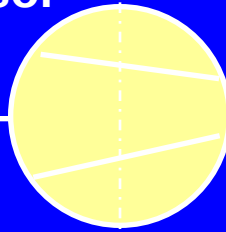


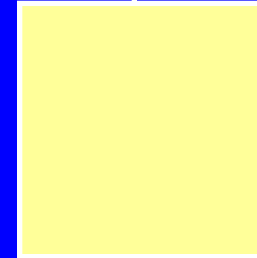
Heat Pumps

Technology and Application

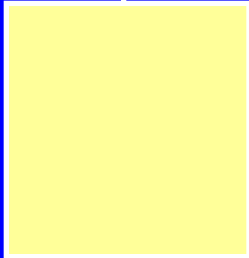
Compressor



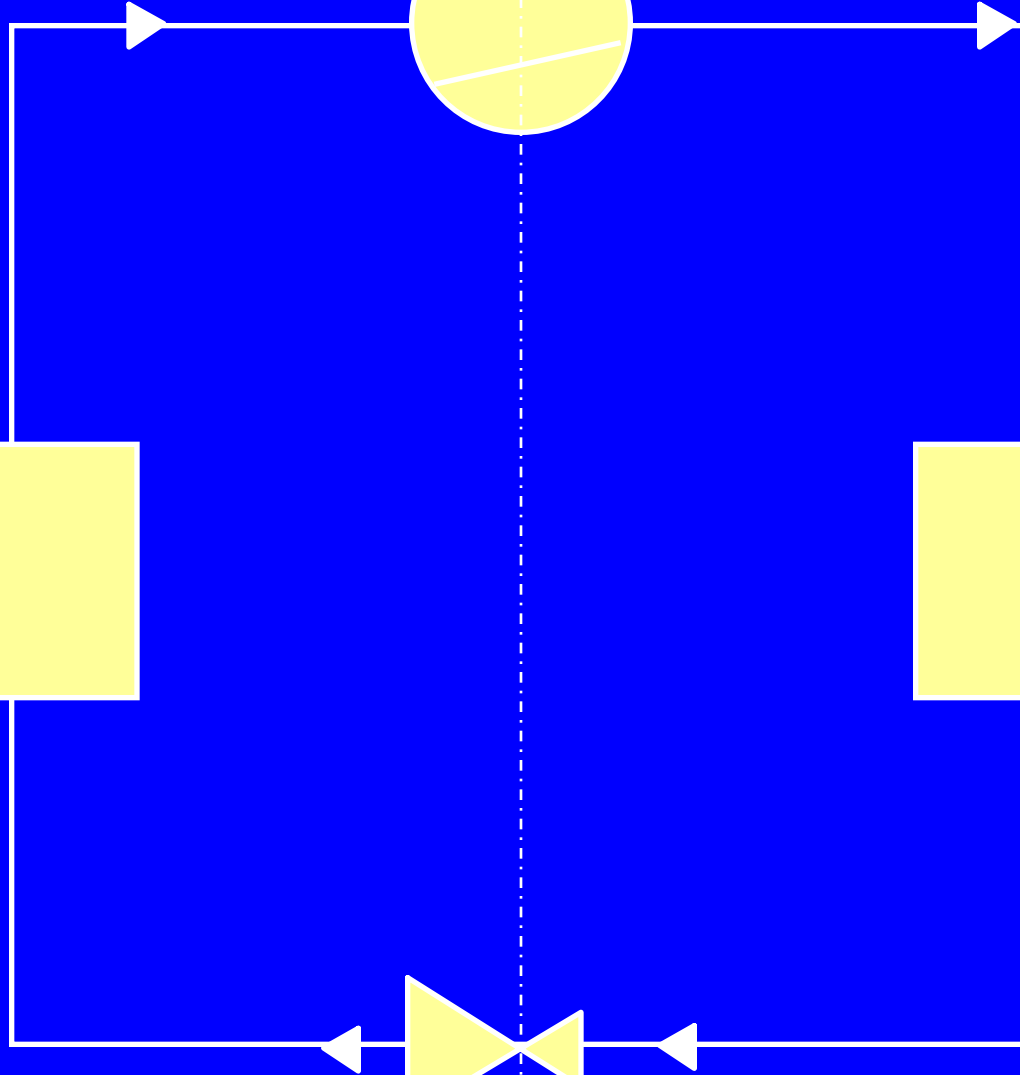
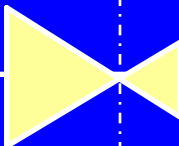
Condenser



