

Technical article

## DHP-H Opti Pro+ Ground Source Heat Pump **Innovative and incomparable** efficiency

Since the launch of the first heat pump for domestic properties in the early 1970s, ground source heat pumps have become a well-known and trusted heating source. Today, the European market hosts a series of heating manufacturers. Many consumers are not able to discern the differences between them and the various heat pump models available: therefore it is worth determining the criteria for evaluation and comparison.

A heat pump is not a complex technology, it works in a similar fashion to a refrigerator with a primary function of heating and a secondary of cooling. The core requirement of a heat pump is dependent upon the buyer, whether it is the user themselves, a developer or an architect to name a few examples.

Until the end of the 80's, no real attention was paid to the level of energy consumption needed to heat a home by investors. Although, many readers will remember the market for thermal insulation was very weak at this time



**Meeting 21 Century heating needs.**

Very low thermal conductivity materials such as silicate blocks or “porotherm” bricks are used by the Construction Industry today. Insulation can now be found from the foundations to the attic of the home including windows where U-value<sup>1</sup> is 1.0 or below. In addition, the use of hot water has changed dramatically. In many new family homes you will not be surprised to find one or more bathrooms of which one has a large bath or Jacuzzi.

Combining our need for more hot domestic hot water and increased home comfort levels. Engineers at one of the most advanced European Laboratories, look for the following objectives in the design and development stages of creating a heat pump:

1. High annual efficiency (Seasonal Performance Factor)
2. Highly efficient hot water production
3. Low sound levels
4. Ease of installation while maintaining an innovative, compact and contemporary design

**Unparalleled annual efficiency through innovative technology**

The main part of the heat pump is the refrigeration circuit which can be described as the “motor” of a heat pump. There are three essential elements that characterise a good quality and efficient refrigeration circuit:

<sup>1</sup> heat transfer coefficient U = 1.0

1. Design
2. Component quality
3. Refrigerant type

Danfoss’ R&D department working on the DHP-H Opti Pro + used cutting edge technology to optimise each of these elements. As a result, this model is a highly efficient ground source heat pump that uses an environmentally friendly refrigerant (R410A). At the heart of this circuit is a scroll compressor meaning:

- A high capacity at low evaporating temperatures (when compared to piston compressors)
- The scroll design attains optimum efficiency in all operating conditions. The efficiency of the compressor actually improves with time, unlike most other types on the market.
- With fewer moving parts, lower noise output and increased longevity, the scroll compressor is the most reliable solution for heat pump applications
- The compressor used in the Danfoss Opti Pro + has been designed specifically for heat pump applications and when operated by the Danfoss control panel will match the heating demands regardless of changing conditions in the home.

The refrigerant circuit within the DHP-H Opti Pro + uses a bespoke, high performance heat exchanger known as a MPHE (Micro Plate Heat Exchanger). In heat pump

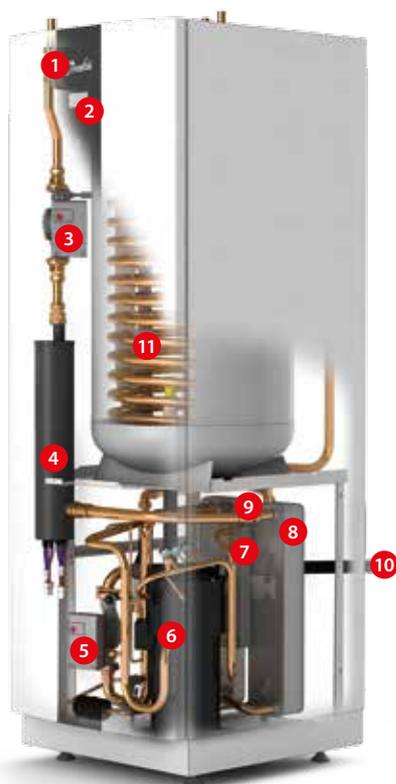


Figure 1: What’s inside a DHP-H Opti Pro+? Number of components: 1) Shunt valve, 2) Control panel, 3) Primary heating circulation pump 4) Auxiliary heater, 5) Brine circulation pump, 6) Scroll compressor, 7) De-superheater (hot gas heat exchanger) 8) Condenser - stainless steel heat exchanger, 9) Evaporator - stainless steel heat exchanger, 10) Brine connection, 11) 180 litre hot water tank

