Heat Pumps 10:00 Friday 12th

AECB the sustainable building association

2009 Annual Conference

Building for a Sustainable Future

Policy | Research | Practice

Oxford Brookes University | 11-12 June 2009

Optional tours of local renovations: 13 June 2009

AECB the sustainable building association

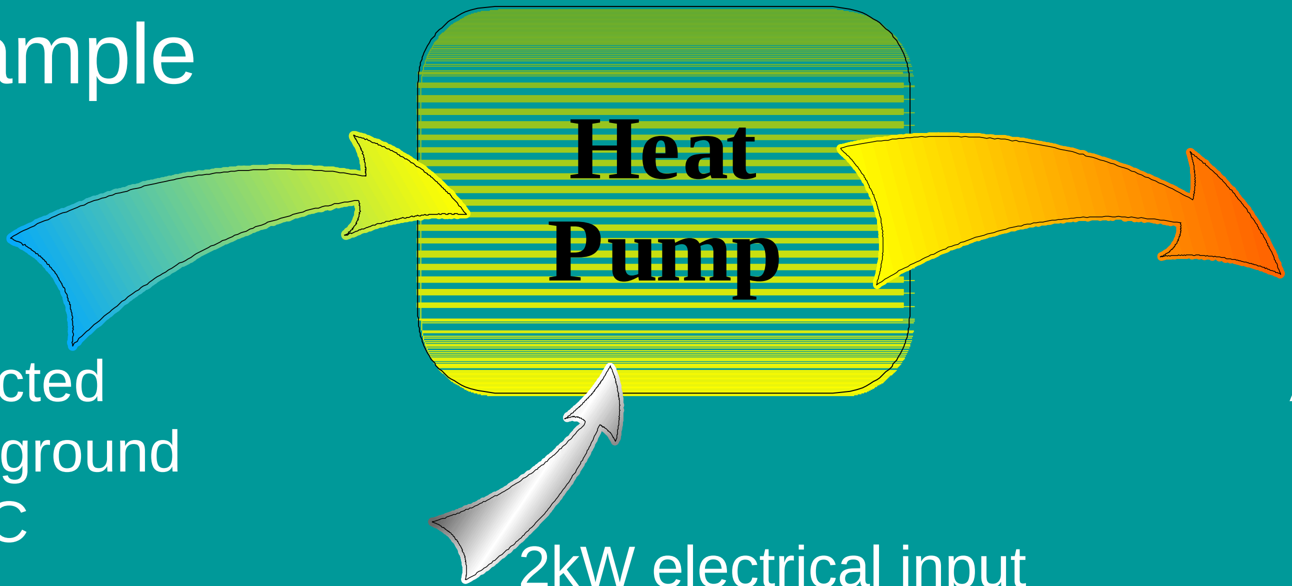
OXFORD BROOKES UNIVERSITY

KNAUF INSULATION it's time to save energy

Greenbuilt building with people for people

AECB Conference June 12th 2009

Example



5kW extracted from ground at 5°C

7kW to house At 40°C

2kW electrical input

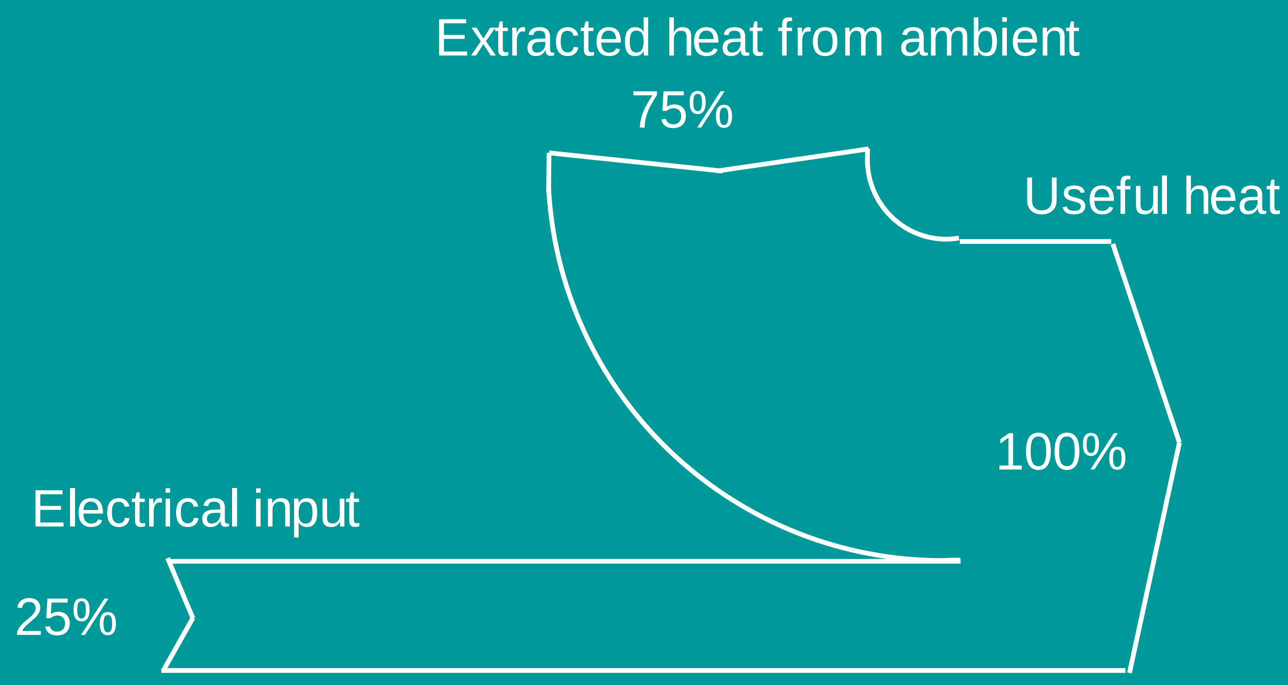
Useful heat output = extracted heat + electrical input

$$\text{Coefficient of Performance, COP} = \frac{\text{Heat output}}{\text{Power input}} = \frac{7\text{ kW}}{2\text{ kW}} = 3.5$$

