Energy Piles for Residential Installations and other low rise buildings

Founded 1971

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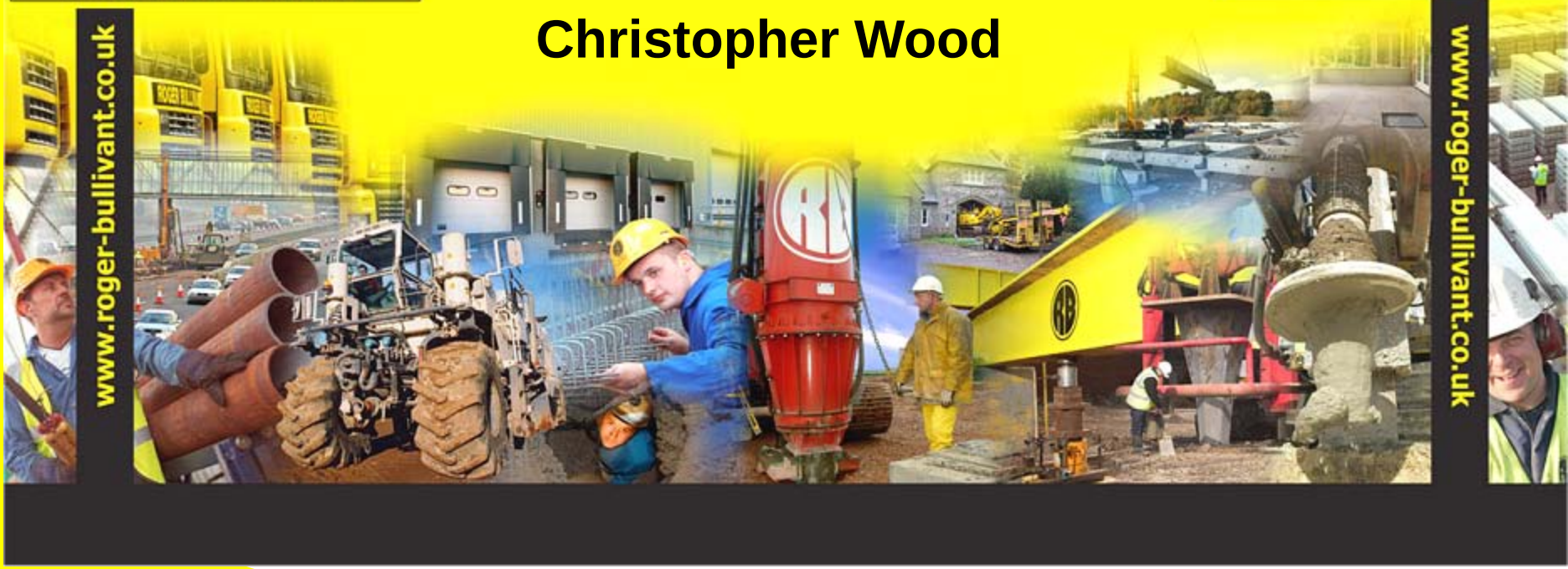
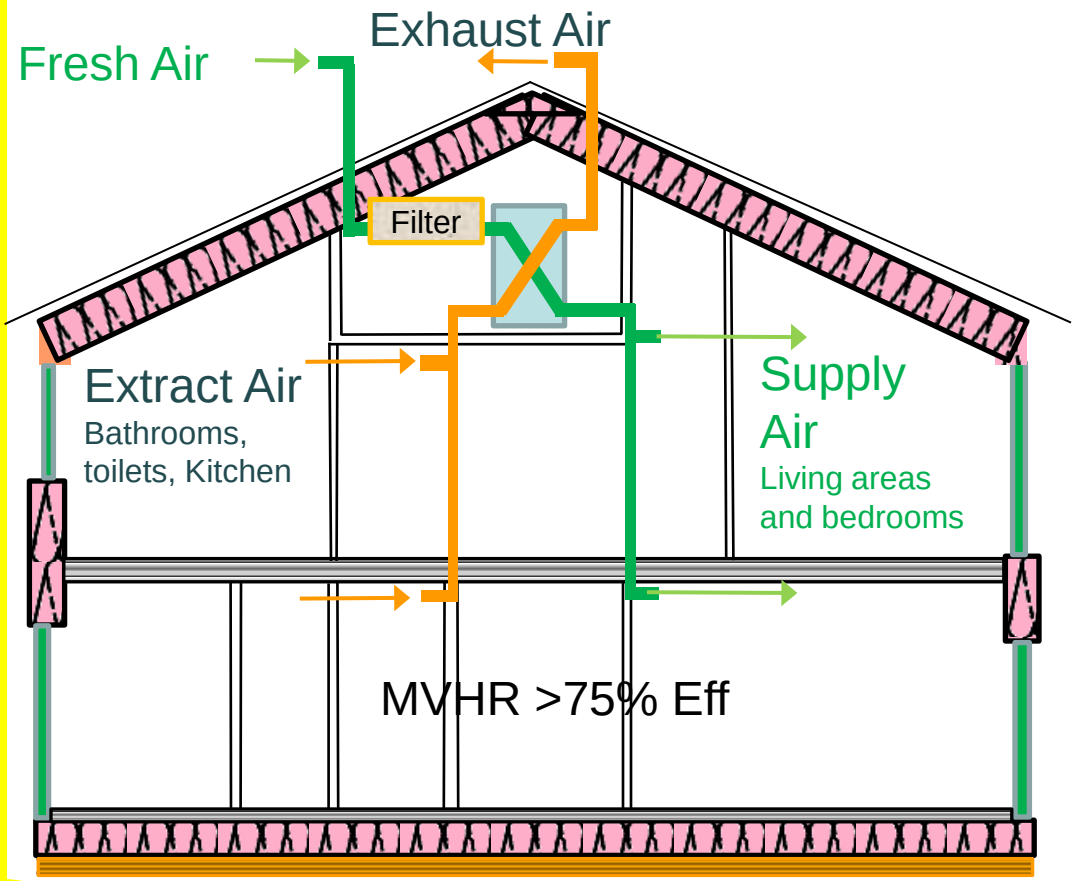
Christopher Wood



