat pumps

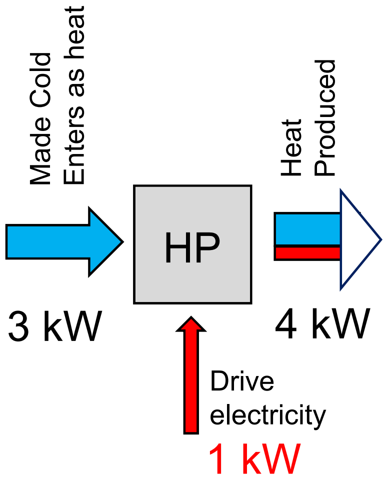
Energy efficiency of a heat pump



COP = coefficient of performance

In heat transformation, energy efficiency is characterized by coefficient of performance.

$$COP = \frac{\text{obtained thermal energy}}{\text{supplied energy to drive the heat pump}} \quad (-)$$

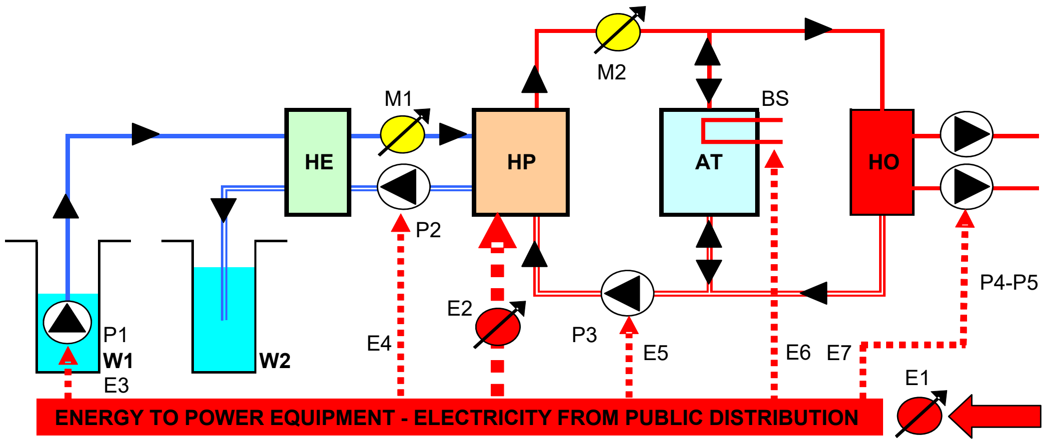


$$\text{COP heating} = \frac{4}{1} = 4$$

$$\text{COP cooling} = \frac{3}{1} = 3$$

$$\text{COP h+c} = \frac{4+3}{1} = 7$$

Energy efficiency of a heat pump



LEGEND :

HE	HEAT EXCHANGER	**BS**	BIVALENT / BACKUP HEAT SOURCE
HP	HEAT PUMP WATER / WATER	**W1-2**	SOURCE SOURCE / INTAKE WELL
M1-2	THERMOMETER	**HE**	HEAT EXCHANGER
E1-2	ELECTRICITY METER	**P1**	SUBMERSIBLE PUMP
AT	HEAT ACCUMULATION TANK	**P2-3**	CIRCULATION MACHINE PUMPS
HO	HEATED OBJECT	**P4-5**	CIRCULATING OBJECT PUMPS

$$COP = \frac{M2}{E2} = \frac{M1+E2}{E2}$$

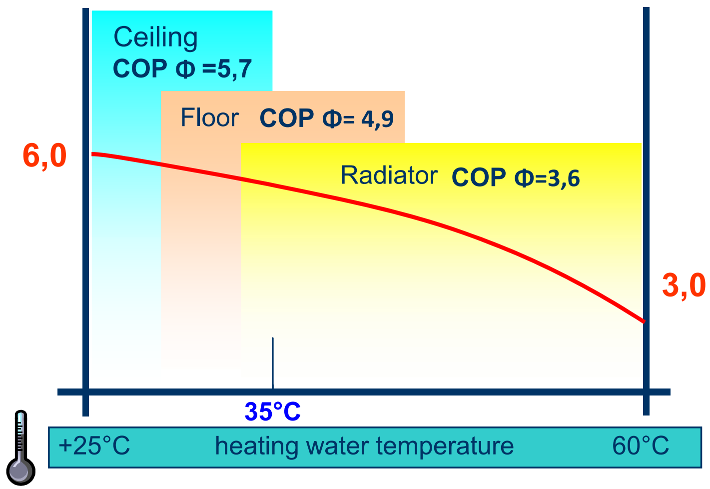
$$SPF = \frac{M2}{E1} = \frac{M2}{E2+E3+E4+E5+E6+E7}$$

SPF = seasonal performance faktor

For the year-round efficiency of the heat pump heat transformation system, energy efficiency is characterized by a seasonal performance factor

