Technical Manual

Forced circulation solar systems

Systems for household or professional applications

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Contents

1. Introduction

1.1. Leveraging solar energy

Depletion of energy resources is one of the key issues the modern world is facing. The increasing concerns over the pollution of the environment caused by pollutants generated by traditional energy sources and the limited energy reserve quantities are the key drivers of the pursuit for alternative energy resources. It is worth stressing that, according to estimates, carbon reserves suffice for just 150 years while the respective oil and natural gas quantities are significantly lower. Hence, leveraging renewable energy sources has become a matter of utmost priority, especially these days when the cost of energy has reached unprecedented heights.

In light of the above, the current legislation on the energy performance of buildings necessitates the adoption of measures - at the level of initial design and in the form of post construction interventions - both to meet the minimum requirements provided by law, and to improve the building's energy performance.

Whether new or existing buildings are involved, interventions aiming at the improvement of energy performance and therefore, its score in energy assessments, as provided in the procedures stipulated by the Energy Performance of Buildings directive, are mainly aimed at the building shell and its electrical - mechanical installations. Among these interventions, installation of Forced Circulation Solar Systems is the most rewarding in economical as well as technical terms. The installation of such systems in buildings, helps to achieve significant reductions in using consumption for domestic hot water heating; furthermore, they can be used as supplements to traditional space & swimming pool heating systems. In essence, they can substitute part of the consumption of oil, natural gas or electricity through the use of solar energy, an unlimited and free resource.

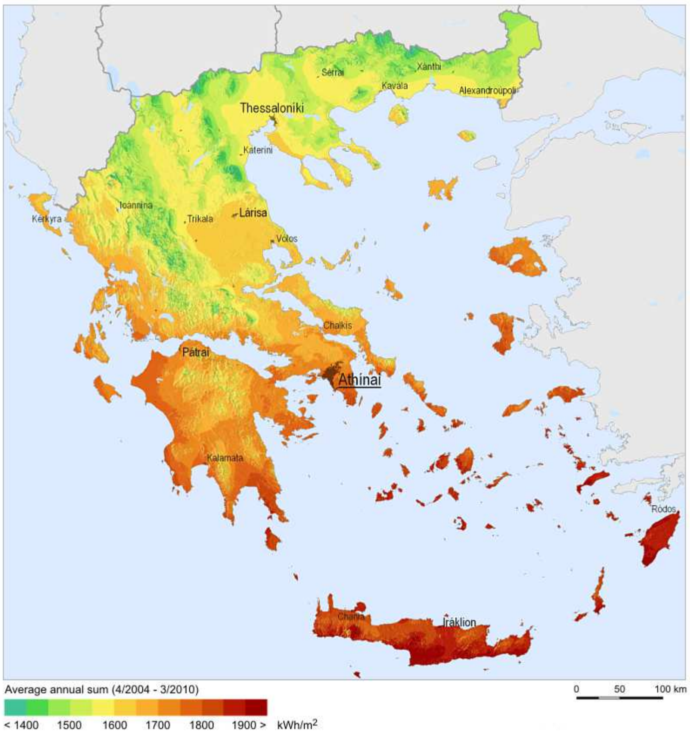
1.2. Arguments in favor of Solar System installation

Installation of a Solar System:

- ✓ Requires moderate building interventions, which do not involve time consuming or high cost operations. Solar collectors can be easily installed on building terraces or roofs. Connections to tanks and heating pipework are especially straightforward.

- ✓ The operating principle of solar systems is based on tapping solar energy; this is a limitless resource as well as the cleanest form of energy, since its generation and use result in no pollutants or adverse emissions to the environment, as the case is for fossil fuels, for instance. Furthermore, Greece is particularly favorable for solar energy generation thanks to the especially high levels of incident solar radiation. The average daily energy delivered by the sun in Greece amounts to 4.6 kWh/m2 (the mean daily rate varies between 2 kWh/m2 and 7 kWh/m2 in winter and in summer, respectively).

- ✓ It is indicatively noted that the annual amount of energy delivered per collector square meter (installed under optimal installation conditions for the geographical position of Greece) is around 700 kWh for flat selective collectors, and may reach as much as 800 kWh in case of vacuum tube collectors. Hence, in light of the current fuel oil prices and taking into account the standard costs of central solar system installations, such systems offer highly attractive investment return times for the installation of central solar systems for DHW production and as supplements for space heating, usually ranging between 3 -5 years. Apparently, the most favorable values refer to low temperature assistance systems (e.g. underfloor heating or fan coil-based systems).



1.3. Description

Solar energy systems for hot water production are distinguished in two types as to their mode of operation: natural circulation or flow, and forced circulation.

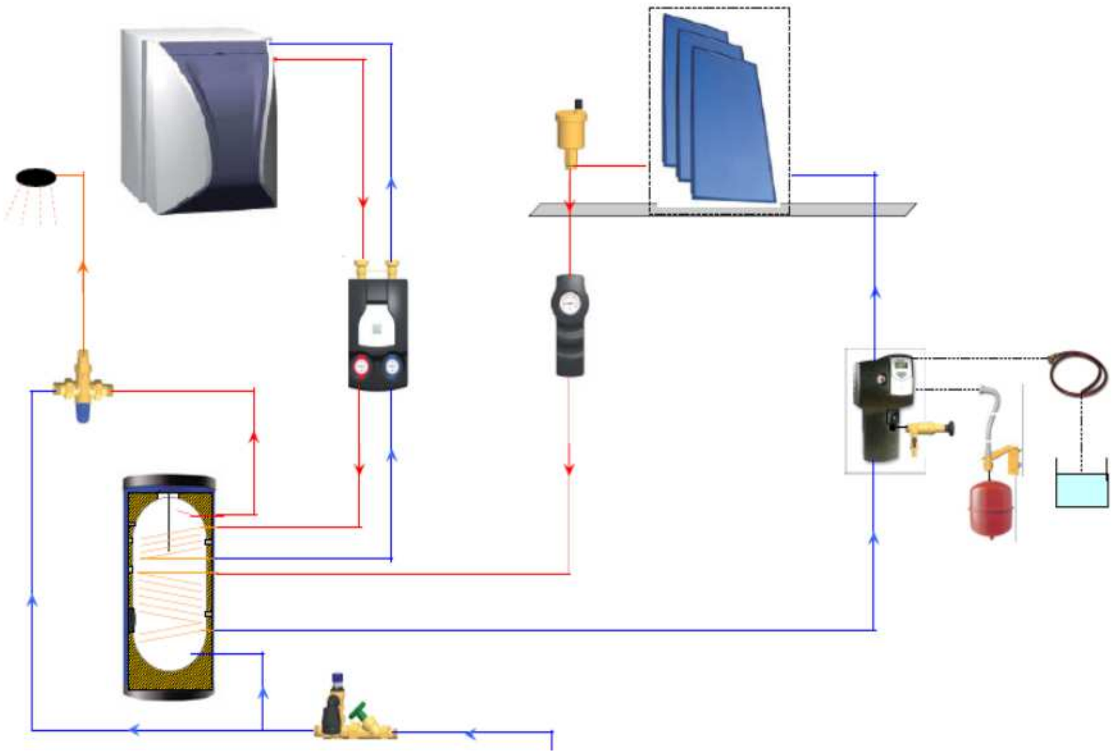
As their names suggest, this distinction refers to the mode of flow of the heat transfer fluid used to heat the domestic water, through the respective circuit.

In the former case, regarding the common thermosyphonic solar water heater, the heating fluid circulates by natural flow, generated due to the difference in density between the hot and the cold fluid. Hence, the hot fluid moves to the top of the tank while the cooler part moves lower towards the collectors.

Conversely, in case of forced flow solar systems, fluid is circulated by a mechanical assist system, using circulation pumps, as the tank is located lower than the collectors.

1.3.1. General Description of Operation

Presumably, the purpose of a solar system is to collect, transfer and store energy. In particular, solar radiation falls on the surfaces of collectors and is stored by the absorber installed inside the collector. Then, the heat transfer fluid flowing through the tubes inside the absorber, absorbs such energy and increases its temperature. Hence, this step involves the conversion of solar energy into heat. The heat transfer fluid (a mix of water and antifreeze) is then delivered to the tank to heat the domestic water. Such heating is performed by way of heat exchangers, i.e. coils immersed in the domestic water that carry the heat transfer fluid, thus radiating heat. This way, the water that surrounds the exchangers is heated and due to the difference in temperature and density, is forced to the top of the tank. It is there that the hot water outlet is located, dispensing water to the consumers. Lastly, the heat transfer fluid, at reduced temperature, is routed again with the aid of the circulation pump to the collector and the above mentioned cycle is repeated.