Modern Low Energy Buildings

- Potentially approaching a Passivhaus

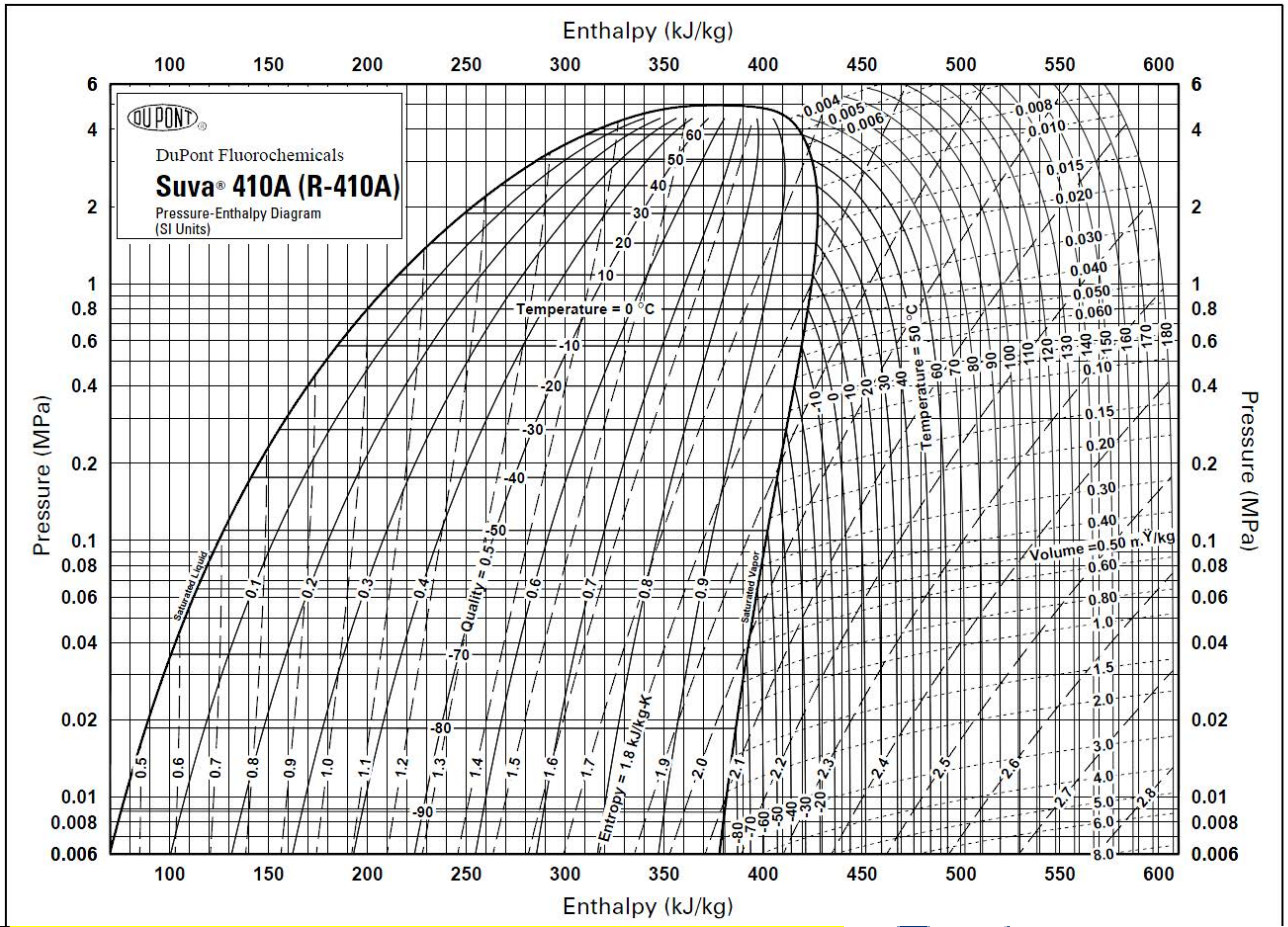


- High air tightness
- Highly Insulated fabric
- High performance glazing
- MVHR – potentially serving all the space heating requirement
- Low Temperature under-floor heating

The lower space heating requirement of modern buildings provides greater opportunities for ground source heat pumps!

Using a Ground Source heat pump

- How do we optimise the efficiency of the heat pump?
- Start by looking at the fundamentals!



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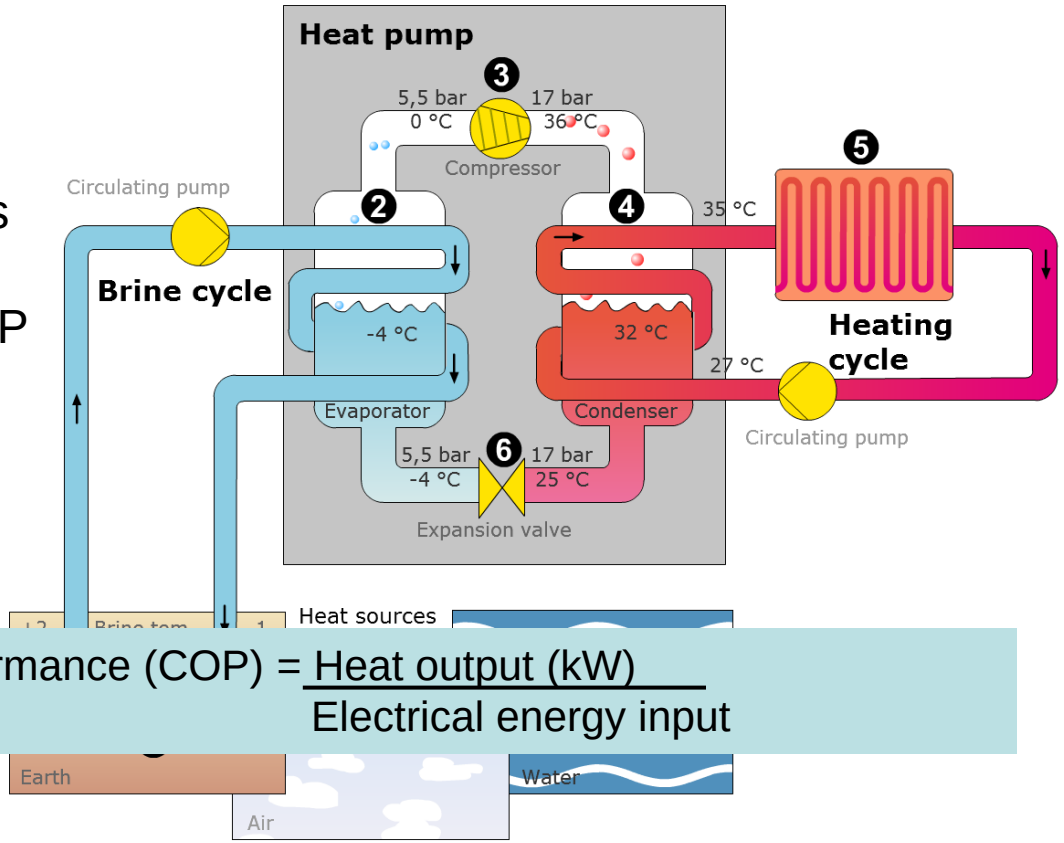
Using a Ground Source heat pump

- How do we optimise the efficiency of the heat pump?
- Start by looking at the fundamentals!

1 °C lower in source temperature reduces heat output by 3-4% and reduces the COP by 0.1-0.2 points



Coefficient of Performance (COP) = $\frac{\text{Heat output (kW)}}{\text{Electrical energy input}}$

Glen Dimplex Deutschland

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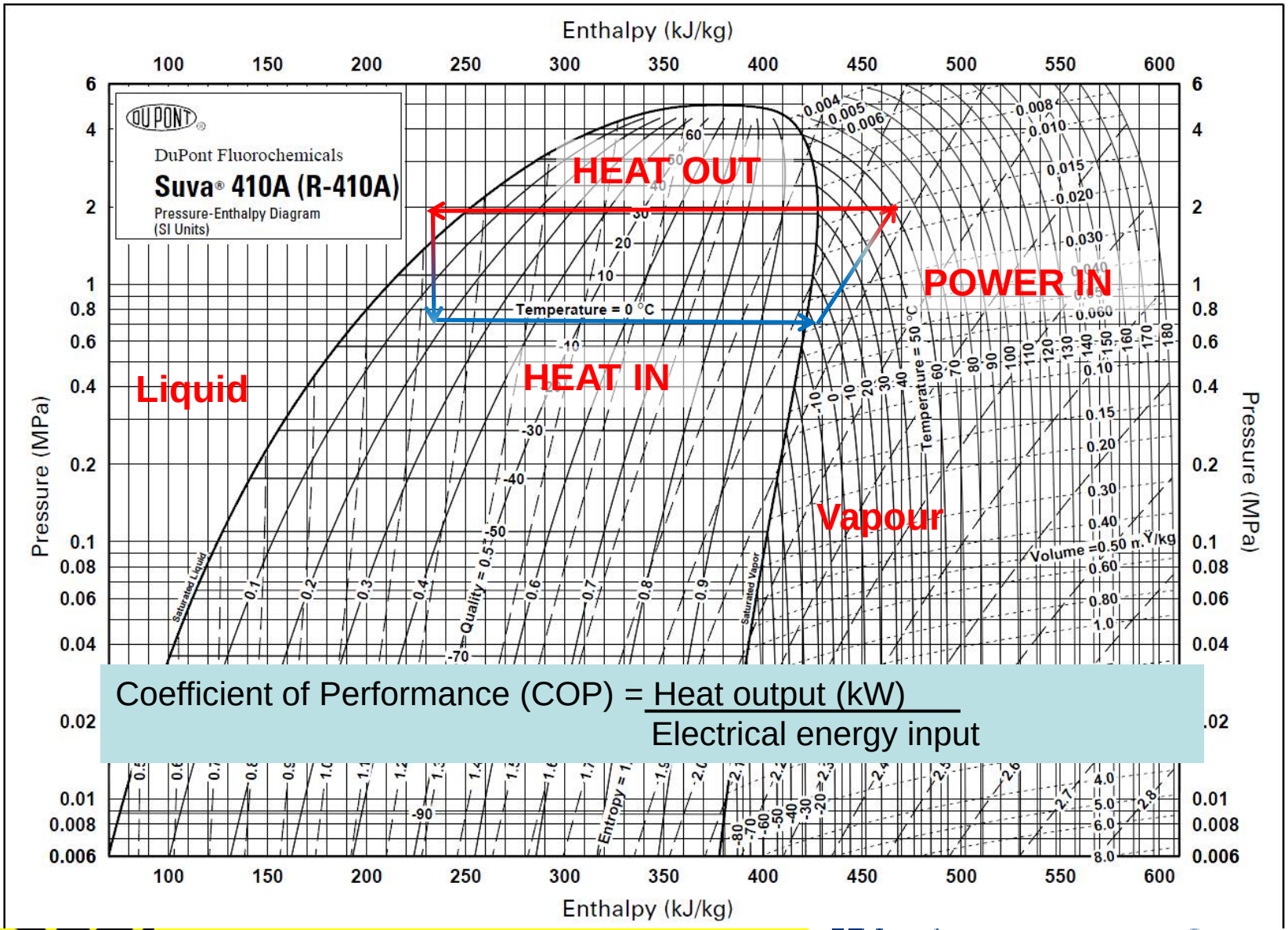
Using a Ground Source heat pump