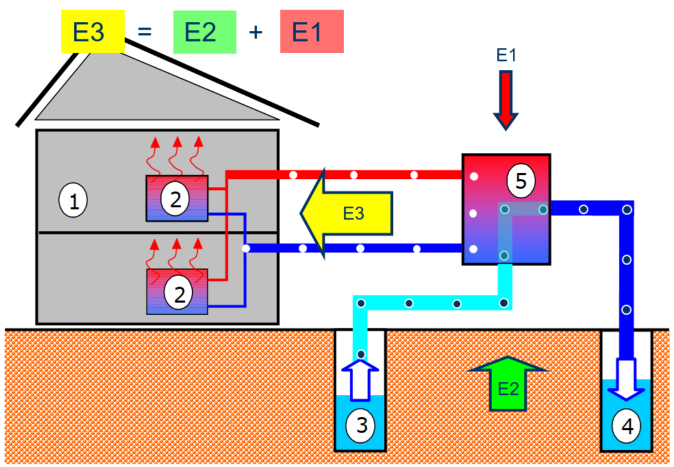
$$\mathbf{SPF} = \frac{\text{obtained thermal energy}}{\text{supplied energy for the propulsion, production and distribution of heat}} \quad (-)$$

Influence of the heating system on the average COP of the heat pump



Heat pumps

HEATING radiators

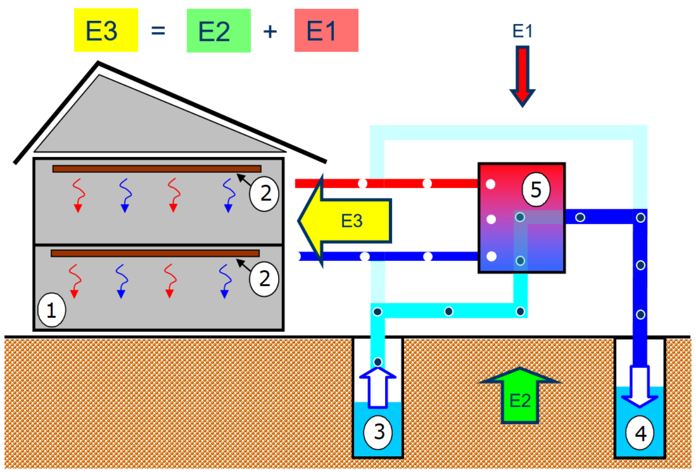


$$SPF = \frac{E3}{E1} = \text{cca } \mathbf{3{,}1}$$

LEGEND :

1 BUILDING - **HEATING**
2 RADIATORS
3 SUCTION WELL (source of heat and cold)
4 INFILTRATION WELL
5 **HEAT PUMP** WATER-WATER - heat source

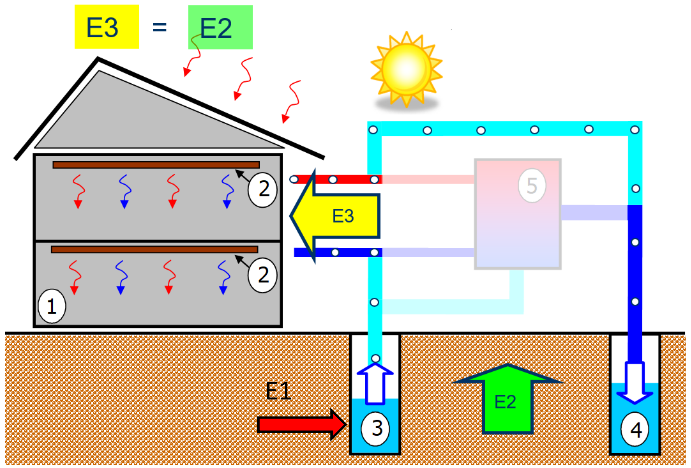
HEATING
ceiling radiant system



$$SPF = \frac{E3}{E1} = \text{cca } \mathbf{4{,}5}$$

SPF = seasonal performance faktor
E1 total supplied electricity for propulsion
E2 heat obtained from the well
E3 heat produced - delivered to the building

PASIVE COOLING
ceiling radiant system



$$SPF = \frac{E3}{E1} = \text{cca } \mathbf{7 - 10}$$

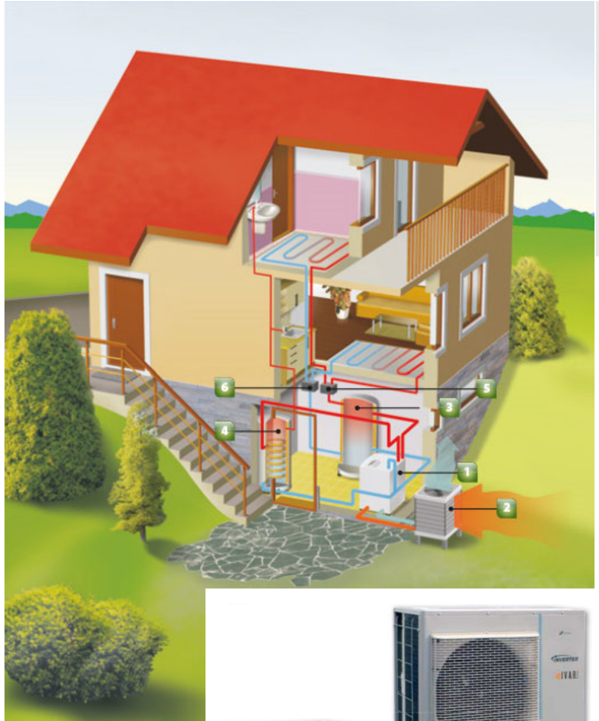
LEGEND :