2. System Dimensioning

Although selecting a water heater is a simple process, exclusively intended for the tenants' hot water requirements, selecting a forced circulation solar system must be thoroughly planned, taking several factors into consideration. One should realize that automation and the development of a standard norm for proper equipment dimensioning and selection in such systems is impossible. Each case should be considered individually. This is the only way to ensure an optimized system and the best possible savings, without running the risk of improper or deficient operation.

It is here that Calpak differentiates itself from its competitors:

Above all, Calpak invests in customer satisfaction, not only through the supply of superior quality products, but also through support services in the design and dimensioning stage of each individual system. Thus, combined with multi - year warranty offered by Calpak, you can rest assured of a reliable and profitable, risk free investment, as opposed to the riskier systems offered by the competitors.

The following sections list a number of basic rules that may guide the selection of the most appropriate equipment.

For further information and assistance, please contact Calpak.

2.1. Calculation of consumption requirements

To calculate the volume of domestic hot water tank(s), it would be necessary to determine the total daily consumption. In cases this is not known or established, an approximation is used, subject to the number of tenants and the overall consumption profile.

Calculating domestic hot water demands can be carried out in 2 ways:

1. The first and most detailed is to add individual consumption values at daily level and to multiply them by the number of persons. In this case, the following daily consumption rates per use type at 40 – 45 °C can be given, by way of example:

   Shower: 35 It
   Bath: 120 It
   Hand washing: 3 It
   Dish washing: 20 It
   Washing machine: 30 lt
   Cooking: 2 It

2. The second approximation for calculating water needs is based on the number of persons and their requirements. In this case - and subject to the consumption profile - the following will apply at 45°C:

   Low consumption: 30 lt per person
   Average consumption: 50 lt per person
   High consumption: 70 lt per person

Of course, it should be noted that these figures are indicative and may change as the case may be. In other words, it is quite possible that a 5 star hotel may present higher hot water requirements compared to a 3 star hotel with the same number of beds, whether volume or temperature of consumed water is concerned. It is equally important to determine other factors, i.e. application of recirculation or not, quality of plumbing pipe insulation etc. Thus, it would be best to define the current needs in consultation with landowners or tenants.

2.2. Collector selection

Selection and installation of the appropriate system collector is conditional upon properly specifying a number of factors to ensure peak performance and energy gain:

1) Collector type
2) Overall size of collector active surface / number of collectors
3) Inclination & Orientation
4) Collector installation and connection

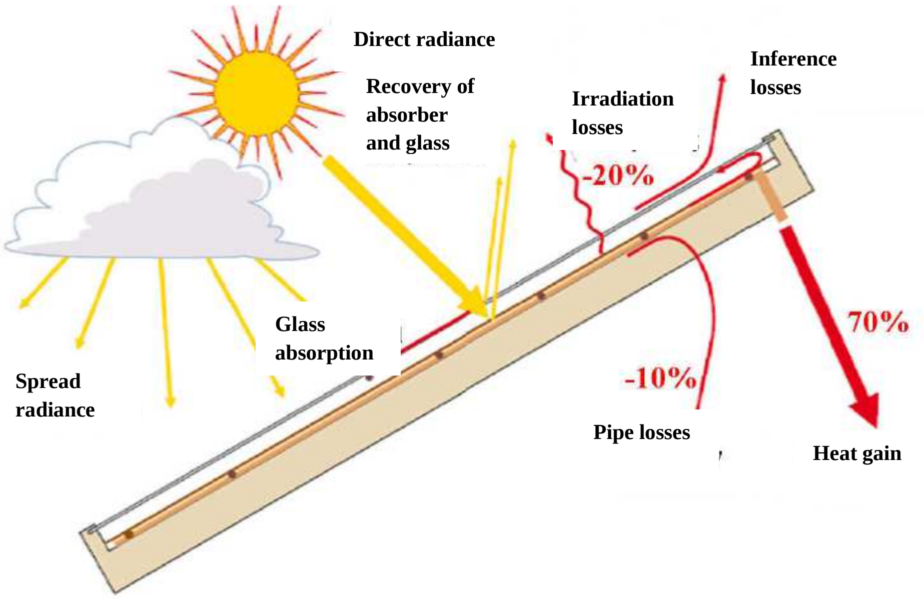
To determine the values of the above mentioned metrics, it is necessary to define a satisfactory overview of the particular installation and its requirements. For this reason, Calpak advises engineers and installers to fill in the solar system preliminary study form supplied by Calpak Technical, attached to this document (p. 95). It should be noted that a condition to fill the particular form is to visit the installation site and to consult with the concerned landlord to obtain a thorough outline of their requirements. This procedure will provide details on the following determinants, which in turn, will determine the selection and dimensioning of collectors:

a) Application type
b) Daily hot water consumption / storage tank volume
c) Place of installation
d) Surface area available for installation, surface type (e.g. flat roof, sloping roof, etc)
e) Other spatial planning restrictions

2.2.1. Specifying collector type

A main collector selection criterion, depending on the case at hand, is its efficiency curve. The efficiency of a collector is the quotient of the effective collector power output divided by the intensity of solar radiation incident on its surface. In other words, collector efficiency is the percentage of incident solar radiation actually utilized by the collector to convert it into thermal energy.

These solar energy losses from the collector can be optical or thermal. Optical losses are the part of the solar radiation lost due to reflection on the collector glass or by the collector's absorber. Hence, losses characterized as optical, are directly dependent upon the construction material of the protective glass and the absorber. On the other hand, thermal losses are the amount of thermal energy released by the collector's surface to the ambient air, due to temperature difference between them.

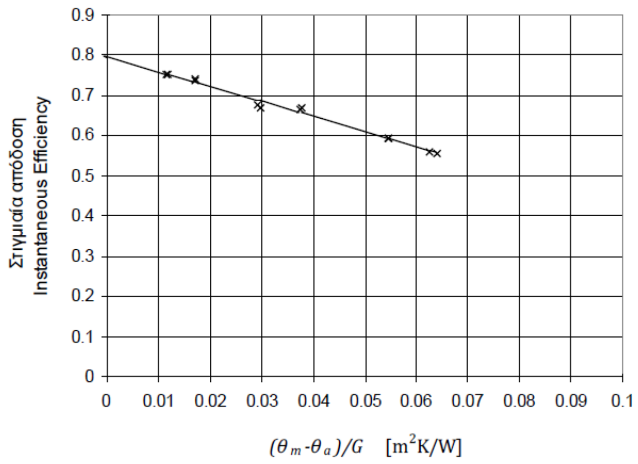


The following graphs present the efficiency curves of Calpak M4 collectors (flat collector) and VTS (vacuum tube collector) as measured and calculated through the following formulas (linear and second degree equations, respectively):

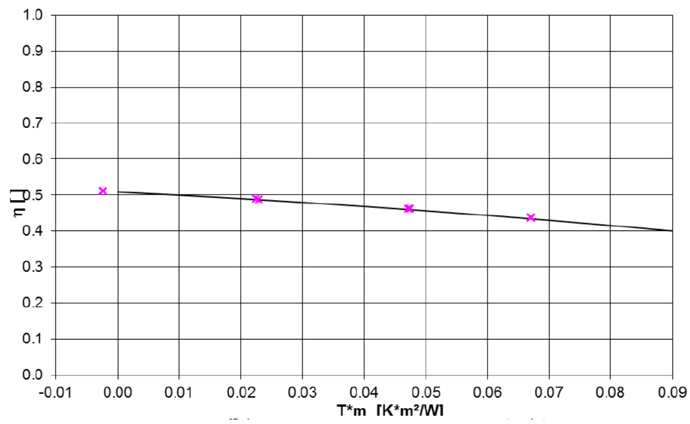
$$n = no - Uo\frac{Tm-Ta}{G}$$

$$n = no - a_1\frac{Tm-Ta}{G} - a_2\frac{(Tm-Ta)^2}{G}$$

Uo (W/m²K) = Total coefficient of collector losses	**no**= Peak collector efficiency (Tm=0)
Tm = Collector ambient temperature	**a1** (W/m^{2}K)= Thermal loss factor (Tm-Ta=0)
Ta= Mean temperature of heat transfer fluid circulating in the collector	**a2** (W/m^{2}K^2)= Dependence of the heat loss factor from temperature
G= Solar radiation strength	



Calpak M4 efficiency diagram
(based on the window surface)



Calpak VTS efficiency diagram
(based on the window surface)

The instantaneous efficiency diagrams show that the Calpak M4 flat collector exhibits less optical losses compared to the Calpak VTS vacuum tube collector. This is reflected on the diagrams, from the initial point of both plots (0.8 % for M4 vs. 0.506 for VTS). In other words, when collector temperature is equal to ambient temperature (ΔT=0), i.e. no thermal loss is observed, a portion of energy is lost due to optical losses. In this case, the vacuum tube collector is less effective than the flat collector due to the parabolic shape of the absorber, which leads to higher radiation reflective surface.