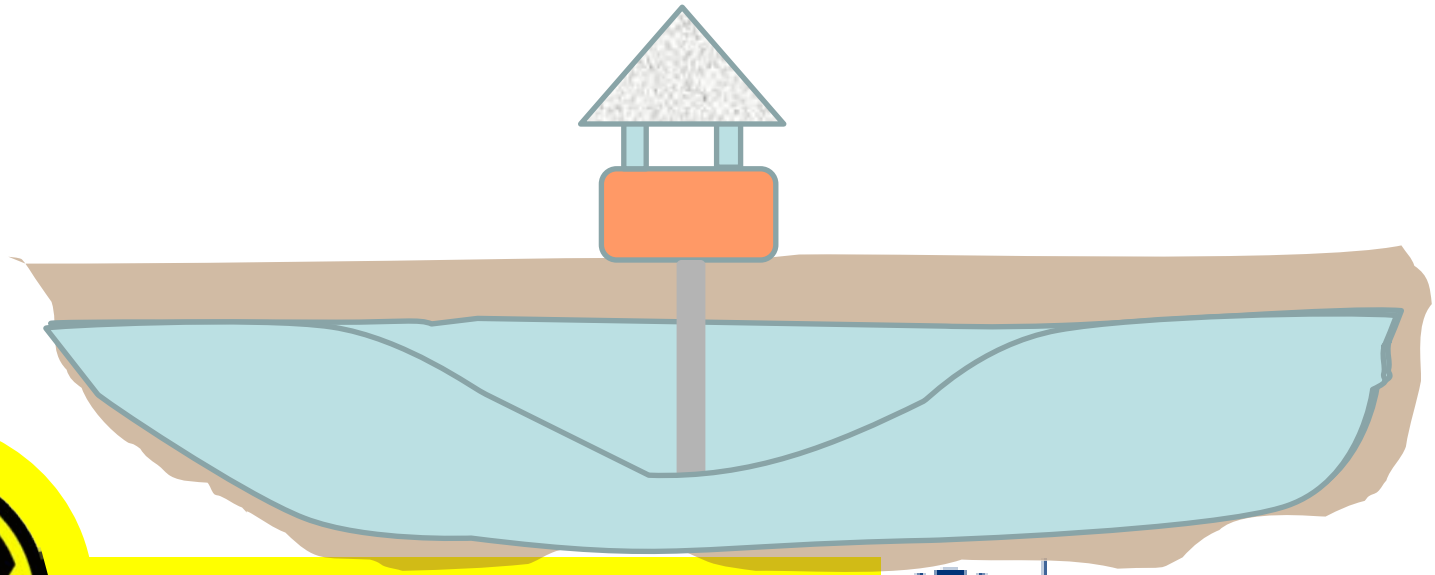


Coefficient of Performance (COP) = $\frac{\text{Heat output (kW)}}{\text{Electrical energy input}}$

What about the heat in the ground?

Basics - Ground heat is like Ground Water!

- Pumping water out of the ground, depresses the water table – A Well!
- The more we pump out the more the level of the well falls

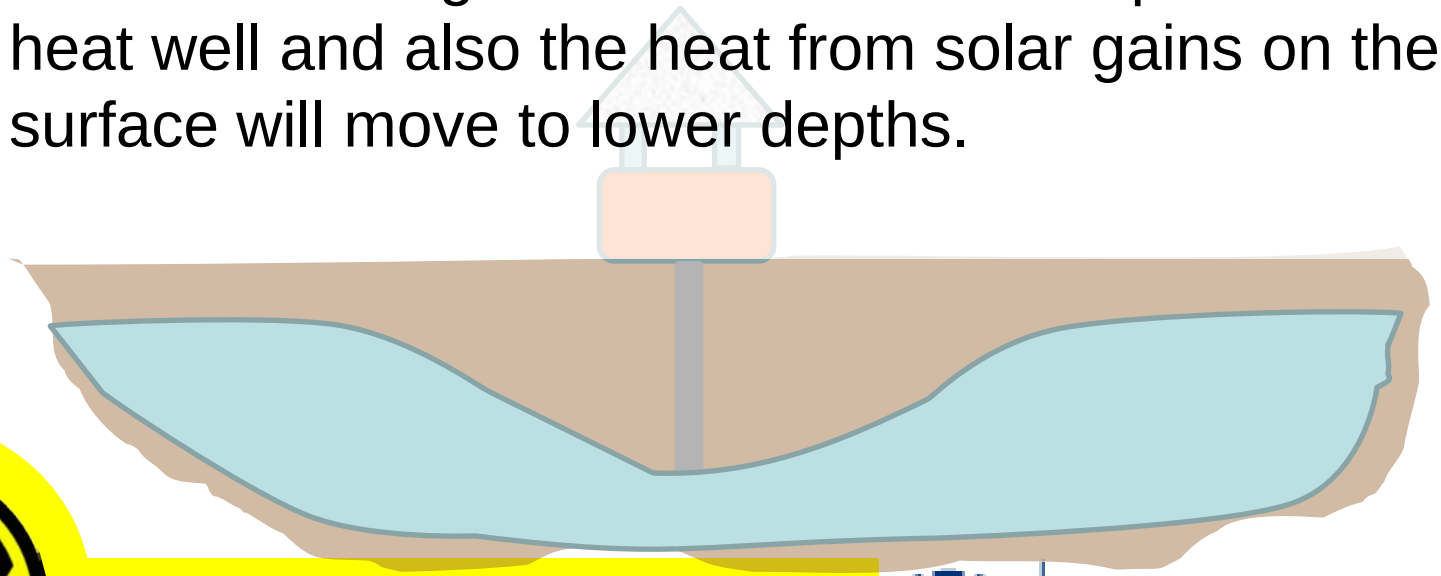


What about the heat in the ground?

Basics - Ground heat is like Ground Water!

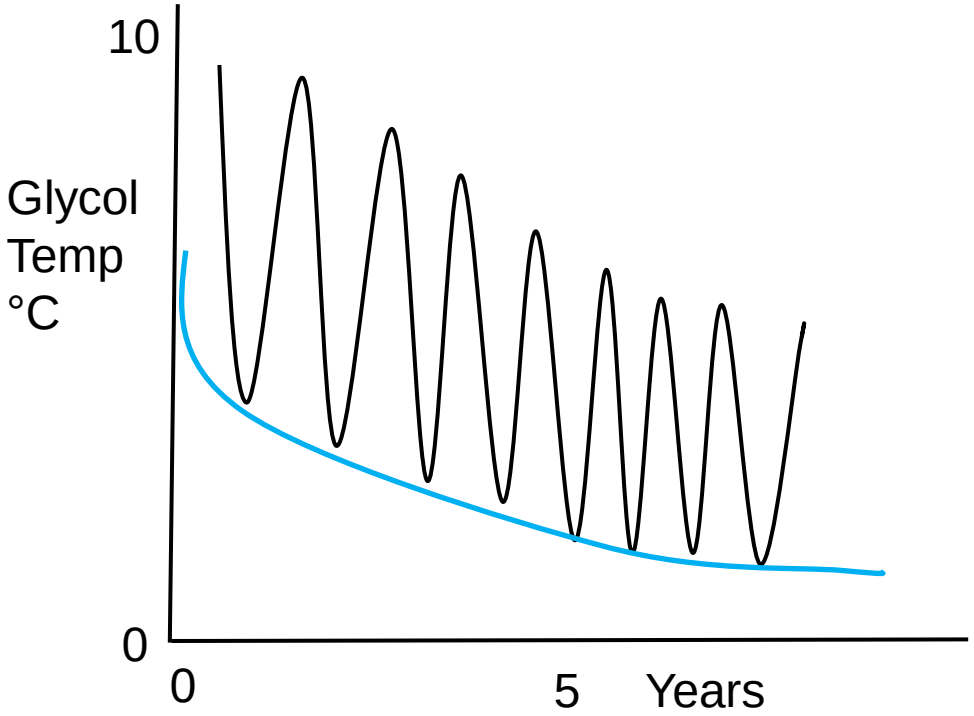
- The same is true inter-seasonally for heat i.e. The ground temperature in the vicinity of the borehole is depressed (for heating only systems).