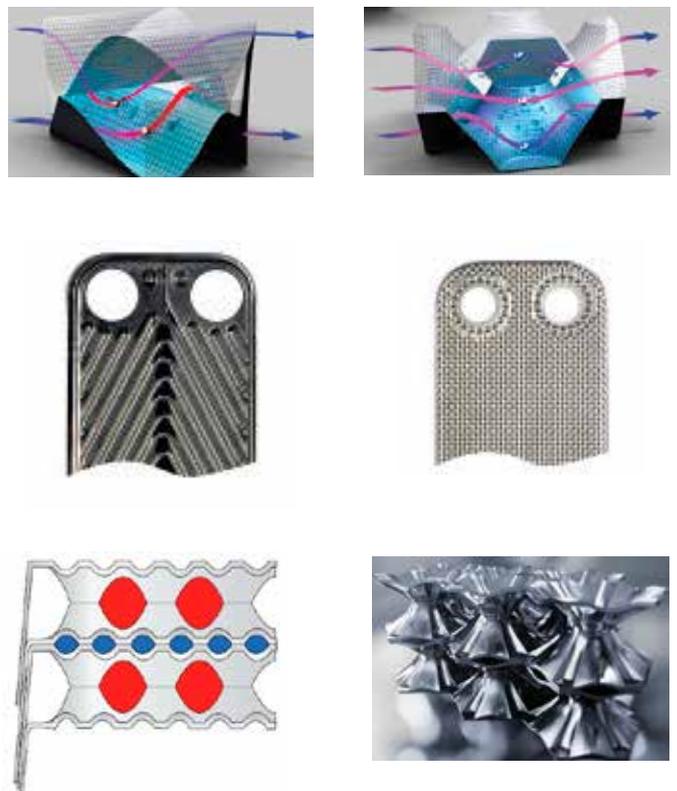


Figure 2, 3: Compared with a traditional BPHE, with its three-dimensional flow, the innovative MPHE has a two-dimensional flow with a more uniform velocity which enhances heat transfer. Figure 4, 5: Left: Herringbone (BPHE) Right: Unique channel plate pattern (MPHE); Figure 6, 7: Principle of asymmetric channels, Asymmetric braze joints

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applications, an appropriate proportion of brine to refrigerant is approximately 10:1, meaning that heat exchangers with channels equivalent to a 1:1 proportion may struggle to correspond with actual operating conditions. With the MPHE, channel proportions are optimised for ground source heat pump application.

The MPHE has an indented surface, improving the flow across the plates for an increased use of surface area: leading to a more uniform flow velocity. Additionally, the plates have a broad, flat brazing area compared with a BPHE (Brazed Plate Heat Exchanger) that reduces stress making the MPHE a more robust component. The result of this development is even greater efficiency. For a improved COP, Danfoss' condensers are designed to work efficiently with variable temperatures and minimal pressure loss. The MPHE has been redesigned as a more compact component for reduced refrigerant charge thus reducing its carbon footprint. In brief, the MPHE with its asymmetric channel geometry, combined with the refrigerant R410A, improves heat transfer whilst minimising pressure loss, producing a state-of-the-art heat pump that delivers optimum efficiency.

The Opti Pro + control panel is designed to automatically calculate the heat demand in the property: the indoor temperature is automatically controlled, enabling the correct heat parameters day and night. As with most ground source heat pumps the indoor heat demand is calculated based on the outdoor temperature. The lower the outdoor temperature, the ambient temperature should remain the same but the heating supply will change relative to the curve and

vice versa in the summer months. This ensures the supply temperature of the water is distributed to the heating system at the ideal flow and temperature, for a comfortable indoor climate all year round.

Heat demand, again dependent upon the outdoor temperatures, is expressed as a varying temperature over time, calculated by an integral value. To calculate the integral value, the controller uses several parameters. A heat deficit is needed to start the pump. There are two integral values at work, the first value starts the compressor, the second the auxiliary heater. During heat production, the deficit is balanced and when the heat pump stops, inertia in the system causes a surplus of heat. The integral value is a measurement expressed in degree minutes.