However, the efficiency curve of the selective collector apparently shows significantly higher negative gradient compared to the vacuum tube collector, where the plot seems almost flat - at first glance. This is attributed to thermal losses which immediately affect the efficiency decrease rate: the VTS vacuum tube collector, thanks to the dual wall glass tubes and their internal air vacuum, offers optimal insulation and as a result, its efficiency remains almost unaffected from temperature conditions (ref. Calpak VTS section).

What could this mean?

The above imply that selection of the most suitable collector technology is immediately dependent upon the envisaged operating conditions and in particular, from the solar radiation strength and the temperature difference between the collector and the atmosphere. As a result:

- When solar radiation is intense and ambient temperature is not especially low (hence low ΔT → left part of the efficiency diagram), the use of **flat collector** is preferred against the vacuum tube type, as it offers the following advantages:
  - Higher system efficiency
  - Preventing excessive collector temperatures: Several operating problems observed in collectors are the result of overheating; the results of such overheating may vary from decreased performance to the actual failure of equipment. Due to their proprietary technology that ensures negligible thermal losses, collectors can develop high inertial temperatures in hot climates and therefore, they are often unsuitable for hot climates, except for certain cases, as discussed below.
- When solar radiation is intense and ambient temperature is low (hence increased ΔT → right section of efficiency diagram), the use of **vacuum tube collectors** is preferred, due to their higher performance to flat collectors.

  Furthermore, vacuum tube collectors are used when the following are required:
  - Domestic hot water which cannot be achieved by flat collectors
  - Collectors are installed at excessive low inclination : the role of collector inclination is discussed in subsequent sections, however it is important to stress that vacuum collectors are ideal when installation should be carried out at very low inclination, under 20° (e.g. due to space planning or appearance restrictions) , or even at 0^o due to the parabolic shape of the absorber, ensuring increased utilization of incident solar radiation.

2.2.2. Dimensioning of Collector Active Surface / Number of Collectors

The type of hot water application should be determined in order to determine the size of the collector field:

1) Demand for domestic hot water (DHW)

The most common application is also the optimal for solar system installation; in this case, the solar field is designed with the aim of achieving an energy coverage level around 50-70%. This solar fraction, also an expression of the rate of energy savings compared to the exclusive use of non - renewable energy sources, can be forcibly contained at lower levels when certain restrictions apply (e.g. space planning or financial restrictions, among others). In any case, it should incorporate a traditional source of energy (electric heating element, oil fired boiler, heat pump, etc) that may address hot water requirements when, due to scarce solar radiation, the solar system will be unable to meet hot water requirements.

An outstanding example of improper system design is collector overdimensioning compared to the installed tank volume, due to the misconception that such a configuration would further increase energy gains.

Nevertheless, installing tanks of commensurate volume is necessary, so as to ensure storage of maximum energy quantity from the solar system at hours when solar radiation is available, in order to:

1) prevent rapid discharge of the tank that would force the contribution of the alternative energy source, hence the reduction of energy savings
2) prevent solar system idling, that would result in overheating and possible failure.

2) Demand for domestic hot water (DHW) & supplementing space / swimming pool heating

Except for domestic hot water, the solar system can be used for supplementing heat to warm spaces or swimming pools. Nevertheless, in such cases, the possibility for covering the required energy is far lower compared to just domestic hot water, amounting to approximately 10-20%.

This fact can be readily explained for the following energy approach:

- In the case of swimming pool heating, there is a large volume of water to be heated, thus energy requirements are significantly increased compared to only domestic hot water demand.
- In the case of demand for supplementary space heating, the required temperatures are significantly elevated and there is a time lapse between energy demand and supply from the solar field, as the system's performance and energy gains are far lower in the winter.

Nevertheless, using a solar system to address further needs can still be a beneficial option that should be considered at all times. It should be stressed that, especially in case of demands for supplementary space heating, the solar system, can be useful for low temperature installations (fan coils, underfloor heating) since in other cases, the necessary high temperatures can be barely achieved through the sun.

Rule of Thumb

- *Indicative ratio of collector surface per volume of stored domestic hot water: 1 m² per 70lt.*
- *Indicative ratio between collective surface per swimming pool surface area (swimming pool heating): Collective surface (m²) = ½ of swimming pool surface (m²)*

2.2.3. Inclination & Orientation of Collector

Both the inclination and the orientation of collectors are two key solar system parameters, whose values directly influence its energy gains and its efficiency. Hence, their determination, performed according to the position of the core source of energy of the installation (i.e. the sun) should always aim at utilizing as much incident solar radiation as possible.

- **Collector inclination**

The following table lists the incident solar radiation per collector m^2 for the Athens region, as a function of the applicable collector inclination with respect to the horizontal plane.

Incident sun radiation on Flat Collectors (w/m^2) in the Athens Area

Inclination	0	10	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
Jan	66	80	91	96	100	104	107	109	111	112	113	112	111	109	107	104	100
Feb	75	84	91	93	96	97	99	99	99	99	98	96	94	91	88	84	80
Mar	104	112	116	118	119	119	119	118	116	114	111	108	104	99	94	89	83
Apr	146	151	152	152	151	149	147	143	139	134	129	123	116	108	101	92	84
May	182	183	181	178	175	170	165	159	153	145	137	128	119	109	100	90	79
Jun	200	200	195	191	185	180	173	166	158	149	139	128	118	108	96	85	75
Jul	213	214	210	205	199	194	187	180	171	162	151	139	128	117	105	91	80
Aug	200	206	206	204	202	199	194	188	182	174	165	155	144	132	121	109	96
Sep	156	168	176	179	180	181	180	178	175	171	166	161	154	146	138	128	118
Oct	106	120	130	134	138	140	142	143	142	142	140	137	134	130	125	119	113
Nov	66	77	86	90	94	96	99	100	101	102	102	101	99	97	95	92	88
Dec	53	63	72	76	79	82	85	87	88	89	89	89	88	87	85	83	80
Σ1	1567	1658	1706	1716	1718	1711	1697	1670	1635	1593	1540	1477	1409	1334	1252	1165	1075
Σ2	1203	1242	1250	1243	1230	1213	1188	1157	1120	1077	1027	971	913	850	784	714	645
Σ3	364	416	456	473	488	498	509	513	515	516	513	506	496	484	468	450	430

The inclination is in degrees (°) to horizontal grade
S1 = Total solar radiation throughout the year
S2= Total solar radiation from April 1st to October 31st
S3= Total solar radiation from November 1st to March 31st

The above table shows that power energy gains will significantly vary, depending on inclination and operating period: in winter (S3) maximum energy gains are realized at inclination 50-55°; for summer operation (S2) the maximum efficiency of the collector is 20°. All year round, the collector seems to absorb peak solar radiation at 30°.

These figures immediately indicate that such determination of optimal collector inclination is dependent upon the use of the solar system:

Use	Optimum inclination
Production of Domestic Hot Water (throughout the year)	30° - 45°
Production of Domestic Hot Water (summer, Apr-Oct)	20° - 30°
Domestic Hot Water (throughout the year) + space heating	45° - 55°
Domestic Hot Water (throughout the year) + swimming pool	30° - 45°
Domestic Hot Water (throughout the year) + space heating = swimming pool	45° - 55°

- **Orientation of Collector**

The rationale employed for orientation is similar to the collector's inclination, aiming at peak thermal gains.