- The surrounding environment will attempt to refill this heat well and also the heat from solar gains on the surface will move to lower depths.



Ground temperature falls over time

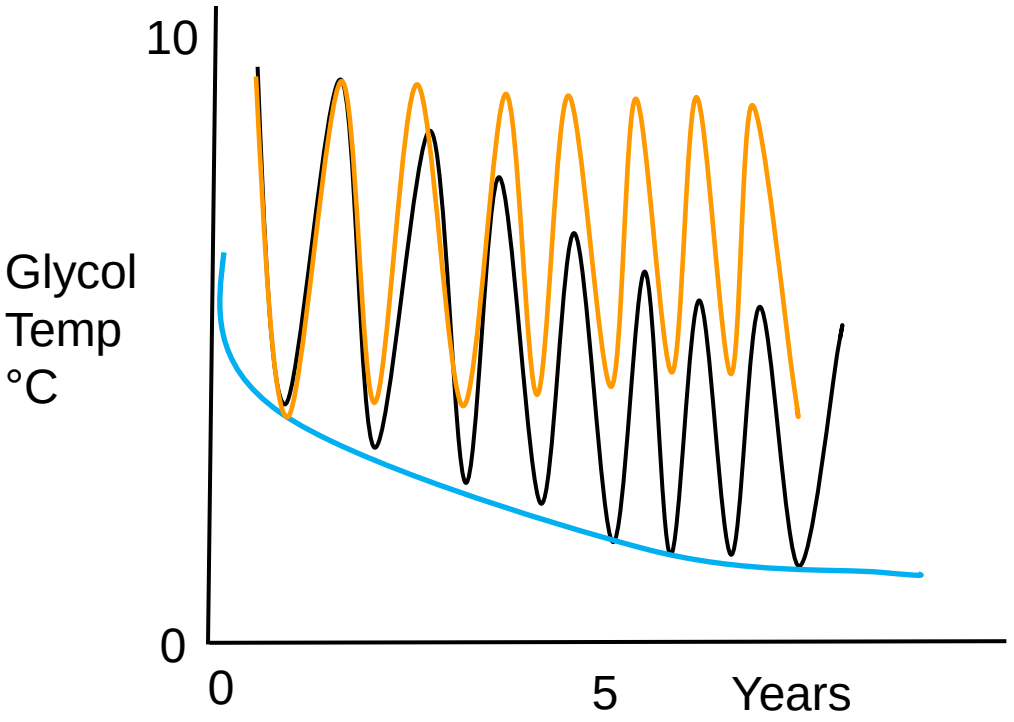
- For heating only heat pumps the year on year extraction of ground heat will cause the ground temperature to fall.



- Heat pump efficiency and heat output is therefore lower than year 0.

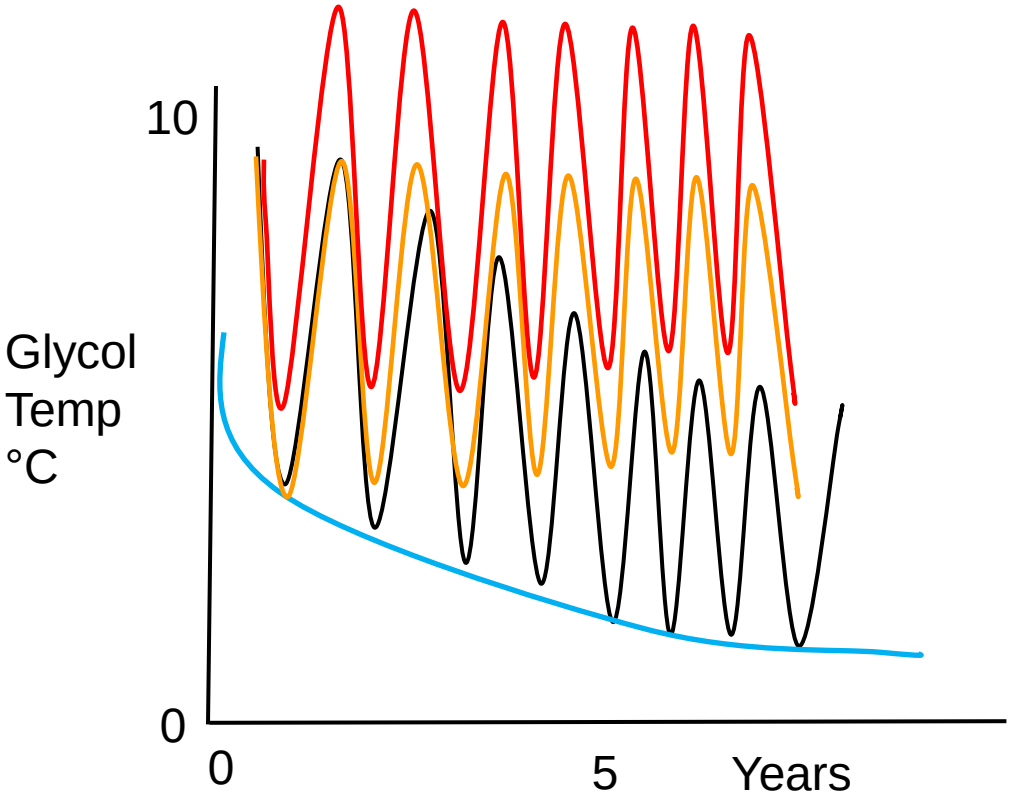
Solar recharging!

- So if we want to maintain first year efficiency – then solar recharge!



Solar recharging!

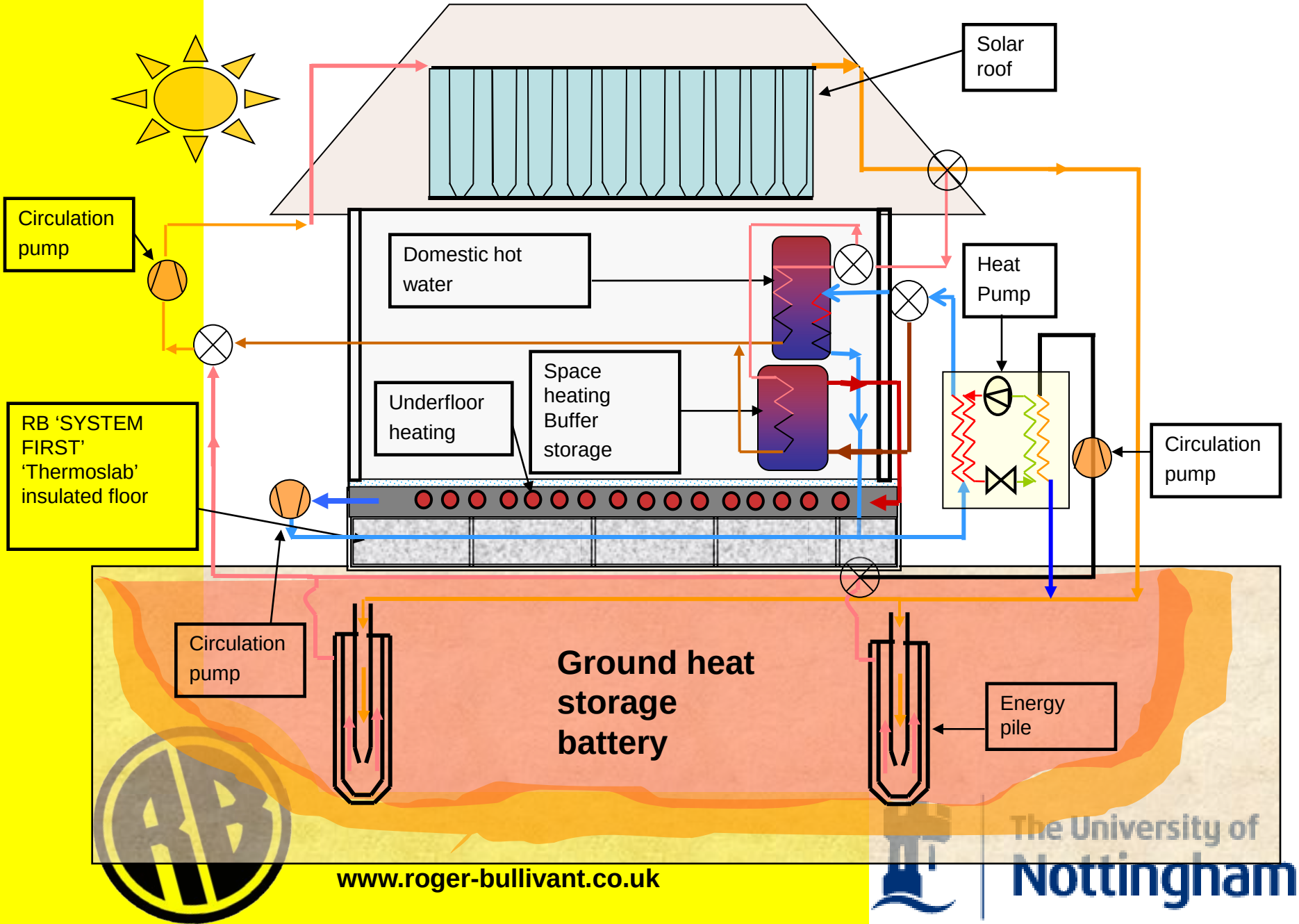
- Heat pump efficiency could be further increased by raising the ground temperature locally. (Dependent upon ground properties and amount of solar heat transferred to the ground.)



