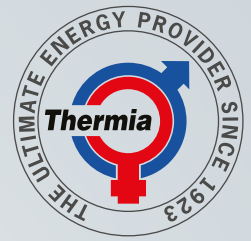


Maximum performance and best all-round economy

Technical article | MEGA ground source heat pump



www.thermia.com



Since the heat pump gained its popularity in the domestic sector, there has been interest from commercial investors such as in the case of larger properties as higher savings from renewable heating can be achieved. Additionally buildings like shops, warehouses, hotels, shopping centres and factories are often located on the border between urban areas with limited access to public utilities.

The Mega ground source heat pump features breakthrough technology such as modulated heating capacity up to 84 kW with a new, advanced control system.

When the investor has limited or no access to such heating sources like natural gas, LPG or oil it is worth considering a heat pump as an alternative. A heat pump is a complex piece of technology, it works in a similar fashion to a refrigerator with a primary function of heating and a secondary of cooling. Here we will outline and evaluate what makes the correct criteria for the commercial ground source heat pump and why it is a leader in its field.

Meeting 21st Century heating needs.

Commercial and public buildings fitted with large windows and conference rooms require heating in the winter but also cooling during the summer. It is not only heating and domestic hot water but also efficient cooling which remains a mandatory function. Moreover in large, modern buildings an important requirement is the possibility to integrate the heating system with the Building Management System (BMS). Another requirement is the need to combine together a cascade of heat pumps to increase power and adjust capacity to fluctuating heat or/and cooling requirements. Cascading in tandem with an auxiliary heater increases the efficiency and safety of the whole heating system. Engineers at one of the most advanced European laboratories, look for the following objectives in the design and development stages of creating a light commercial ground source heat pump:

1. High annual efficiency (Seasonal Performance Factor)
2. Intelligent controls – remote control and/or connection to BMS system
3. Low sound levels



Figure 1: Grouhnd source heat pump Mega, size: 900 mm width, 850 mm lenght, 1744 mm high.

Unparalleled annual efficiency through innovative technology (SPF/SCOP).

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

- Design
- Refrigerant type
- Component quality

The R&D department of Thermia working on the Mega 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). In addition at the heart of this circuit is a newly developed Performer VZH inverter driven scroll compressor from Danfoss.

In the refrigerant circuit we have utilized a new scroll comprssor Danfoss VZH with modulated heating capaticy. The modulated speed of compressor can be varied accodring to the frequency whilst keeping power levels at a constant. The frequency can vary between 25Hz and 100Hz. Thanks to the varied frequency a maxumim heating capacity from 25% to 100% is obtainable.

Heat pumps with inverter driven scroll compressors have two main advantages favorable to the user.

The heat pump adjusts its heat load to the current heat demand, which allows maximum comfort at a minimum level of energy consumption. The real investments is realized when considering the diffrences in heating demand during winter and summer. When

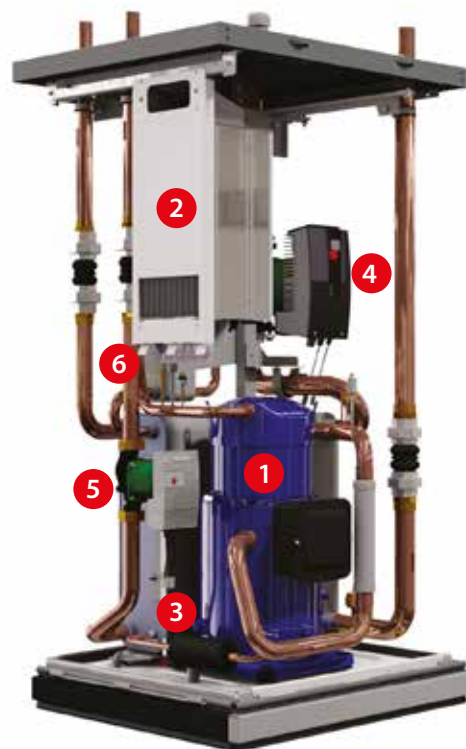


Figure 2: What's inside a Mega? Number of components: 1) Scroll compressor 2) Inverter 3) Electronic expansion valve, 4) Brine circulation pump 5) Heating circulation pump (condenser), 6) De-superheater (hot gas heat exchanger)

during the summer the heat pump is used to produce only hot water.