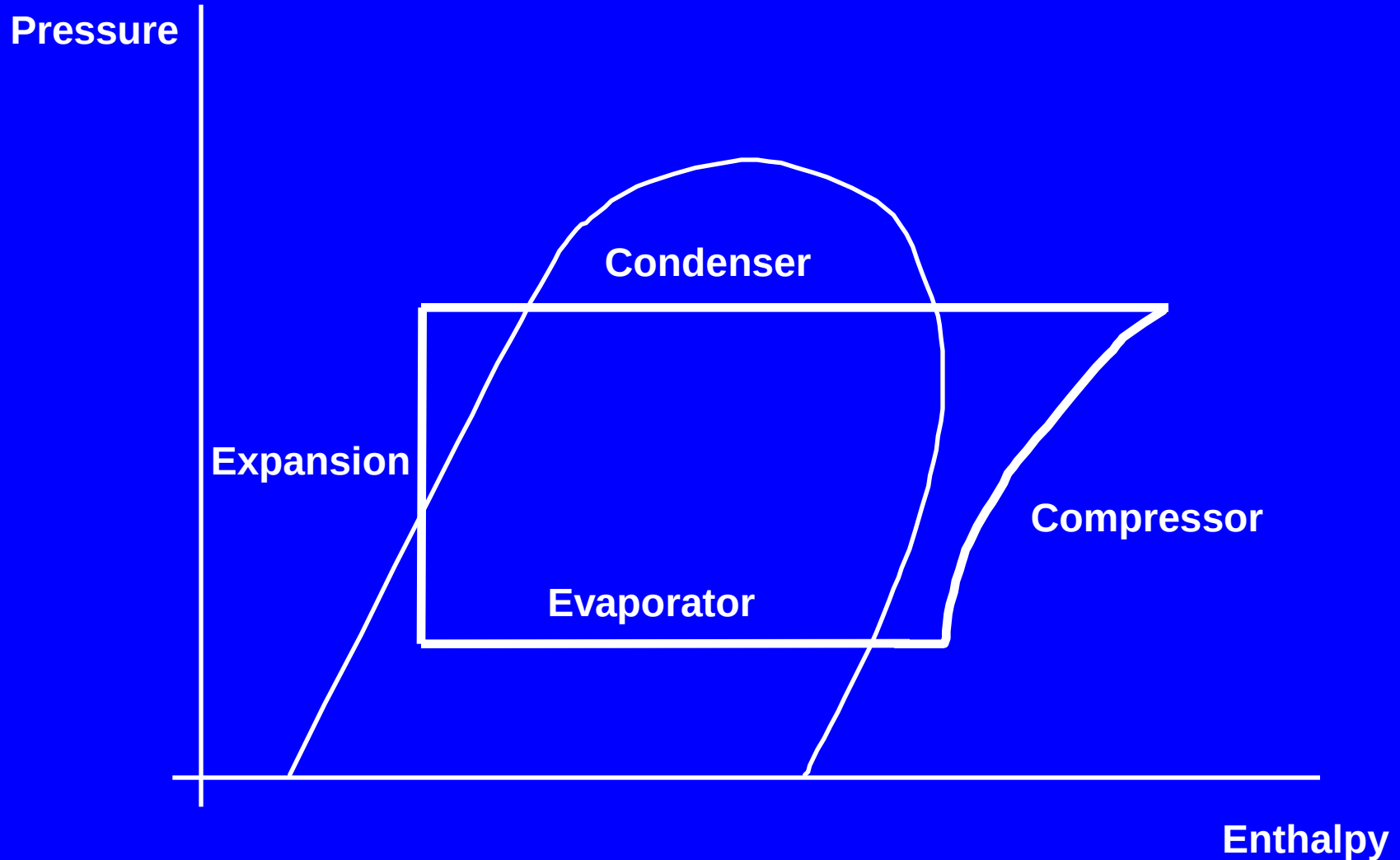
Evaporator



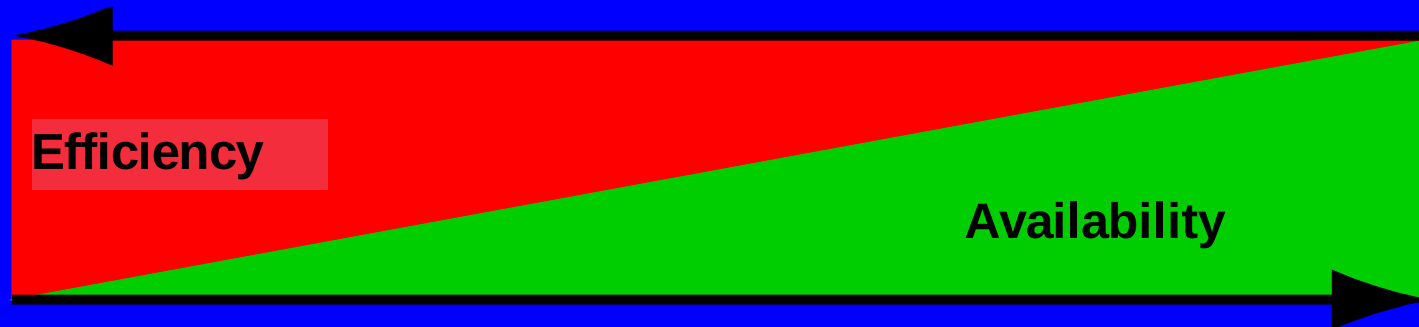
Expansion Device



Vapour Compression Cycle



Efficiency & Availability of Heat Sources



