uponor

PLUMBING & HEATING
SOLUTIONS

**UNDERFLOOR HEATING
WITH GROUND SOURCE
HEAT PUMPS**

A guide to using Underfloor Heating with Ground Source Heat Pumps

Introduction

There is increasing interest in these environmentally friendly systems due to the potential for low running costs, reduction in use of fossil fuels, and the reduction in CO_2 emissions. It is not the intention to discuss the individual features and benefits of Under Floor Heating (UFH) and Ground Source Heat Pumps (GSHPs), however, this document is intended to give the User, Installer and Specifier some useful points for selecting and designing an UFH system to gain the maximum benefits from a GSHP installation.

This document will be useful for those who have already decided to use this type of system and are keen to understand how they maximise the benefits of the synergy between two proven technologies.

Energy Efficiency of the System

A GSHP is designed to extract solar energy from the ground and convert this to useful energy, which can be used for heating and also hot water generation within the building. It uses electricity to run the compressor and to pump a mix of water and food grade antifreeze solution around the primary ground loop pipe work.

A well-designed system will be capable of transferring 4kW of useful thermal energy into the building for every 1kW unit of electricity consumed by extracting 3kW of free solar energy transferred from the outside ground. The efficiency of a heat pump is given by its Coefficient of Performance (COP), which is simply the thermal output divided by the electricity consumed, i.e. in the example above: 4kW/1kW = COP of 4.

Or in other words, the GSHP is 400% efficient by producing 4 times the amount of thermal energy from one unit of electricity - although this disregards the efficiency of electricity generation at the power station. To achieve an efficient COP of about 4 requires careful consideration of a number of practical issues, such as:

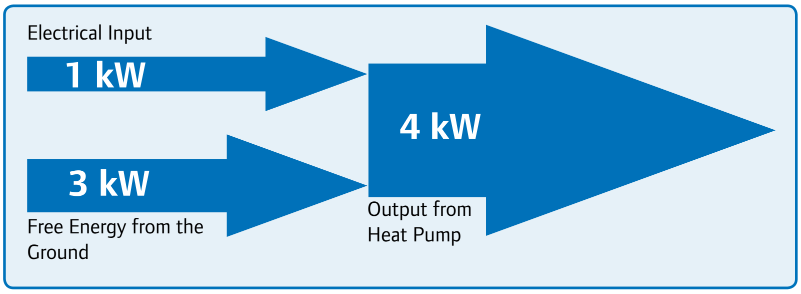


Fig 1 : Typical Energy Balance Diagram for GSHP

- Insulation of the building fabric
- Air tightness of the building
- Whether a heat recovery and ventilation (HRV) system is employed
- Temperature of water/ antifreeze solution in the ground loop(s)
- Design water temperature for the underfloor heating
- Structure and thermal mass of the underfloor heating system
- Floor covering resistances
- Control system

An accurate assessment of the building heat loss is very important when sizing a GSHP. The two components of building heat loss are: 1) the thermal losses through the building fabric and 2) the level of air infiltration from outside. Buildings should be designed with energy conversation in mind, air tight and with a high level of thermal insulation. Because of the high capital costs a GSHP is sometimes sized to handle part of the total design load, with the balance usually made up by an auxiliary electric heater. A GSHP sized at 50% of the design load is likely to meet at least 80% of the annual heating requirements, while a unit sized at 75% will meet the heating requirement most of the time, apart from times of very cold weather.

Key Factors

Insulation of the Building Fabric
The insulation level within the building is a fundamental factor in the suitability of a GSHP system. A high level of thermal insulation will produce low building heat losses. A low heat loss means that the UFH system can run on lower water temperatures, which in-turn leads to a higher COP for the GSHP. It is of utmost importance that good quality insulation has been specified and that the building is well insulated throughout. The insulation within the ground floor is of particular importance when UFH is installed, as increased floor temperature will result in higher downward losses when compared to a radiator system. For this reason - and especially if floor coverings have fairly high thermal resistance, such as carpet or wooden floors - ground floor insulation should be supplemented in excess of Building Regulation requirements to reduce downward losses to less than 10 W/m^2.