Moreover the utilization of a heat pump with modulated heating capacity enables omitting an auxiliary heater and buffers. In consequence this reduces investment costs while providing a simple heating solution. A heat pump with modulated heating capacity means that the user pays only for current heating or cooling demand, no more, no less.

It is worth noting that heat pumps with inverter driven compressors are about 30% more efficient compared with heat pumps with fixed speed compressors and about 10-15% more efficient compared with heat pumps equipped with two compressors, so called tandem. Another advantage of a heat pump with an inverted driven compressor is lower start current.

Using inverter technology the start current can be lowered up to 70% which is of great importance when dealing with electrical grids that have limitations.

The VZH scroll compressor includes additional features for enhanced protection and improved efficiency:

- wider application envelope which allows higher condensing temperatures at low evaporating temperatures
- R410A optimized and dedicated scroll profile resulting in lower axial clearance for leakage reduction and better compressor efficiency
- the patented 'tip seal technology' used by the VZH makes a dynamic contact between the scrolls and provides a perfect axial sealing. (It is the only

technology that ensures efficient, highly durable sealing over the long axial surface in large capacity scrolls.) – This sealing technique guarantees the highest volumetric efficiency, low friction losses and directly contributes to a high COP

- lead free polymer bearings which offer excellent performance under a diverse range of loads and enhances compressor behaviour under poor lubrication conditions
- a patented oil injection system ensures optimal efficiency at low speed by improving the scroll set seal
- oil circulation ratio (OCR) has been reduced and correct separation between oil and refrigerant has been secured
- permanent magnet motors with high efficiency at all speeds; high motor efficiency means less heat transferred from the motor to the refrigerant giving better compression efficiency; permanent magnet motors are about 5% more efficient compared with induction motors
- by controlling the compressor with the frequency converter the compressor motor is operated without imbalance and is resistant to change in the phase sequence

The refrigerant circuit within the Mega uses a bespoke, high performance heat exchanger known as a MPHE (Micro Plate Heat Exchanger). In heat pump 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



Figure 3: Performer VZH scroll compressor with inverter

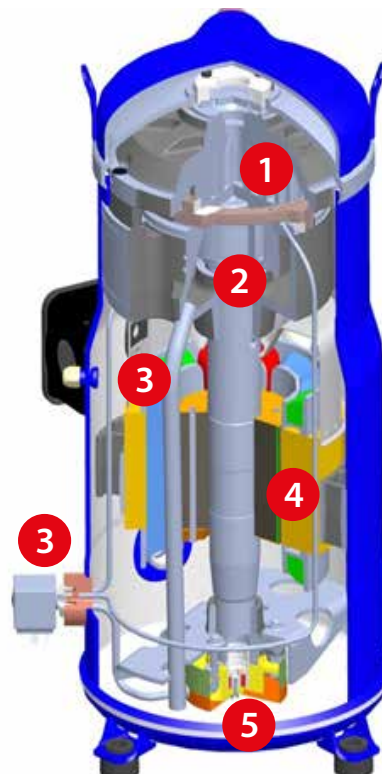


Figure 4: X-ray view of VZH scroll compressor, Number of parts 1) Scroll, 2) Lead free polymer bearings,, 3) Oil injection, 4) Permanent magnet motor, 5) Oil strainer

correspond with actual operating conditions. With the MPHE, channel proportions are optimised for the ground source heat pump applications.

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 an improved COP, 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 refrigerant system pump that Mega uses is an electronic expansion valve. In the ground source heat pump there is not as much differentiation in temperature fluctuations as an air source heat pump however the electronic expansion valve has two main advantages: a wide range of performance and precision in the modulation of refrigerant flow.

The temperature of the brine has the ability to fluctuate in connection with the changing of the seasons. The electronic expansion valve delivers precise doses of refrigerant to the evaporator, and thus optimises

the compressor performance to the changing brine temperatures. The changing temperature of the brine across the evaporator has a positive effect on the refrigerant evaporation pressure and consequently stops the possibility of condensing vapours occurring from the refrigerant.

One key benefits Mega heat pump gives is the precise and continuous regulation of electronic expansion valve which works in harmony with the changing speed of the compressor, thus regulating the amount of refrigerant flow. In addition the elimination of excess unwanted condensed vapours is made possible through the precise regulation of the electronic expansion valve with the changing conditions of the compressor.

