Nick Salini
Technical Director

Introduction to Ground Source Heat Pumps

About us…

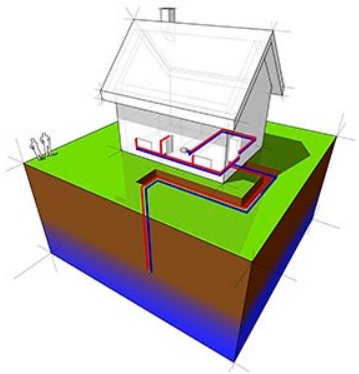
We established **Thermal Earth** in 2006 after recognising the need to move away from burning fossil fuels to heat our homes and building with more sustainable methods.

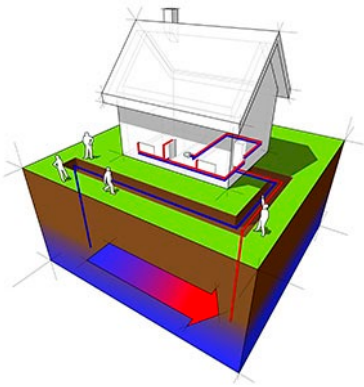
Originally focusing on the installation of Ground Source Heat Pumps (GSHPs), we found that knowledge and experience in proper design and installation in the UK was extremely limited.

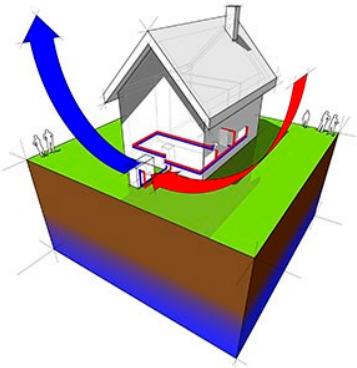
What is a Heat Pump?

A heat pump is a heating and cooling device that extracts energy from the air, water or ground and compresses it into a usable temperature to provide efficient heating, cooling and hot water to almost any building.

Energy is captured in various ways by our planet. We then use a heat pump to absorb this energy with a relatively small amount of electricity to compress this heat into a useable temperature to be used for space heating/cooling and hot water to almost any building.

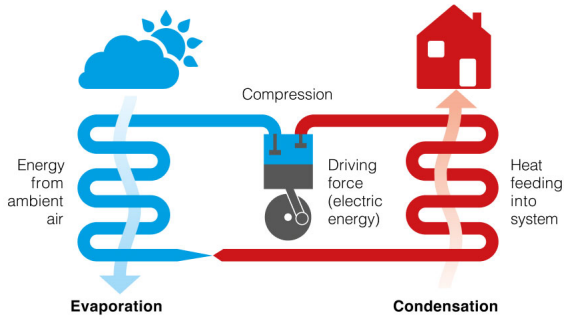


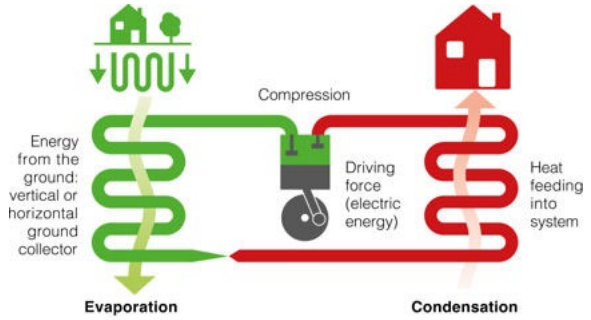




How does a GSHP work?

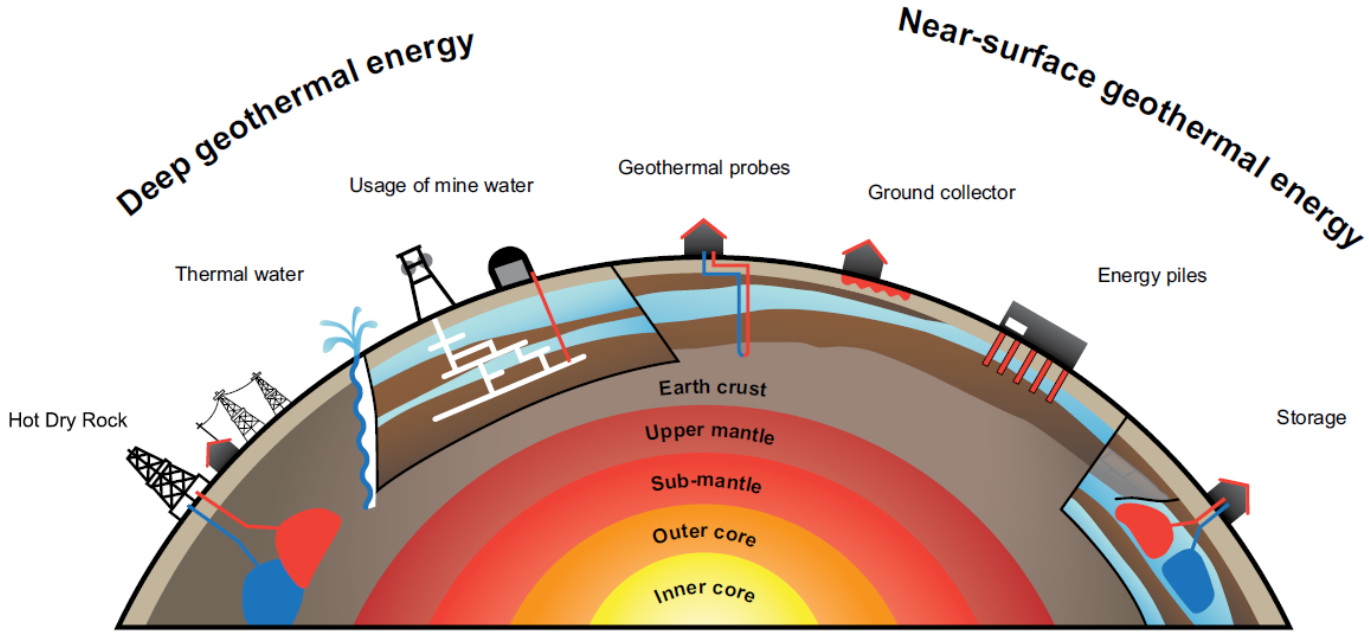
A ground source heat pump works by absorbing energy (approx. 10-12°c) from the ground with a network of shallow buried pipes. These pipes have a fluid inside circulating through them at a lower temperature than the surrounding ground.



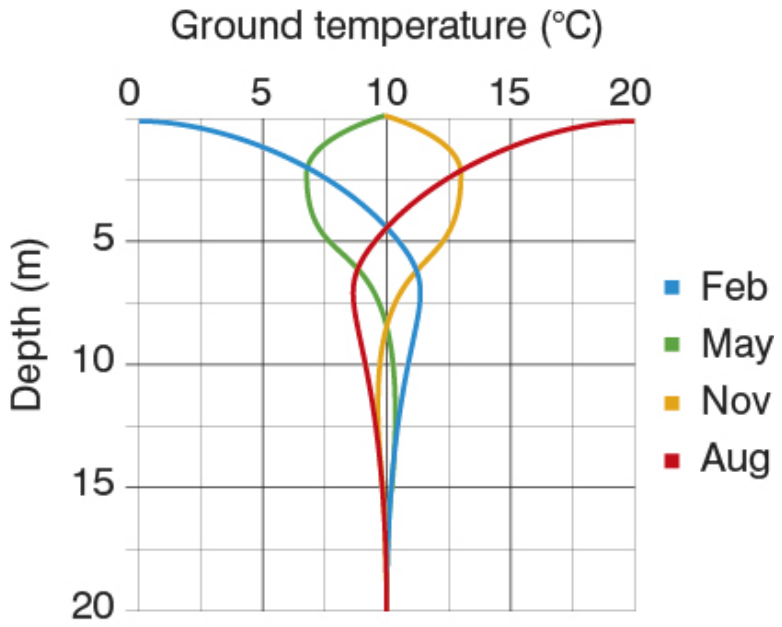


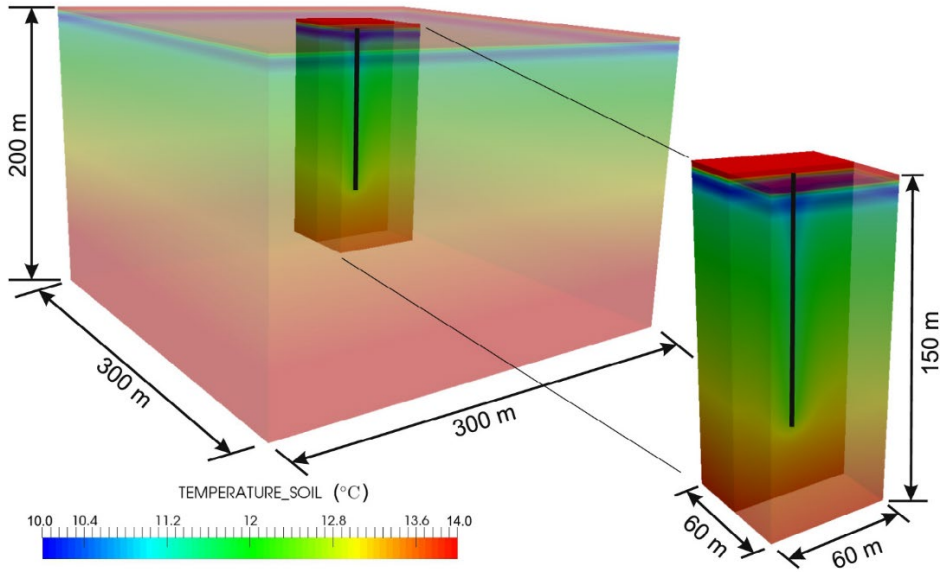
FUNDAMENTAL OF GEOTHERMAL ENERGY

Geothermal energy is the energy that is stored in the form of heat under the Earth ‘s solid surface. 30 – 50% of this energy originates from the time of the Earth ‘s creation and can be described as the residual heat of the processes that took place at that time. The main part, around 50 – 70%, is the result of the continuous decay of radioactive elements in the Earth‘s interior; a small remainder is due to direct sunlight and/or the indirect heat exchange with the air or rainwater seeping through the Earth‘s surface.