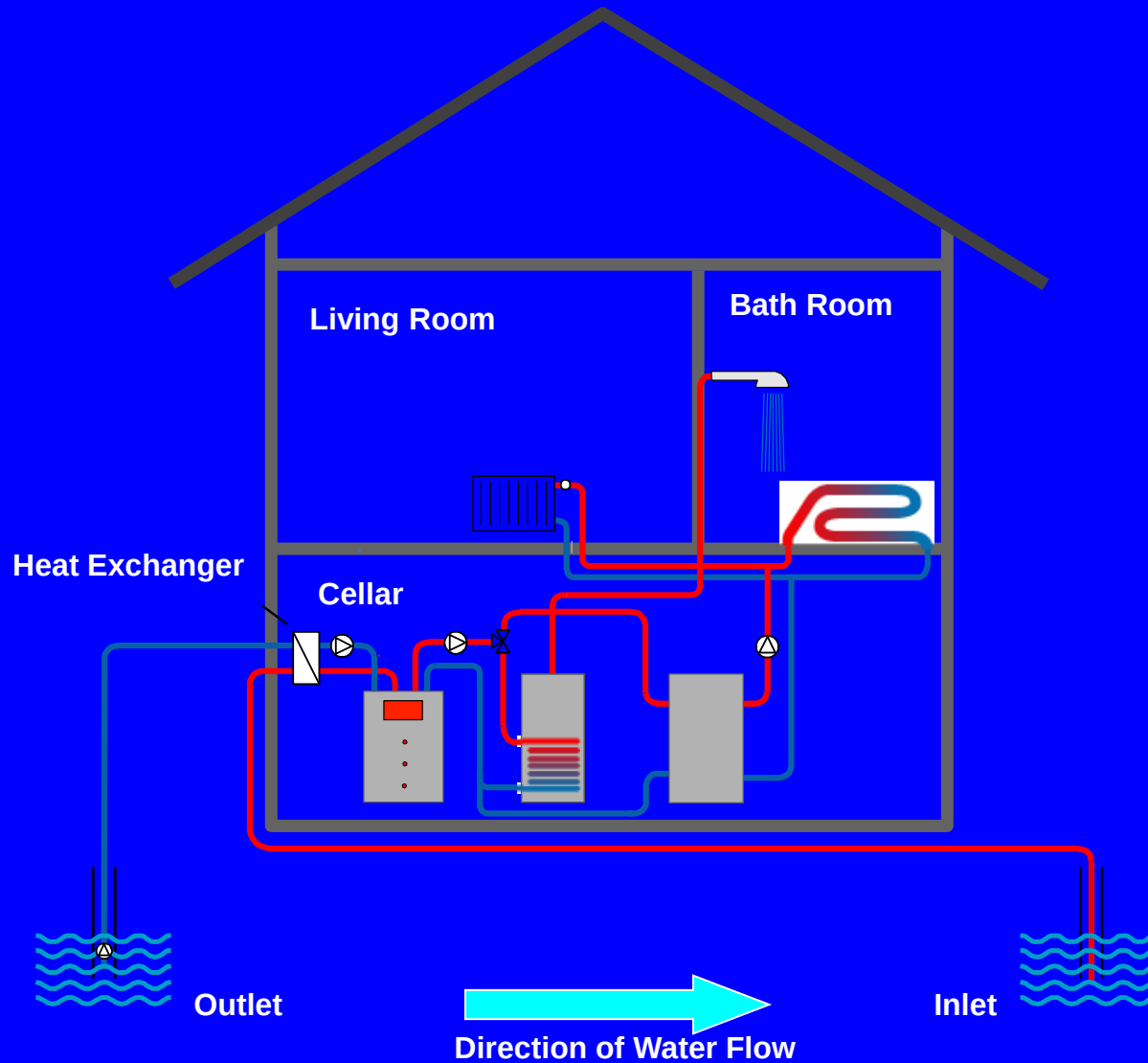
Absorbers

**Ground
Water**

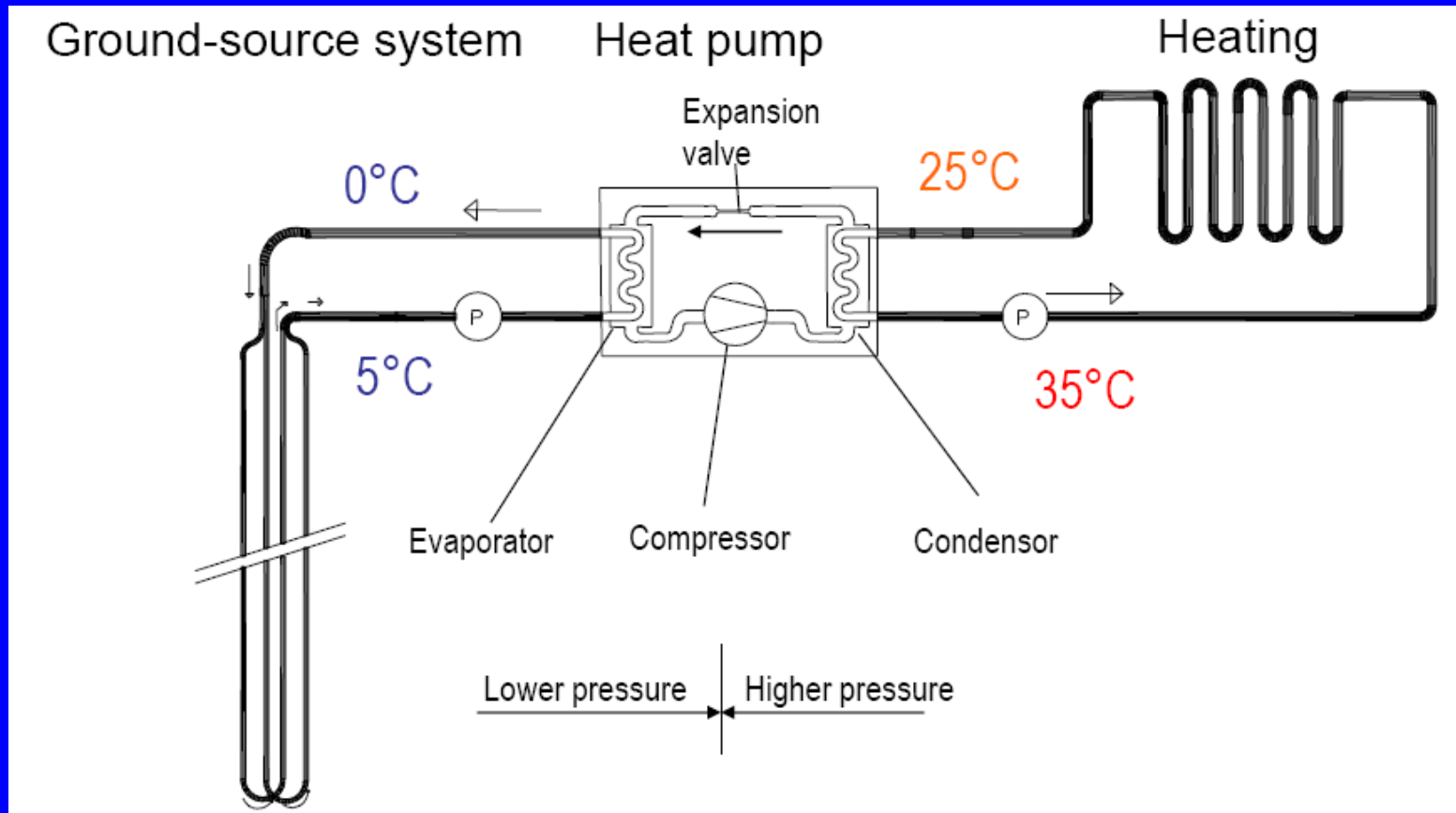
Ground

Air

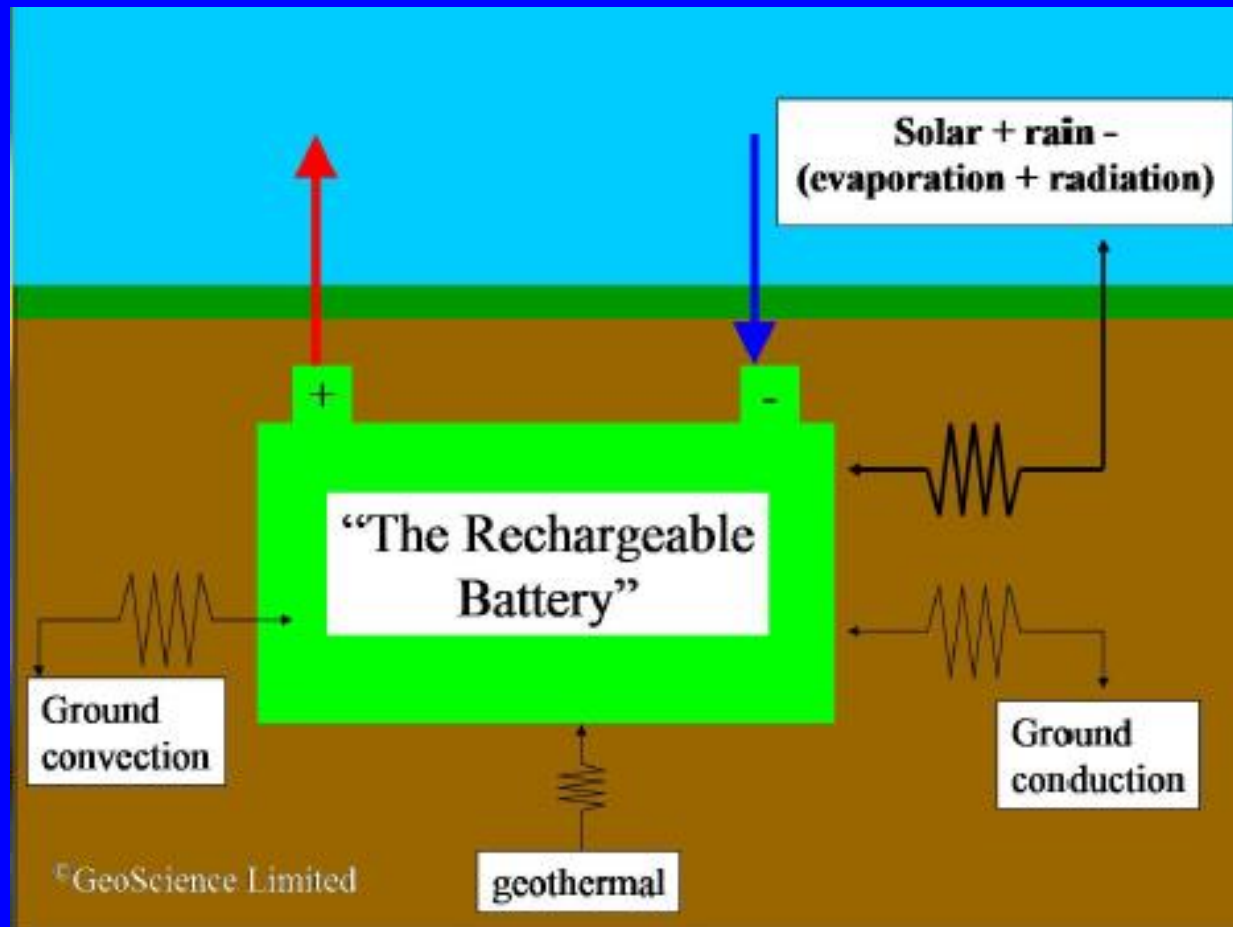
Water Source Schematic