Air tightness of the building
The building air tightness is a major component of the overall building heat loss. Uncontrolled infiltration of external air can result in relatively high heat losses during the winter period. Rooms with open fires, where air change rates can reach 5 per hour, should be avoided. It is recommended that an air leakage pressure test should be carried out to verify that the design air infiltration rates are met.

Heat recovery and ventilation
These systems are designed to remove warm air from certain rooms within the building, such as kitchen and bathroom areas, extract it through a heat exchanger to pre-heat outside air, and to supply this tempered fresh air to other rooms within the property. The systems enable better control of air infiltration rate and provide heat exchange efficiencies of around 90% in converting heat from the extracted air to the incoming fresh air. Heat energy is recovered therefore reducing the load on the GSHP and enabling the UFH to run at lower water temperatures, which in-turn improves the system efficiency.

Temperature of the solution in the ground loops
Higher COP's will be achieved when the difference between primary side and secondary side temperatures are small; primary side being the entering temperature of the water/antifreeze solution into the GSHP, while secondary side being the outlet temperature to the UFH system. So a relative high temperature of the water/ antifreeze solution in the ground loop system is beneficial; usually GSHP systems will run on entering temperatures ranging between -5°C to +12°C. The design and type of GSHP and ground loop will need to be discussed and agreed with the GSHP supplier.

Design water temperature for the UFH
Higher energy efficiencies will result with UFH operating below 45°C water flow temperature; the lower the better. Factors determining the design water temperature for an UFH system include:

1) The floor structure and type of UFH system installed - pipes embedded within screed/ concrete floors is best;

2) The pipe spacing and pipe size – larger pipes installed at tight pipe centres is best;

3) Water flow rate and design temperature difference – systems should be designed with 5°C temperature difference;

4) The room temperature – room temperature set-points of 20°C or less is preferred;

5) Thermal resistance of floor covering(s) - low thermal resistance coverings are desirable, e.g. tiles, slate, marble etc;

6) The room heat losses – ultra insulated buildings will gain the most benefit.

Structure and thermal mass
Solid screed or concrete floors offer the best solution for floor structure and, ideally, should be used for both ground and upper floors. Other systems such as timber suspended, with aluminium heat emission plates or a reflective foil (Unifoil), should only be used when heat requirements are so low as to allow them to satisfactorily operate well below the 50°C – 55°C mean water temperature normally required. The same applies to floating floor systems, which consist of a heat emission plates sitting above insulation and usually a chipboard floated deck. Although floating floors have the option of being installed with a dry screed system (e.g. Fermacell or similar boards), as opposed to chipboard, which would result in required water temperatures approaching that of a solid screed/concrete floor.

Careful consideration should be given to UFH systems of mixed construction, as different water temperatures may be required, even in ultra low energy buildings.

A system with pipes embedded in a 75mm screed would give the system thermal mass; heat transfers from the water in the UFH pipes and slowly warms up the screed, some of the heat is retained in the screed while some is gently released to warm the room. This degree of thermal inertia allows the possibility of utilising cheap rate electricity to charge the floor overnight to give a proportion of the heat output needed during the following day.

Floor covering thermal resistance

UFH will work with most types of floor coverings. However, it should be understood that coverings with relatively high thermal resistances will need to increase the UFH water temperature to offset building heat losses, and will result in a lower COP and therefore higher running costs.

The table below shows a graphical representation of floor heat outputs for different floor structures and various floor covering resistances.