A correctly set heat curve and heat demand calculated by the algorithm 'integral value' always ensures that the heating system is kept at the lowest level whilst still fulfilling the customer's indoor heat comfort needs. Reduced operating time, and a start stop operation of the compressor ensures high durability and energy friendly benefits.

Another innovation in achieving high energy efficiency is the Opti technology which uses speed controlled circulation pumps on the brine and heating sides. Working with  $\Delta t$  3°C on the brine side, we secure a correct and complete evaporation of the refrigerant in the evaporator. Additionally the constant  $\Delta t$  ensures that the ground source operates according to the demand of the heat pump. The ground source borehole or loop will remain operational throughout the year, especially in winter. Variable speed flow on the heating side allows us to react in unison to the heat demand of

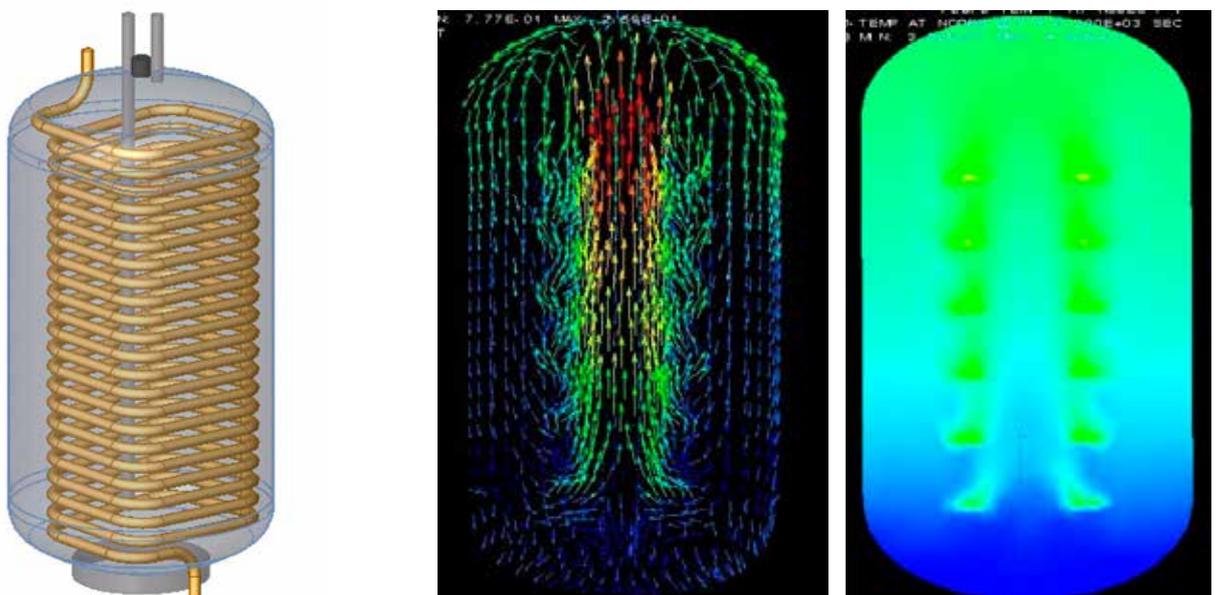


Figure 8,9,10: TWS hot water tanks are specially designed for heat pumps. In the photograph, the hot water is represented by the green colouring and cool water by the blue. The technology layers the hot water in the hot water tank so that the heat can be used in the best way.

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the home. Responding to fluctuating conditions inside the heating system, where slight temperature degree deviations are natural, continuity of high efficiency is further supported by Opti technology. In other words, the whole system: the ground source (brine), refrigerant circuit and the heating circuit works in complete harmony. A heat pump equipped with a speed controlled circulation pumps is 5-6% more efficient compared to heat pumps equipped with standard circulating pumps.