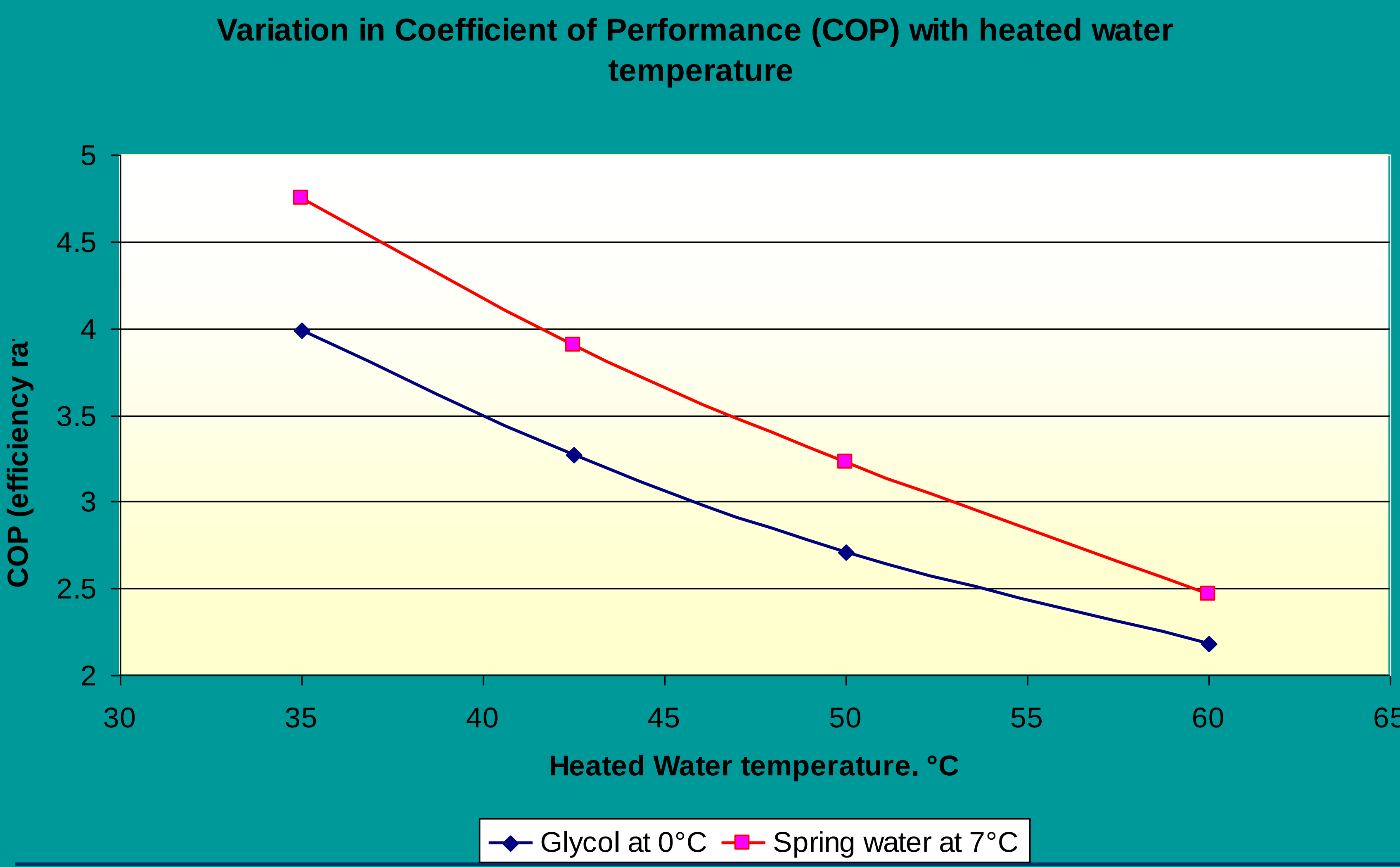
John Cantor

Sankey diagram

Heat Pump, COP4



Variations in Efficiency



www.heatpumps.co.uk

Types of heat pump

Ground Source heat pump

- Horizontal trench
- Vertical borehole
- Ground water source

Air Source

- External air
- Ventilation air

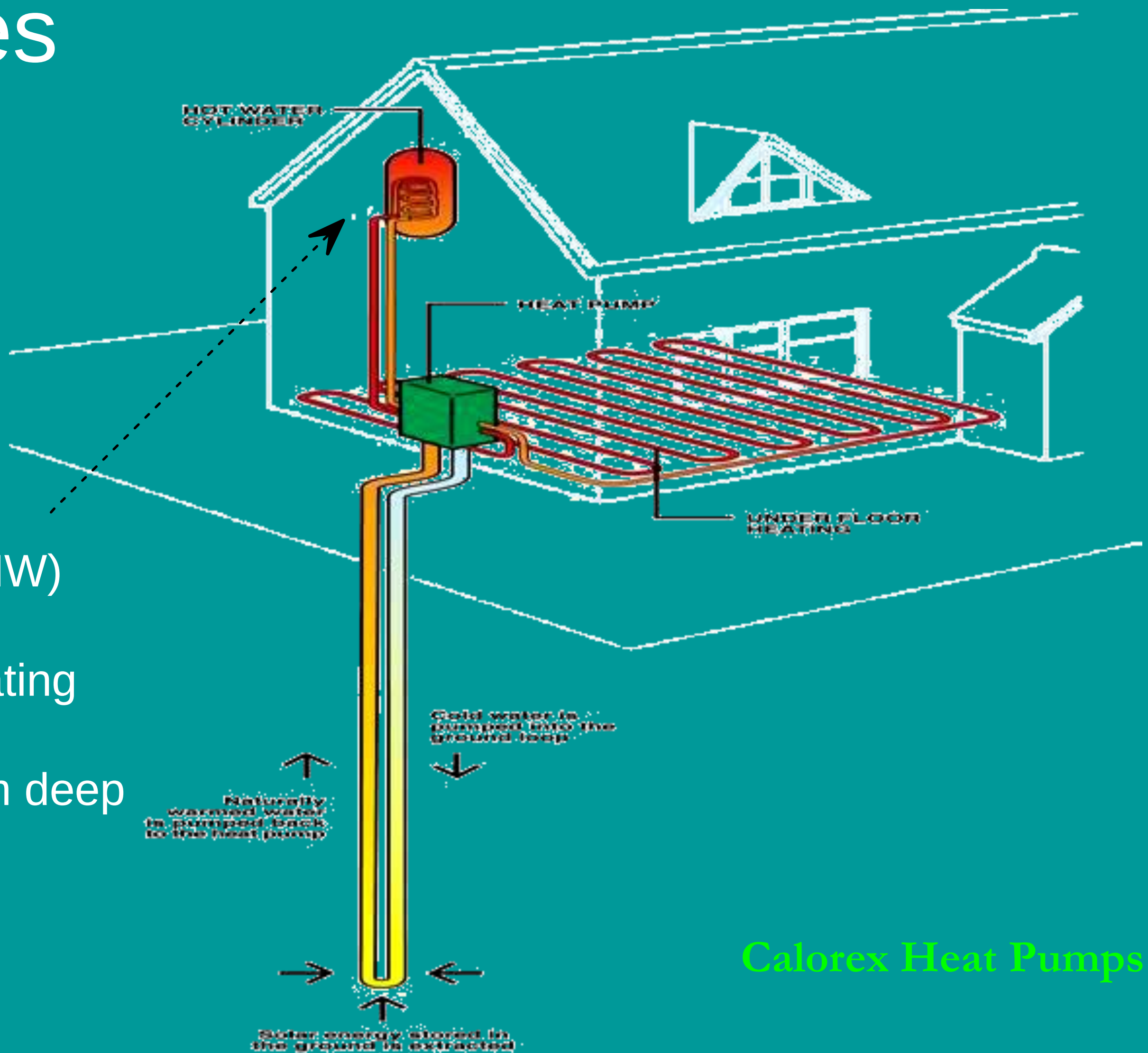
Uses for heat :

- Underfloor heating
- Radiators
- Domestic hot water (DHW)

Horizontal collectors

Boreholes

- Hot water (DHW)
- Underfloor heating
- Borehole 100m deep



Calorex Heat Pumps Ltd.

Ground water

- Spring water often at 10°C all year