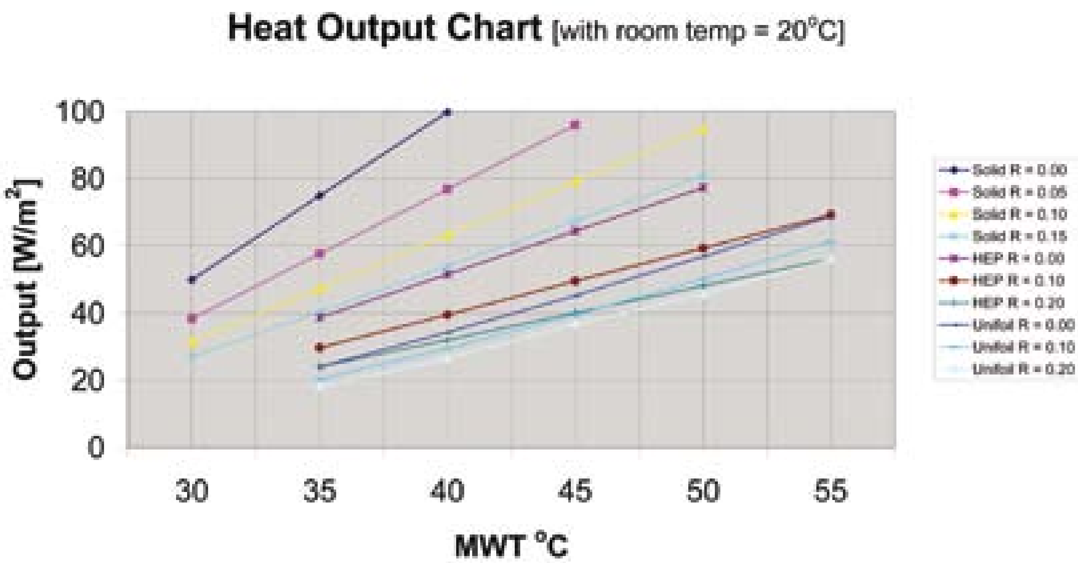
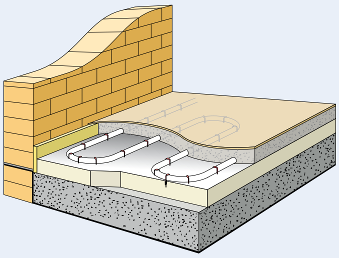


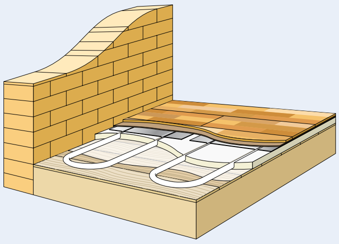
Fig. 2 – Table showing floor output at various mean water temperatures

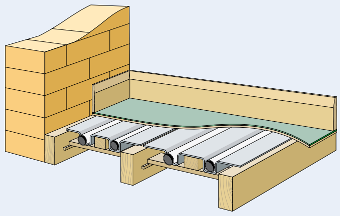
Floor Constructions & Thermal Resistance

Solid Floor
Screed or concrete floor with 15mm pipes spaced at 200mm centres.
Where R = thermal resistance of the floor covering [m²K/W].
R = 0.00, typically: tiles, slate, marble or stone.
R = 0.05, typically: vinyl or thin laminate.
R = 0.10, typically: carpet or laminate.
R = 0.15, typically: heavier tog carpet or solid wood floor.

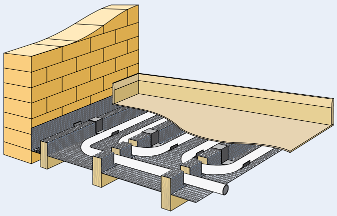


Heat Emission Plates
Timber suspended or floating floor with 15mm pipes spaced at 200mm centres and heat emission plates (HEP's) effectively covering 85% of the floor area.
Where R = thermal resistance of floor covering on top of 18mm chipboard deck [m²K/W].
R = 0.00, typically: tiles
R = 0.10, typically: carpet or laminate.
R = 0.20, typically: heavier tog carpet or solid wood floor.





Unifoil
Timber suspended with 15mm pipes spaced at 200mm centres fixed in 50mm void above Unifoil highly reflective material.
Where R = thermal resistance of floor covering on top of 18mm chipboard deck [m²K/W].
R = 0.00, typically: tiles
R = 0.10, typically: carpet or laminate.
R = 0.20, typically: heavier tog carpet or solid wood floor.