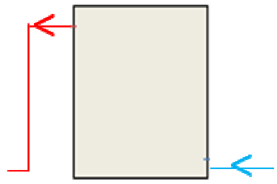
In this case, it is demonstrated that in areas north of the Equator (Northern Hemisphere), including Greece, the collector's orientation should ideally face south; respectively, in the Southern Hemisphere, orientation should ideally face north.

The following table shows reference rates of reduction of collector efficiency when deviating from optimal orientation:

SOUTH	SOUTH-EAST	SOUTH-WEST	EAST	WEST
0%	-11%	-7%	-35%	-30%

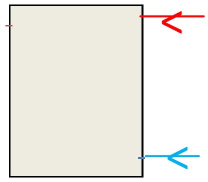
2.2.4. Collector installation and connections

The aim of collector connection layout is to avoid pressure drops from excessive friction in the circuits as well as system protection against overheating effects. Thus, balancing of the system is necessary, by ensuring uniform volumetric flow rate per installed collector unit.



Heat transfer fluid intake and return from opposite sides of the collector: Water flow continues to the same direction

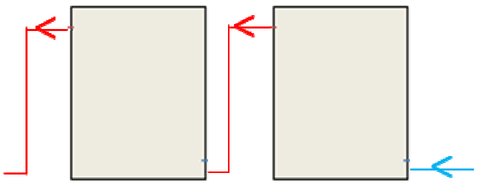
<u>For this reason, it is necessary to select collectors of the same type (e.g. only flat collectors) and of the same design (e.g. vertical) to provide the required circuit uniformity. In addition, it is advisable that water intake and return to the circuit is performed through different collector sides, so as to reduce hydraulic circuit friction.</u>



Heat transfer fluid intake and return from the same collector side: Water is forced to change direction and this results in increased friction in the circuit, hence increased pressure drop

- **Connection of collectors in series**

In case of connection of collectors in series, the hot water released from a collector is delivered to the inlet of the next in line, i.e. water entering each collector is pre-heated from the upstream unit. This mode of connection is particularly easy to install and ensures equal water volume in each collector (in essence, the entire incoming water quantity is transferred between collectors), however presents some significant drawbacks:

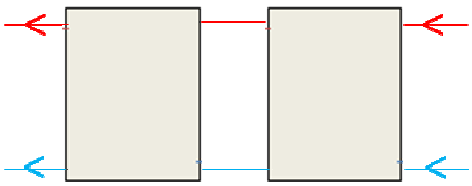


Series connection of collectors

1) *<u>Increase of pressure drop</u>*: In this case, the total pressure drop of each array equals the sum of pressure drop of individual collectors.
2) *<u>Risk of overheating</u>*: As of the sustained intake of preheated water in collectors, the temperatures developed may reach especially high levels, resulting in increased risk of evaporation and collector failure. For this reason, it is not advisable to connect in series large numbers of flat collectors; in cases of vacuum tube collectors, this connection method should be avoided, as of their particular construction that leads to the development of high stilling temperatures.

- **Connection of collectors in parallel**

When conducting collectors connections in parallel the heat transfer fluid circulated in a common cold water header; from there, it is distributed in equal rates to the individual collectors of the array to allow heating and return to a common hot water header. This connection layout is most suitable and allows linking of up to 8 collectors per array, to offer:



Parallel connection of collectors

1) *Decrease of pressure drop*: In this case, the total pressure drop of each array equals the sum of pressure drop of each of the collectors.
2) *Prevention of risk of overheating* compared to connection in series, as the heat transfer fluid intake to each collector is always found at low temperature.

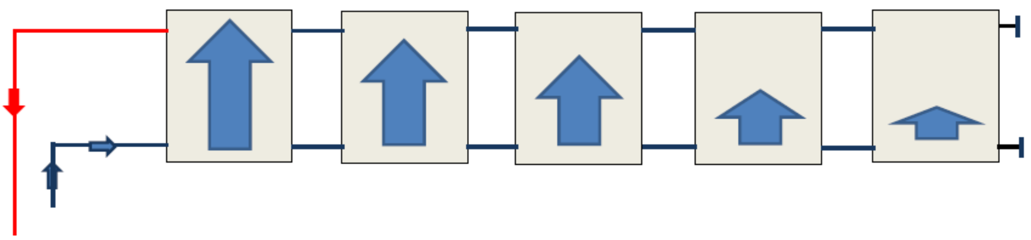
Per each array, it is advisable to install up to 8 collectors in parallel layout without the risk of imbalance in the hydraulic circuit.

- **Connection between arrays – Tichelmann connection (reverse return)**

In projects requiring linking above 8 collectors (maximum number of collectors connected in parallel) or certain space restrictions apply, installers should resort to the creation of individual arrays. In such cases, all the above mentioned connection rules still apply; it is suggested to have parallel connection of collectors as well as parallel connection between individual arrays.

The issue that emerges is to balance the supply of water in the system, an issue that should be given particular attention.

The following figure shows that volumetric water flow in the collectors presents significant variations, in this wrong connection method: As cold water enters the bottom of the array, it tends to follow the shortest path; for this reason, its main volume runs through the first collectors ; as a results, the last ones are often idle and the entire system runs a major risk of overheating and failure.

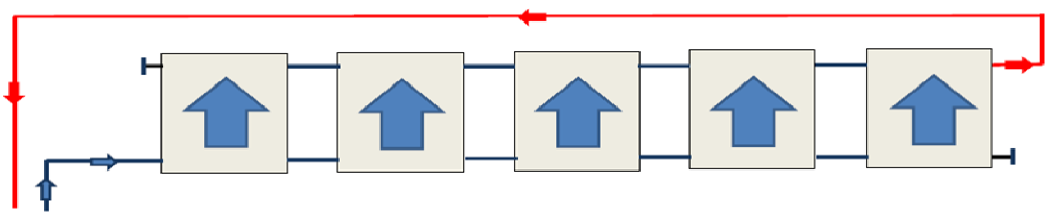


Wrong connection layout: the first collector fed with water is the first to return

For this reason, connection between arrays must always follow the Tichelmann principle that determines that:

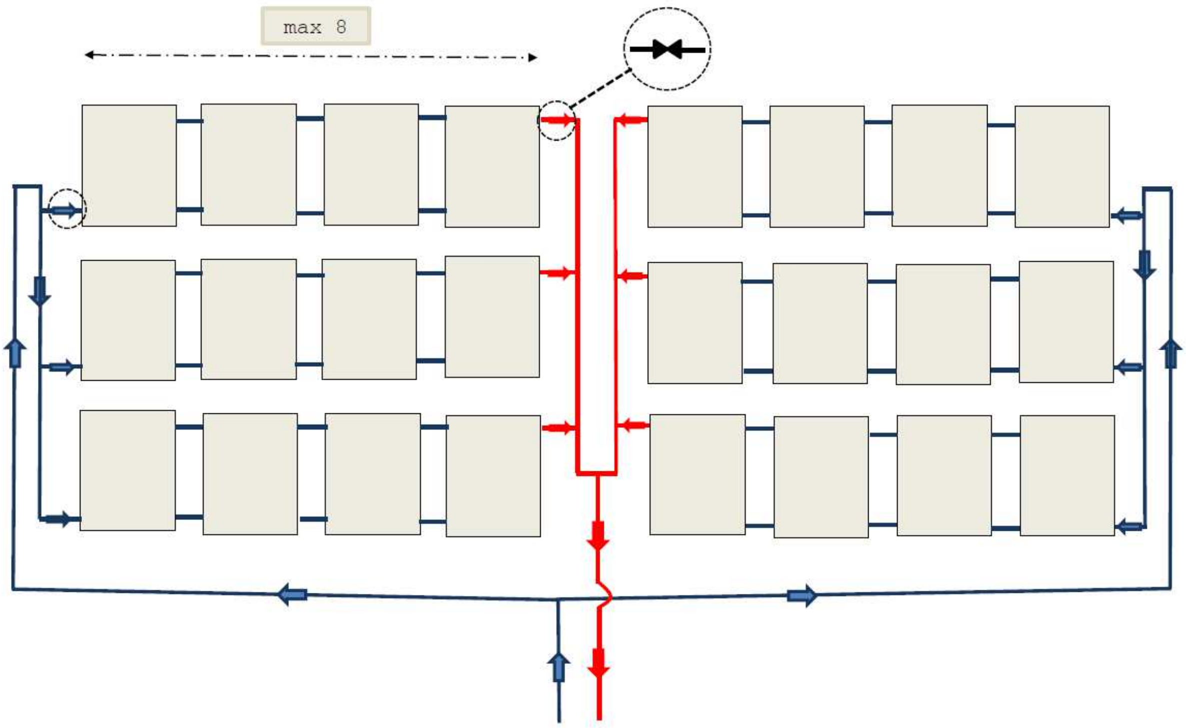
The Tichelmann principle: In each collector, the overall pipeline length (heat transfer fluid intake and return from the circulation pump) should be equal to the rest.