Besides the benefits of the construction of the electronic expansion valve, of importance is also superheat control. Thanks to adaptive superheat control the refrigerant supplied to the evaporator is precisely regulated and based on true heat demand which maximises the efficiency of the refrigerant circuit whilst saving energy.

In observing figure number five we can see the comparison between adaptive superheat control and fixed superheat control in addition to the thermostatic expansion valve. The comparison clearly shows that electronic expansion valves with adaptive superheat control are 10% more efficient than valves with fixed superheat control.

The electronic expansion valve allows superheating of vapours at the right level in all conditions, and ensures

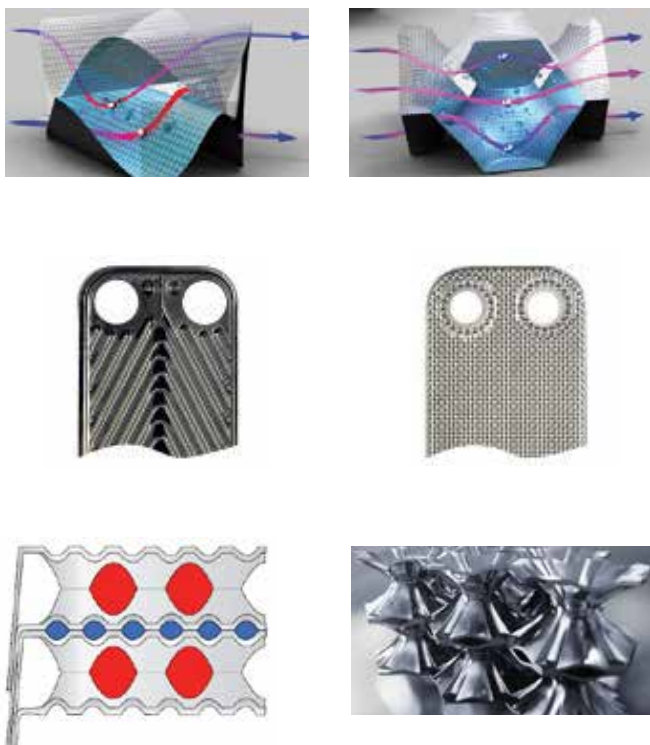


Figure 5, 6: Compared with a traditional BPHE, with its three-dimensional flow, the innovative MPHE has a two-dimensional flow with a more uniform velocity which enhances heat transfer. Figure 7, 8: Left: Herringbone (BPHE) Right: Unique channel plate pattern (MPHE); Figure 9, 10: Principle of asymmetric channels, Asymmetric braze joints

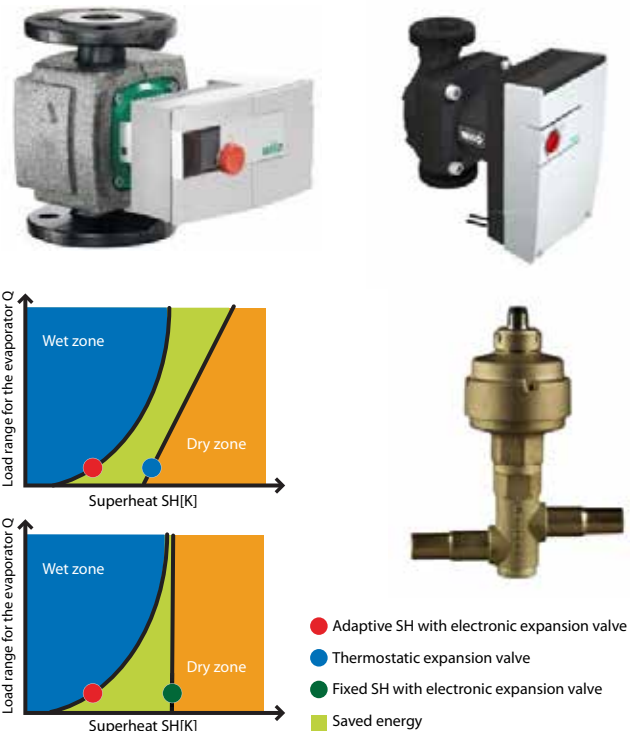


Figure 11, 12, 13: The A Class circulation pumps Wilo Stratos and Wilo Para, electronic expansion valve ETS
Figure 14: Adaptive superheat control

a more effective use of the heat source, thus lowering the systems thermal inertia and enabling a more controlled precision of the whole system.