Coefficient of Performance (COP)
Figure 3 (right) shows the importance of the UFH water temperature in determining the operating COP of the GSHP. The output temperature is the flow temperature of the UFH system. Some GSHP manufacturer's preset their unit to run with an UFH return temperature of 30°C, which with a 5°C temperature difference equates to a 35°C flow temperature. However, it can be seen from figure 2 that 35°C flow temperature would usually suit solid floor constructions only, unless the heat requirement dropped below 40 W/m²; an unlikely scenario in all but the ultra low energy buildings.

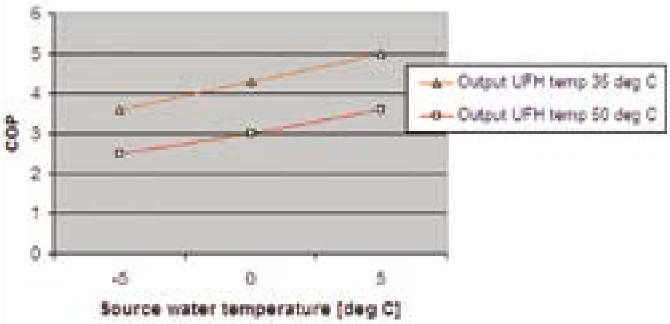


Fig. 3 – Coefficient of Performance (COP) graph for typical GSHP's

Controls, Thermal Storage and Radiant Cooling

Control System

During the heating season the outside temperature remains above design conditions for the majority of the time, which means the system needs only cater for part load conditions during these periods. A weather compensator controller is usually incorporated into the GSHP and this will vary the water temperature to the UFH based on the temperature outside. During mild weather the GSHP will be operating on a lower UFH water temperature, which will meet the lower building heat loss and result in higher system energy efficiency, COP.

Because room heat losses do not always change solely in proportion to the outside air temperature – factors such as solar gains and internal gains from people, cooking, lighting and other appliances can also affect the room heat loss – then room temperature control for individual rooms is usually recommended. It is normal practice to run GSHP systems 24 hours per day to eliminate start up loads and make the most of cheaper rate electricity tariffs.

Buffer tank or hot water thermal store

A buffer tank or thermal storage cylinder is often used between the GSHP and the UFH system. They both provide a buffer of stored hot water for the UFH system, but have the benefit of reducing the cycling of the GSHP, and allowing the use of controls to open/close loops on the UFH system, i.e. individual room control. A thermal store will normally have a section towards the top to produce hot water and may have additional connections for a solar panel and/or other heat generator. An electrical immersion heater is often used for supplementary heating and backup purposes. Generating domestic hot water via the GSHP will reduce efficiency because output temperature required is higher than for UFH. If the system incorporates hot water storage then time control to maximise the use of cheaper tariff electricity is recommended.

Cheap rate electricity

Details of economy 7, economy 10, and in some areas special GSHP tariff, should be checked out with your electricity supplier. Your GSHP provider may suggest or provide energy storage equipment, in addition to the GSHP, to make the most use of cheap rate tariffs. Renewable energy sources can also be used, such as: solar panels (photovoltaic) and wind turbines.

Radiant Cooling

Some GSHP's have a cooling option, which is enabled by reversing the GSHP operation. It is feasible that this could be utilised in the summer by circulating cool water around the underfloor piping to provide some degree of comfort cooling. If comfort cooling is specified then careful consideration should be given to the design of the underfloor heating and cooling system. To gain the maximum cooling capacity of around 45 W/m^2, the floor should be of solid screed/concrete construction and have negligible floor covering resistance, e.g. tiles, slate, marble, stone etc. In addition to this, pipes should be tightly spaced and a water temperature difference of around 3°C is desirable. The control system will need to incorporate winter/summer changeover thermostats and controls, and to eliminate the risk of condensation, include for dew-point control sensor(s). It is important that both the GSHP and the UFH suppliers are informed when cooling is being considered.