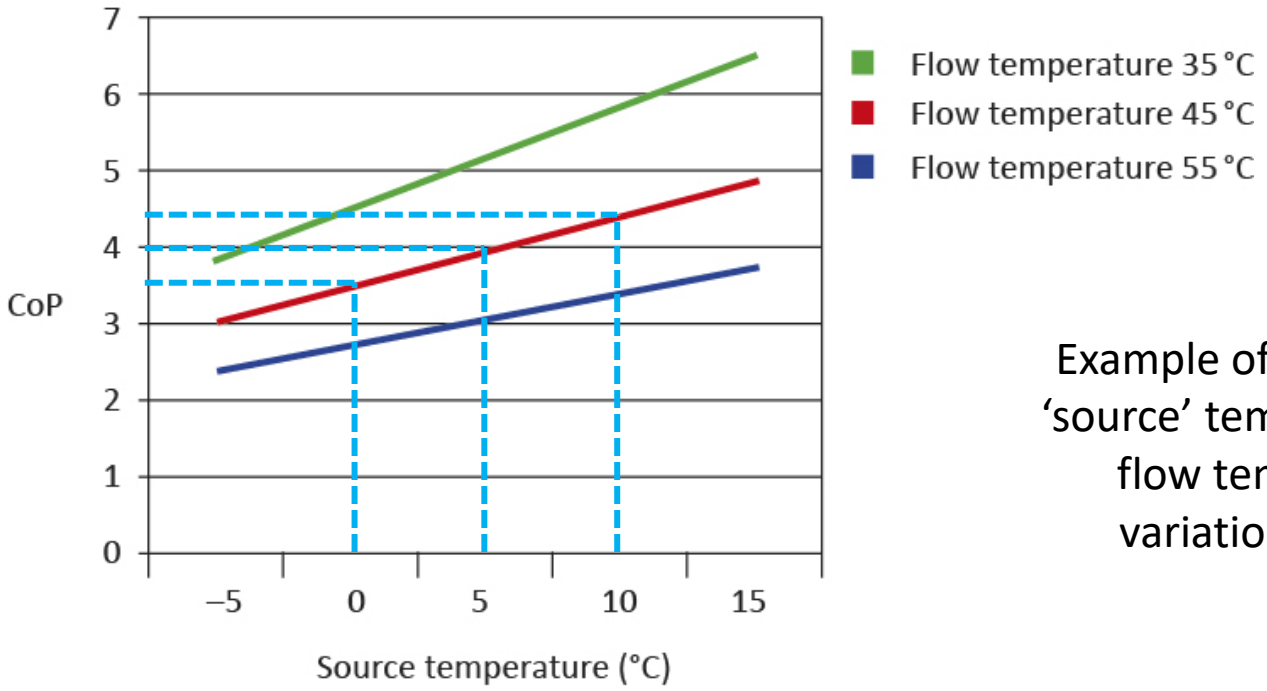
Why do closed loop ground source heat pump offer higher long-term performance?