It should be noted that according to European Directive 2005/32/EC<sup>2</sup> of the EU Parliament that from the beginning of 2015 all circulation pumps (built into heat pumps) should have a coefficient of efficiency EEI (Energy Efficiency Index) no less than 0.23. The circulation pumps used in Opti Pro+ already meet this Class A requirement. An important part of ensuring the efficiency of the DHP-H Opti Pro+ heat pump refrigeration system is that it is refrigerant filled and hermetically sealed in the factory. Each heat pump is tested at the end of its production line and marked with an individual serial number. This is a clear difference in quality compared to air and ground source, direct evaporation heat pumps requiring refrigerant to be filled on site.

### **The comfort of hot water when you need it!**

Hot water on demand has become increasingly important for many consumers. Danfoss' heat pumps with integrated hot water tanks provide constant hot water: quickly refilling the tank to the desired temperatures. The DHP-H Opti Pro+ contains two

<sup>2</sup> Commission Regulation (EC) No 641/2009 of 22 July 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for glandless standalone circulators and glandless circulators integrated in products

technologies that are responsible for hot water production.

The first is TWS technology (Tap Water Stratification), the thermal stratification inside the storage tank. This effect is achieved by a spiral-shaped coil that runs through the entire height of the storage tank. The heat transfer area and the thread space is designed to provide hot water production to the expected temperature and volume in the shortest possible time. The water tank is made of stainless steel with a coil surface area of 1.85 m<sup>2</sup> for the 180 litres model and 2.2 m<sup>2</sup> for the tank holding 286 litres. Hot water is taken from the upper part of the tank, so layering runs from the top to the bottom of the tank. TWS technology gives 15% more hot water and at twice the speed compared to a double wall water heater.

The second technology is HGW (Hot Gas Water heater). In a typical refrigeration circuit there is an evaporator, a compressor and a condenser in which the heat for the heating system is extracted. The Opti Pro+ has an additional exchanger called a de-superheater (hot gas heat exchanger) between the compressor and the condenser. In the de-superheater you can find hot gas on one side and water from the heating system on the other. The gas temperature at the compressor outlet is more than 100°C. It can reach up to 95°C at the top of the hot water tank, and 91°C at the bottom of the tank. This is a remarkable new standard of hot water production. The Opti Pro+ hot water production efficiency is 3.6 - 4.73, while other heat pumps on the market do not exceed 2.5.

For the user, the HGW technology means that the 180-liter tank can produce up to 419 litres of water at 40°C in contrast to other heat pumps on the market

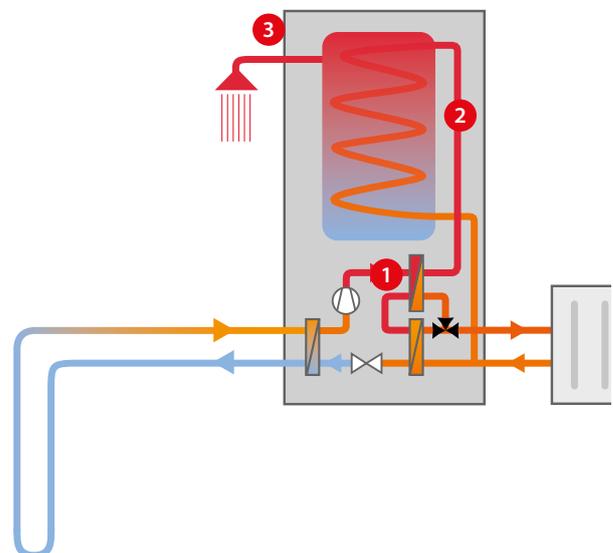


Figure 11,12,13: De-superheater (hot gas heat exchanger) - stainless steel heat exchanger located between evaporator and condenser:

1) A small portion of the heated water that is on the way to the house's heating system passes the extra de-superheater; 2) There it is heated up further, between 50 °C and 90 °C, before going into the water tank; 3) The result is that, at no additional cost, you get more, and hotter hot water during the months of the year that the house is heated.

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that can only supply 180-220 litres of water at 40°C. In winter, when the heat pump is required to heat the house at the same time as the hot water, the two functions can be performed simultaneously: which many other brands of heat pump cannot do. Moreover, hot water is heated at the lowest possible cost. It should be noted that both technologies enable efficient production of hot water and allow savings of about 800 kWh<sup>3</sup> (close to 150 Euro) every year.