Piled Foundations – Ideal ground heat exchangers for new buildings!

- Convenient length and number of, influence a useful volume of ground. i.e. Building heat load vs thermal capacity of the influenced volume of ground
- Foundation becomes a ground heat battery – ‘Therma-foundation’
- Therma-foundation provides potential for increasing heat pump efficiency
- Cost effective method of installing ground loops

‘Therma-foundation’ Ground Heat Storage Battery



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Energy Piles for low rise buildings

- Adding plastic pipe to the pile reinforcement cages. Simple?

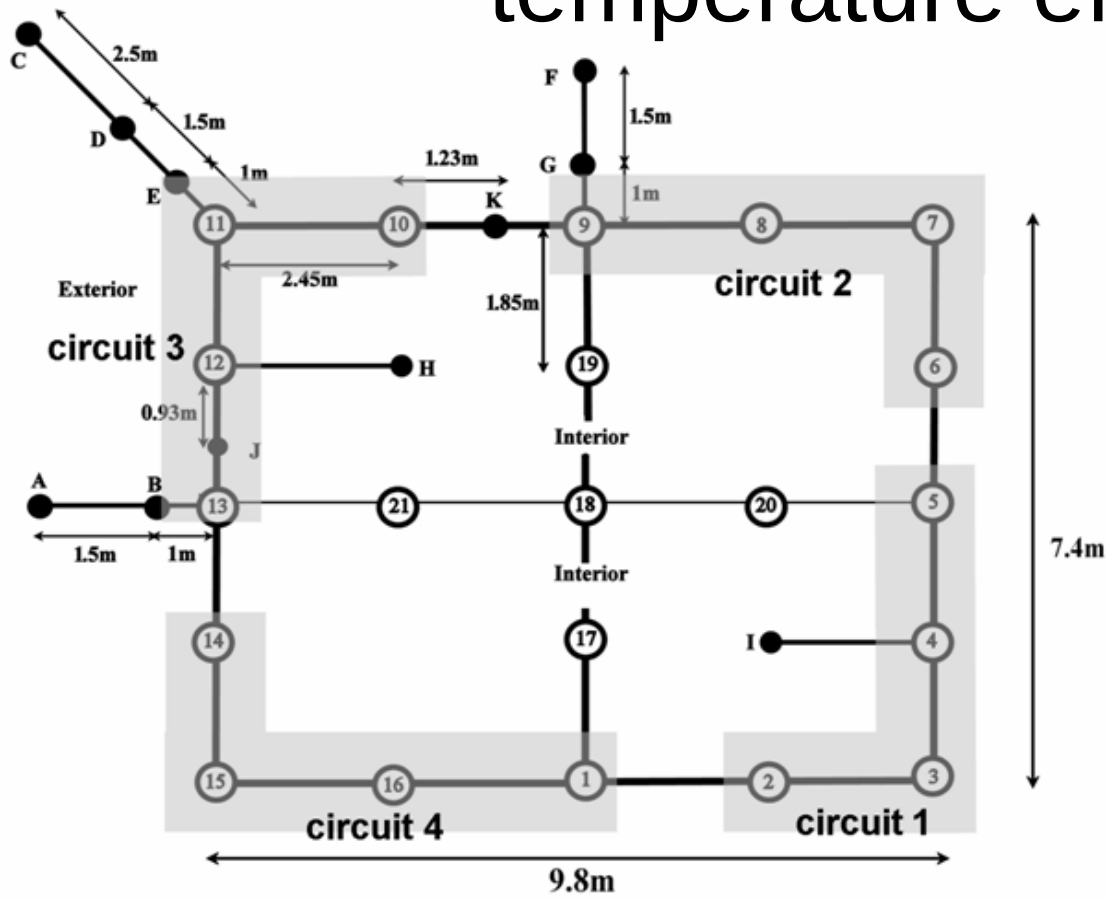
  Energy piles present a new problem as they fall outside of rules of thumb and conventional loop sizing guidelines for boreholes

- Considerations:
  - Heat loads
  - Pile spacing – structurally determined and irregular
  - Flow rates and pressure loss - Header circuit design
  - Thermal influence upon the piles

- Historic problems – Energy piles were installed in Europe over 20 years ago

  - Heat loads were much higher due to lack of insulation and heat recovery.

Primary research – ground temperature effects



- Plot equivalent to two semi detached starter homes or one larger 72m² detached.
- 21 piles to 10m. 300mm diameter. 1 x 32mm OD pipe U tube in each pile. Pile separation 1.86 to 2.46m
- Temperature monitored at 5m and 10m depth on each pile