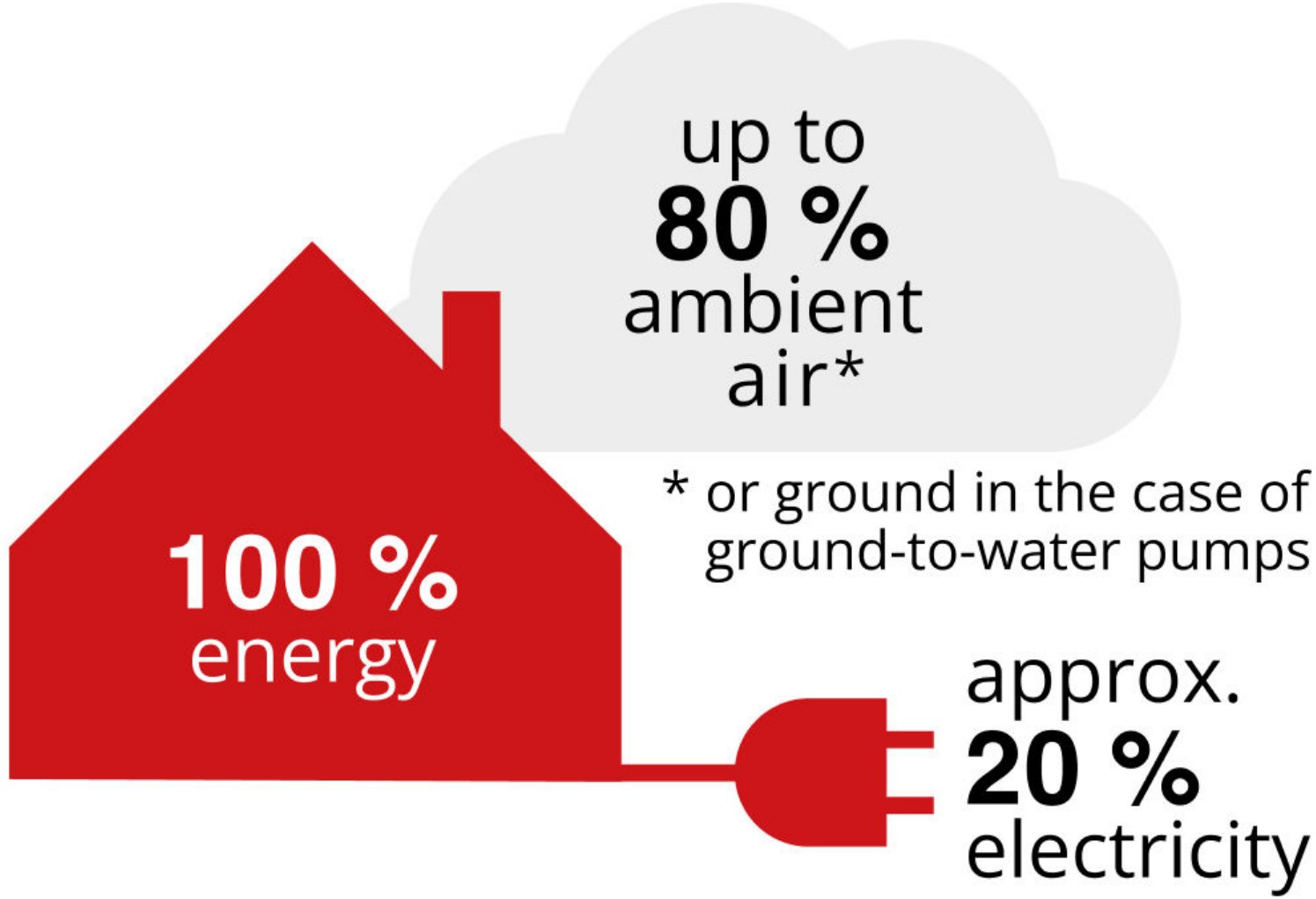


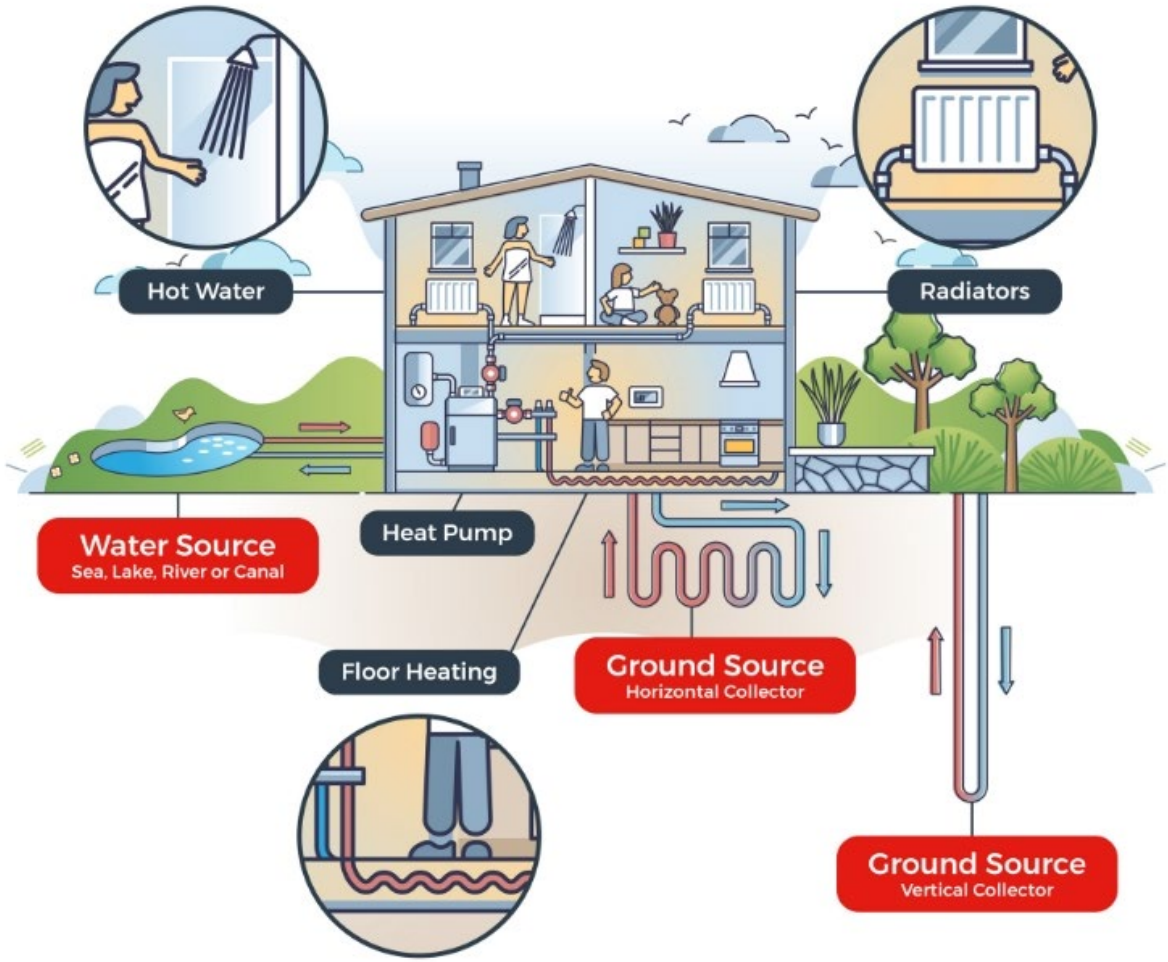
Typical relationship between ground temperature and ground depth for a location with a 10˚C mean annual external temperature

Heat pump coefficient of performance



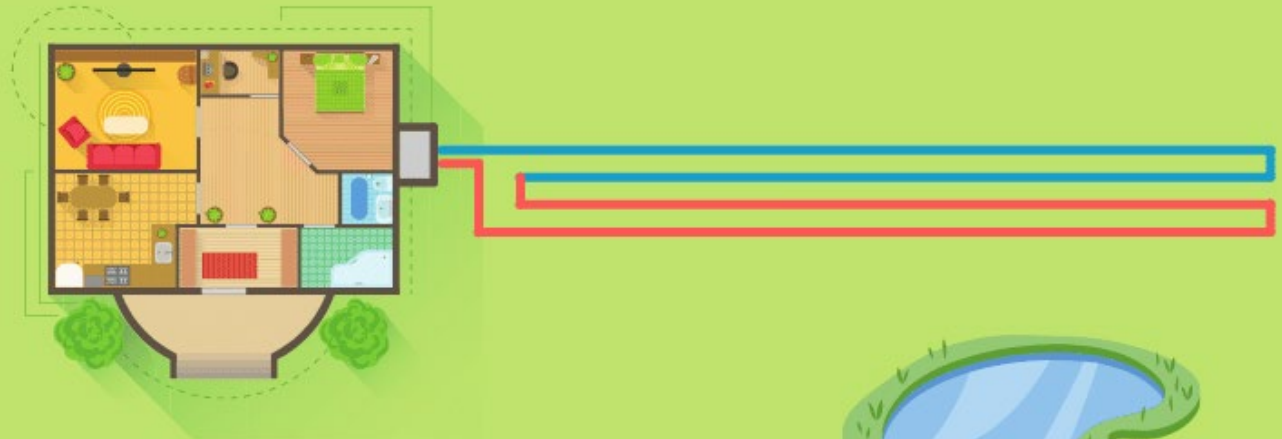
Example of the effect of ‘source’ temperature and flow temperature variations on CoP


up to
80 %
ambient
air*
* or ground in the case of
ground-to-water pumps
100 %
energy
approx.
20 %
electricity



Courtesy of GSHPA

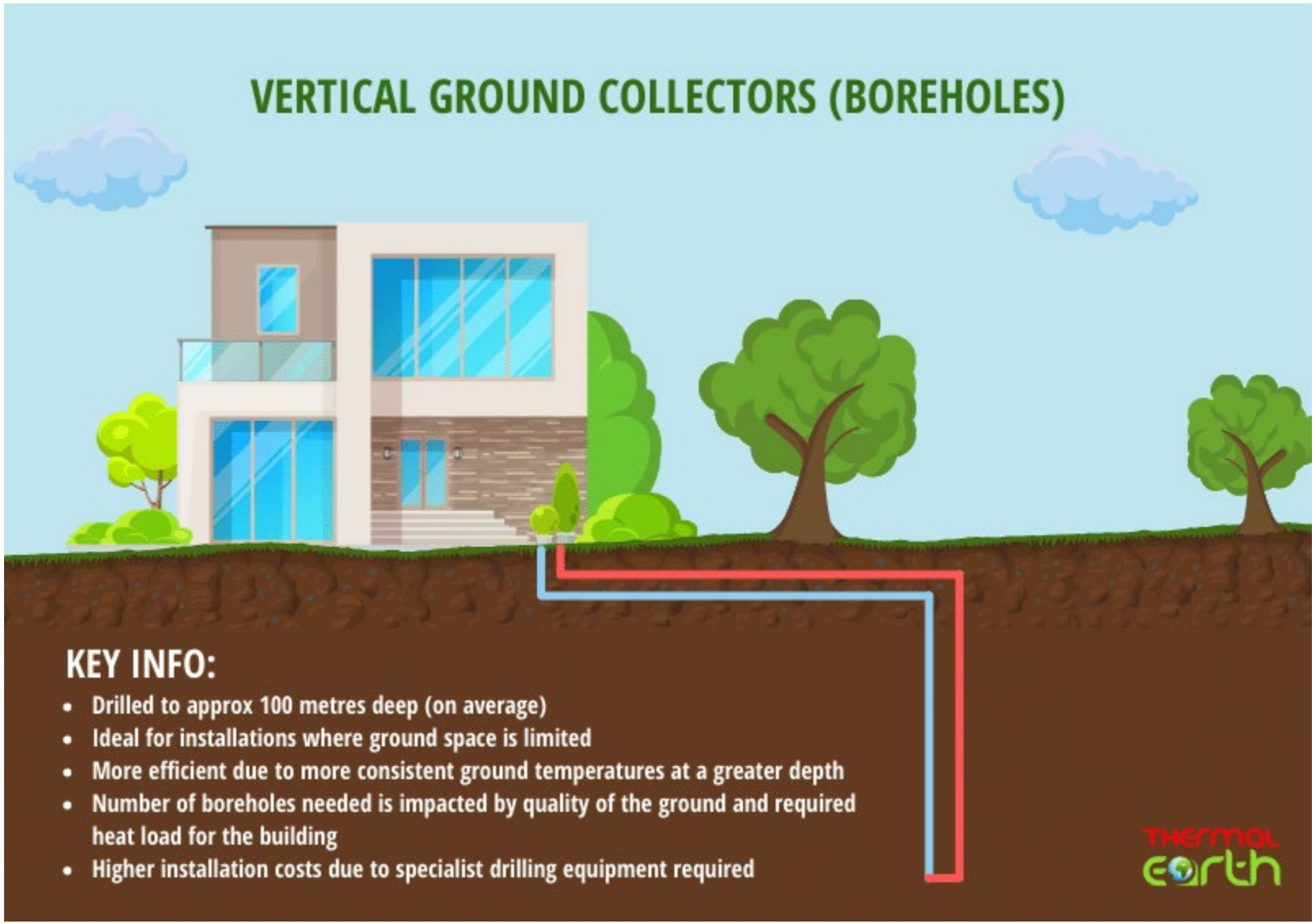
HORIZONTAL GROUND COLLECTORS (STRAIGHT PIPE)



KEY INFO:

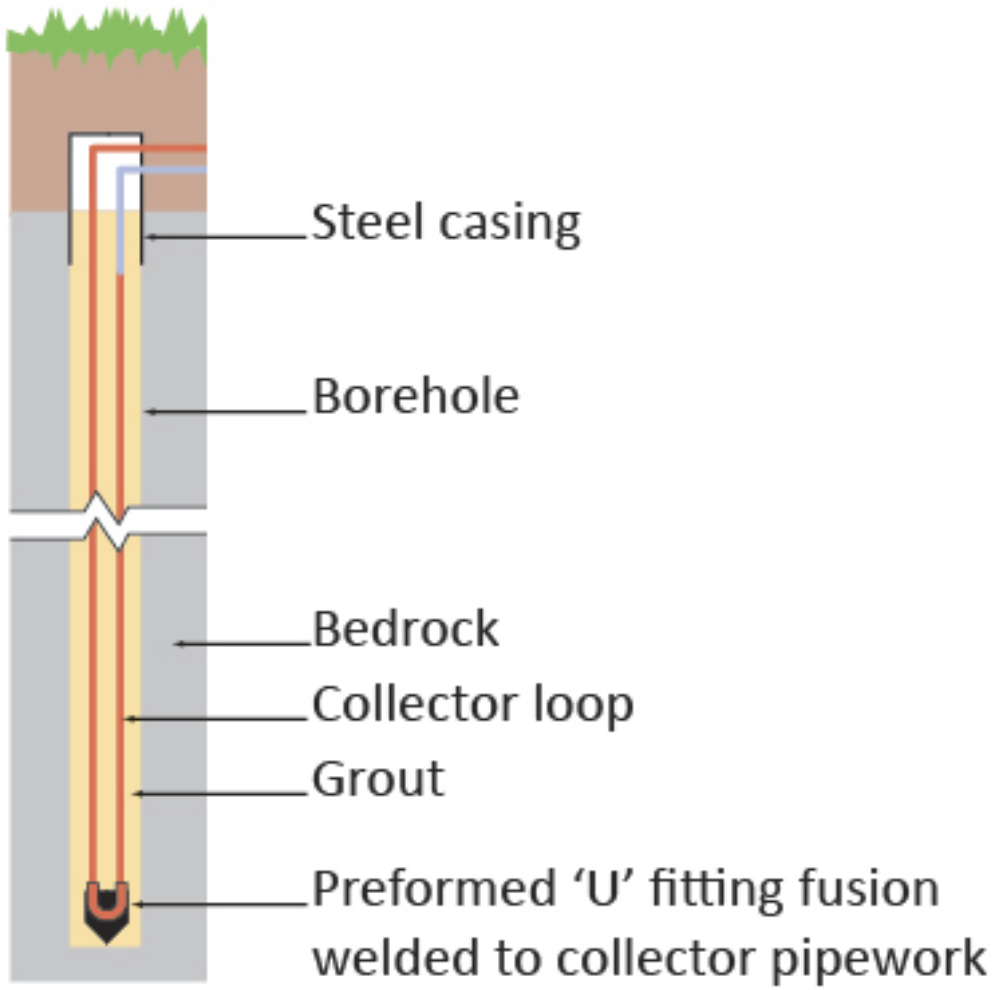
- Trenches are dug around 1 metre deep and 0.5 metres wide
- Each trench runs approx 100 metres away from the property and 100 metres back
- Number of trenches will depend on quality of the ground and required heat load for the building
- More cost-effective than vertical collectors

Horizontal Collectors…


VERTICAL GROUND COLLECTORS (BOREHOLES)
KEY INFO:
• Drilled to approx 100 metres deep (on average)
• Ideal for installations where ground space is limited
• More efficient due to more consistent ground temperatures at a greater depth
• Number of boreholes needed is impacted by quality of the ground and required heat load for the building
• Higher installation costs due to specialist drilling equipment required

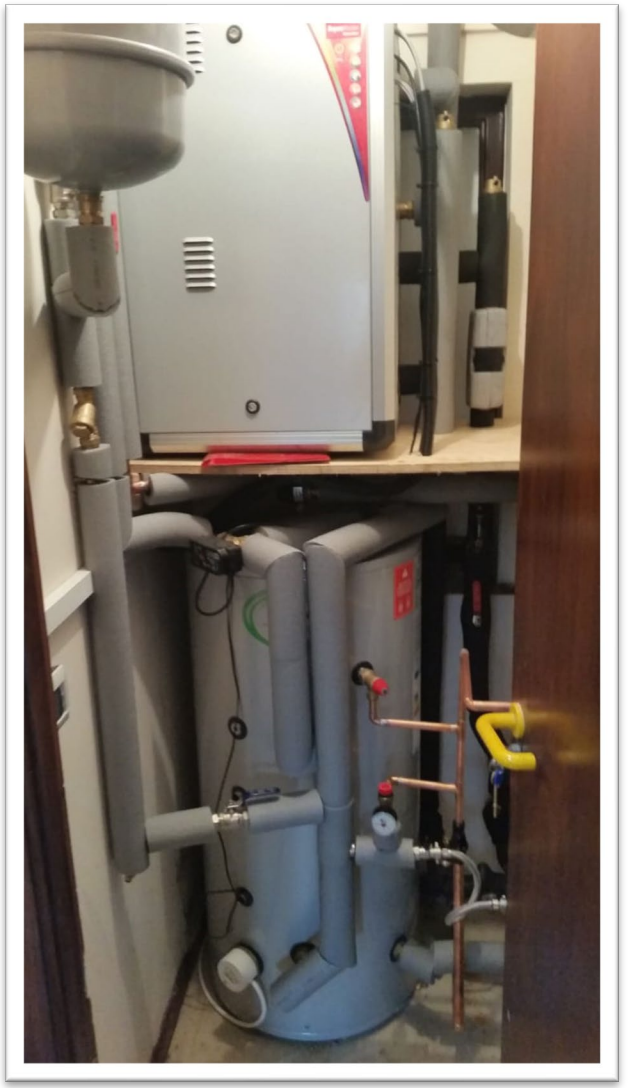
Vertical Boreholes…

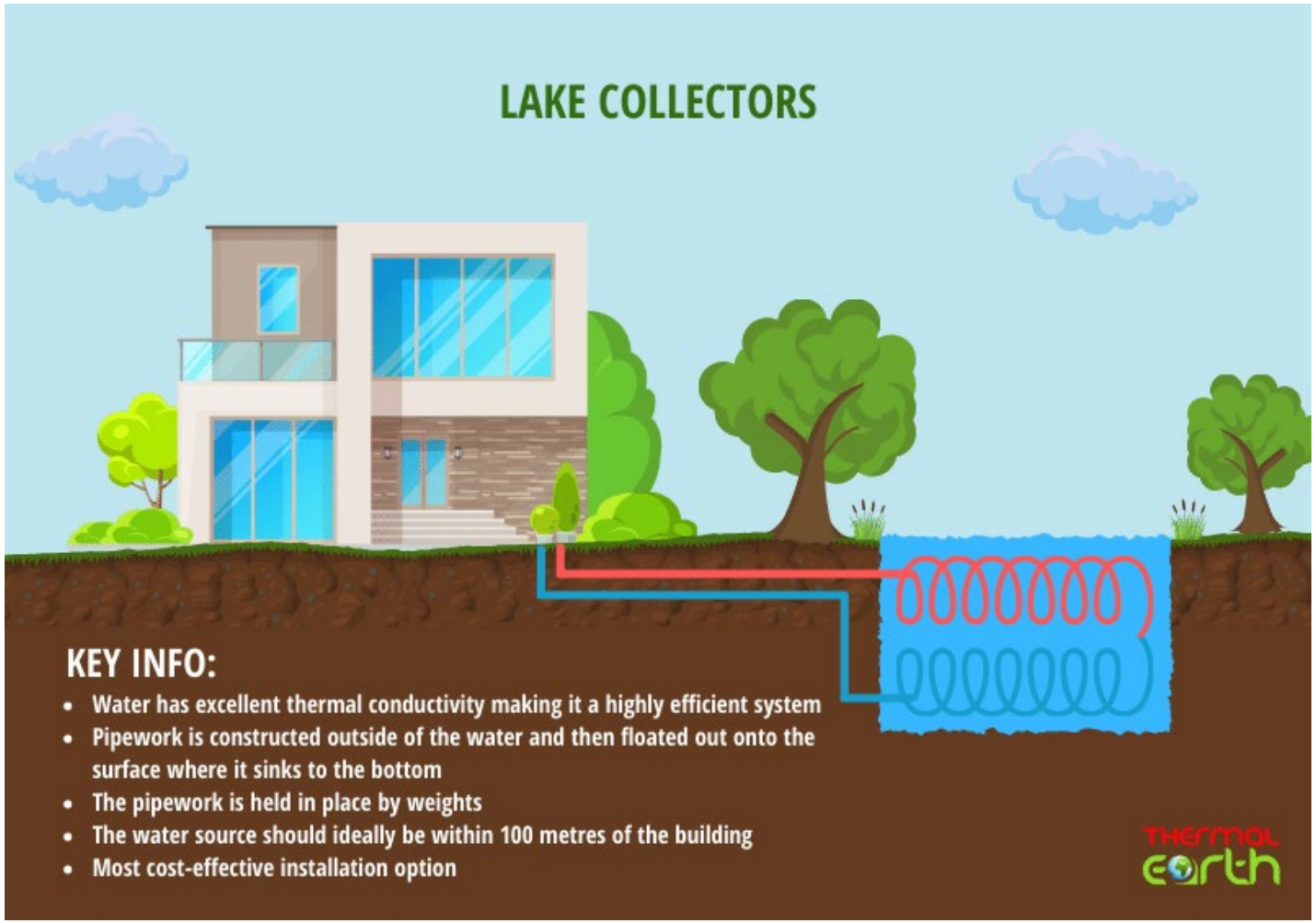
Vertical Boreholes…


Steel casing
Borehole
Bedrock
Collector loop
Grout
Preformed ‘U’ fitting fusion welded to collector pipework