- Can be pumped directly through heat pump if non corrosive
- Certain heat pumps can tolerate corrosive water
- Very high efficiencies can be achieved
- Can be used with horizontal-trench pipe work

Ground source heat pump units

Kensa

Calorex

Hot water cylinder, buffer cylinder & heat pump unit


NIBE
Nibe


IVT

Direct expansion unit (DX), Hydrocarbon refrigerant.

Neura , Austria.

Air source heat pump

5kW Air Source. Ecodan with variable frequency compressor.

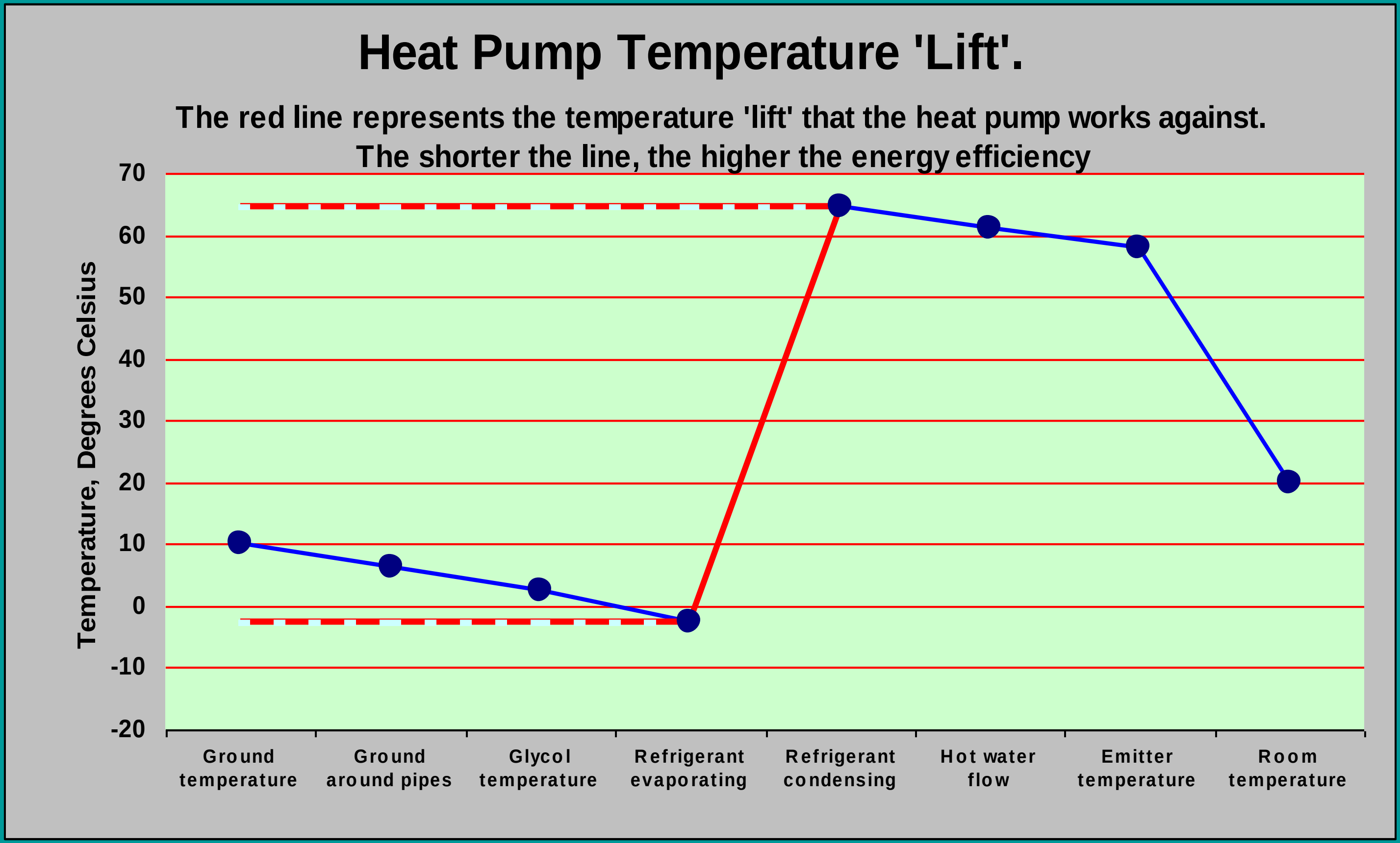
What affects the energy efficiency of a heat pump system?