### Tranquil levels of sound

The DHP-H Opti Pro+ as a unit, base frame and all connections is designed to minimise:

1. Vibrations derived from the scroll compressor
2. Sound level (noise) derived from the scroll compressor

A ground source heat pump, typically installed within a detached home inside a plant room or garage, operates for several hours a day, therefore it is important that the noise levels are kept to a minimum. Each DHP-H Opti Pro + heat pump is equipped with a compressor that during operation mode operates at low noise levels so not to disturb the inhabitants.

The Opti Pro+ series are equipped with scroll compressors that due to their cutting edge design generate sound at a low level compared to other compressors. The compressor itself has been mounted on a base frame constructed with a special rubber suspension. To further reduce vibration and sound transfer the connections

3 Compared to conventional heat pumps with built-in water heaters - assumption 4.000 kWh for hot water consumption @ 2,5 COP i.e. app. 1.600 kWh, The EU-27 average price (this price is weighted with 2010 national consumption for the household sector) is EUR 0.184 per kWh

between the compressor and refrigerant circuit is supported by another rubber suspension. Furthermore, the heat pump cabinet is equipped with a sound barrier made from glass wool panels. Delivery to the installation site includes a rubber collar coupling and flexible conduit to pair the heat pump to the heating system and reduce vibration transfer. Sound power levels of the DHP-H Opti Pro+ 8 kW is 44.5 dB(A)<sup>4</sup>. DHP-H Opti Pro+ boasts one of the quietest heat pumps on the market.

### Plug & Play: An installers dream

Another objective at the design stage of the heat pump was simplicity in both the hydraulic and electrical connections. A heat pump unit is constructed so that the brine pipes can be connected on either the left or right-hand side of the pump to tailor this to suit the needs of the property. The unit has prefabricated openings to connect the energy supply, sensor and communication cables, with the electrical supply connections clearly marked for ease of install, so easy in fact, the installer only needs a screwdriver in his toolbox!

All Danfoss ground source heat pump models include brine and heating side circulation pumps and an auxiliary heaters. All ground source heat pumps delivered by Danfoss come complete with basic start-up components such as:

- filler device
- safety valves
- outdoor sensor

4 Sound power level measured according to EN ISO 3741 at BOW45 (EN 12102).

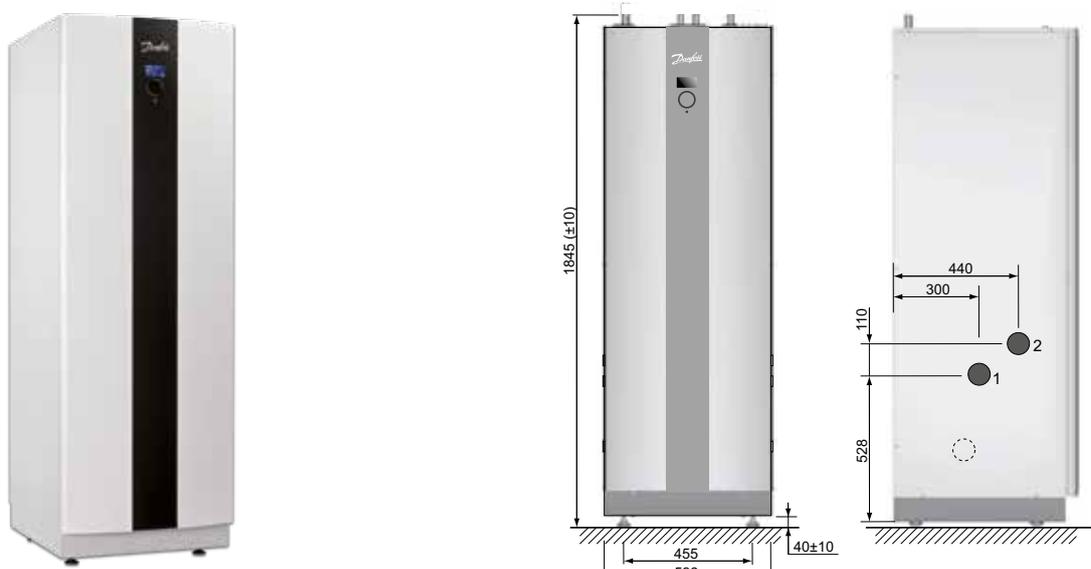


Figure 14,15 : The DHP-H Opti Pro+ has an inbuilt 180 litre hot water tank. The DHP-H Opti Pro+ is available in 6, 8, 10, 13 kW sizes. 1) Brine in, 2) Brine out