As shown in the following figure, this layout has the effect that the collector closest to the circulation pump - thus having the least pipe length at intake - will have the longest pipes in the return of the heat transfer fluid to the solar system. Respectively, the reverse will apply to the farthest collector, however the aggregate length of pipes for each collector will be the same at all times. This method ensures equal pipe friction over the entire system; the result is uniform water flow in the collector field and system balancing (in larger collector fields, the addition of a regulation valve for safety reasons, might be necessary.)

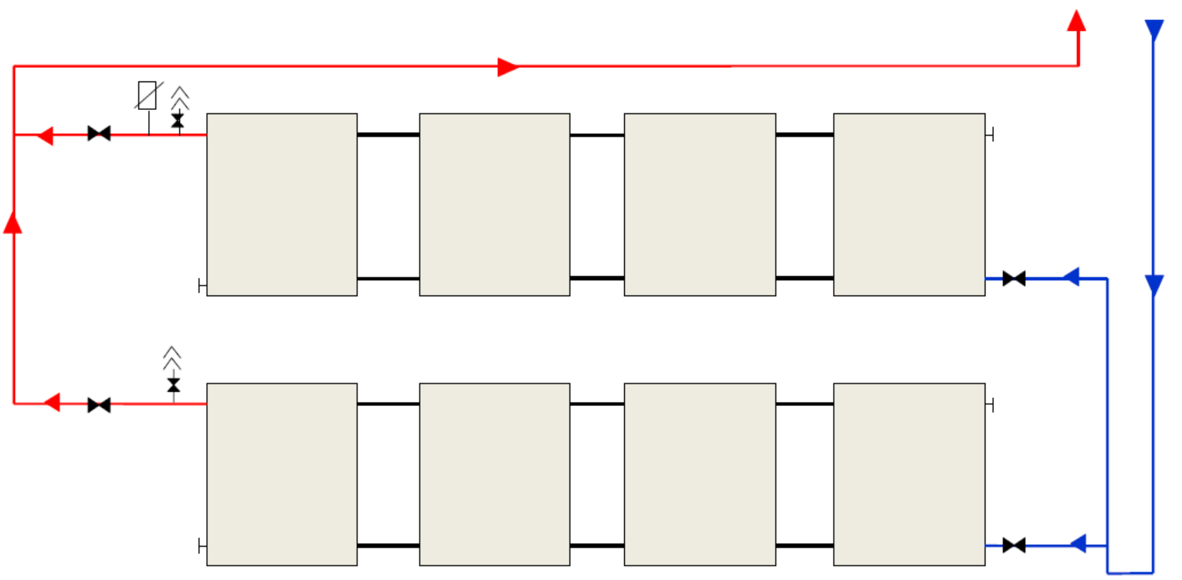


Tichelmann connection layout: the first collector fed with water is the last to return

Reference collector connection layouts



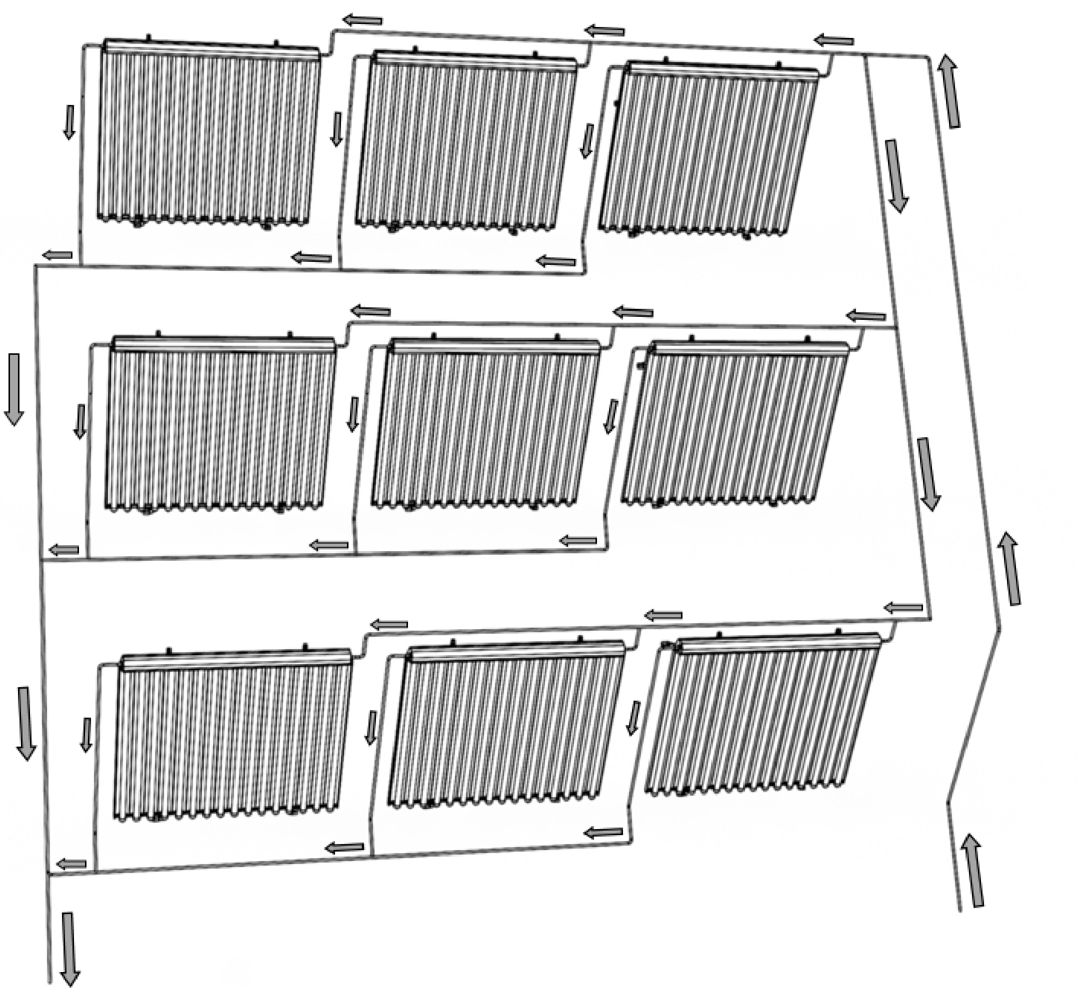
Connection of 24 collectors



Connection of 8 collectors

Installation of vacuum tube collectors - VTS

CAUTION! The above mentioned drawings are NOT applicable to the VTS collector . The latter is equipped with a single inlet and outlet in opposite sides, thus direct connection of the first collector's header to the second, constitutes a series - not parallel - connection. Thus, parallel connection of collectors in arrays, according to the Tichelmann principle, is implemented as follows:



Parallel connection of 9 VTS collectors with reverse-return

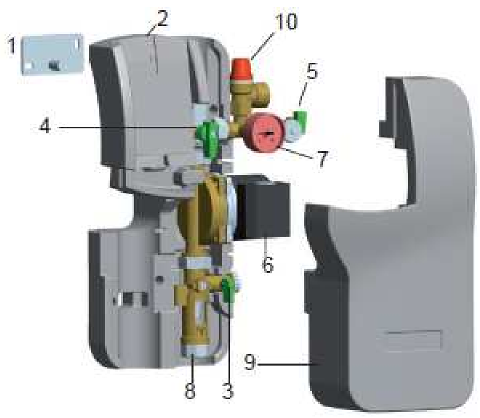
For more information on the installation of VTS collector, ref. page: 76.