1 BUILDING - **HEATING** / **COOLING**
2 CEILING RADIANT SYSTEM
3 SUCTION WELL (source of heat and cold)
4 INFILTRATION WELL
5 **HEAT PUMP** WATER-WATER - heat source

Heat pumps

Types of air heat pumps

SPLIT



1. Heat pump
2. Separate air evaporator
3. Heat storage tank for heating
4. Hot water tank
5. Distributor of floor heating
6. Collector of underfloor heating

SOURCE - AIR

- Original heat pumps under -7°C did not heat current until -20°C
- After 3500 m^3/h freezing occurs (cca 6 – 8 minutes the defrost heat is turned – condensate drain = 30 - 100 liters/day)
- Suitable for solution via accumulation tanks
- Sensitive to accumulation tank size (the size of the accumulation tank affects the switching of the heat pump) – lifetime of the heat pump

COMPACT

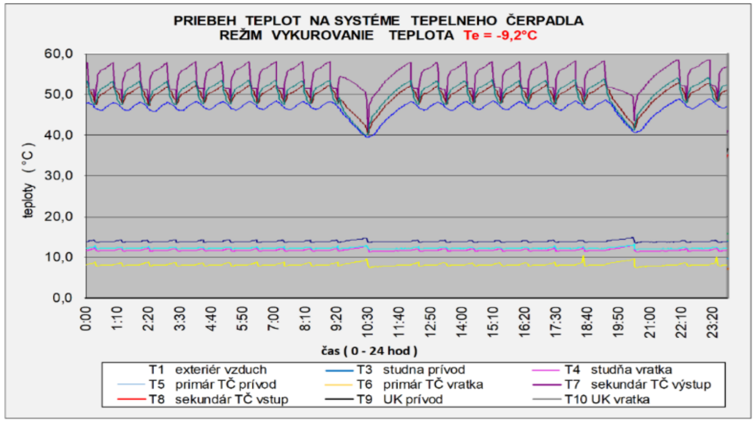
1. Compact heat pump air/water
2. Heat storage tank for heating
3. Hot water tank
4. Distributor of floor heating
5. Collector of underfloor heating

Heat pump

Types of water heat pumps

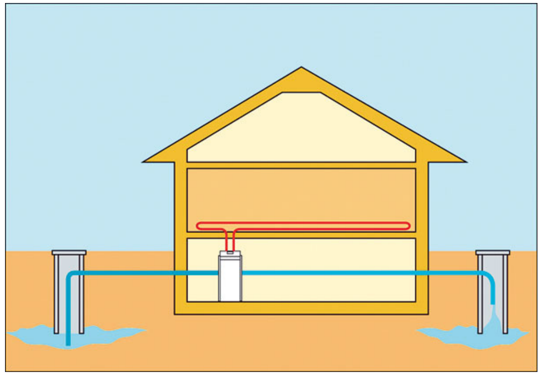
Water / Water from well

1. Heat pump
2. Source well with submersible pump
3. Suction well
4. Heat storage tank for heating
5. Hot water tank
6. Distributor of floor heating
7. Collector of underfloor heating



SOURCE - WELL
MOST BENEFICIAL OPERATION

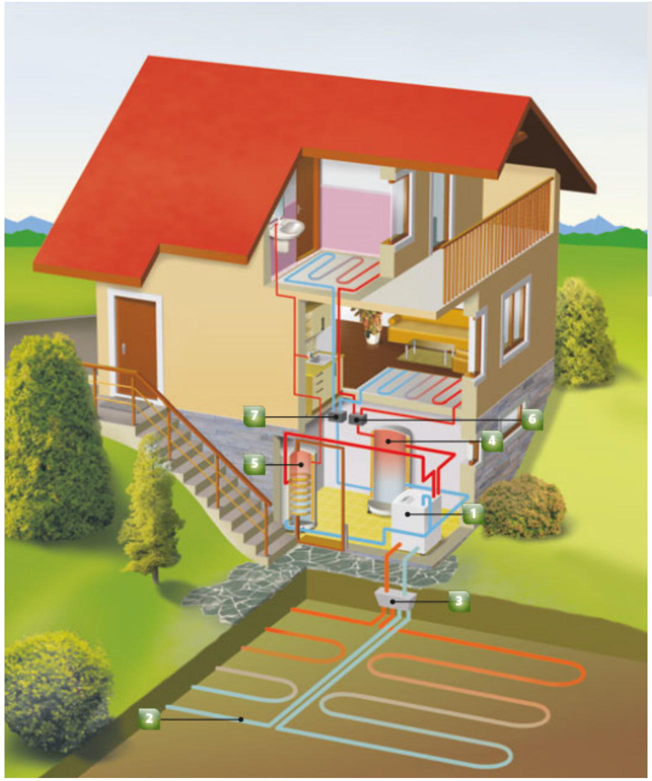
- COVERAGE OF WATER 3-5 m^3/hour for 10 – 15 kW (pumping test 1 month,...) we must return the water
- WATER TEMPERATURE cca 10°C usability up to +7°C and is blocked at +5°C
- WATER COMPOSITION (chemicals must not be flocculated in the water)