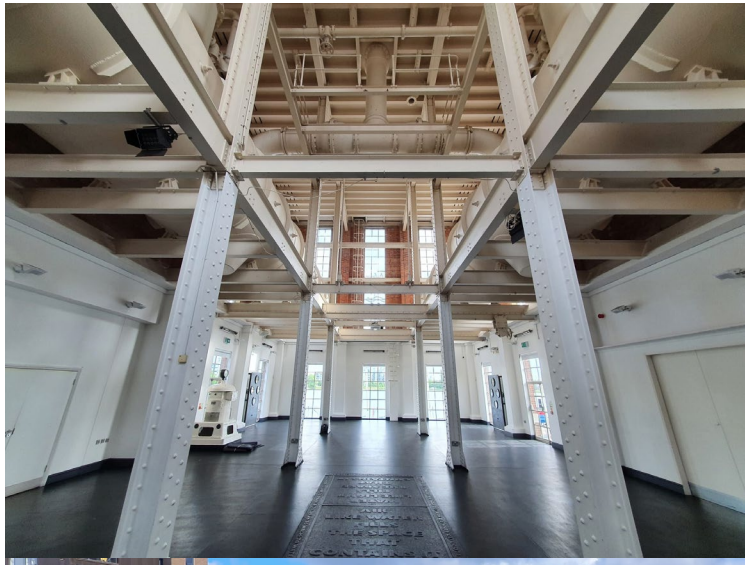
Connecting up loops or boreholes…

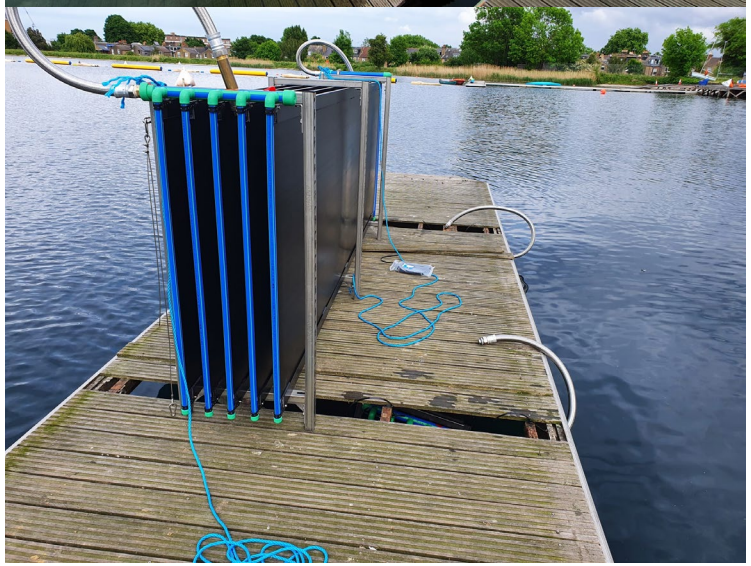
Retrofit GSHP?




LAKE COLLECTORS
KEY INFO:
• Water has excellent thermal conductivity making it a highly efficient system
• Pipework is constructed outside of the water and then floated out onto the surface where it sinks to the bottom
• The pipework is held in place by weights
• The water source should ideally be within 100 metres of the building
• Most cost-effective installation option

Pond/Lake Collectors Loop…



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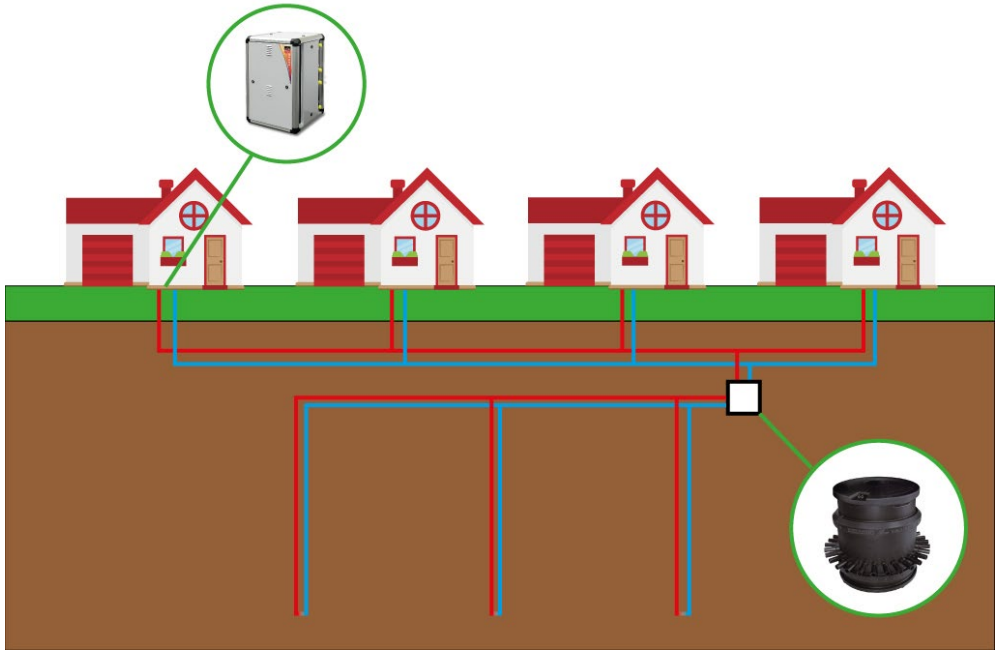
Thermal Response Test (TRT)

Shared Ground Loop/Networked GSHP



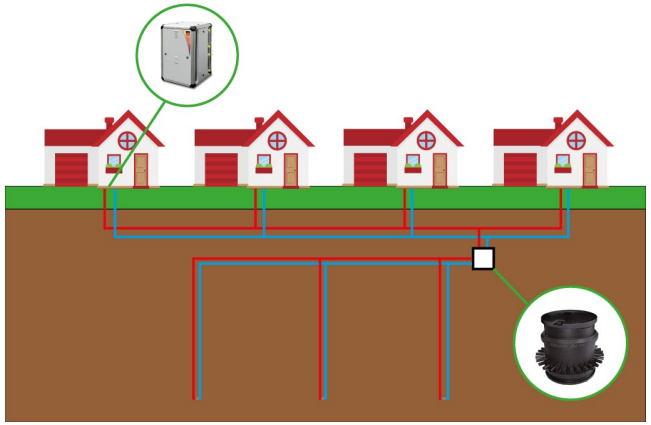
Micro-grids…

Micro-grids…

Wider opportunity for shared ground loop GSHP systems?

A “**shared ground loop**” is the name given to a district heating network where at least two or more properties have an individual heat pump connected to a communal ground loop.
The shared ground loop is installed as a series of boreholes, central to either a community of houses or serving one large building of multiple dwellings.

These types of systems have a number of technical advantages and have significant financial advantages.



Key Advantages of GSHP SGL systems:

Long term investment – Ground arrays have a lifespan of up to 100 years.

No need for planning – There is no requirement for planning permission as the systems meet the criteria for permitted development.

Cost effective - Can often reduce the overall amount of boreholes required for the project as a whole. The most expensive part of any borehole is the first 0-30m.

Controllable & simple – As each property has their own heat pump, they can be controlled independently with each property setting their own comfort levels with radiators or underfloor heating.

Additionally, as all heat pumps are ‘local’ to each property they are connected to each properties electrical supply and require no separate billing or metering.

Key Advantages of GSHP SGL systems:

Versatility: Shared ground loops are suited to any building, whether it be new builds or retrofits. The loop can be expanded at any time in the future to expand the network. The boreholes of the system can be distributed flexibly across the site.

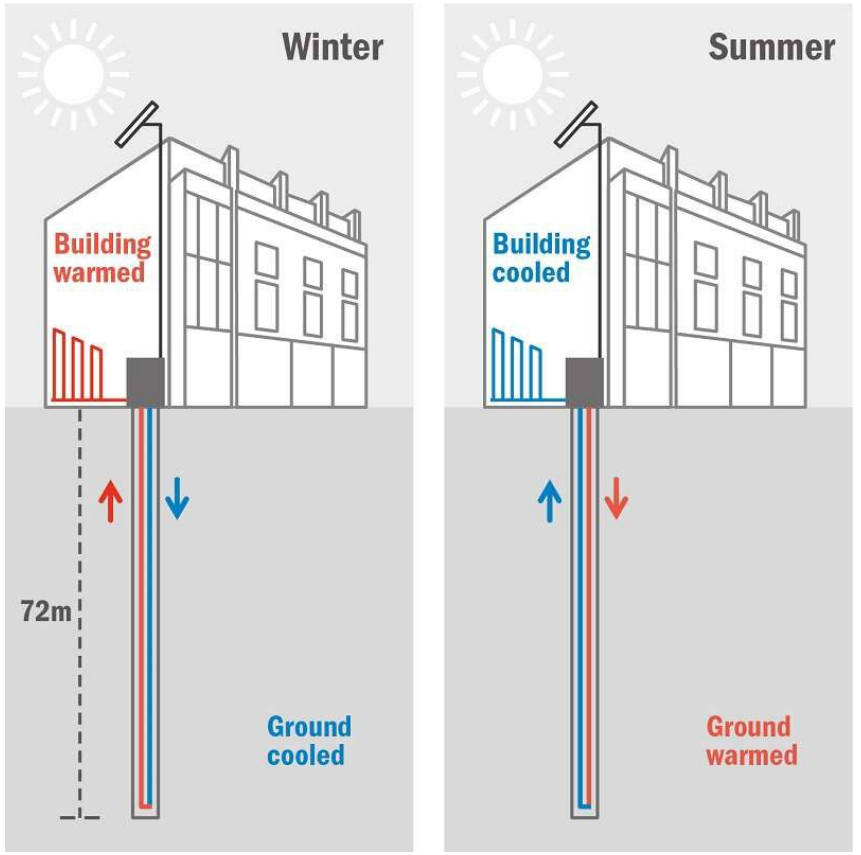
Resilience: Should a fault with an individual heat pump occur anywhere on the shared ground loop network, it will not affect any other heat pump connected to the system. Each heat pump is entirely independent of one another, so should a heat pump go down or need maintenance, no other heat pump is affected.