2.3. Solar Station

In addition to collectors and hot water storage tanks, Calpak also supplies the corresponding solar stations necessary for the proper performance of the solar system.

The solar station, constituting the brain of the solar system, consists of two parts:

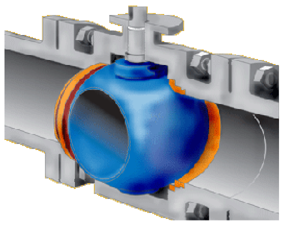
1. the controller regulating the automation of the entire system
2. the hydraulic section including the circulation pump and other components necessary for ensuring proper system performance. These are listed below:



1	Wall – mounting bracket
2	Back half of the insulation
3	Drain valve
4	Ball valve with integrated non - return valve
5	Fill valve
6	Circulation Pump
7	Pressure gauge
8	Flowmeter
9	Front half of the insulation
10	Safety valve 6 bar

Drain valve:

The drain valve is a mechanical part used for system drainage. It comprises of two main parts, an exterior handle and an inner hollow sphere. When the valve is open, i.e. the outer handle faces the direction of flow of the heat transfer fluid, circulation through the circuit is performed naturally through the cavity of the sphere. When the tap is manually turned by 90^o, then the inner sphere also rotates and its walls block the circulation of fluid, thus allowing system discharge.



Non-return valve:

Ensures the flow of heat transfer fluid to the indicated direction to prevent reverse gravitational flow, e.g. to avoid circulation from collectors to the tank in the night, when the collectors temperature is low.

Safety valve:

The role of the safety valve is to ensure that pressure is within the permissible limits : when this exceeds the set peak value, the safety valve will open to blow off the circuit.

Circulation Pump:

All circulation pumps used on Calpak solar stations are inverter based, as stipulated by law. Please refer to page 53 for information on circulation pump operating limits.

Wilo Yonos Para 15/1-7 PWM2 circulation pump

Controller:

Solar station controllers are equipped with installer friendly used interface; they can be satisfactorily commissioned after wiring to the system, pursuant to the set factory settings.

The system's operating principle is based on differential temperature control : the controller monitors the temperatures of the collectors and the tank and when the temperature difference exceeds the set limit (Tcontroller – Ttank > starting ΔT), it commands the circulation pump to start heating of water in the tank. When this value drops under a certain limit, operation of the circulation pump stops to prevent cooling of water. In case a second tank (secondary) is fitted to the system through a 3-way valve, the controller will start heating it after having ensured the desired temperature on the primary. In cases where collector temperature is insufficient for water heating, the controller commands the auxiliary source to heat the tank.

Controller Deltasol SL

One may wonder why the use of a common differential thermostat is not preferred instead of the controller. The following two reasons explain why the controller is necessary for solar systems:

- ✓ The controller supplies additional services / capabilities, necessary for proper system functioning, such as:
  - Overheating protection
  - Antifreeze protection
  - Ability to run heat dump etc
- ✓ The controller ensures peak performance from the solar system:

  The elementary heat transfer formula states:

Q=c*V*ΔT	where:
	Q= thermal energy flow
	c= specific heat capacity of the fluid
	V= flow of heat transfer fluid
	ΔT= temperature difference

The above formula indicates that for any specific moment when Q obtains a specific value, flow and temperature difference are inverse proportional. Hence, the following cases are to be distinguished:

- ➢ *<u>High flow and low ΔT</u>*

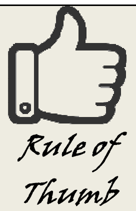
  In this case, due to low ΔT:
  - The circulation pump operates for a limited period and the operating time is insufficient for heating of water in the tank.
  - As of the limited time the circulation pump is in service and therefore the inertia of the system, the temperature of collectors increases and they are at risk of overheating.

- ➢ *<u>Low flow and high ΔT</u>*

  In this case, due to the high ΔT:
  - The circulation pump remains operational for extended time, resulting in high energy consumption.

Thus, one may conclude that ΔT should remain within specific limits (10<=ΔT<=15) throughout the day' however Q will continuously vary due to the variation in solar radiation strength.

<u>It follows that adaptation of flow rate to the applicable operating conditions and, therefore, the use of controller and inverter circulation pump with variable rotation, instead of standard differential thermostat, is necessary.</u>



Recommended flow rate per m^2 of collector *: 40- 60 lt/ m^2 /h*

2.4. Expansion Vessel

The expansion vessel is an inseparable component of the hydraulic circuit. It significantly contributes in ensuring proper performance of the solar system. This tank serves two purposes:

1) Admission of water expansion due to temperature increase
2) Maintaining constant system pressure to avoid pressure drop that could result in the development of steal pressure in the network.

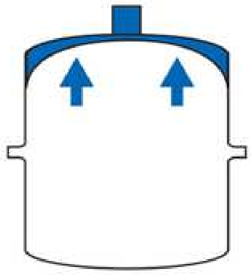
in terms of design, the expansion vessel is closed, cylinder shaped, with an inner flexible membrane that separates the interior in two parts. One threaded part to allow connection to the solar system, essentially receives the expansion of the circuit's heat transfer fluid, while the other part contains gas at a specific pressure. When the water of the closed circuit is heated, its pressure increases and when entering the expansion vessel, it pushes the membrane and thus occupies more volume in the vessel, thus releasing the pressure.

- **Pressure regulation**

To ensure correct system performance, further to the suitable vessel volume, it is necessary to set the proper pressure settings:

1. **Initial pressure Po:** The definition of initial pressure refers to pressure to be regulated in the expansion vessel, before connection to the installation. The expansion vessel is manufacturer supplied at gas pressure at 1.5 bar or 3 bar (depending on vessel volume), however change of setting is necessary to consider the static height of the installation.

   The initial pressure is calculated by the following formula:
   Po = Hstat + 0.2 bar where Hstat is the static pressure.

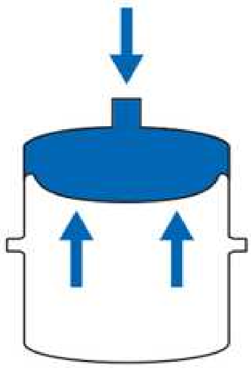


Initial pressure Po

Thermal fluid

2. **Filling pressure, Pa:** The filling pressure is the pressure to prevail in the network, at the point of connection of the vessel, when filling and the water is cold. In other words, filling pressure ensures the necessary regulation of pressure values and, as a consequence, of volumes on both sides of the vessel (heat transfer fluid & gas).

   The filling pressure is regulated as follows:
   Pa = Po + 0.3 bar = Hstat + 0.5 bar

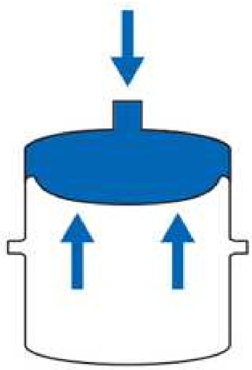


Filling pressure, Pa

Thermal fluid

3. **Final installation pressure, Pe:** The definition of the final installation pressure refers to the maximum permissible circuit pressure, i.e. when water is at the maximum temperature.

   To calculate the final pressure, the following formulas are used:
   Pe max = Pa + 1 bar = Hstat + 1.5 bar.



Filling pressure, Pa

4. **Safety valve activation pressure Psv:** The pressure where the safety valve opens for system protection.

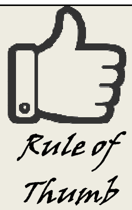
The following formula is used to calculate the final pressure:
Psv = Pe + 0.5 bar.