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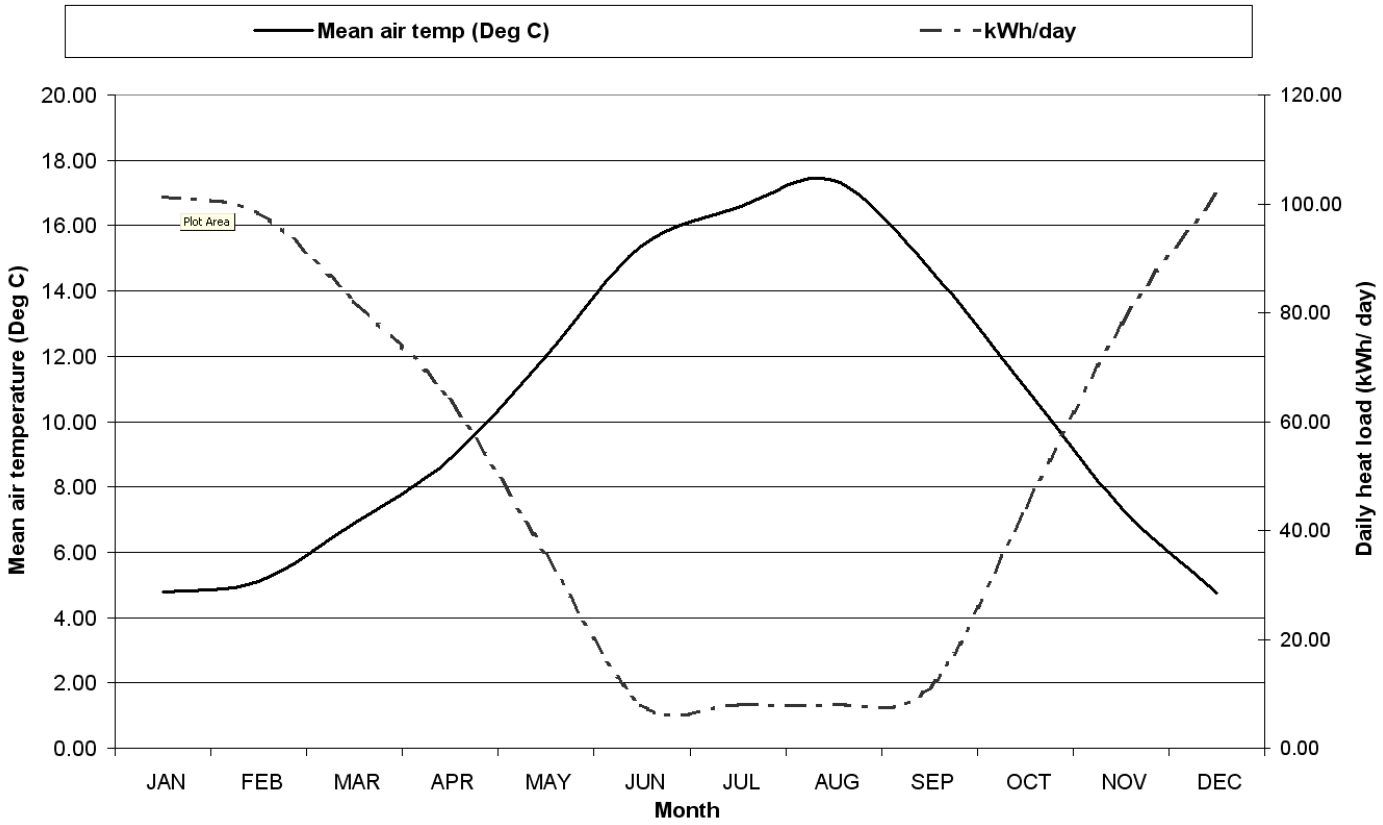
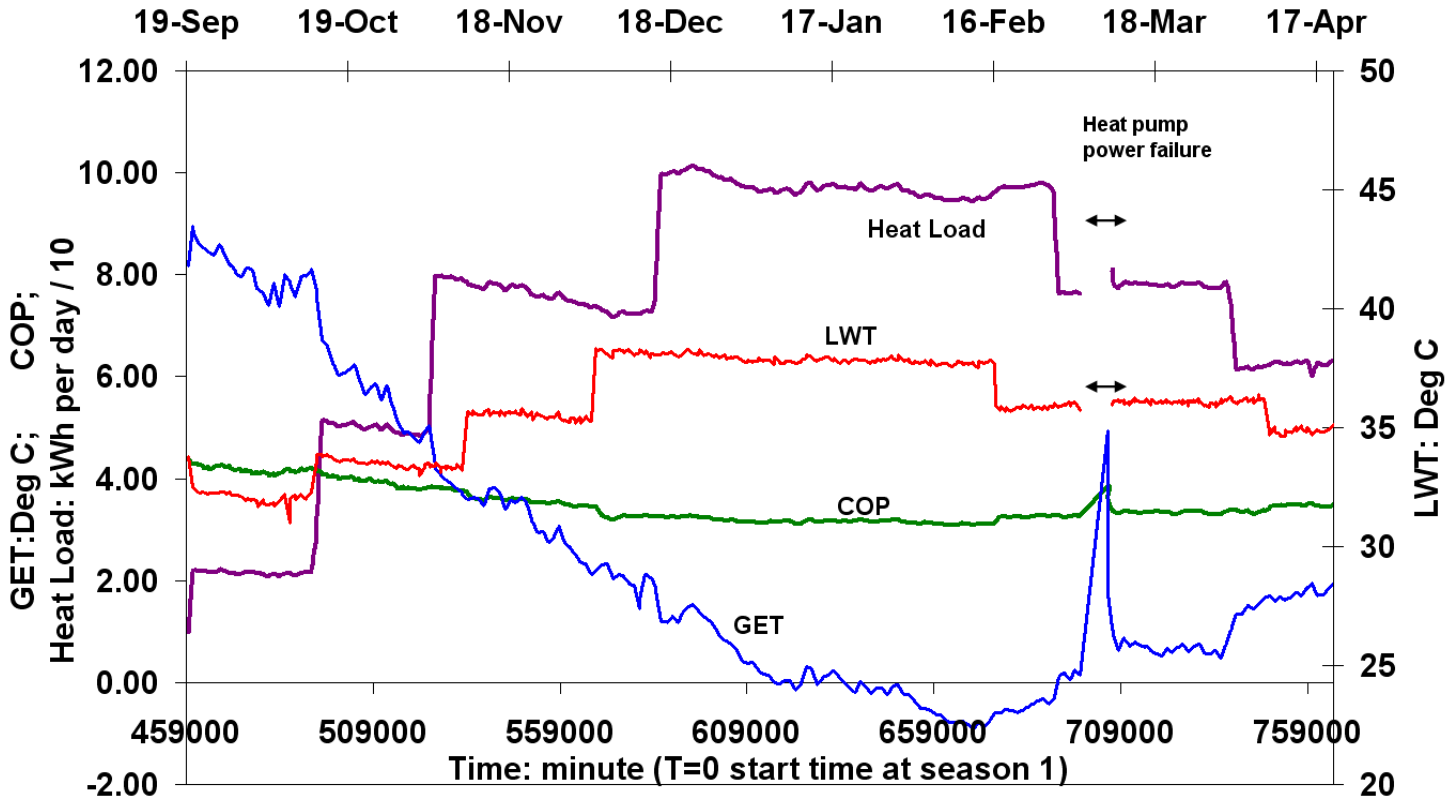
Heat loading

- 27W/m² at 4.8deg C
- Heat load per month calculated by interpolation with respect to the average outside air temperature
- Heat pump 5.6kW. COP of 3.6 = 25W/m (linear m of pile)



Heat pump monitored parameters



Period (Date)	Seasonal Performance factor	Heat output (MWh)
04/11/07 to 22/05/08	3.62	17.24
22/05/08 to 19/09/08	3.54	0.80
19/09/08 to 22/04/09	3.40	15.15

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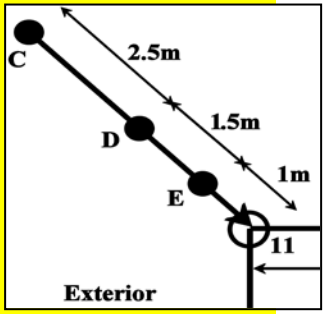
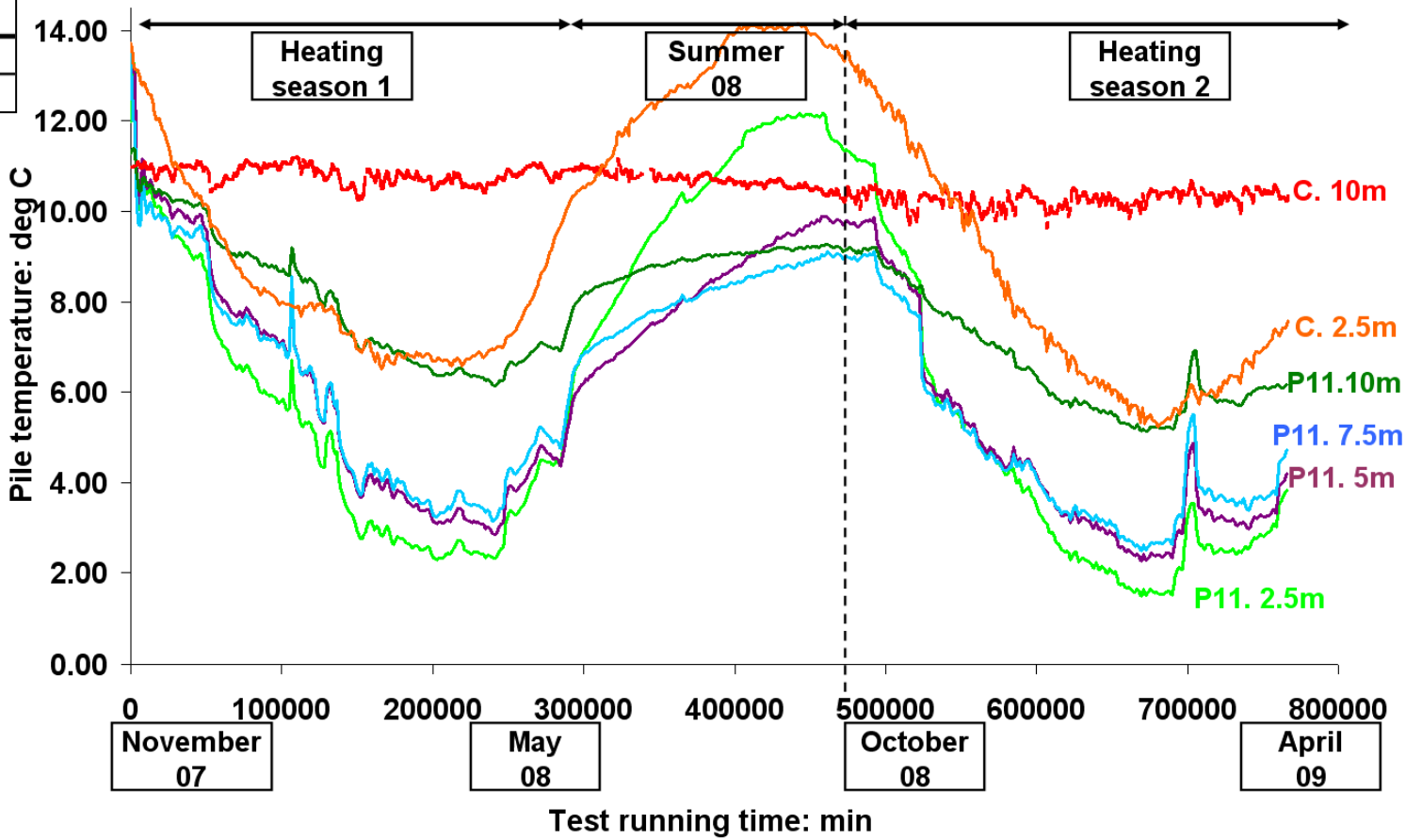
Temperature of pile 11 and far field array location C at various depths