Can GSHP provide cooling?

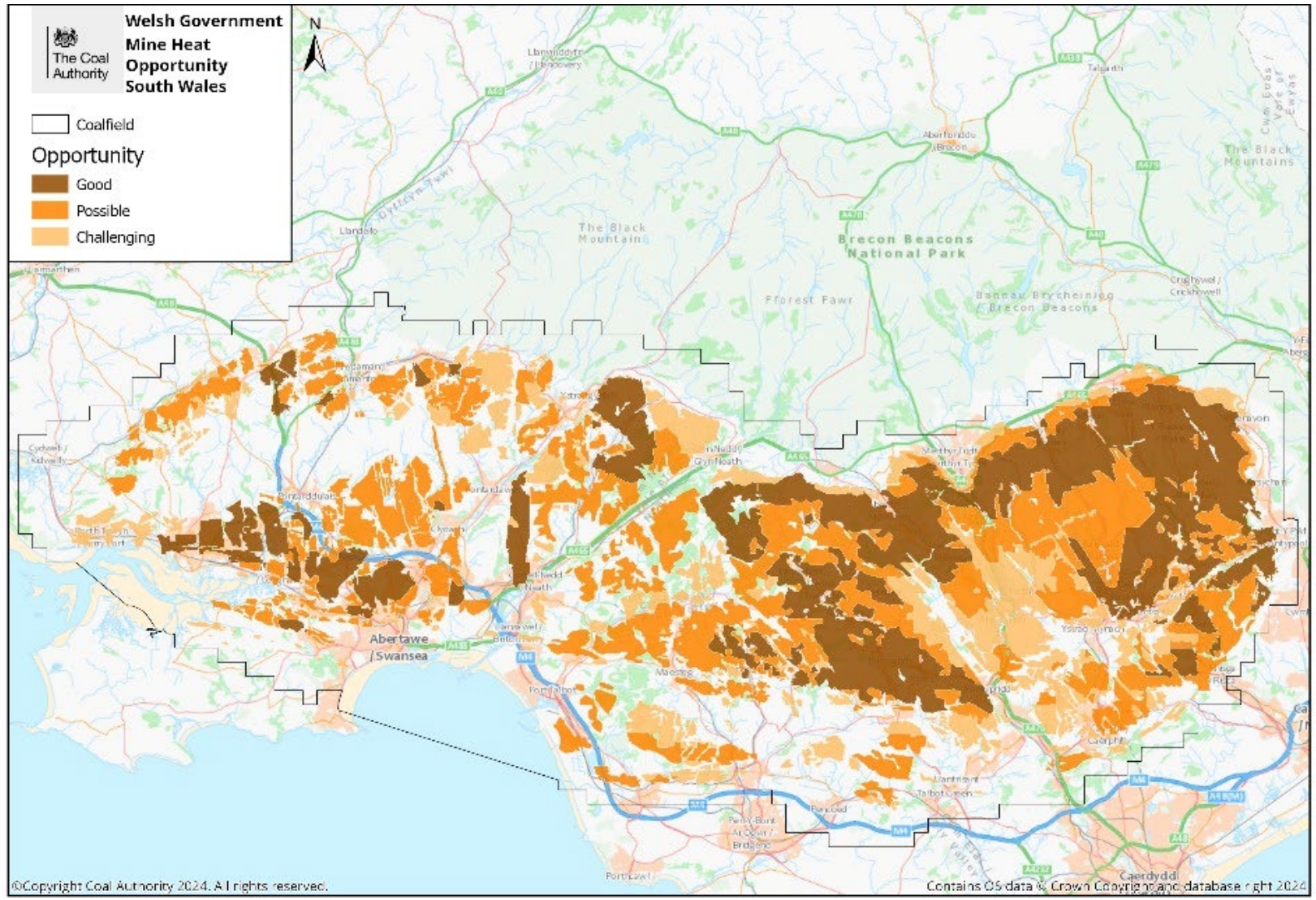
Yes. GSHP can provide cooling in a number of ways. They include…

- Passive Cooling
- Full/Active Cooling
- Simultaneous Cooling

Whenever we do offer cooling its has a double benefit where we recharge the ground with the energy from the home in the summer to be used in the winter.



GSHP for old buildings?


Welsh Government
Mine Heat
Opportunity
South Wales
The Coal Authority
N
Coalfield
Opportunity
Good
Possible
Challenging
Brecon Beacons National Park
The Black Mountains
Abertawe / Swansea
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THANK YOU

sero

Should there be a fuss about Ground Source Heat Pumps?

TPAS

Andy Sutton RIBA

CoFounder & Chief Innovation Officer

5 November, 2024

Should there be a fuss about Ground Source Heat Pumps?

Image © Manu Fernandez/Associated Press

- You may not have heard (!),
  but there's a Climate Emergency,
- The affect of this is that we need to stop putting Greenhouse Gases into the air, the most common of which is Carbon Dioxide (CO_2),
- This is sometimes called "decarbonising"
- The ideal goal to let no carbon or other Greenhouse Gass escape into the air, which can be called "Net Zero",
- Net Zero is means a total of no carbon is emitted into the atmosphere over the course of a year.

Should there be a fuss about Ground Source Heat Pumps?

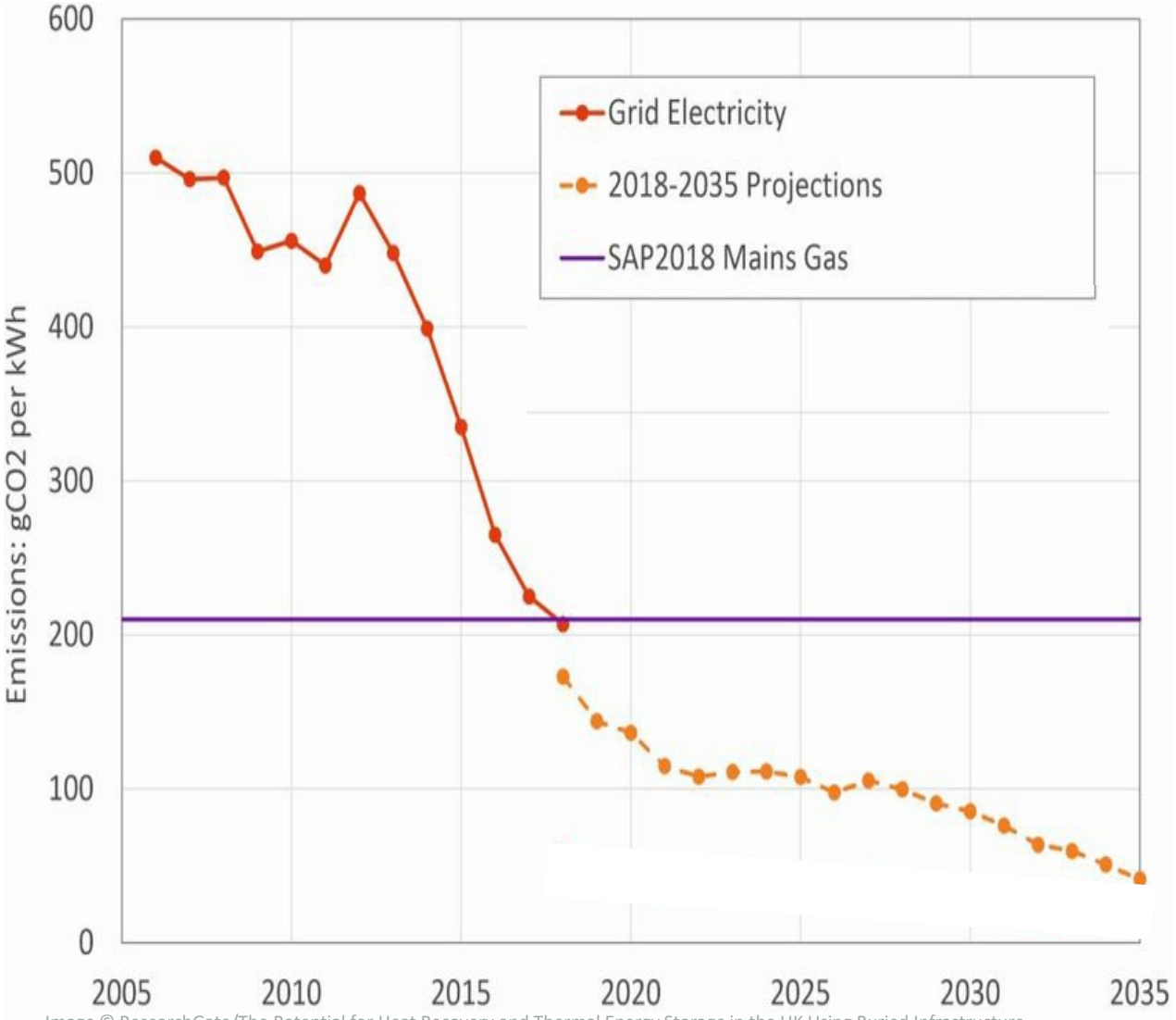
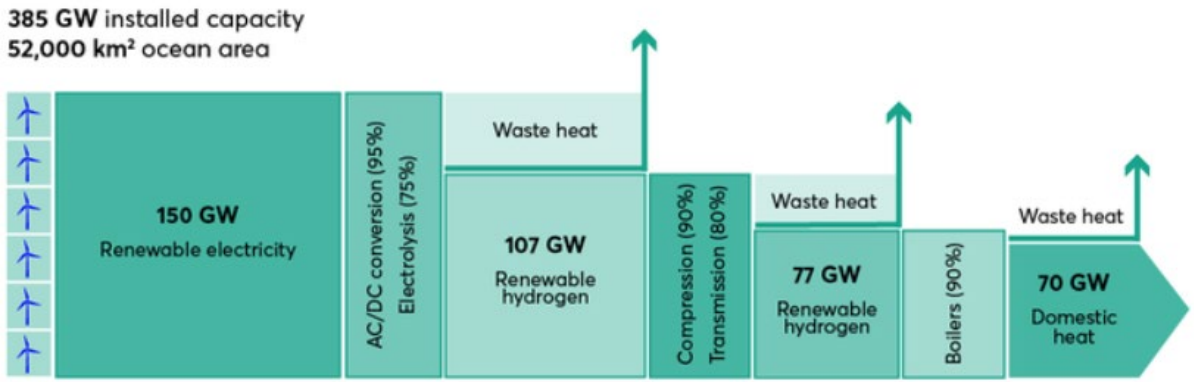