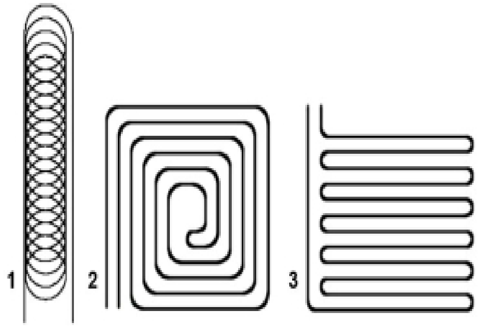
Heat pumps

Types of ground source heat pumps

Flat ground collector



1. Heat pump
2. Flat ground collector
3. Distributor and collector of ground collector
4. Heat storage tank for heating
5. Hot water tank
6. Distributor of floor heating
7. Collector of underfloor heating



1. Slinka
2. Špirálové uloženie
3. Meander

SOURCE - FLAT GROUND COLLECTOR

- LAYING DEPTH 1,2 – 1,5 m
- WITHDRAWAL OF PIPES 0,5 – 1,0 m
- HIGH PUMPING WORK loop max. 150 m
- IMPROPER INSTALLATION REDUCES EFFICIENCY
- CONNECTION TO CIRCUITS inlet – return = MORE CIRCUITS
- DEEP ROOT PLANTS DO NOT GROW – trees
- THE VEGETATION PERIOD IS MOVED BY cca 2 months
- SPECIFIC SOIL POWER:
  spacing 0,6 – 1,0 m depth 1,2 – 1,5 m lenght 100 m
  cca 20 W/m^2
  Dry sandy soil
  Do not place under the object

Heat pumps

Types of ground source heat pumps

Dry well

1. Heat pump
2. Dry well
3. Heat storage tank for heating
4. Hot water tank
5. Distributor of floor heating
6. Collector of underfloor heating

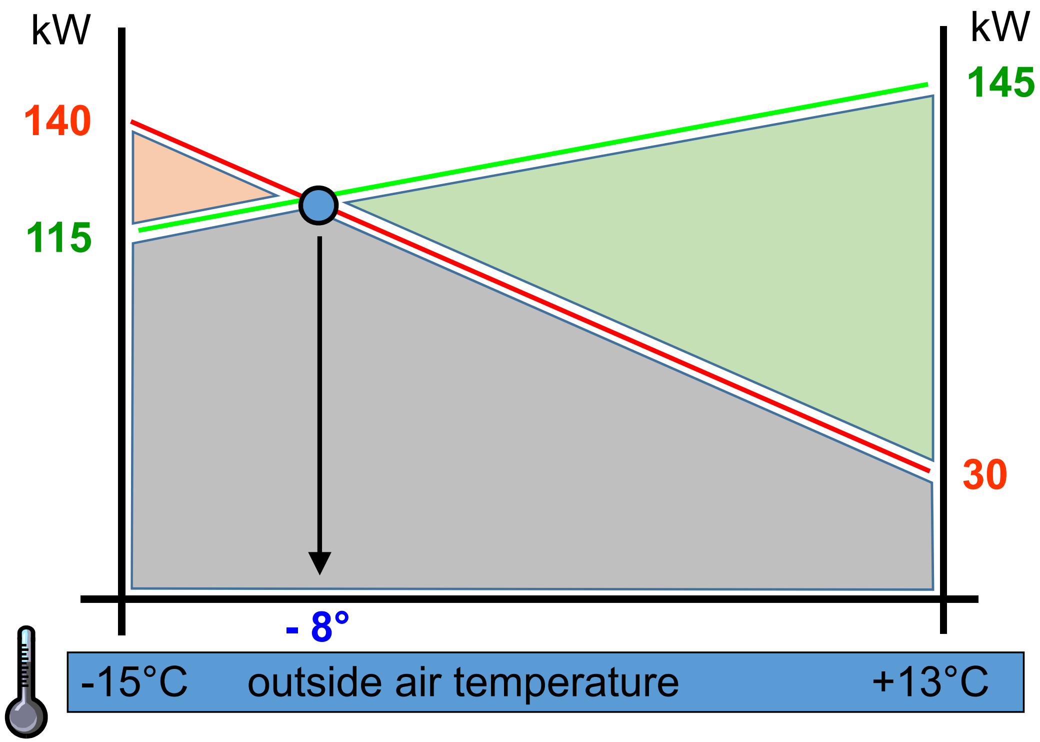
SOURCE - DRY WELL

- DO NOT DRILL UNDER THE OBJECT distance of at least 2 m due to pressurized water
  15 m underground is no longer affected by surface temperature
- DRILL SPACING is about 10% of their depth (the problem of drilling vertically the possibility of crossing drills,...)
- Optimal drilling depth 100-120 m (deeper drilling has larger pumping works)
- The specific power of the drill is cca 55 W/m
- Possibility to use the dry well for cooling in summer
  Groundwater dew point problem= 12°C (EXAMPLE room 25°C humidity 60% = dew point cca 15°C)
  Difference max 6°C between air and ceiling temperature
- Heating DHW takes cca 1 hour when the HEATING or COOLING is stopped
- Cooling capacity is cca 1/3 from heat losses