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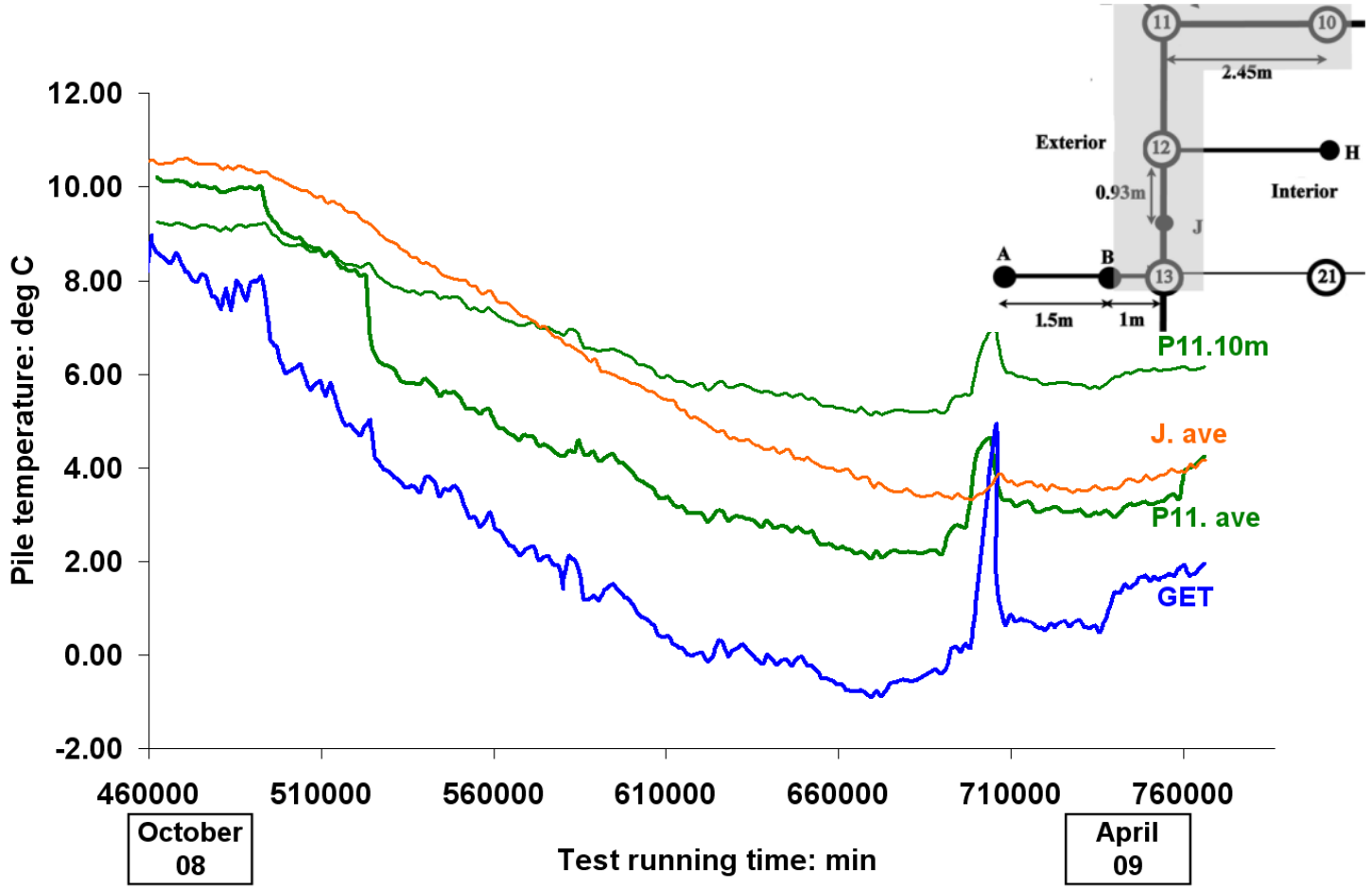
Average temperature of the centre of pile 11 in relation to GET and other temperature sensing locations



(averages calculated from depths 2.5, 5 and 7.5m)

Therma-foundation & Solar roof

- Solar roof only provides ground heat recharge – can not directly assist heat pump

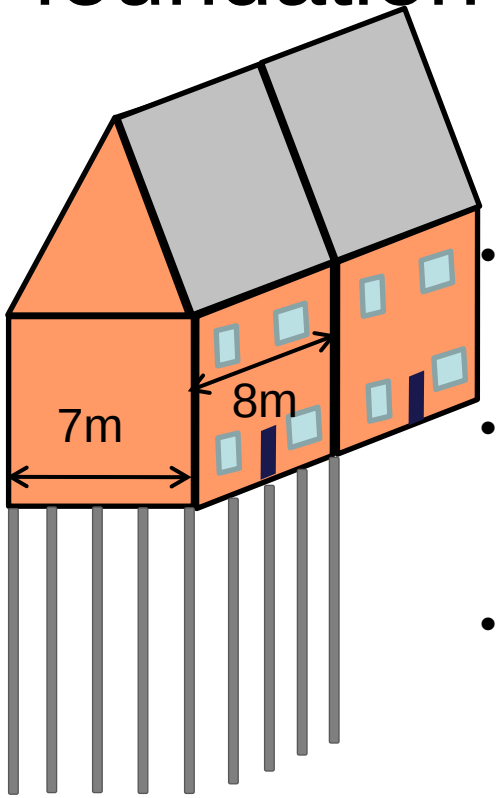
Solar Roof Initial Results

- 3 months tested after June 21st. Total Roof averaged close to17 kWh per day. Or just under 0.6kWh/m^2

- Running 15hrs per day. Mean of 40W/m^2, peaking at 100 to 120W/m^2

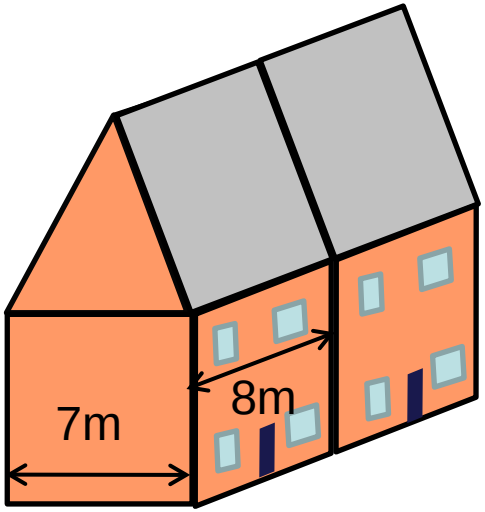
- Metal roof up to 45% greater heat transfer than conventional concrete tile

Example Application of Therma-foundation and Solar roof



- Roof with 40 ° pitch. South facing roof area of 36m^2
- Daily heat yield of 22kWh for summer period
- 2200 kWh across 100 days of mid summer

Piled Foundations – A diurnal heat store



- Diurnal storage plays a significant role in the autumn and spring months
- Heat contained closely in the concrete pile
- Heat transferred in the day to the pile reclaimed in the evening by the heat pump

- 15 piles. 220mm diameter to 8m length. Total thermal capacitance of 2.2kWh/K.
- Low energy house requires less than 10kWh per day for space heating in the Autumn/Spring
- Solar roof in October/ March days can achieve 0.2-0.5kWh/m^2 per day = 7 -18kWh in example (3-8 °C rise in temperature of pile, but in reality less due to leakage)

Installation – Basement + 2 stories

- 60 energy piles. 7m depth. 2 x 20mm OD U tubes (Rehau Pe-Xa) in each pile.
- Header circuit consists of 12 series systems of 5 piles. All series circuits connected in parallel by means of a manifold.
- Loops were fabricated on site and strapped to the cages.
- Pressure tested. Loops inserted into the hole, whilst under pressure.