- **Calculation of expansion vessel volume:**

The following formula is applied to calculate the necessary expansion vessel volume:
Vn = V * (Pe+1)/(Pe-Po)

where:

- **V**: the total circuit fill volume, i.e. the sum of collector fill volume and hydraulic network fill volume.
- **Pe**: Final installation pressure
- **Po**: Initial installation pressure

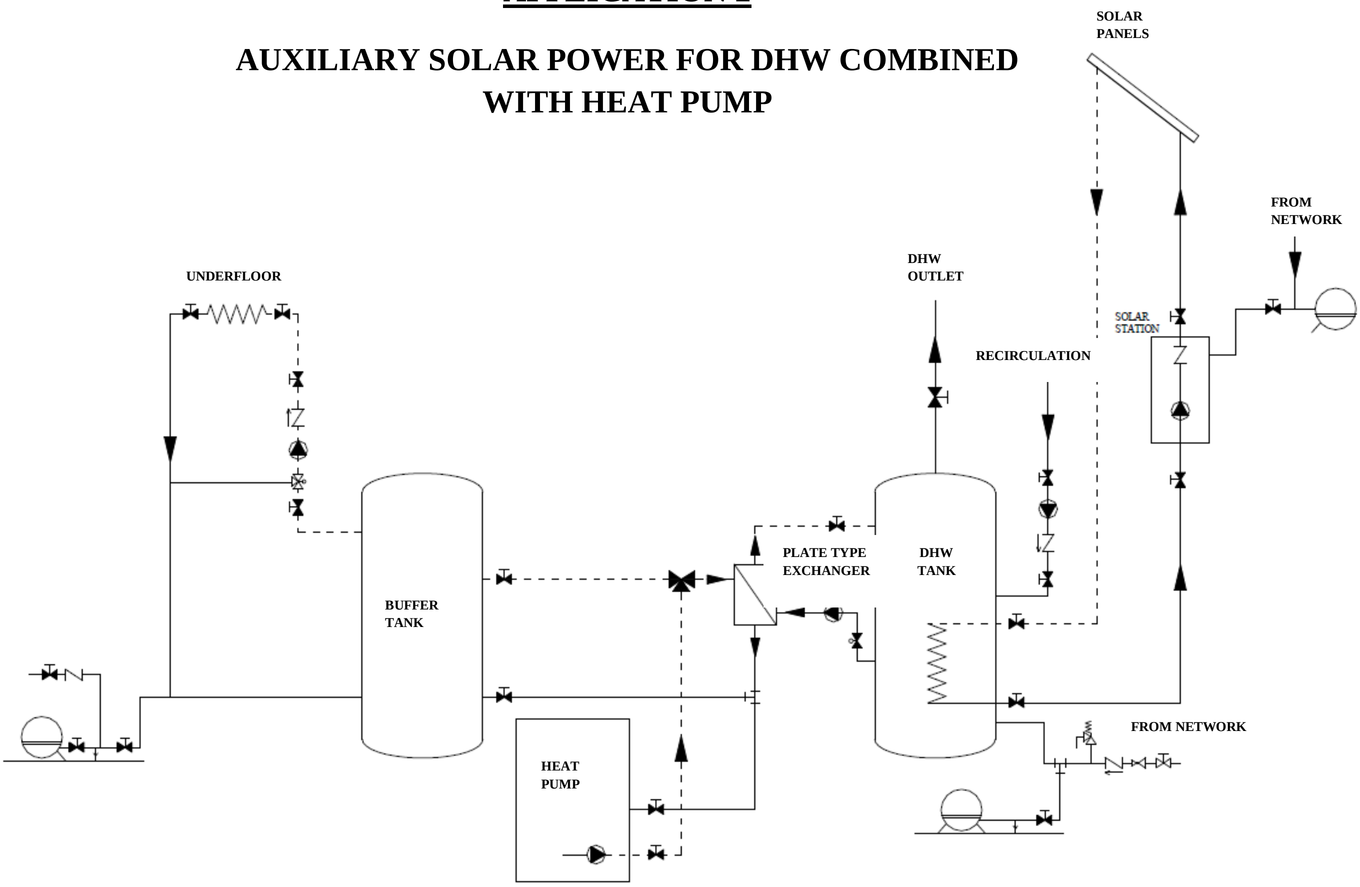


Pressure regulation - Application example:
Let distance between hot water tank room – collectors 10m and the required temperature of water to steam conversion is 125° C instead of 100° C. In this case, pressure will be: 2.5bar (to ensure higher boiling point)+ 1 bar(due to 10m static height) = 3.5bar

2.5. Indicative Application Drawings

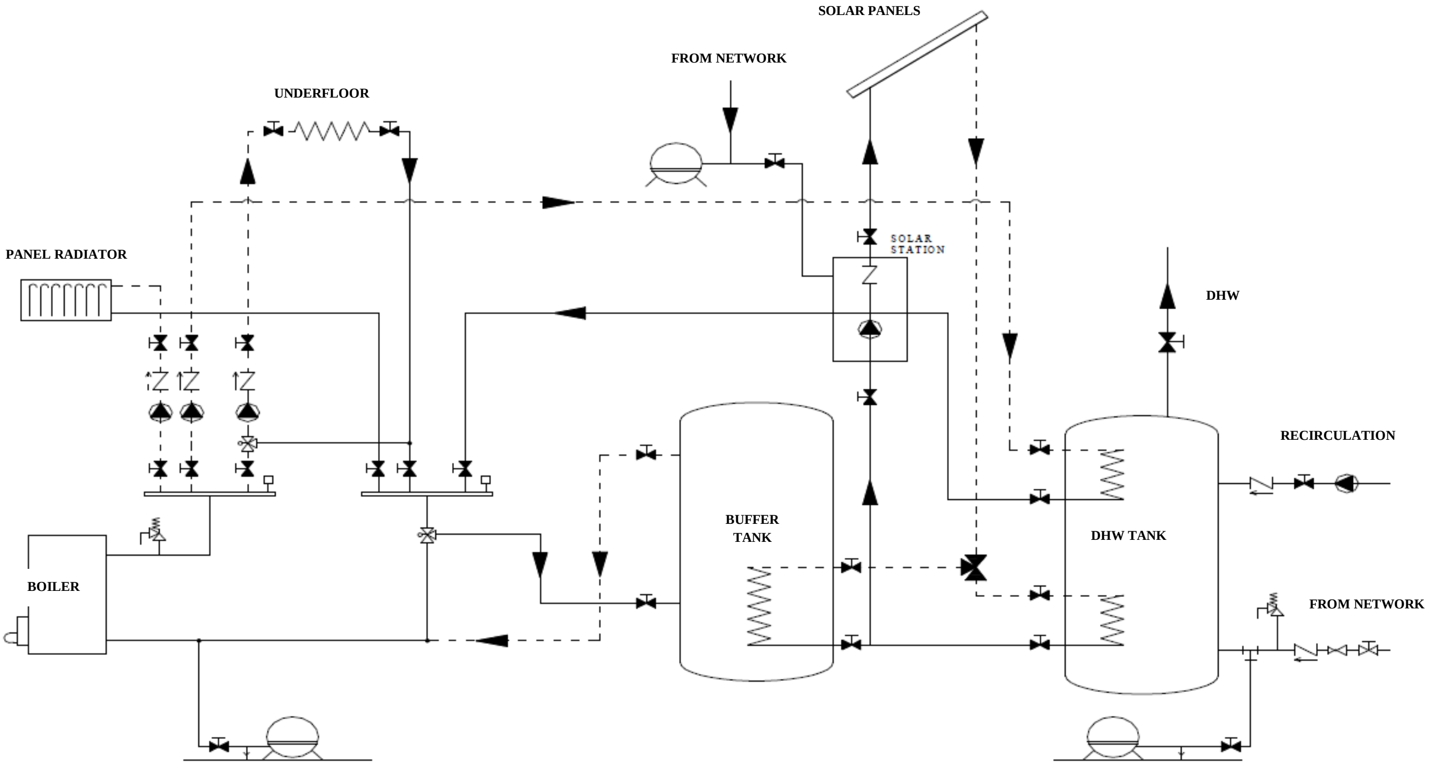
APPLICATION 2

AUXILIARY SOLAR POWER FOR DHW COMBINED WITH HEAT PUMP



APPLICATION 1

AUXILIARY SOLAR POWER FOR SPACE HEATING



3. Calpak solar collectors

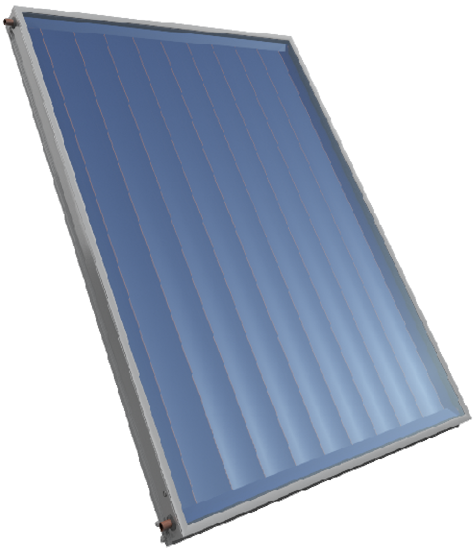
3.1. Solar flat collector Calpak M4

The M4 Calpak collectors are flat plate vertical or horizontal array collectors, with aluminum sheet absorbers, with vertical copper pipes welded onto them, ending, at their upper and lower ends, in two horizontal headers. The heat transfer fluid circulates between the vertical and horizontal pipe grid.