Heat pumps

Method of designing heat pumps

The course of heat losses of the building and the course of heat pump output



The course of heat loss of the object

The performance course of the heat pump

Energy supplied by the heat pump

Energy missing = supplied by a bivalent source

Excess energy = possibility of delivery to another point of consumption

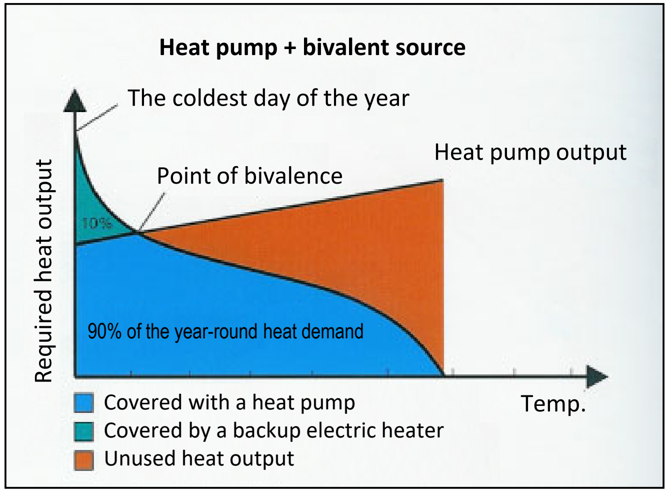
Bivalent point - heat pump output = heat loss of the building

The optimal design of the heat pump is at a bivalence point of approx. -8 ° C

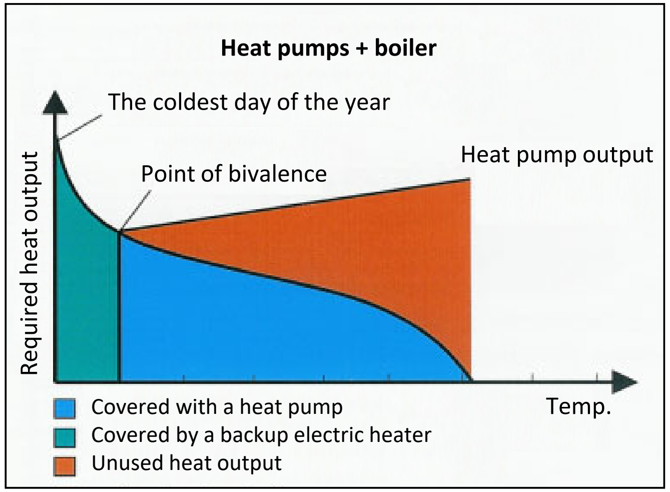
Heat pumps

Method of designing heat pumps – DEMONSTRATION OF SIMULATIONS effect on COP and SPF

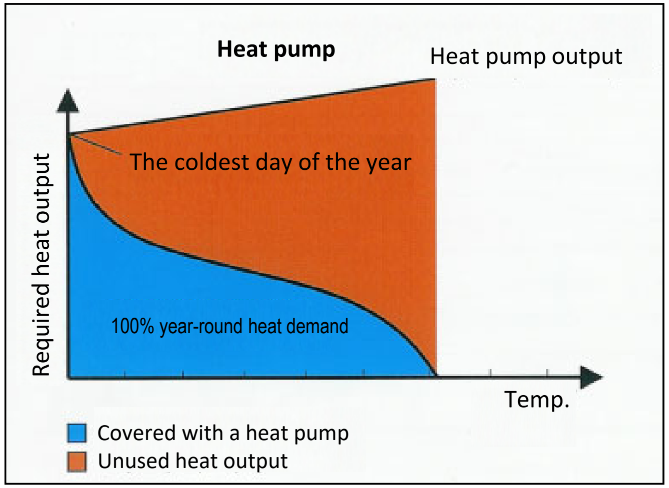
Depending on how the heat pump and bivalent heat source are used



The entire temperature range is provided by the heat pump + the missing power is supplemented by a bivalent heat source



The heat pump provides performance only up to the bivalence point. Below the bivalence point temperature, the entire heating output is provided by the boiler