Pile installation

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Backfill and Slab

Building has under floor heating – in the summer passive cooling of the concrete floor provides thermal comfort and also puts heat back into the ground

Installation –3 storey dwelling

- 10 Energy piles. 12m depth. 2 x 25mm OD U tubes (Rehau Pe-Xa) in each pile.

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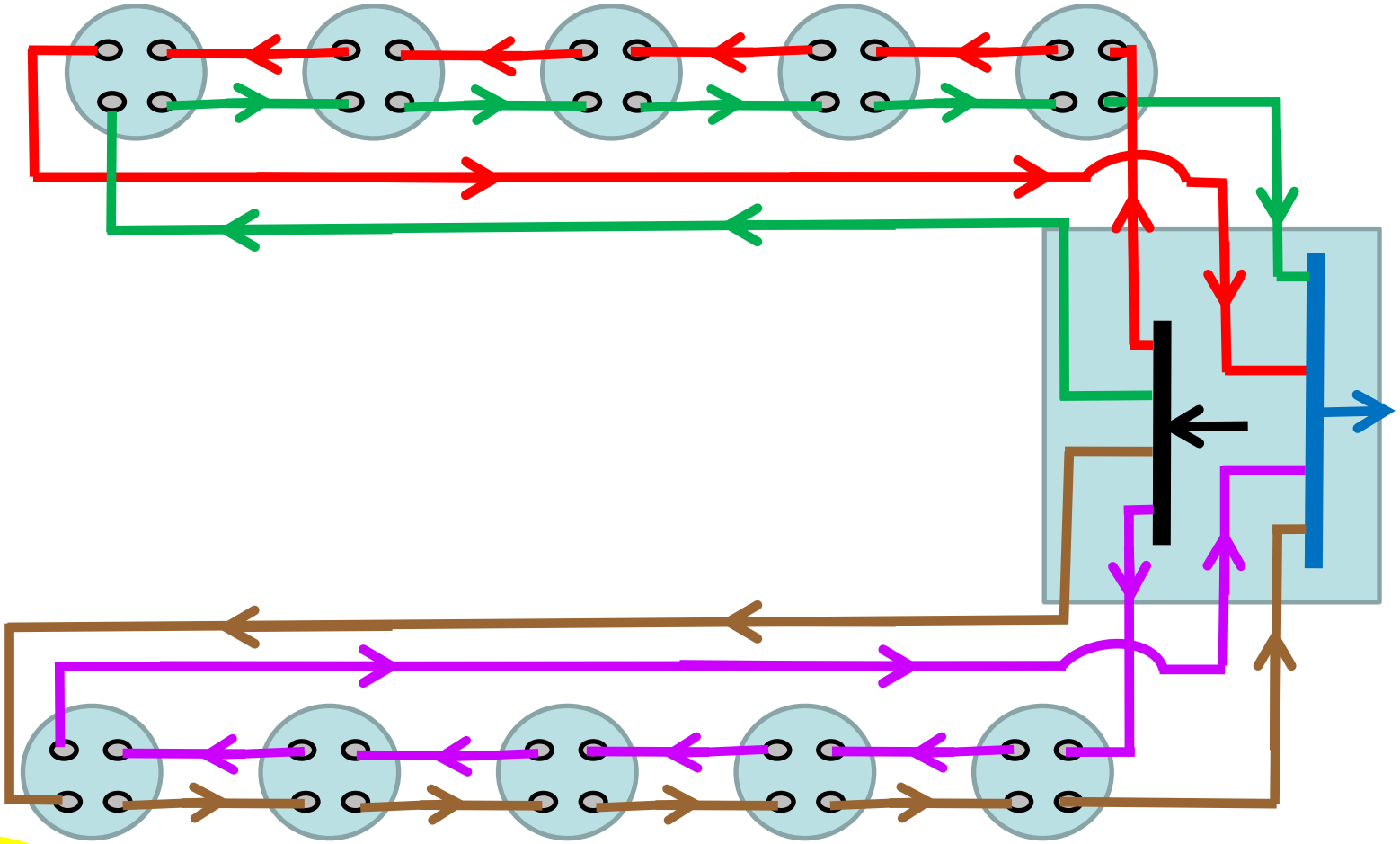
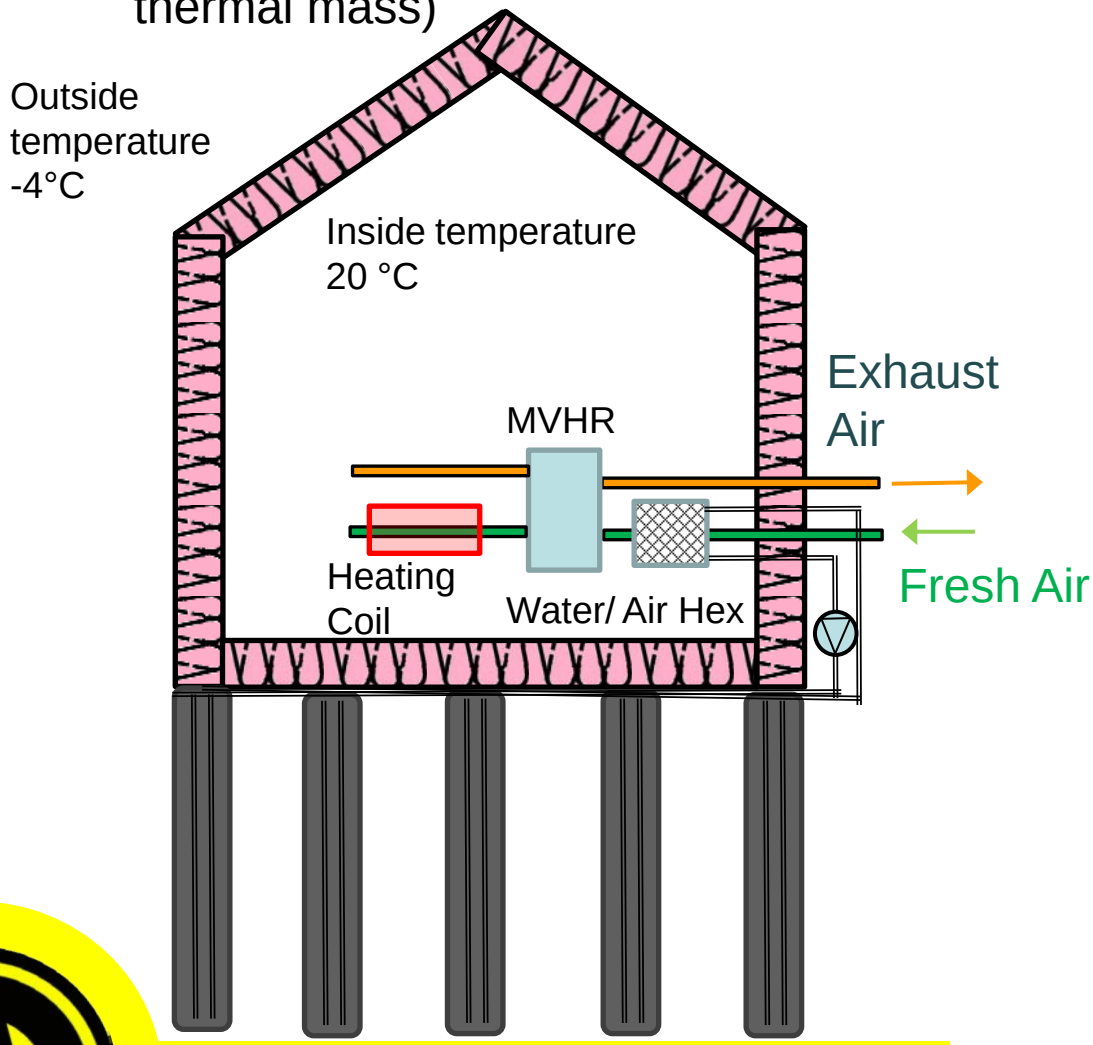
Header circuit



Energy piles - Passive techniques

(More specifically the access to and use of ground heat capacity / thermal mass)



- Ideal solution for lightweight buildings
- Preheats ventilation air in the winter.
- Cools ventilation air in the summer Or provides passive cooling of floor slab via the under-floor heating circuit

Summary

- Piled foundations are a useful and cost effective method of installing ground heat exchangers
- Solar recharging is a method of optimising COP/SPF, particularly with heating only systems (residential)
- In commercial buildings use the ground source for both cooling and heating – Optimises diurnal cycles
- Possible use of piled foundations for passive techniques (access of high thermal mass)

Thank you for listening!

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