Summary

GSHP's are considered to be energy efficient appliances and ideally should be coupled with heat emitters operating at the lowest possible water temperature to gain optimum benefits. UFH is the best choice of heat emitter as it has a large surface area, with a relatively low floor surface temperature, and therefore a low circulating water temperature is required. This document clearly shows that floor construction, floor covering thermal resistance, and building heat losses are main factors in determining the water temperature for the UFH system. And that floor constructions other than screed/concrete should be used with considerable caution, even with modern well-insulated buildings. Also shown is the importance that UFH water temperature plays in the overall efficiency of the GSHP system.

Recommended further reading:

- Domestic Ground Source Heat Pumps : Design and installation of closed-loop systems.

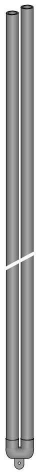
  Energy Best Practice in Housing
  www.est.org.uk/bestpractice

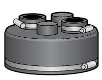
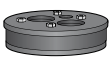
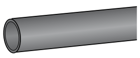
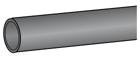
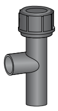
- Renewable Energy Fact Sheet 5 on Ground Source Heat Pumps

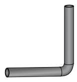
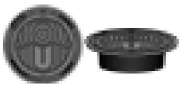
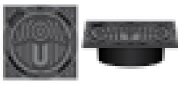
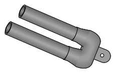
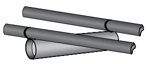
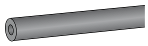
  Energy Savings Trust
  www.est.org.uk/schri

Product Range Energy Systems

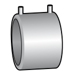
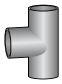
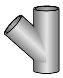
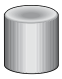
Uponor Energy Systems Pipe, Fittings and Accessories

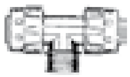
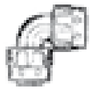
	Description	Code	Pack Qty
Double-walled collector with return elbow attached for rock and lake energy heat pumps Lead time approx 6 weeks.			
	PEM 40x2.4, 2x50m	ES648001	50m
	PEM 40x2.4, 2x80m	ES648004	80m
	PEM 40x2.4, 2x100m	ES648006	100m
	PEM 40x2.4, 2x150m	ES648011	150m
	PEM 40x2.4, 2x200m	ES648016	200m
	PEM 40x2.4, 2x250m	ES648037	250m
Single-walled collector for ground energy Ex Stock.			
	40x2.4 100m	ES640919	100m
	40x2.4 200m	ES641219	200m
	40x2.4 250m	ES642819	250m
	40x2.4 300m	ES641519	300m
	40x2.4 400m	ES642919	400m
	40x2.4 500m	ES643319	500m

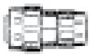
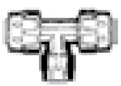
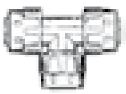
	Description	Code	Pack Qty
Top parts to plastic collector for energy well Lead time approx 3 weeks.			
	Rubber hood, pressure sealed 138-168mm	ES659917	1
	Expander cap for steel pipe 168mm	ES659892	1
	Expander cap for steel pipe 138mm	ES659927	1
	PEM 40 x 3.7 PN 10 6m straight length	ES640119	6m
	PEM 40 x 2.4 PN 6.3 6m straight length	ES640019	6m
	Tee pipe 40mm with venting nipple for electric socket fusion	ES659918	1

	Description	Code	Pack Qty
	Wall elbow 40mm. L = 1m	ES659937	1
	Snap-in lid 315mm for inspection chamber	ES352595	1
	Round nodular iron cover for asphalt garage driveway	ES261902	1
	Square nodular iron cover for paved garage driveway	ES261903	1
Bottom parts and sinking weights for the plastic collector for rock and lake energy systems. Lead time approx 3 weeks.			
	Return elbow for rock or lake collector with mounting ring for bottom weight or hauling rope. Pipe connection 40mm.	ES659878	1
	Round bottom weight made from compact concrete with a fastening hook for return elbow and a fastening hook for series connection of further bottom weights. Diameter = 85mm and length = 0.5m. Equivalent to a 12kg weight made from ordinary concrete.	ES659880	1
	Distance weight 12kg normally mounted at c/c 3m for 40mm pipe. Local conditions can affect the weight setting.	ES659947	1
	Nylon fastening tape 370mm (not included in the price for the weights)	ES699996	1
Plastic pipe insulation and other installation material Lead time approx 3 weeks.			
	Tubolit DG 42/9 2 metres for 40mm pipe	ES659894	2m
	Yellow marker band 125mm 250-metre roll	ES659920	250m