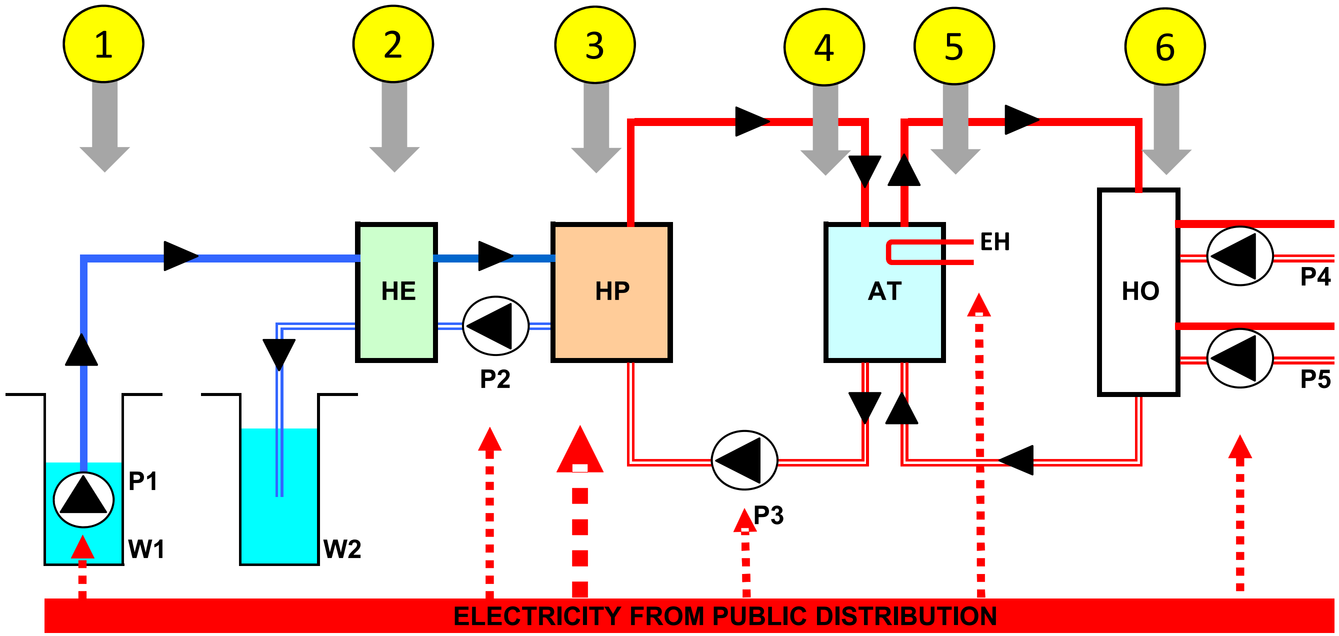


The heat pump provides the entire output without the need for a bivalent heat source

Heat pumps

Principles of design of heat pump system elements that affect SPF

Water/Water from well



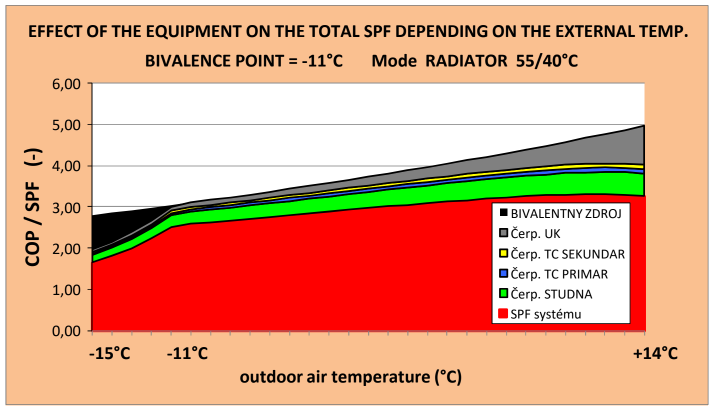
LEGEND :

HE	HEAT EXCHANGER	**W1**	SUCTION WELL (SOURCE)
HP	HEAT PUMP WATER / WATER	**W2**	IMPACT WELL
AT	ACCUMULATION TANK	**P**	PUMP
HO	HEATED OBJECT	**EH**	ELECTRIC HEATER