It should be noted that according to European Directive 2005/32/EC¹ of the EU Parliament that from the 1st of August 2015 all circulation pumps (built into heat pumps) should have a coefficient of efficiency EEI (Energy Efficiency Index) no higher than 0.23. The circulation pumps used in Mega already meet this Class A requirement. Speed-controlled circulation pumps are about 5-6% more efficient compared with step modulated circulation pumps.

It is a fact that in the last 10-20 years the use of domestic hot water has changed dramatically. This is particularly evident in such places like hotels, where pools and SPAs are more and more popular.

In ordinary refrigeration circuits there is an evaporator, a compressor and a condenser in which the heat for the heating system is extracted. The Mega has an additional exchanger called a de-super-heater (hot gas heat exchanger) between the compressor and the condenser. In the de-super-heater you can find hot gas on one side and water from the primary hot water tank on the other. The gas temperature at the compressor outlet can be more than 100°C and can heat water up to 95°C just behind the de-super-heater. This is a remarkable new standard of hot water production.

¹ 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

In winter, when the heat pump is required to provide heating 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. For the investor, the 'hot gas' technology means about 13% more efficient hot water production and savings every year. Thermia Mega for domestic hot water and control of the hot water circulation system (TWC function) is able to meet extraordinary demanding requirements from commercial properties.

An important part of ensuring the efficiency of the the Mega 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.

Intelligent controls

The key element responsible for overall heat pump operation is performed by the main controller. The new controller in the Mega heat pump boasts a touchscreen color display in addition to user friendly iconic symbols that are easily recognisable giving the user stress free control.

Advanced control systems in Mega provide such functions as:

- the heat demand calculation is based on an algorithm



Figure 15, 16: Thermia Mega ground source heat pump without its housing. De-super-heater – hot gas heat exchanger and rubber compensators.

- similar to PID (proportional-integral-derivative)
- the heat pump (compressor) always functions at optimal conditions – inside „the envelope”
- the electronic expansion valve is controlled directly by the main heat pump controller – efficiency is maximised through a full and concise data exchange between the heating system and the refrigerant circuit
- an intelligent and adaptive system which recognises an immediate change in seasonal factors comes as standard with Mega as opposed to other heat pumps that have a delay during seasonal change
- a full and precise overview from the refrigerant circuit allows for a quick diagnosis
- seven points along the heat curve can be chosen allowing for a more precise configuration between the heat pump and the heat demand, moreover the same seven points along the heat curve can be chosen for shuntgroups
- the ability to store ‚My favourite’ heat curve
- restoring parameters to factory levels is made possible on a single line level
- the circulation pumps are controlled by the main controller and adjust in relation to the speed of the compressor
- combination of 16 heat pumps in one cascade on a master/slave, where operating time for each heat pump is controlled so all of them work evenly
- the control of five heating or cooling circuits
- control of the external heating peak source, such as an oil or gas boiler or electric heater

- each shuntgroup maybe equipped with its own indoor temperature sensor
- passive cooling, which is the removal of heat surplus without running the compressor, using only the brine circulation pump
- active cooling is to remove the heat surplus to the ground source (brine) and hot water using a compressor, active cooling can be performed simultaneously during heating
- Water Charging System (WCS) function that manages hot water charging for the hot water heaters through a heat exchanger
- Tap Water Control (TWC), which is a feature that provides the required temperature of the hot water circulating in the system, giving it a high level of comfort and prevents the growth of legionella bacteria
- ability to be controlled remotely – online connection
- communication with Building Management Systems using the Modbus protocol
- EVU (Energieversorgungsunternehmen) which means that the heat pump maybe switched on or off remotely by the electricity supplier according to the current tariff
- during operations it is possible to read the consumption of electrical energy as well as the heat energy delivered
- heat for swimming pools, comercial air heaters in addition to other heat receivers

Controllers utilized by Thermia are dedicated to the application of the heat pump and in application where



Figure 17: Color display of Thermia Mega. Under the display is located a USB port.