- Source temperature
- Type of source
- Season of use (winter only, all year)
- Efficiency of collector

- Output temperature
- Type of emitter (radiator, underfloor etc.)
- Insulation levels
- Temperature requirements of building

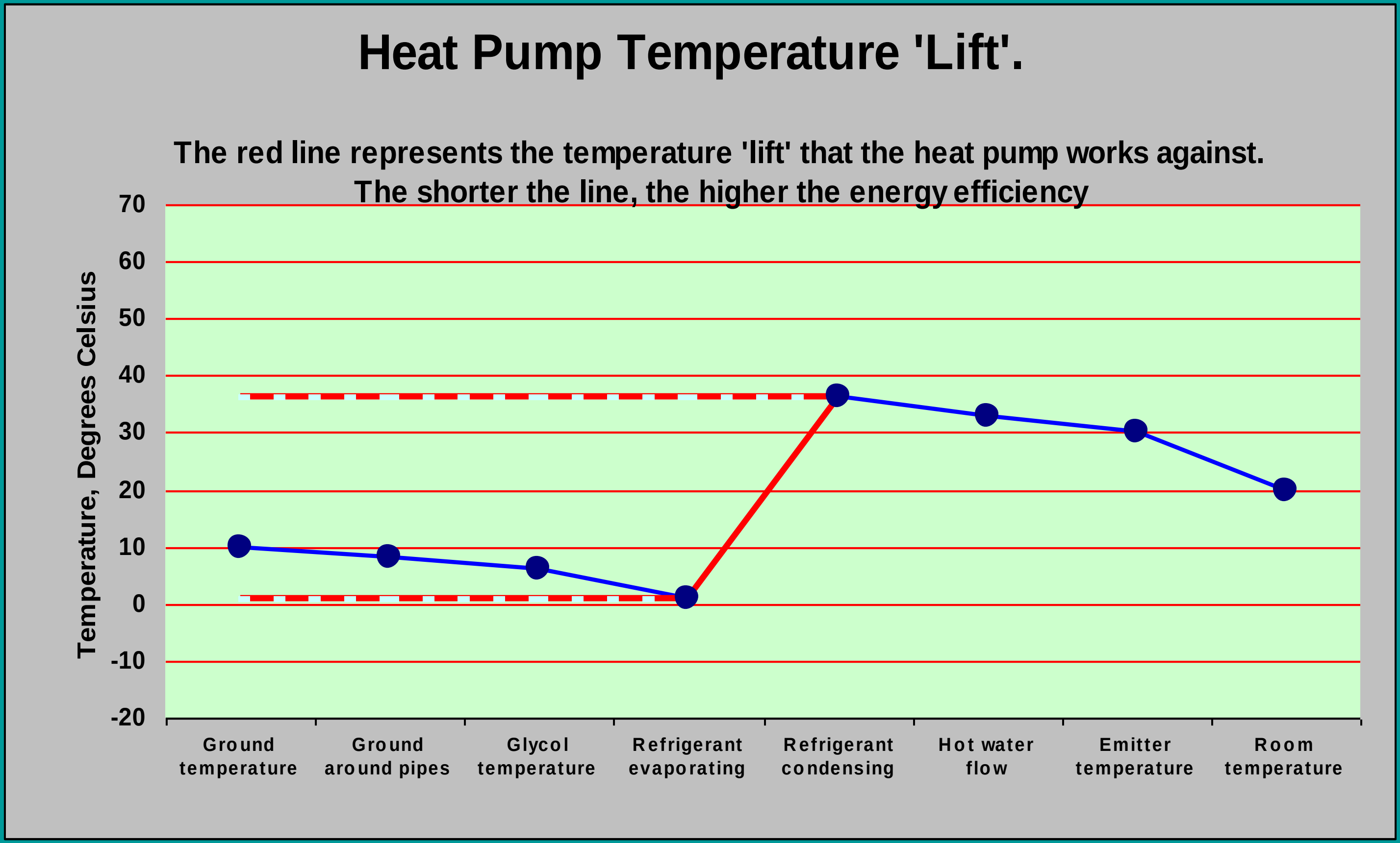
- Efficiency of heat pump unit.
- Need for, and efficiency of, fans and pumps
- Backup heating
- Controls