HEAT PUMP SYSTEM ELEMENTS ASSESSED

DEFINITION OF PRINCIPLES - EXAMPLE OF MEASUREMENTS

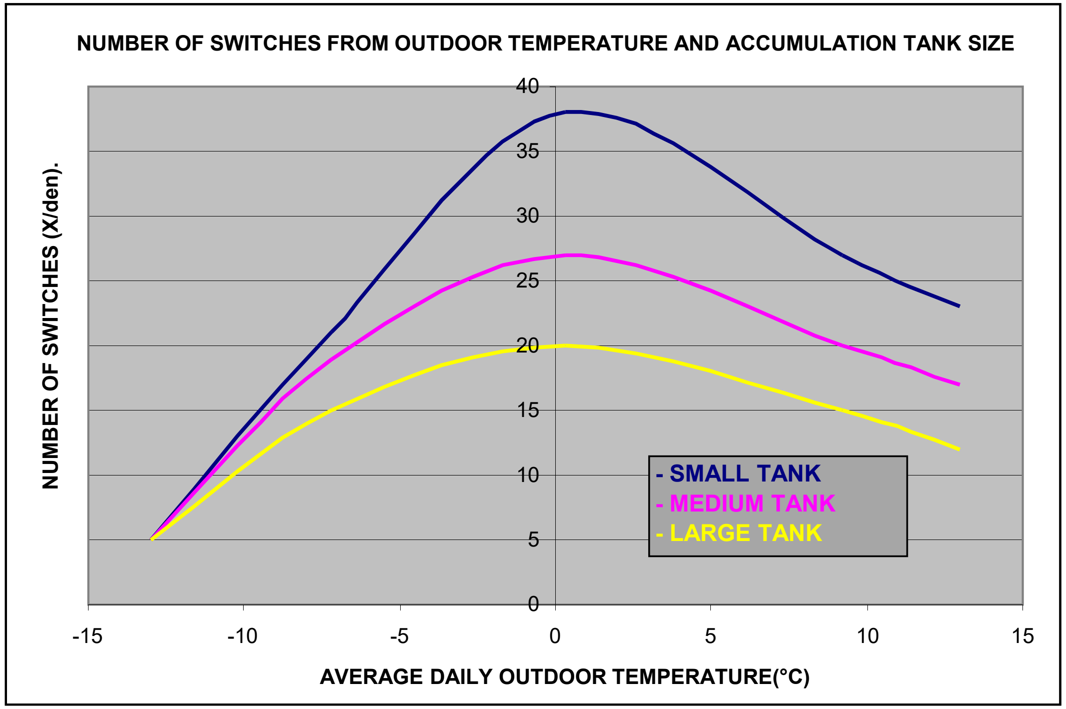
1. Source well with submersible pump
2. Heat exchanger
3. Heat pump
4. Heat storage tank
5. Bivalent heat source
6. Sampling point - heating system



Heat pumps

Energy storage – dependence of the number of switching on the heat pump on the size of the storage tank

Water/Water from well



DEMONSTRATION OF MEASUREMENTS AND SIMULATIONS

1. Heat pump
2. Source well with submersible pump
3. Suction well
4. Heat storage tank for heating
5. Hot water tank
6. Distributor of floor heating
7. Collector of underfloor heating

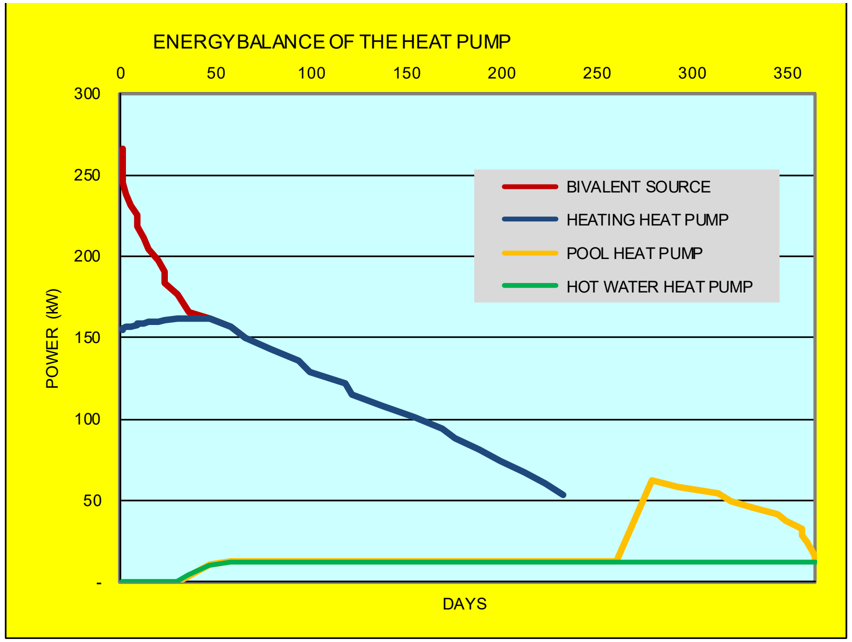
Heat pumps

Energy balance – DEMONSTRATION OF SIMULATIONS

Water/Water from well

Family house

1. Heating 10 kW
2. Domestic hot water 4 persons
3. Outdoor pool 25 m2 operation 90 days



HEATING HEAT	25 605	kWh	77.3%
HEAT WATER HEAT	4 457	kWh	13.4%
MADE HEAT	**33 138**	kWh	100%
HEAT PUMP HEAT	28 621	kWh	86.4%
BIVALENT SOURCE HEAT	1 442	kWh	**4.4%**
TOTAL HEAT	33 138	kWh	100%
ELECTRICITY FOR HEAT PUMP	5 147	kWh	77.9%
. . . FOR SUPPORTING EQUIPMENT	897	kWh	13.6%
. . . FOR BIVALENT SOURCE	1 442	kWh	21.8%
TOTAL ELECTRICITY	**6 610**	kWh	100%