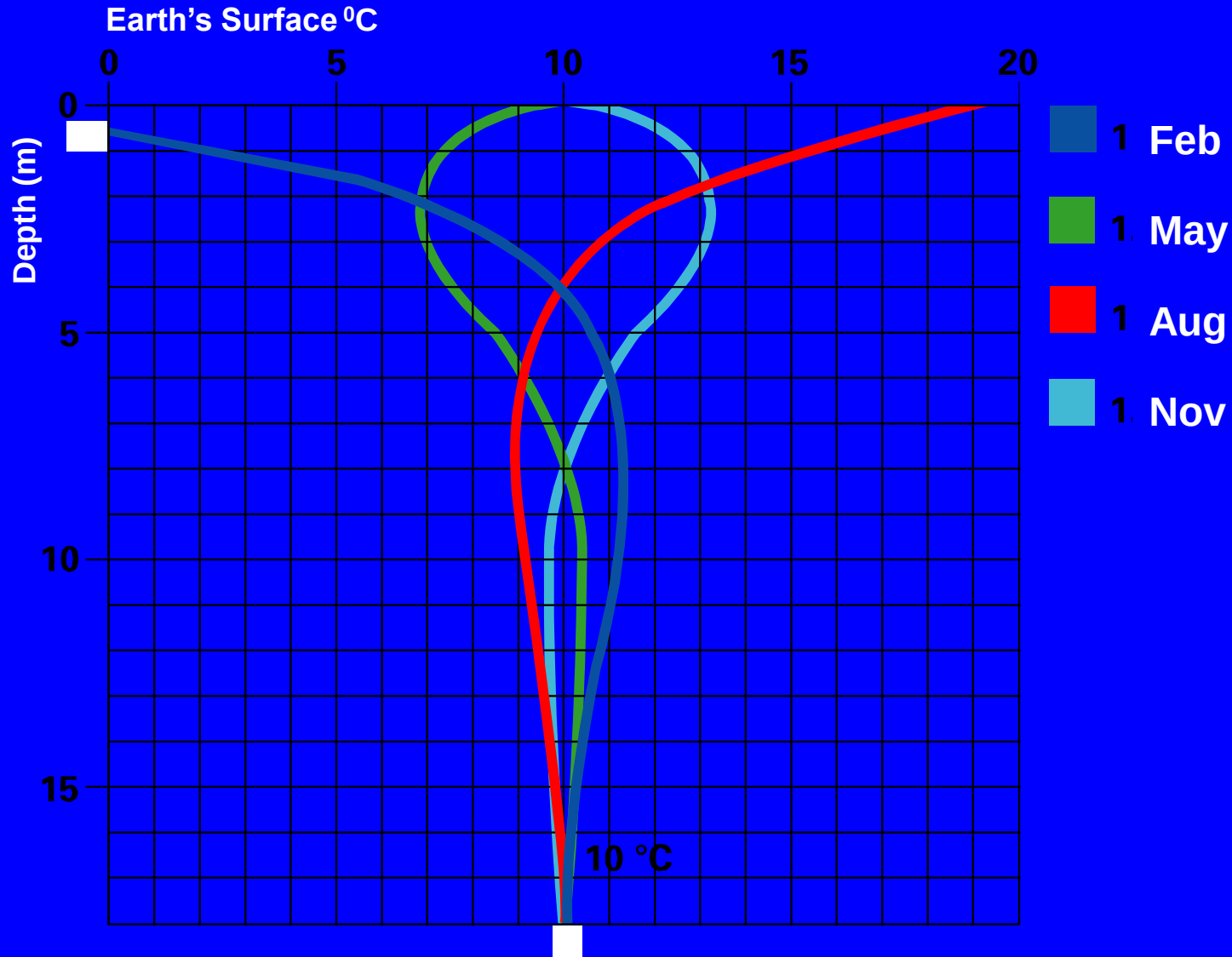
Ground Source Heat pump



Energy “Collection”



Yearly Temperature Differential in Undisturbed Ground



Installing the Ground Probe