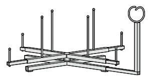
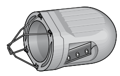
Uponor Energy Systems Pipe, Fittings and Accessories

	Description	Code	Pack Qty
Electrofusion pipe fittings for collector 40mm			
Lead time approx 3 weeks.			
	Straight connector 40mm	ES695604	1
	Elbow 88.5° 40mm	ES695643	1
	Elbow 45° 40mm	ES695641	1
	Branch 88.5° 40-40mm	ES695614	1
	Branch 45° 40-40mm	ES695537	1
	UV-stabiliser fitting		
	40-R20mm	ES695591	1
	40-R25mm	ES695592	1
	40-R32mm	ES695593	1
	40-R40mm	ES695594	1
	End cap 40mm	ES695584	1

	Description	Code	Pack Qty
MDPE Compression Fittings			
Lead time approx 3 weeks.			
	40mmx1¼″x40mm MT take off tee	ES516040E	1
	40mmx1½″x40mm MT take off tee	ES516040F	1
	40mm 90° Elbow	ES5130400	1
	40mmx1″ Male thread adaptor	ES511040D	1
	40mmx1¼″ Male thread adaptor	ES511040E	1
	40mmx1½″ Male thread adaptor	ES511040F	1
	40mmx1¼″ Male thread elbow	ES519040E	1
	40mmx1½″ Male thread elbow	ES519040F	1
	40mmx1¼″ Female thread elbow	ES518040E	1
	40mmx1½″ Female thread elbow	ES518040F	1

	Description	Code	Pack Qty
MDPE Compression Fittings			
Lead time approx 3 weeks.			
	40mm Straight coupling	ES5100400	1
	40mm x1″ Female thread adaptor	ES601040D	1
	40mm x1¼″ Female thread adaptor	ES601040E	1
	40mmx1″x40mm FT take off tee	ES515040D	1
	40mmx1¼″x40mm FT take off tee	ES515040E	1
	40mm End plug	ES5210400	1
	40mm Equal tee	ES5140400	1

Tools

	Description	Code	Pack Qty
Assembly aid for the collectors			
Lead time approx 6 weeks.			
	Collector spool	ES018230	1
	Pipe cutters 16-40mm	ES018237	1
	Pipe cutters 50-63mm	ES018238	1
	Chamfering tool 16-63mm	ES018236	1
	Electrofusion apparatus	ES016505	1

Uponor Pre-Insulated Pipe

Uponor Pre-Insulated Pipe

Uponor Pre-Insulated Pipe is the proven name for the innovative, flexible, pre–insulated plastic piping system to transport a variety of liquids both inside and outside of buildings. The system also comprises a complete range of products for heating and hot and cold water supplies.

Its material properties give long service life and as the pipes are low-weight and highly flexible, they can be installed easily and quickly, even over obstacles and round corners.

Uponor Pre-insulated pipe can be used for a wide variety of applications, a few of which are detailed below.

By Medium

- Potable Water
- Heating Water
- Cooling Water
- Sewage
- Foodstuffs and Chemicals

By Use

- Connecting up individual buildings
- Construction of a supply network
- Urban engineering
- Liquids for industry

The Advantages:

Easy to handle:

Easy to handle: low-weight and highly flexible, the pipe can be installed around any obstacle.

No need for special tools for assembly:

No special-purpose tools what so ever are needed for any phase of the assembly.

"Endless" pipe lengths from the coil:

No connections nor compensators - just roll off the length of pipe you need!