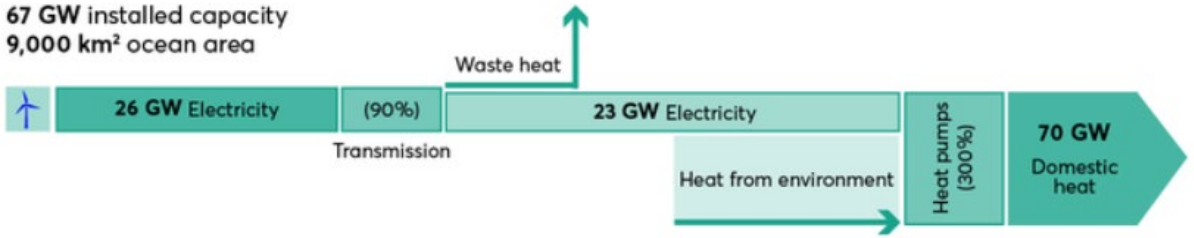
Image © ResearchGate/The Potential for Heat Recovery and Thermal Energy Storage in the UK Using Buried Infrastructure

- Much of our current energy comes from burning fuels, especially fossil fuels,
- Burning generates carbon as it releases the chemical energy in the fuel, so all fuel which is burnt generates carbon that could drive Climate Change,
- The UK therefore needs to “decouple” providing useful energy from emitting carbon,
- Electricity is the **only** major transportable and useful energy that can be ‘generated’ without carbon emissions,

Should there be a fuss about Ground Source Heat Pumps?



Hydrogen home heating



Heat Pump home heating

Image © NESTA/why hydrogen is not the solution to decarbonising our homes

- "***But Hydrogen!***" you cry,
- Green hydrogen has a big part to play in Net Zero as a solution to some industrial processes, and possibly as long term "fuel" storage to balance the Grid,
- But green hydrogen to heat homes means Resident's heating bills are forecast to be around 70% higher than from simply electrified heating,
- Plus hydrogen is still burning, and generates air pollution (and Greenhouse Gases if it's not a 'clean' burn)

- *PS - the same impact is true for light transport*

Should there be a fuss about Ground Source Heat Pumps?

Image © Harley Davidson

- Hopefully three slides got you from **Climate Change** to **Electrifying Everything**!
- What that means in everyday life is, over the coming years, we will all…
  - Travel in electric transport, from buses & trains to cars & motorbikes,
  - Heat our homes and our hot water with electrically powered heaters

Should there be a fuss about Ground Source Heat Pumps?

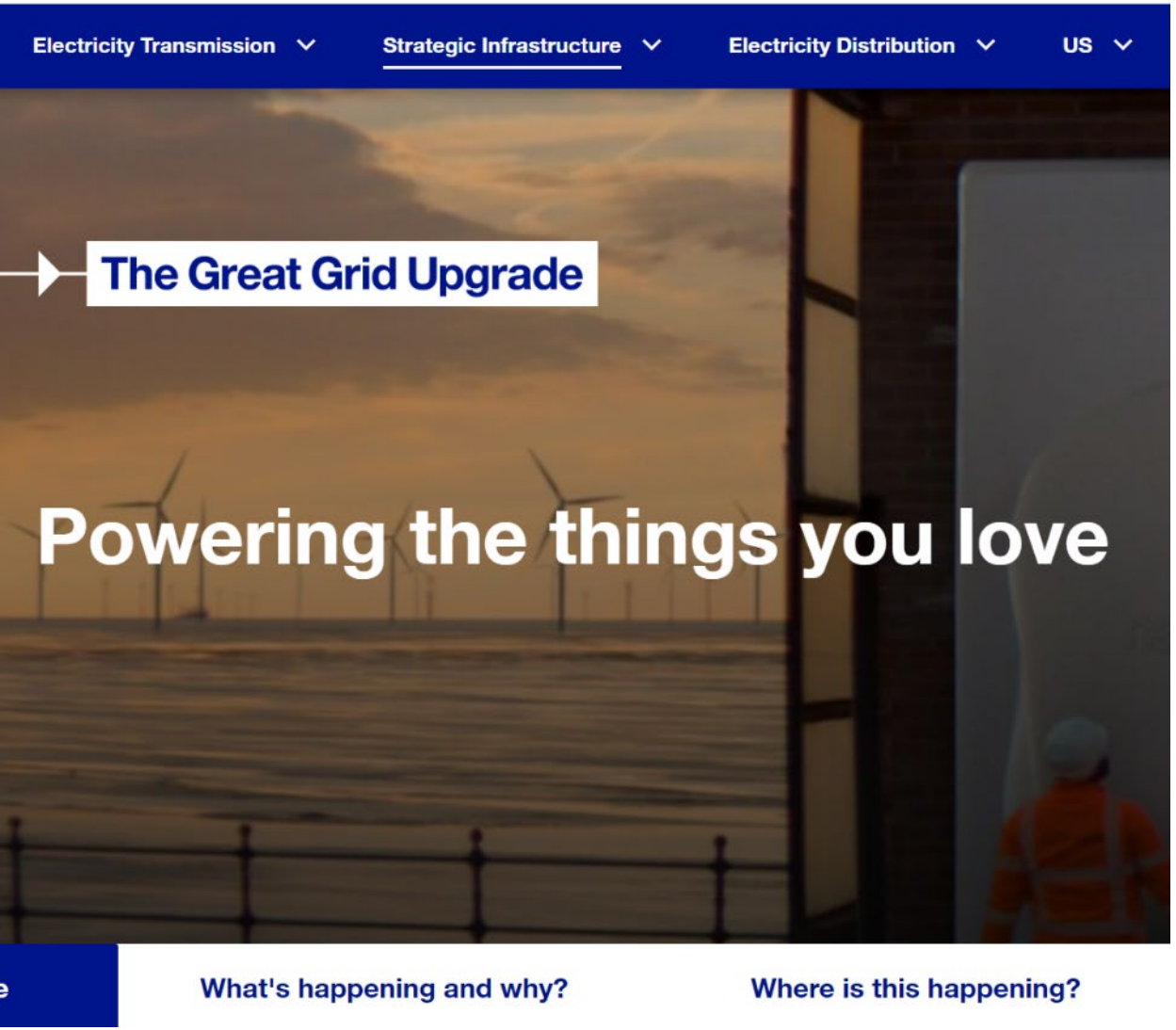


Image © National Grid

- *"**But the Grid won't cope!**"* you say, (and you'd be right, today)
- The UK National Grid is undergoing a significant reinforcement and increase in renewable 'generation',
- Our decisions about home heating (and more), impact how much the National Grid will have to upgrade,
  - Best case, it roughly doubles
  - Worst case, it's six times more!
- Remember, grid upgrades are paid through all of our energy bills…

Should there be a fuss about Ground Source Heat Pumps?