Installing the Ground Probe



Typical UK Heat Pump Installation



Trench with installed Ground Loops



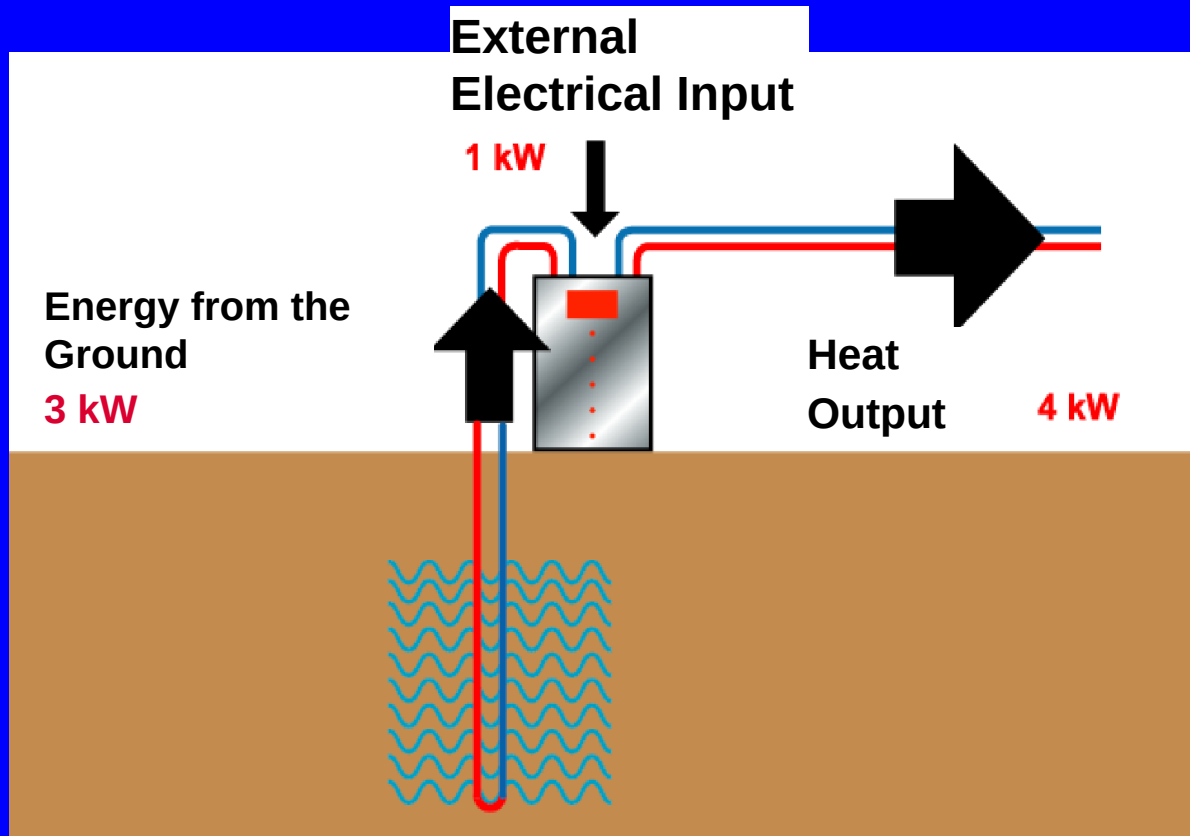
Why Ground Source? Benefits:

- ✦ Continuous & reliable access to the ground's constant temperature 8° – 13°C
- ✦ Works night & day, all year, in all weathers
- ✦ Renewable energy – ownership
- ✦ Sustainable – long term
- ✦ Ideally suited for space heating
- ✦ Uses proven technology
- ✦ Economics: Low Energy Buildings

Benefits: CO₂ Reductions

- ✦ Installing GSHP results in a dramatic reduction in CO₂ emissions of up to 60% (Compared to a modern condensing gas boiler)
- ✦ Using green, renewable electricity will give zero emissions – 0% CO₂

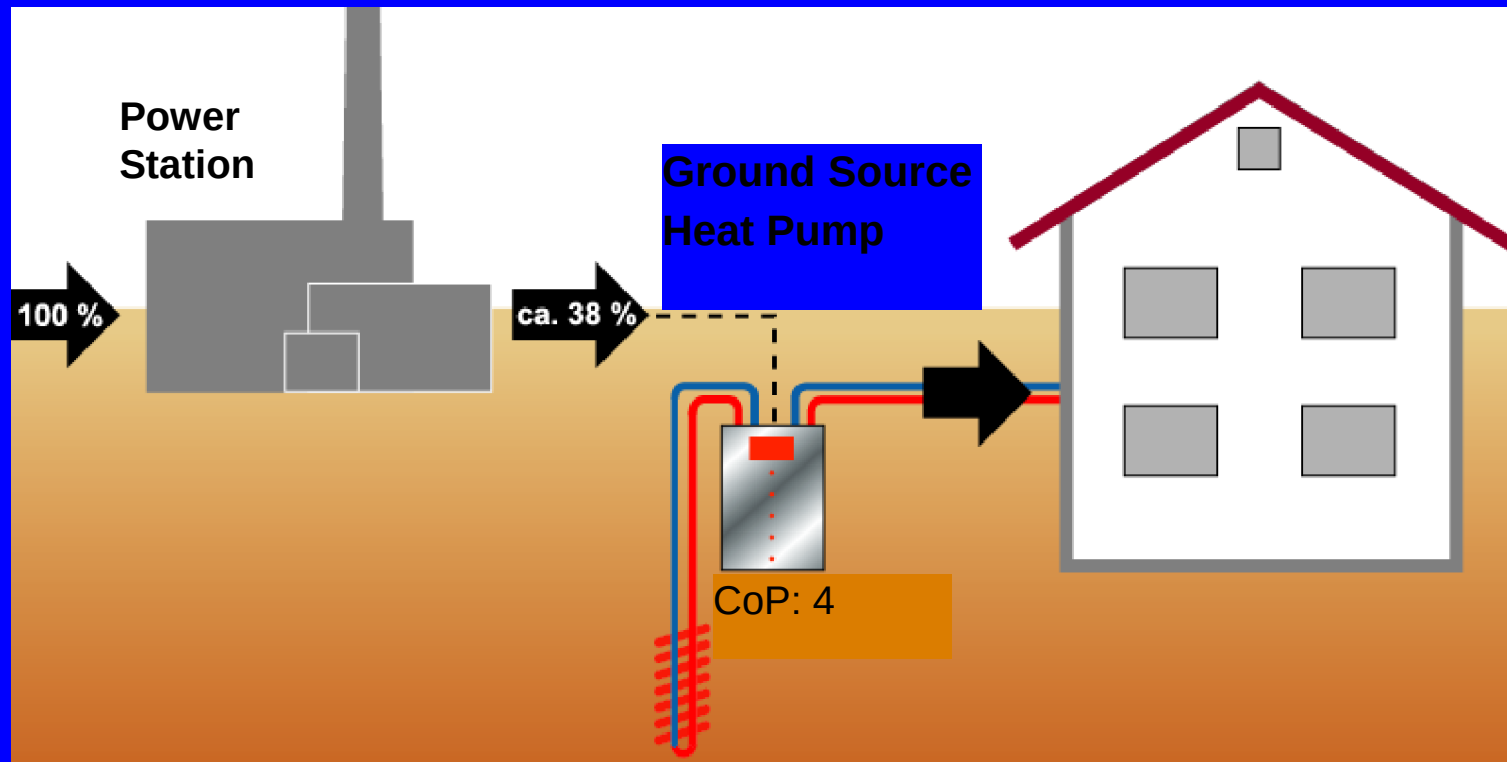
Performance and Output (Coefficient of Performance- CoP)



$$\text{CoP} = \frac{\text{Heat Output}}{\text{Electrical Input}} = \frac{4 \text{ kW}}{1 \text{ kW}} = 4$$