Fixed lengths - delivery service:

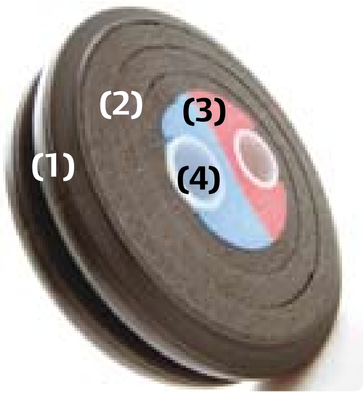
Pipes can be cut to size as required and delivered direct to the construction site - saving time and money!

Rapid work progress:

Small trenches and quick, easy installation and job progress is guaranteed!

Service:

From the planning phase to work completion we can offer you a comprehensive service package.



(1) Ribbed jacket pipe made of impact proof polyethylene. Very flexible with high load bearing capacity

(2) Excellent low weight PEX foam heat insulation

(3) The two coloured 'dog bone' prevents mix ups in flow and return connections

(4) Corrosion proof, oxygen impermeable carrier pipe made of PEX material

Uponor Pre-Insulated Pipe product range.

This overview will give you an initial impression of the Uponor Pre-Insulated Pipe programme and primary applications. It is supplemented by available pipe couplings, T-pieces, bends, chambers, wall sleeves etc. – in brief – everything you need for a complete Uponor Pre-Insulated Pipe system.

On request, we can send you detailed work sheets, delivery program and price list or our product catalogue with installation instructions.

Tailor-made lengths, delivered exactly when you need them.

We offer you our Uponor Pre-Insulated Pipe Cut to Measure Service, if you need to have exact material specifications for your construction project, as fixed lengths can save you costs.

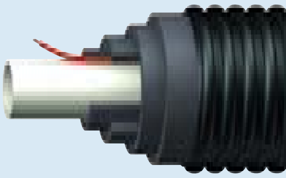
No unnecessary time loss. No unnecessary wastage. No unnecessary disposal costs.

And what you order will be delivered as quickly as possible to where you need it.

Also available are pipe couplings, T-pieces, bends, chambers, wall sleeves etc. – everything you need for complete Uponor Pre-Insulated Pipe systems.

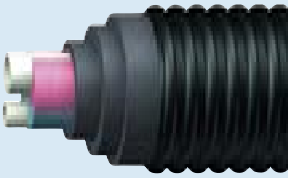
Aqua Single

- PE-X pipe for potable water, hot water Max. 95 °C/10 bar
- Approved by the German Water and Gas Board
- Carrier pipe 25, 32, 40, 50, 63 ø mm
- Trace heating cable on request



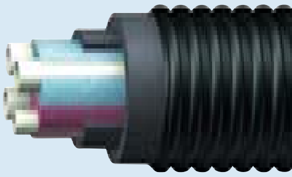
Aqua Twin

- PE-X pipe for potable water, hot water Max. 95 °C/10 bar
- Hot water and circulation pipe in one jacket
- Approved by the German Water and Gas Board
- Carrier pipe 25/25, 32/25, 40/25 and 50/25 ø mm



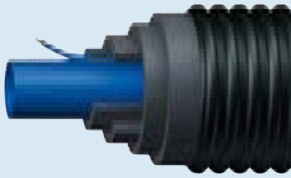
Quattro

- 4-line pipe, combination of Aqua Twin and Thermo Twin
- Suitable for building connection from mains via chamber



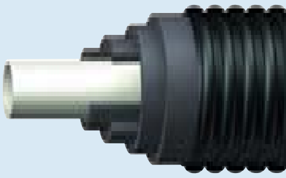
Supra

- Single PE-100, Max. 20 °C/16 bar for potable water, cold water, waste water transport, cooling water
- 25 -110 ø mm
- On request with frost-protection cable



Thermo Single

- Single PE-X pipe with EVOH for heating water Max. 95 °C/6 bar
- Carrier pipe 25 -110 ø mm
- On request with trace heating cable

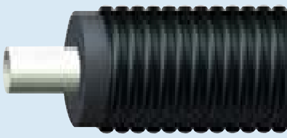


Thermo Twin

- Twin PE-X pipe with EVOH for flow and return lines
- 2 x 25, 2 x 32, 2 x 40, 2 x 50, 2 x 63 ø mm