www.heatpumps.co.uk/heatpumpcalculator.html



COP about 2

www.heatpumps.co.uk/heatpumpcalculator.html



COP about 4

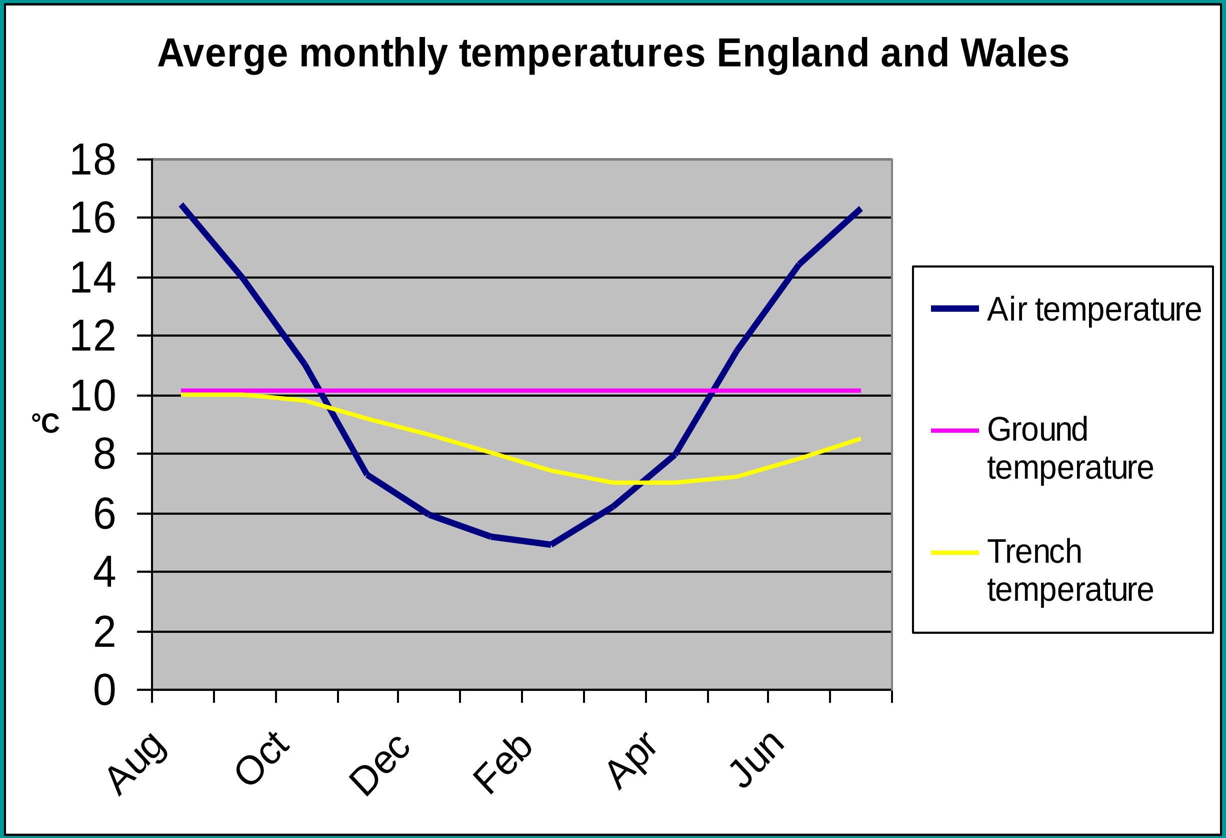
Straight pipe

Coiled pipe

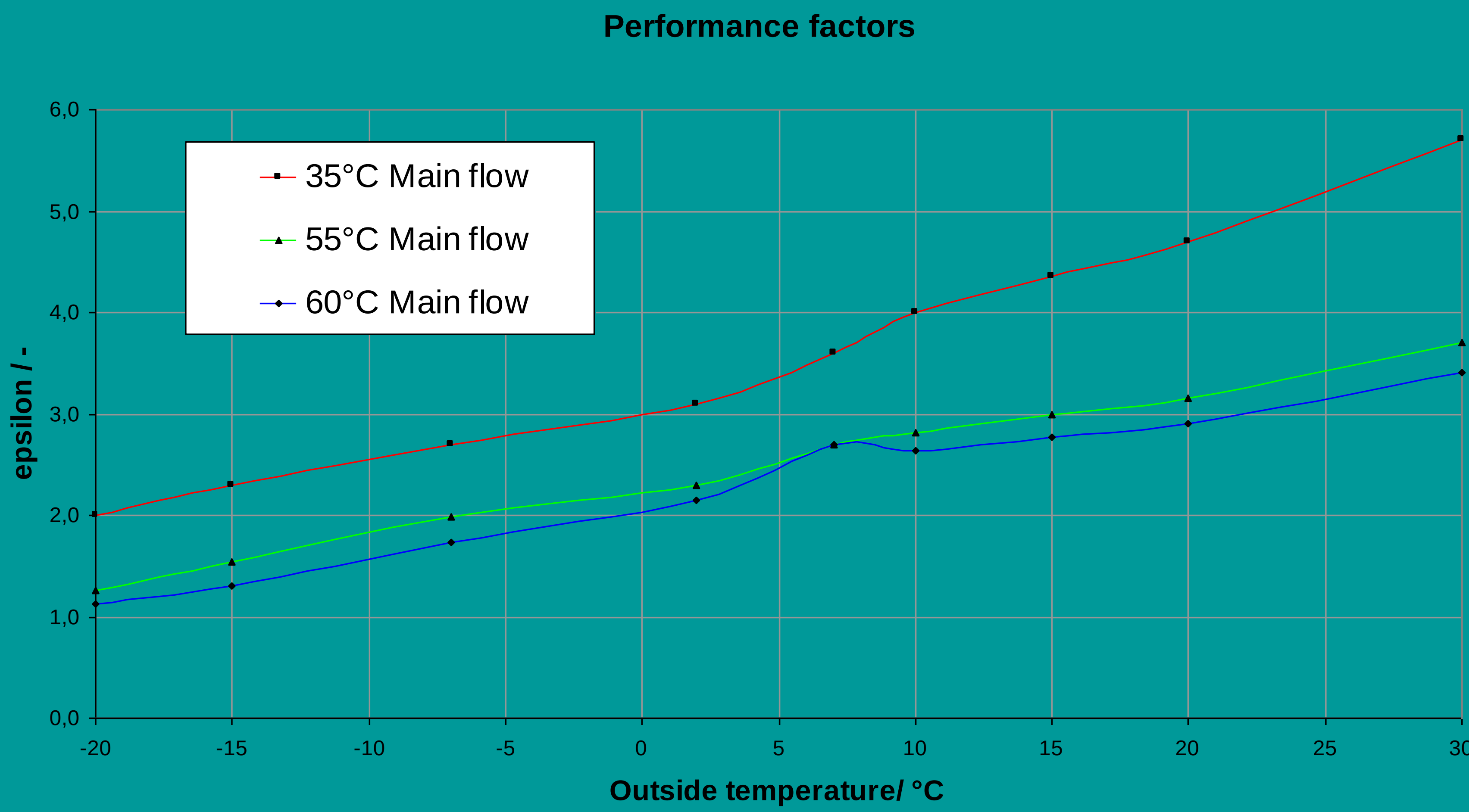
Horizontal trench Ground Source

- Quick and easy
- A lot of ground has to be moved
- Big digger required
- Space required for spoil.
- Common method in Germany.