The Heat Pump Energy Equation

Power Station – Ground Source Heat Pump



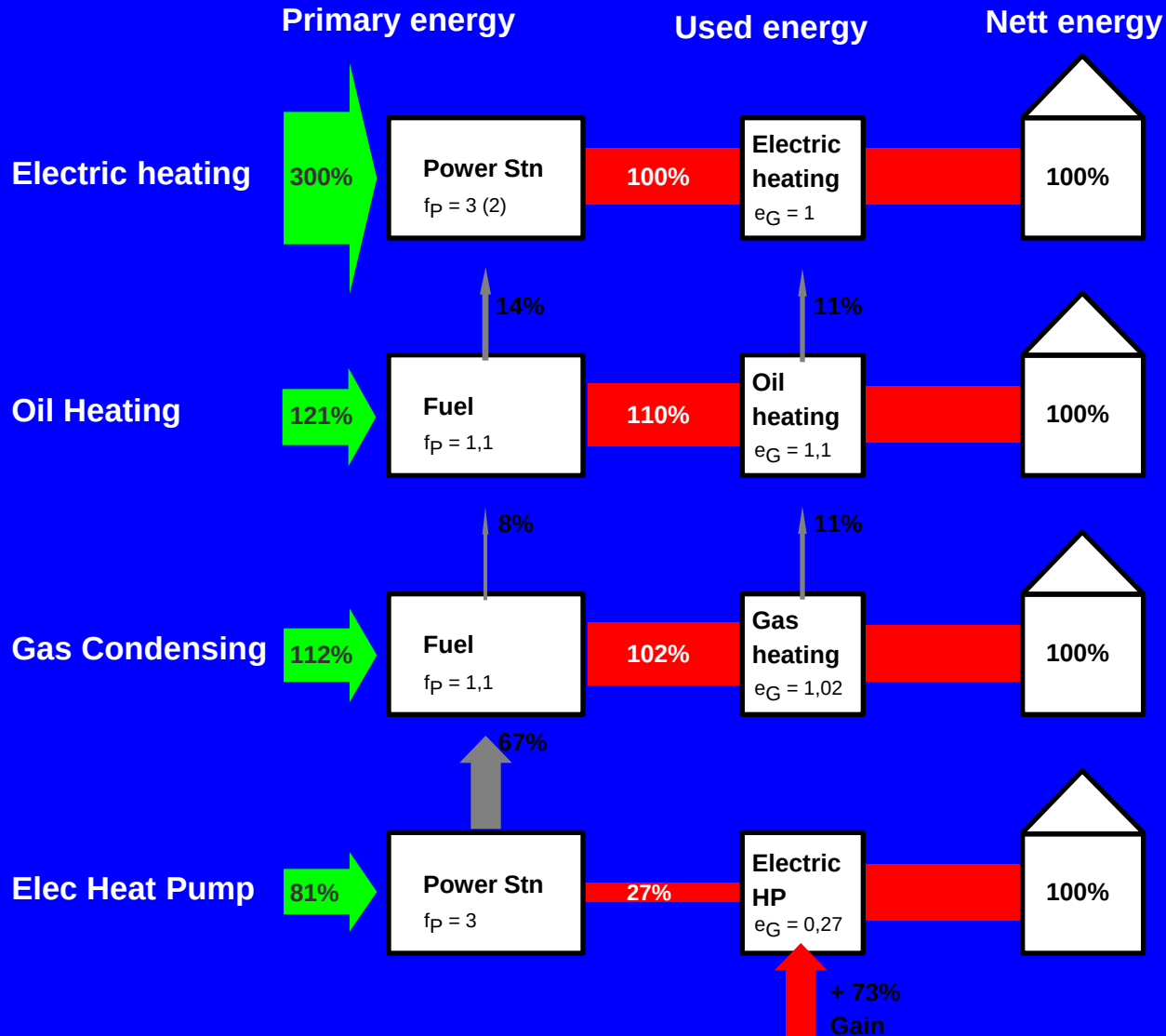
Example:

Power Station Efficiency ca. 38%

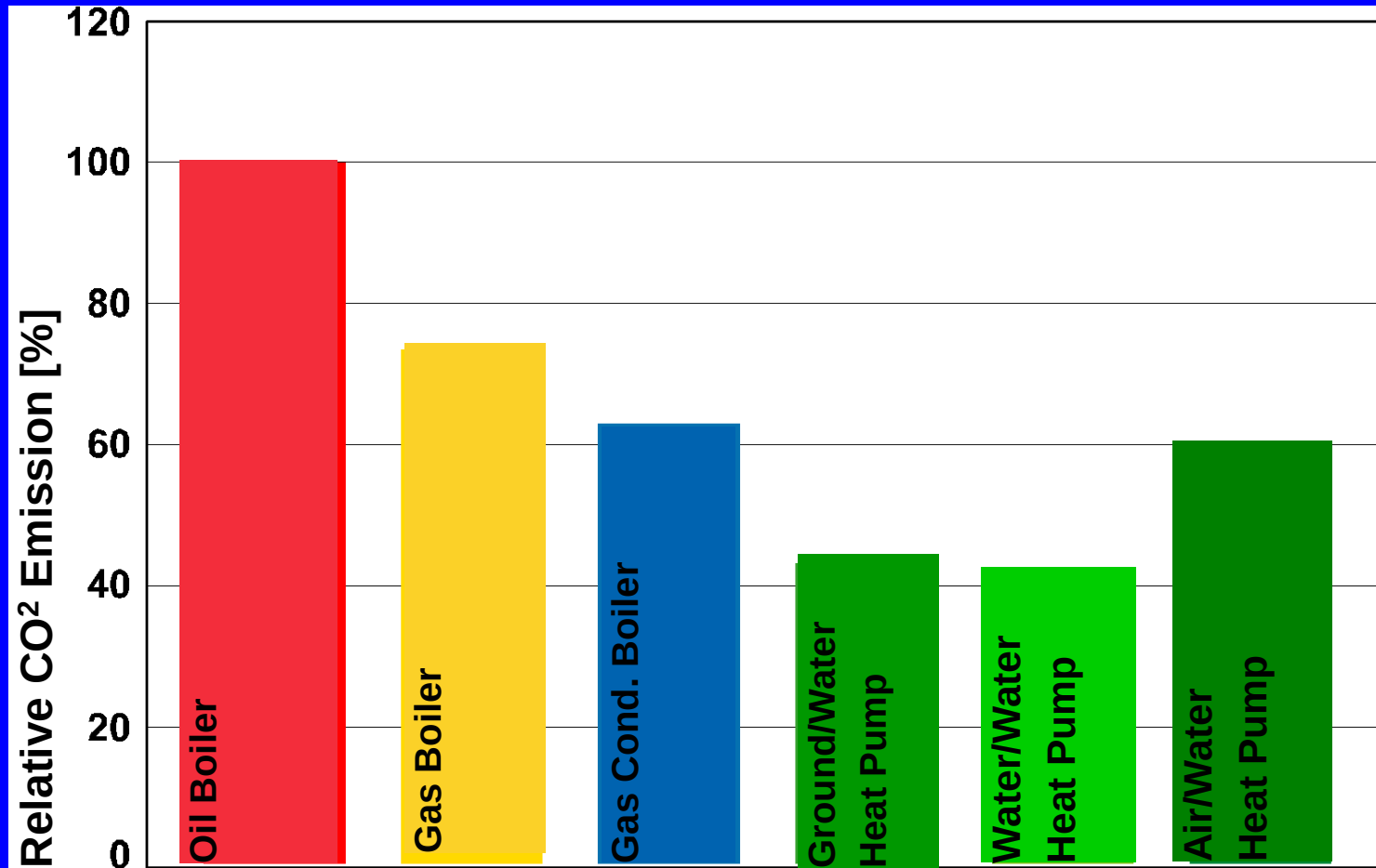
CoP Heat Pump $\beta = 4,0$

$$\frac{\text{Heat Output}}{\text{Primary Energy}} = \eta \cdot \beta = 1,52$$

Energy Production Chain for 'Low Energy' Use



Relative CO² Emissions of the Different Heating Systems



Heating comparison for different technologies

	Cond. boiler	ASHP	GSHP
Heating load (kWh)	100	100	100
Seasonal efficiency	88% *	300% SPF**	400% SPF***
Energy input (kWh)	113.6	33	25
Cost of energy (p/kWh)	1.5	4.5	4.5
Cost of input energy (£)	1.7	1.49	1.125
CO ₂ emitted (kg)	21.6	14.2	10.75

* From www.sedbuk.co.uk

** From Hundy, GF, Institute of Refrigeration, 2004-2005

*** From International Energy Agency

Source: BSJ January 2006

CoP and Heating System Temperature

General Rule:

The lower the difference in temperature between the input or environmental temperature, and the heating system temperature the higher the CoP

Therefore:

- Heat Pumps are ideal for Low Temperature Heating systems
- Ground/Water and Water/Water Heat Pumps can
 - year-round and singularly provide all the required heat
 - Ground water and soil usually deliver between 0 and 12°C
- Air/Water Heat Pumps on cold days will need an additional
 - heat source

CO₂ Emission Factors

Approved Document L2A 2006

Fuel	Kg CO₂/kWh
Natural Gas	0.194
LPG	0.234
Oil	0.265
Coal	0.291
Biomass	0.025
Grid Supplied Electricity	0.422

CO₂ Emission Factors

SAP 2009

Fuel	Kg CO₂/kWh
Natural Gas	0.198
LPG	0.245
Oil	0.274
Coal	0.318
Biomass	0.047
Grid Supplied Electricity	0.517

Cooling comparison for different technologies

	ASHP	GSHP
Cooling load (kWh)	100	100
Seasonal efficiency	280% SPF**	320% SPF***
Energy input (kWh)	35.7	31.25
Cost of energy (p/kWh)	4.5	4.5
Cost of input energy (£)	1.61	1.4
CO ₂ emitted (kg)	15.3	13.2

Source: BSJ January 2006

Environmental Impact Indices

- **Ozone Depletion Potential (ODP)**
- **Global Warming Potential (GWP)**
- **Total Equivalent Warming Impact (TEWI)**

Ozone Depletion Potential (ODP)

A number defining the ratio of impact on ozone of a chemical compound compared to the impact of a similar mass of CFC-11 defined as having an ODP of 1.

Global Warming Potential (GWP)

A number defining the ratio of the global warming caused by a substance compared to a similar mass of CO₂.

Total Equivalent Warming Impact (TEWI)

Is a function of refrigerant and CO₂ emissions over the lifetime of the plant, comprising of:

- The direct effect from total lifetime refrigerant emission
- The indirect effect from estimated energy consumption