Thermo Mini

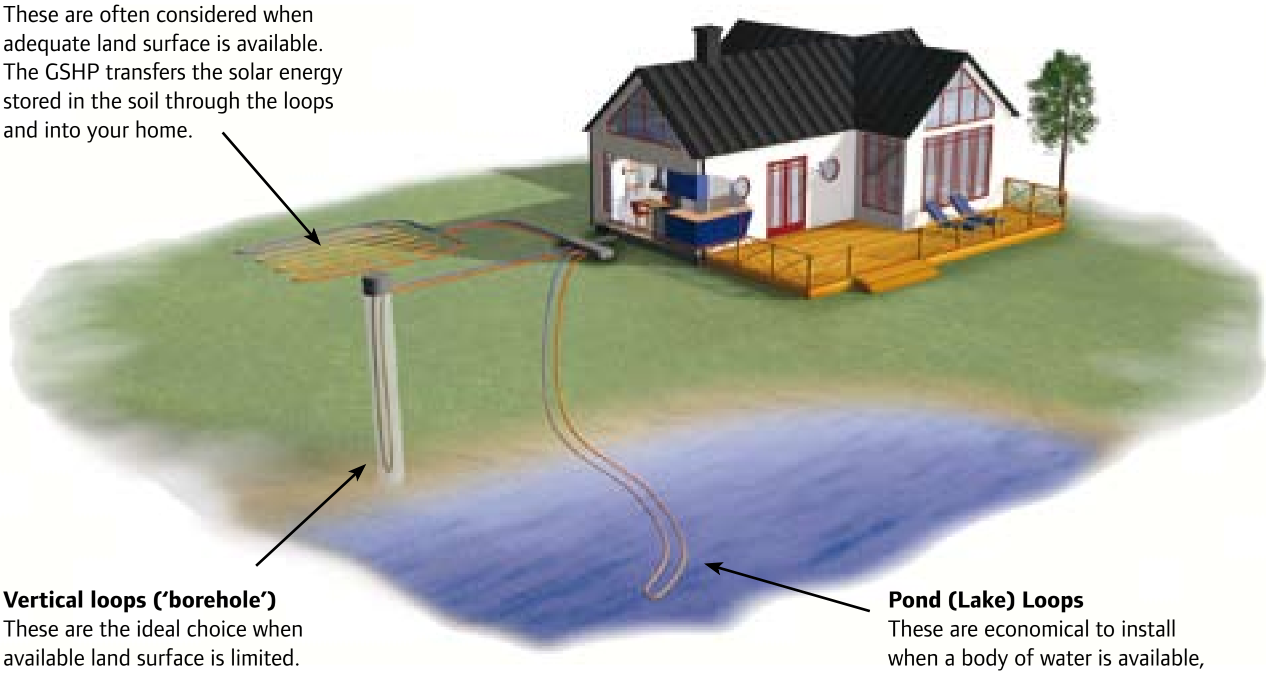
- Single PE-X pipe with EVOH for heating water Max. 95 °C/6 bar with small jacket pipe
- Carrier pipe 25 and 32 ø mm
- On request with trace heating cable



The contents of this brochure are provided for guideline only, please consult our technical manuals for full up-to-date information. The information in this publication is correct at the time of going to press.

Uponor reserves the right to alter specifications and operating parameters for all our Underfloor Heating & Plumbing Systems at any time as part of our policy of continuous product development.

Horizontal Loops ('slinkies')
These are often considered when adequate land surface is available. The GSHP transfers the solar energy stored in the soil through the loops and into your home.



Vertical loops ('borehole')
These are the ideal choice when available land surface is limited. The GSHP transfers the stored geothermal energy through the closed loop circuit. The transferred energy is ideal for heating and cooling.

Pond (Lake) Loops
These are economical to install when a body of water is available, because excavation costs are virtually eliminated. Coils of pipe are simply placed on the bottom of the pond or lake.

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