The First Law of Thermodynamics:

Energy
can neither be
Created nor Destroyed

It can only be changed from one form to another

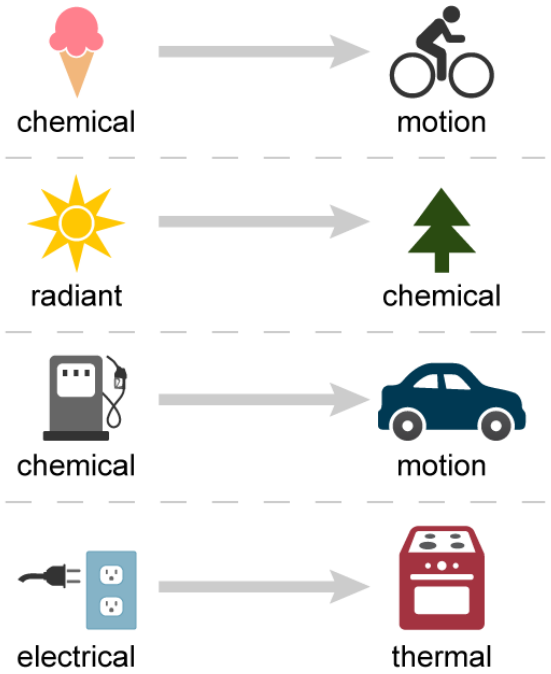


Image © US Energy Information Administration

- With electric heating, it's worth thinking of the First Law of Thermodynamics,
- This can also be thought of as *"There's no such thing as a free lunch"*
- Using electricity to generate heat falls into two main approaches…
  1. Those that follow the First Law
  2. Those that follow the First Law *but get creative on the exam paper*

Should there be a fuss about Ground Source Heat Pumps?

- Electrifying Option 1 - “Direct” Heating
- This generates heat from electricity, and it does so at nearly 100% efficiency,
- A gas boiler generates heat at up to 92% efficiency (usually a bit lower),
- Direct electric therefore delivers about 1 unit of heat for every unit of electricity,
- Direct electric heating includes…
  - Night storage heaters,
  - ‘bar’ radiant fires,
  - Infra-red heating,
  - Immersion heaters & kettles.

Should there be a fuss about Ground Source Heat Pumps?

- The First Law can't be broken;
  Energy In = Energy Out
  always,
  everywhere,
  forever *

- But…
  there's no "law" that stops us tapping into additional energy from another source to use **as well as** electricity.

*unless physics in this universe changes ;-)

Should there be a fuss about Ground Source Heat Pumps?

- Electrifying Option 2 – ***Creative thinking***
- Heat Pumps use electricity AND a second **source** of heat energy
- Heat energy is everywhere – anything warmer than -273°C has heat energy,
- Making something hotter only takes applying pressure (as a pump does),
- A heat pump takes a source of heat, and uses electricity to ‘squeeze’ it,
- Heat pumps can achieve beyond 300% efficiency of heat measured just on the electricity they use (of course, they are also using the other heat source)

Should there be a fuss about Ground Source Heat Pumps?

- Electrifying - Electric & **Air Source**
- Source of heat is Air, so they have a ‘fan’ unit outside to blow air over the heat collector pipes,
- Properly installed they usually achieve efficiencies around 250%-300%
- **Pros**
- Easiest (therefore cheapest) heat pump to install,
- Heat pumps can all do cooling (when designed to), as they are basically the same as air conditioning units,
- **Cons**
- Air is cooler in winter, when you need the most heat,
- External unit needs free air movement,
- External unit has a fan making a small amount of noise.

Should there be a fuss about Ground Source Heat Pumps?

Image © energy-tec.co.uk

- Electrifying - Electric & **Water Source**
- Source of heat is Water, they have a long heat collector pipe in a lake (or mine),
- Properly installed they usually achieve efficiencies around 300%-500%
- **Pros**
- If a in mineshafts, highest source heat temperature,
- Can normally do ‘free’ cooling as well, which requires less power than typical air conditioning solutions,
- **Cons**
- Water is cooler in winter, when you need more heat,
- Installation & cost dependent on available source,
- Can impact the aquatic conditions in lake/river, “Open source” can have further ecological impacts,

Should there be a fuss about Ground Source Heat Pumps?

Image © Sero

- Electrifying - Electric & **Ground Source**
- Source of heat is Ground, they have a long heat collector pipe in in a borehole or coiled buried under an area of land,
- Properly installed they usually achieve efficiencies around 300%-500%
- **Pros**
- Most stable temperature source heat in the ground,
- Borehole version has very limited ground ‘take’,
- Can normally do ‘free’ cooling as well, which requires less power than typical air conditioning solutions,
- **Cons**
- Installation of ground array is expensive for 1 home,
- “Open source” can have ecological impacts,

Should there be a fuss about Ground Source Heat Pumps?

Image © Pablo Blazquez Dominguez /Getty Images / Smithsonian

- Why am I a fan of Ground Source?
  Art & Science:
  The Science;
  - Most stable heat source during winter when we use most heat, meaning often most efficient,
  - Usually long life & low maintenance, with ‘ground arrays’ often with 100+ years design life,
  - Capable of providing ‘free’ cooling, which also can ‘recharge’ the ground temperature,
- The Art;
  - No external (above ground) fan units, meaning our future doesn’t have to look like this - this is not what I trained as an architect for!
- I think we’re sleepwalking into this future

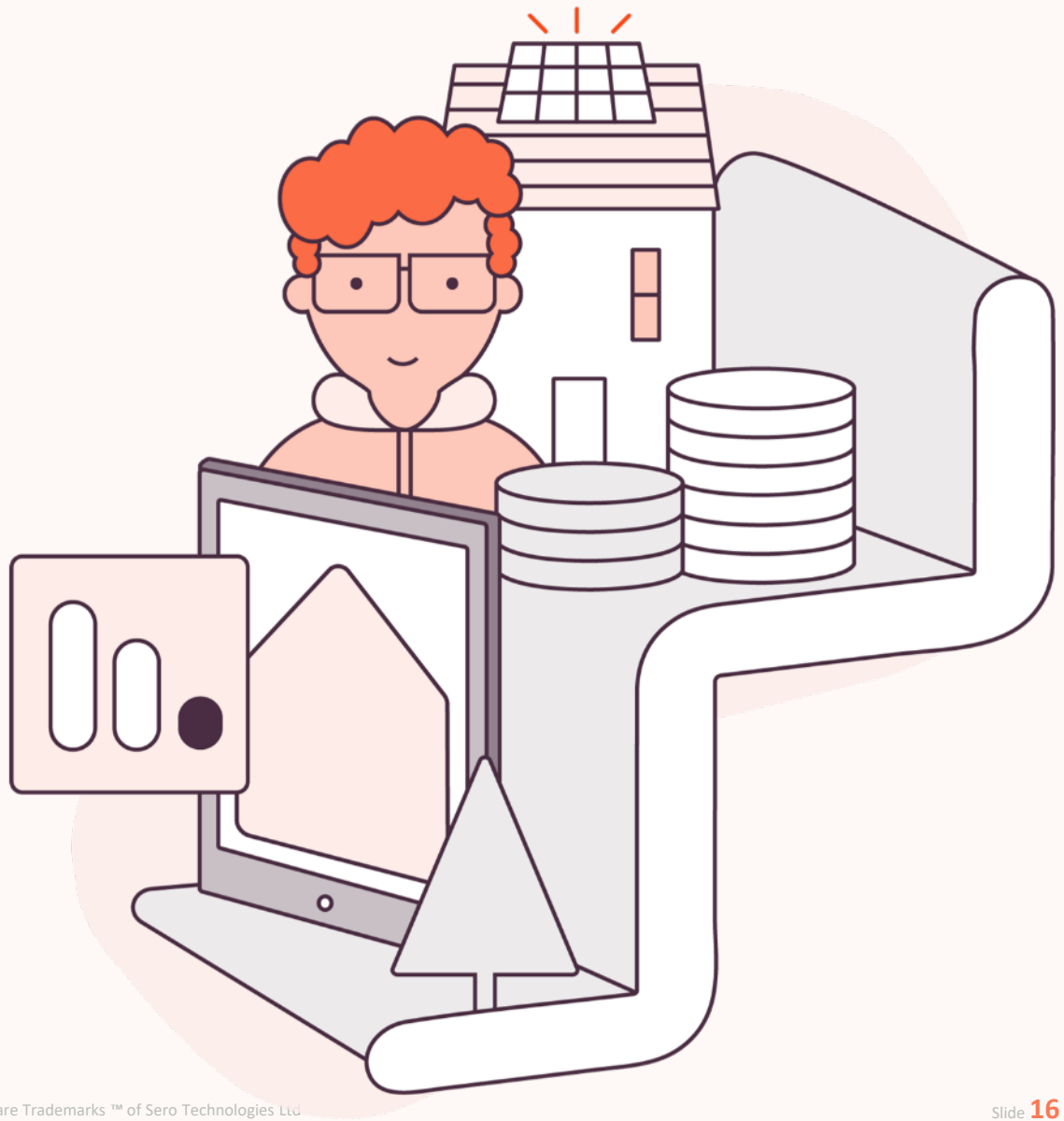
Should there be a fuss about Ground Source Heat Pumps?

Image © Wales & West

- What's Stopping Ground Source?
  - It costs more up front than air source heat pumps to install in small numbers,
  - But at large scale, ground arrays can be installed more competitively.

- If only…
  - We had organisations who had the legal rights to dig up streets (and maybe were used to laying pipes and who needed to get "off" fossil fuels),
  - We could lay networks of ground arrays street by street, with homes choosing to 'tap in' when they were ready to switch to a heat pump,
  - They'd pay a small service charge (likely less than the savings on the bill due to the higher efficiency) to repay the cost of the infrastructure.

Thank you!



Andy Sutton RIBA

e: Andy@Sero.Life

t: 079 6817 8243