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- expansion and bleed tank
- rubber bellows for coupling
- flexible conduit
- dirt filter with shut-off valve

In short, everything necessary for a fully operating heat pump. This saves the installer’s time by cutting out the need for unnecessary trips to the plumbing store.

Another incredible tool that supports commissioning and empowers the installer is Danfoss OnLine, an optional application allowing control of the heat pump remotely. Using OnLine the most important parameters (possible alarms) can be monitored via the internet using a laptop, tablet or smartphone (both iPhone or Android) anytime, anywhere. Information about the status of the pump can be obtained without having to drive to the installation site.

Danfoss has been manufacturing heat pumps for 40 years: utilising our experience and expertise, we have more than 50 heat pump solutions that can be tailor-made to a variety of different properties.

**Caring for customer values and comfort**

Many investors and home builders ask themselves, what heat pump should I buy for my property? Or even which manufacturer? Heat pump branded manufacturers seems to be quite similar, and for most investors it is difficult to make a real comparison. Therefore, in brief let us persuade you beyond doubt to - why a heat pump from Danfoss?

We boast the position of Danfoss as:

- Danfoss heat pumps boast the highest in annual efficiencies (measured by the SPF factor: Seasonal Performance Factor), which means lower energy bills
- We are at the forefront in technological innovation, particularly in hot water production, volume and production
- Danfoss heat pumps offer low sound levels and the flexibility to install the heat pump wherever feasible
- Installations are simplified: giving our installers time to be on other sites, and the homeowner to have heating within a few hours



Figure 18, Danfoss OnLine at PC, tablet and smartphone - graphical user interface and Apps icon

Figure 19, Passive cooling module

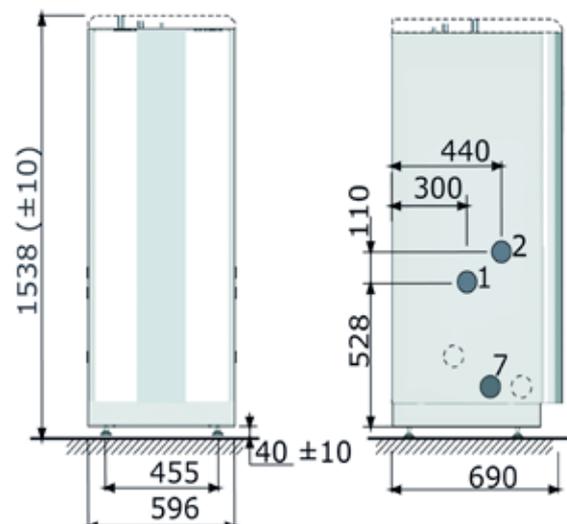


Figure 16,17 : The DHP-L Opti Pro+ is available in 6, 8, 10, 13, 17 kW sizes. 1) Brine in, 2) Brine out, 7) Return pipe from water heater

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- We offer a wide range of units with a power capacity from 6 to 17 kW, both for integrated and external water tanks
- All our heat pumps are suitable for new builds and retrofits
- Each heat pump is also compatible both with under floor heating and radiators alike
- Danfoss is the only manufacturer with over 80 years' experience in the design and manufacturer of heating solutions

Danfoss should be your first choice if you want correct dimensioning and professional heat pump commissioning that gives economical, safe, convenient and comfortable heating for years to come.



Figure 20 Sample installation of ground source heat pump: DHP-L Opti Pro+ and DWH Opti



Figure 21 Sample installation of ground source heat pump: DHP-H Opti Pro+

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