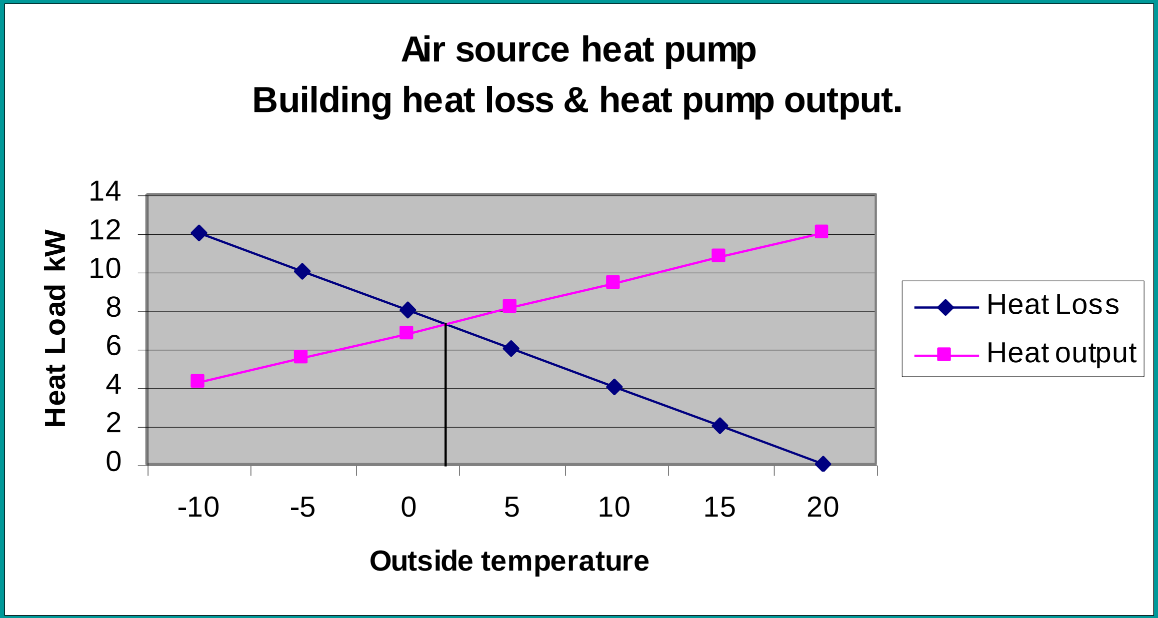
Ground Source issues



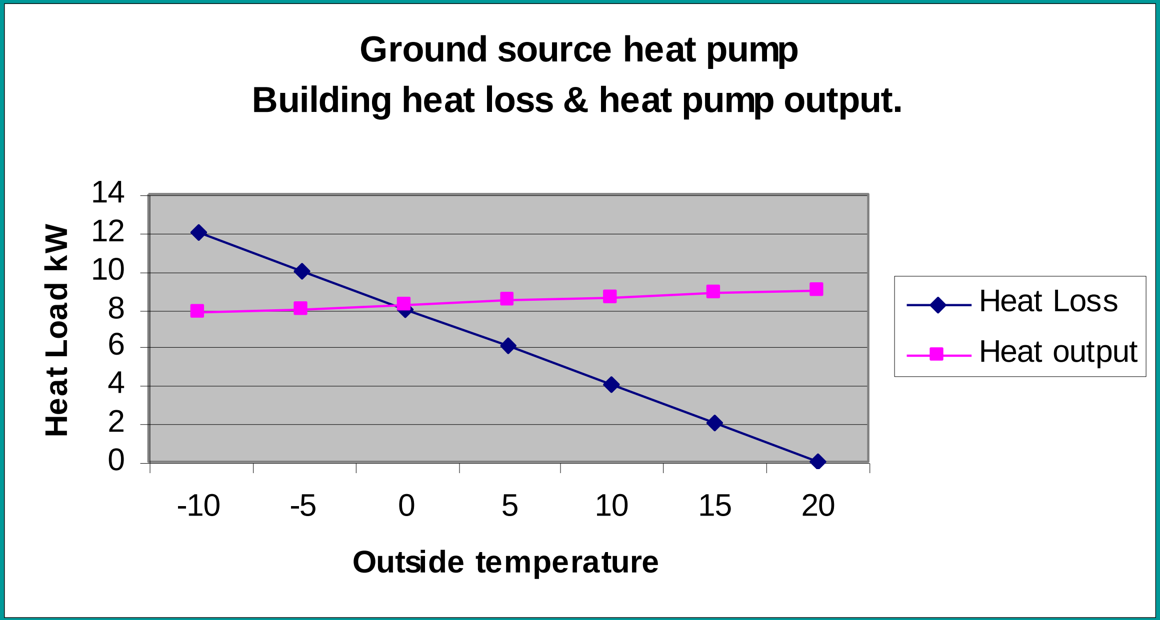
Air source heat pump. COP v ambient temperature



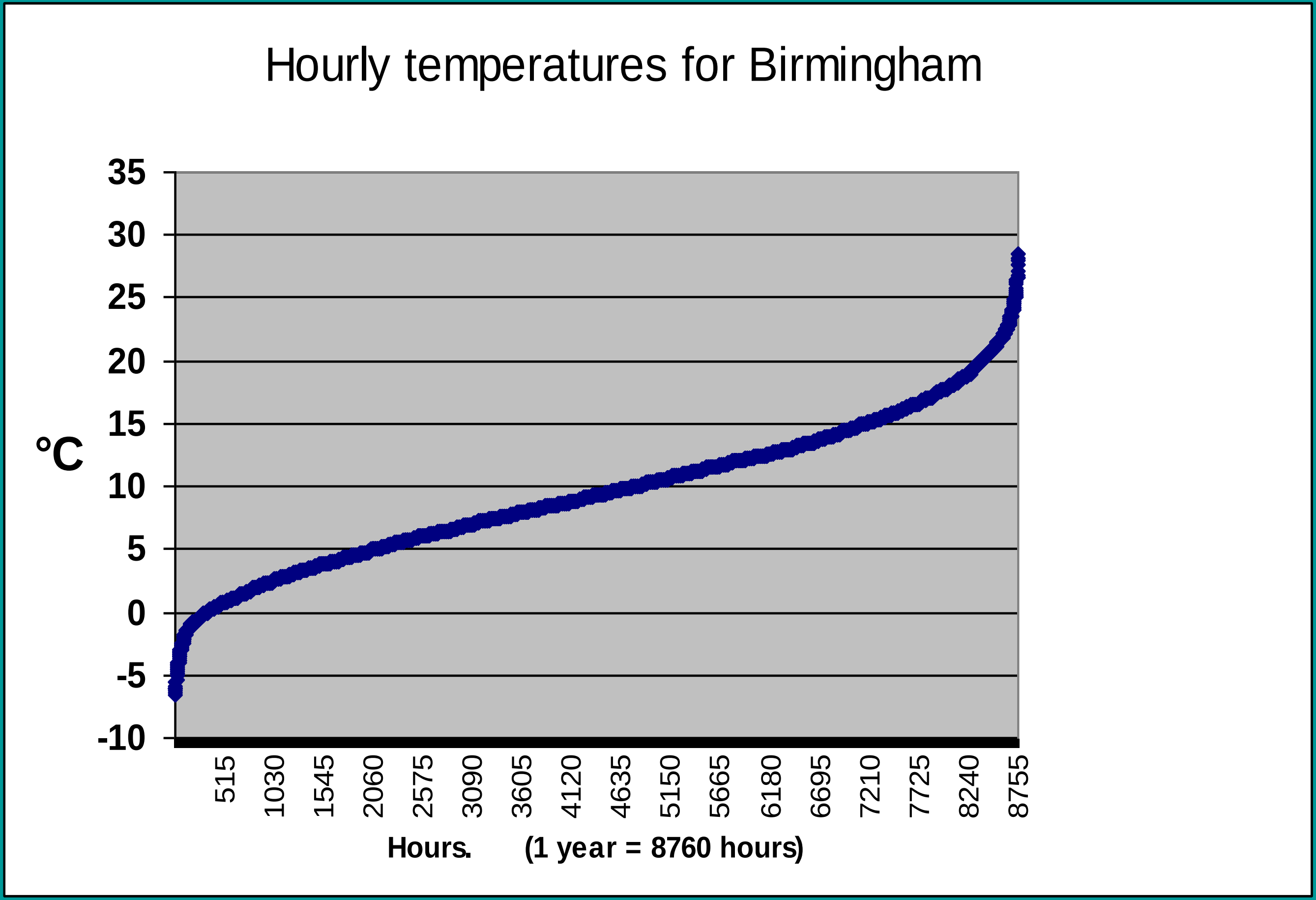
Stiebel Eltron



Air source heat pump
Building heat loss & heat pump output.
Heat Load kW
14
12
10
8
6
4
2
0
-10
-5
0
5
10
15
20
Outside temperature
Heat Loss
Heat output



Ground source heat pump
Building heat loss & heat pump output.
Heat Load kW
14
12
10
8
6
4
2
0
-10
-5
0
5
10
15
20
Outside temperature
Heat Loss
Heat output