HEATING	COP =	6.05	SPF =	4.16
HOT WATER	COP =	3.72	SPF =	3.30
SYSTEM	COP =	5.56	**SPF =**	**4.02**

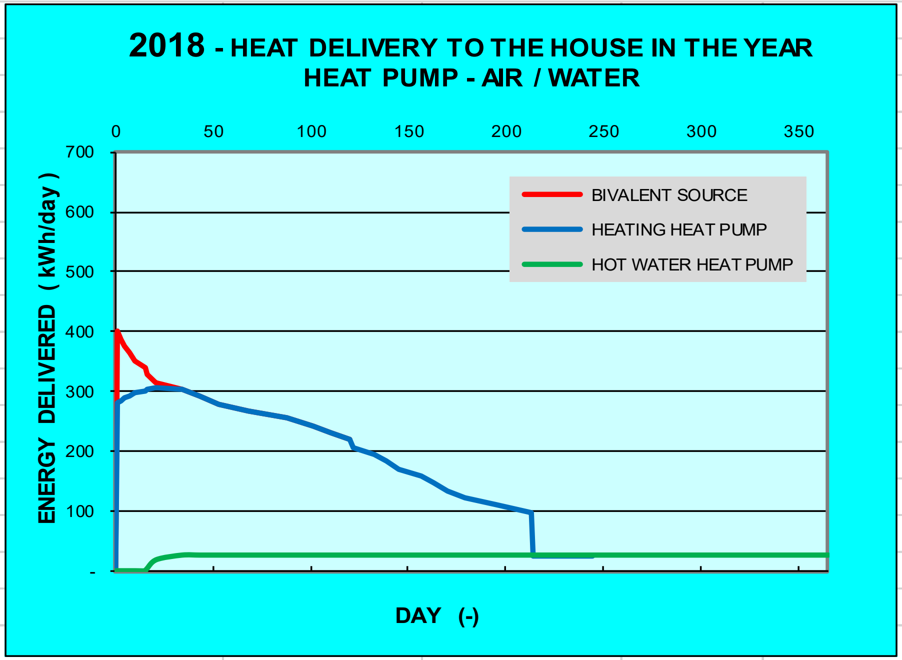
Heat pumps

Energy balance – DEMONSTRATION OF SIMULATIONS

Air/Water

Apartment building

1. Heating 18 kW
2. Domestic hot water - 10 persons



HEATING HEAT	40 593	kWh	80.5%
HEAT WATER HEAT	9 833	kWh	19.5%
MADE HEAT	**50 426**	kWh	100%
HEAT PUMP HEAT	49 366	kWh	97.9%
BIVALENT SOURCE HEAT	1 059	kWh	**2.1%**
TOTAL HEAT	50 426	kWh	100%
ELECTRICITY FOR HEAT PUMP	16 094	kWh	93.8%
. . . FOR SUPPORTING EQUIPMENT	0	kWh	0.0%
. . . FOR BIVALENT SOURCE	1 059	kWh	6.2%
TOTAL ELECTRICITY	**17 153**	kWh	100%

HEATING	COP =	3.04	SPF =	2.91
HOT WATER	COP =	3.18	SPF =	2.74
SYSTEM	COP =	0.00	**SPF =**	**2.94**

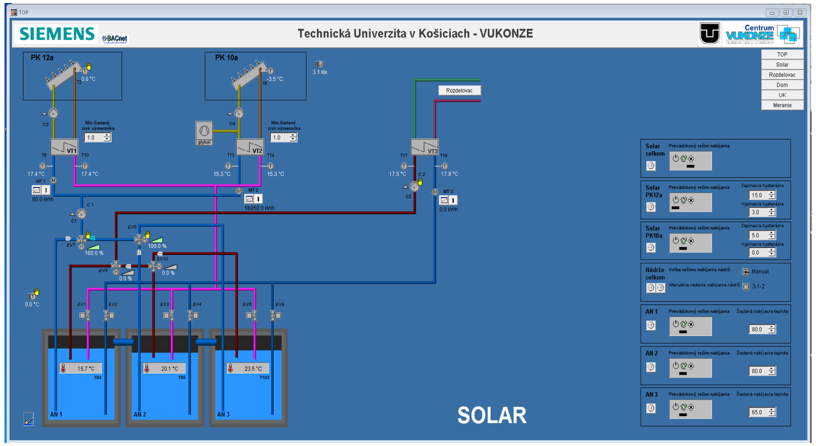
NESICA

Main activities of the project – Slovakia - excursions

Centrum VUKONZE
TECHNICKÁ UNIVERZITA V KOŠICIACH

EcoPoint
OFFICE CENTER KOŠICE

UVP TECHNICOM



VUKONZE
- Hot water solar collectors
- Long-term accumulation of energy in water
- Photovoltaic panels
- Accumulation of electrical energy in batteries

EcoPoint
- Deep earth drilling
- Long-term accumulation of energy in the ground
- Heat - Cold – heat pump, accumulating concrete core (heating/cooling)

TECHNIKOM
- Wells – active and passive cooling, heat pumps, energy recovery by heat pumps

Thank you for your attention