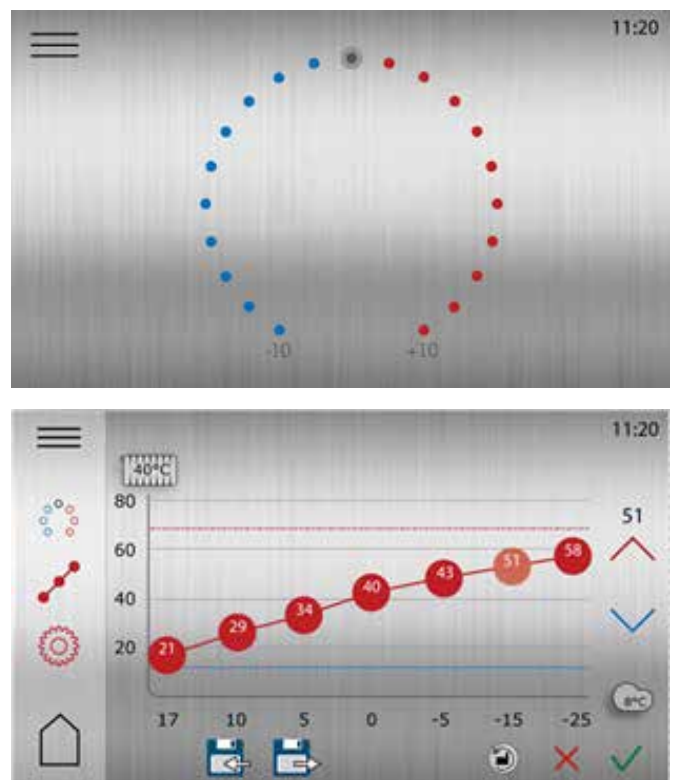


Figure 18: An example of the touch screen menu display.

the heat pump works in tandem with another auxiliary heat source. On the Mega control board below the display can be found a USB port for the updating of software.

Tranquil levels of sound

In winter, the heat pump works up to several hours a day and it is important for it to function in a quiet manner. In most commercial buildings there is always a place where the heat pumps are located and the sound level coming out of them seldom bothers users of the facility. At such properties like a nursery or hotel in the forest (low acoustic background) sound levels can be an important criteria.

The Mega 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

Vibration isolation constitutes the primary method for controlling structural vibration. VZH scroll compressors are designed to produce minimal vibration during operations. The use of rubber isolators on the compressor base plate or on the frame of a manifolded unit is very effective in reducing vibration being transmitted from the compressor to the unit. Once the supplied rubber grommets have been properly mounted, vibrations transmitted from the compressor base plate to the unit are kept to a strict minimum.

For sound radiating from the compressor, the emission

path is airborne and the sound waves are travelling directly from the machine in all directions. The VZH scroll compressor is designed to be quiet and the frequency of the sound generated is pushed into the higher ranges, which not only are easier to reduce but also do not generate the penetrating power of lower-frequency sound. Use of sound-insulation materials on the inside of unit panels is an effective means of substantially reducing the sound being transmitted to the outside.

Additional components which reduces vibration is a rubber compensator installed in the brine and heating pipes, both in supply and return. (see figure nr 10). Sound power levels of the Mega^{XL} varies from 55 dB(A)² at 1500 rpm up to 63 dB(A) at 6000 rpm. The Mega boasts one of the quietest heat pumps on the market.

Caring for investor values

Many investors at the beginning stage of a project consider the use of heat pumps, especially if the investment is located outside the city with limited access to gas or district heating. Many investors ask themselves, what heat pump should I buy for my property? Or even which manufacturer? Heat pump branded manufacturers seem 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 Mega heat pump from Thermia is your number one choice?

- boasts the highest levels in annual efficiency

² According to EN12102 and EN ISO 3741. Compressor speed 1500–6000 rpm.