Hourly temperatures for Birmingham
°C
35
30
25
20
15
10
5
0
-5
-10
515
1030
1545
2060
2575
3090
3605
4120
4635
5150
5665
6180
6695
7210
7725
8240
8755
Hours. (1 year = 8760 hours)

Heat Pump sizing

- Often sized closely to design heat loss
- Constant heating more common

- Sometimes sized significantly less than design heat loss

Backup energy use

(the 3rd column is only relevant if the backup is electric)

Size of heat pump compared to design heat loss	Contribution required from backup heating	Seasonal Performance Factor (SPF)
100%	0%	3.7
90%	3.5%	3.4
80%	6.5%	3.15
60%	18%	2.5

Seasonal Performance Factor (SPF) is the average COP over the year, and includes any backup electricity used

Performance data

Examples

Air source heat pump data			
Air 7°C, water 35°C	Heat output	8.96	kW
	Power input	2.42	kW
	COP	**3.7**	
Air 0°C, water 35°C	Heat output	7	kW
	Power input	2.3	kW
	COP	**3.0**	
Air 0°C, water 55°C	Heat output	6	kW
	Power input	3.1	kW
	COP	**1.9**	

Ground source heat pump data			
Brine 0°C, water 35°C	Heat output	8.3	kW
	Power input	1.8	kW
	COP	**4.6**	
Brine 0°C, water 50°C	Heat output	7.8	kW
	Power input	2.5	kW
	COP	**3.1**	

- **Rated size is Heat-Output, not Power-Input**
- **This must be known along with the conditions**

Backup heating

- Many heat pump units have an integral electric element
- Sometimes required for legionella protection of hot water

Other backup options:

- Boiler
- Wood

Control of Backup

Usually configured as follows:

1. Alternative — Usually used with radiator in retrofit
2. Parallel — Underfloor systems
3. Part parallel — Large radiators or poor underfloor

Underfloor heating

Underfloor heating distribution manifold

There are normally more pipe loops
with a system designed for a heat pump.

Heat Pump design

Boiler design

The buffer tank debate

Why use buffer cylinders?

- To minimise stop/start (cycling) of the compressor
- To accommodate substandard emitter circuits

How do they affect efficiency?

- Improve compressor run duration
- Usually improve, but sometimes reduce efficiency
- Implications for circulation pump power

How can they be designed out?

- Better control of systems
- Thermal storage in emitter circuits
- Variable capacity heat pumps

The finer details

Power circulating fluids.

•Heat pumps tend to operate more continuously that conventional systems. This is more reason to use ‘A’ rated circulators.

•Pipe diameters must be large enough so required pump pressure is low

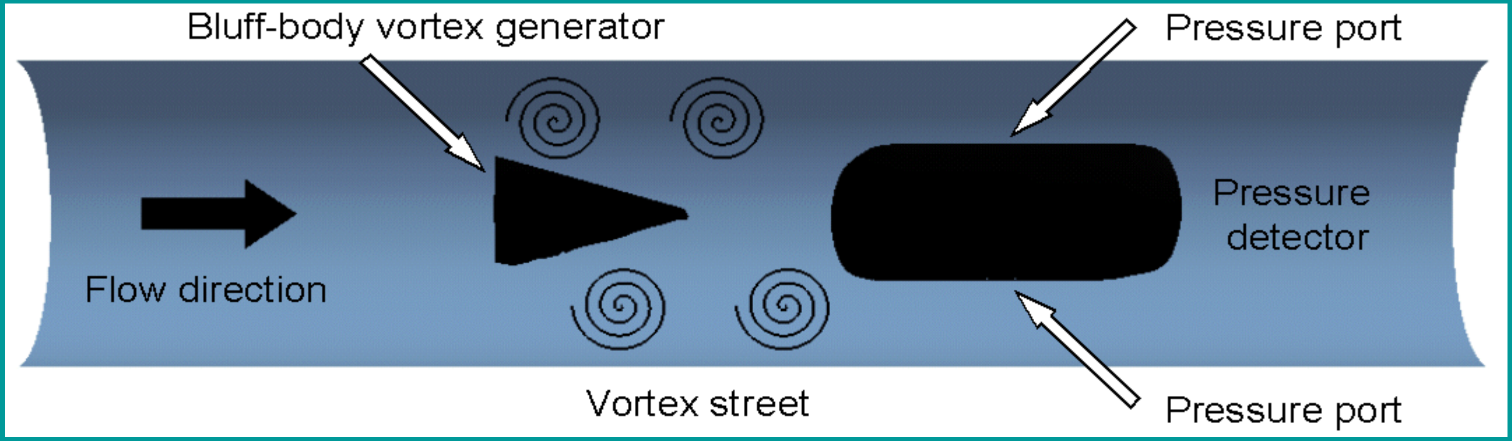
•The further the ground source from the heat pump unit, the larger the pipe diameter required.

•Control systems must be designed and set correctly

Measuring the actual heat produced

It is not easy to measure heat. This can only be done using a flow sensor and two temperature sensors.
In the past this has been expensive and/or unreliable, since flow sensors have been usually either a paddle, or ultrasonic.

New technology from Grundfos Direct Sensors can make monitoring of heat more reliable and affordable.



Clever electronics calculates the actual water flow rate.
The actual heat (kW) is calculated from the flow rate and the temperature rise across heat pump.
This can be compared to the electricity consumption to give a instantaneous or average COP figure.

Future developments ?

Variable speed/ variable capacity compressors

Buffer tanks ?

Expansion valves

Much better control systems required

Optimisation

No expected quantum leaps

Improvements + cost cutting = no change

As electricity supply grid improves, heat pumps become more viable