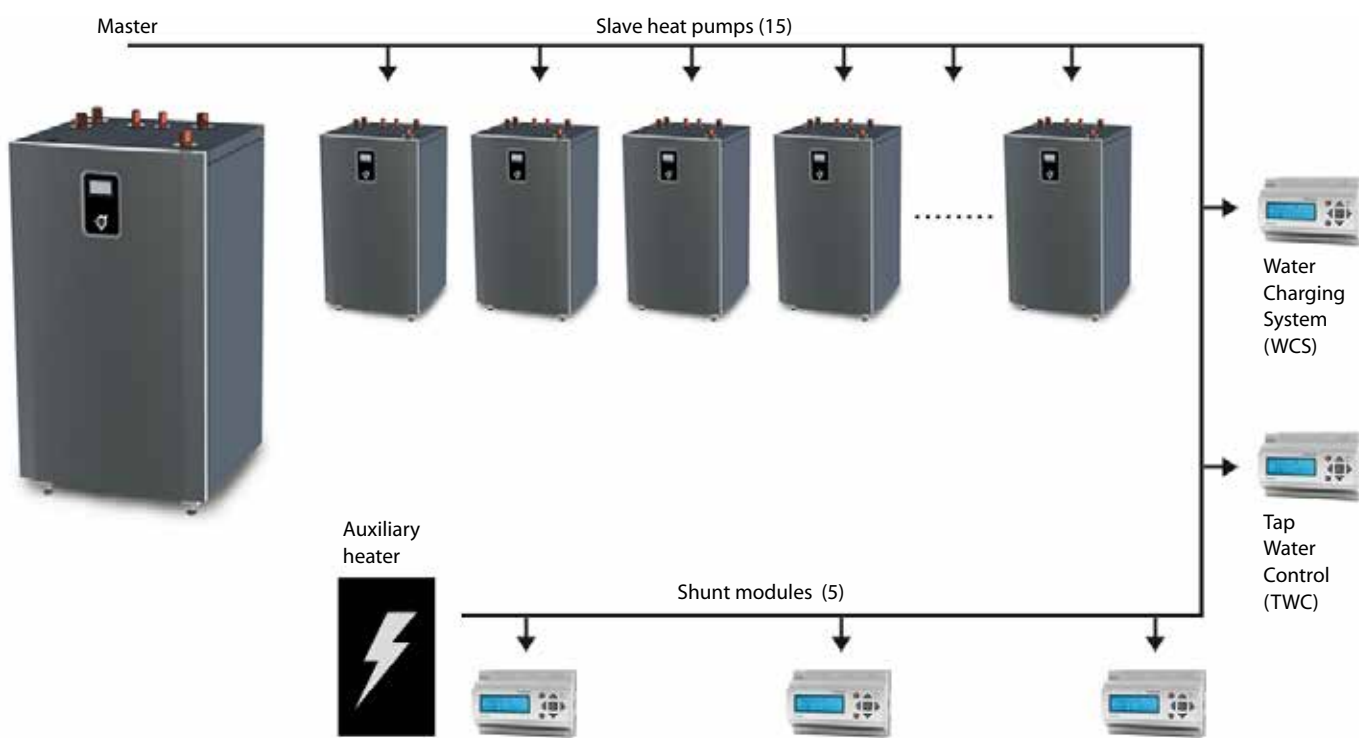
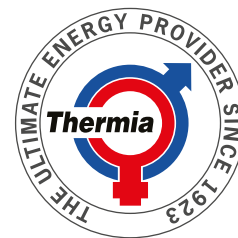


Figure 19: System solution supported by the controller



Technical article **Mega Ground Source Heat Pump**

- (measured by the SPF factor: Seasonal Performance Factor), which means lower energy bills
- from 2015 on, consumers and investors will find a standardized energy efficiency label on things like heat pumps, gas heaters, and chp-systems such as washing machines and dishwashers. The essential thing is that all heating systems will be merged into one class and, thus, be directly comparable. The rating system for heating heat pumps classifies them into nine efficiency categories. A++ is the best energy efficiency category, G denotes appliances with extremely poor values. Thermia Mega is in the top group, rated in category A++.
 - offers three models: Mega^M 11 – 41 kW, Mega^L 14 – 54 kW; Mega^{XL} 21 – 84 kW with cascading option up to 16 units, which allows up to 1344 kW
 - three functions from one device: heating, hot water and cooling
 - control of five shunt groups
 - we are at the forefront in technological innovation, particularly in hot water production, control and volume
 - intelligent control: remote control and option to connect to BMS via Modbus
 - control of any auxiliary heater
 - compatible both with under floor heating and radiators alike
 - extremely low sound levels
 - heat pump manufacturer with a long and proven experience in the production of refrigeration components

Thermia Heat Pumps has been manufacturing heat pumps for over 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. These solutions are not only in the form of documentation, but have been tried and tested in many commercial installations located in the harshest of Nordic climates.

Thermia 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.