The surface processing of the aluminum sheet is of selective quality, achieved with the ecological "Sputtering" method by TINOX. The major advantage of these surfaces is that they double as black bodies in the process of solar radiation absorption (high absorbency) and as mirrors to minimize the collector's thermal losses. In this respect, they are far better than common collectors with black solar paint, or with a lower quality selective processing.

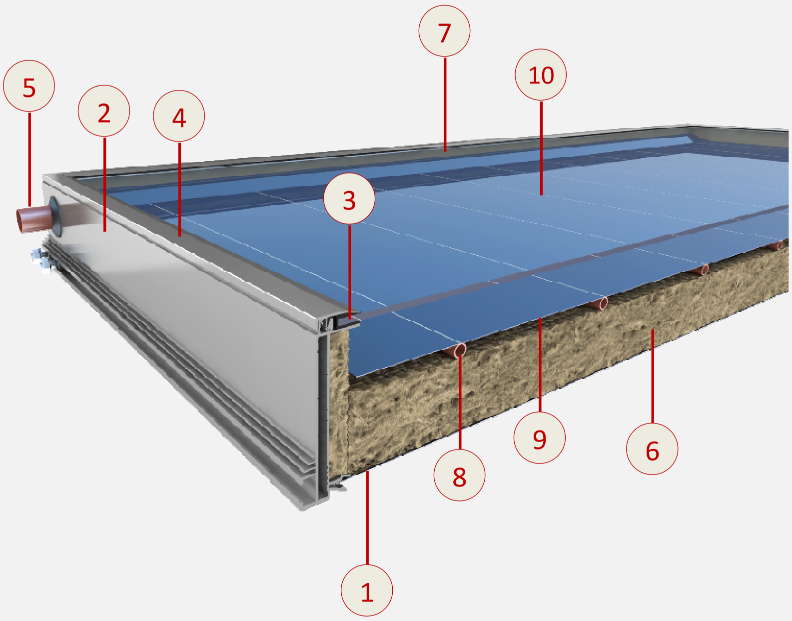
Description - Characteristics

- The copper pipe grid consists of vertical Φ8 tubes, spaced at 100mm intervals, and welded onto the 0.3mm aluminum sheets with UTRASONIC technology (high frequency welding). The small distance, the thickness of the aluminum and the proper welding, maximises the transfer of heat from the heated aluminum sheet to the vertical pipes and, finally, to the heat transfer fluid circulating inside them.

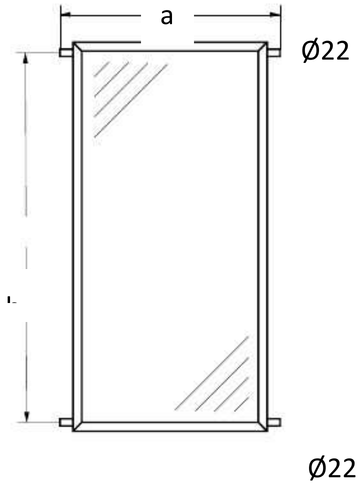


- To reduce flow friction, the headers have a diameter of Φ22.
- The absorbers are placed inside a double-walled aluminum frame, with a recess-groove at its perimeter, in which 10 M8x16 screws are inserted, to facilitate installation.
- On the front, there is a clear safety glass cover (low iron, mistlite, tempered), 3.2 mm thick, that is fitted on the aluminum frame with mechanical clamping, with an inserted EPDM gasket, resulting in much better waterproofing.
- On the back, and around the absorber, there is thermal insulation with $50kg/m^3$ density, 40mm thick rock wool.
- The back of the collector is a 0.5mm aluminum sheet, for mechanical protection of the rock wool.
- The perimeter frame consists of double wall aluminum profile, 1.2mm thick for peak rigidity and reduced lateral thermal losses.

- The operating pressure of the closed circuit of the collectors can be 6 or 10 bar, depending on the installation design, considering that collectors can withstand even higher pressures.
- The Calpak M4 collectors are designed for installation on flat roofs and sloping roofs, by using the corresponding supports that are available as accessories.



1. Back of 0.5mm aluminum sheet
2. Aluminum frame double-walled, 1.2mm
3. Copper fins (with ultrasonic welded assembly)
4. Aluminum clip
5. EPDM sealing gasket
6. Aluminum clip
7. Absorber header from Φ22 copper pipe
8. Thermal insulation with rock wool with 50kg/m^3 density and 40mm thickness.
9. Low iron (Tα =91.5%), mistlite, tempered safety glass, 3.2 mm thick
10. Vertical copper Φ8 pipes
11. Absorber with 0.3mm thick aluminum sheets and with selective surface processing by TINOX (α=0.95, e=0.035)
12. Welding of flaps on the vertical tubes with the ultrasonic method



Distances of hydraulic connections						
Collector type	**M4 200**	**M4 210**	**M4 260**	**M4 260H**	**M4 300**	**M4 300H**
Distance a (mm)	1,035	1,293	1,293	2,170	1,563	2,060
Distance b (mm)	1,973	1,613	2,023	1,146	1,913	1,416

Technical Characteristics

			M4 200	M4 210	M4 260	M4 260H	M4300	M4 300H
Configuration			Vertical	Vertical	Vertical	Horizontal	Vertical	Horizontal
Total surface area		m^2	2.04	2.13	2.64	2.64	3.00	3.00
Window surface		m^2	1.87	1.96	2.44	2.44	2.83	2.83
Absorber surface		m^2	1.82	1.91	2.40	2.40	2.78	2.78
Dimension: Length X Height X Thickness		mm	986 x 2.071 x 86	1.244 x 1.711 x 86	1.244 x 2.121 x 86	2.121 x 1.244 x 86	1.502 x 1.996 x 86	1.996 x 1.502 x 86
Active heat capacity (c)		kJ/ (m^2K)	5.67					
Weight (empty)		kg	34.5	36	42	42	50	50
Content of heat transfer fluid		l	1.60	1.60	1.8	1.8	2.0	2.0
Thermal efficiency, based on the window surface	**Output rate (η0)**	%	80.0					
	Heat transmission factor a1	W/(m^2K)	3.56					
	Heat transmission factor a2	W/(m^2K^2)	0.003					
Absorber Absorbency		%	> 95					
Absorber Emission		%	< 3.5					
Max. operating pressure		kPa/bar	1,000/10					
Standby temperature		°C	177.6					
Angle of incident solar radiation correction factor (50°)			0.89					
Annual energy performance in Athens (Tm=25°C)		kWh	1,738	1,821	2,267	2,267	2,630	2,630
Annual energy performance in Athens (Tm=50°C)		kWh	1,104	1,157	1,440	1,440	1,670	1,670

3.2. Solar Vacuum Tube collector Calpak VTS

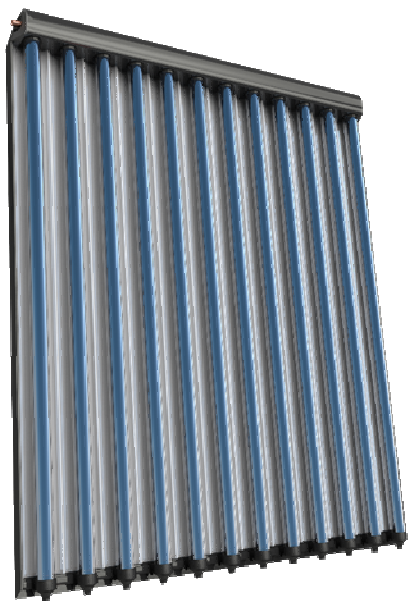
Calpak VTS collectors are the only vacuum tube collectors with U-pipe technology, manufactured and delivered in Greece. Their construction comprises dual wall glass tubes with air vacuum between their walls. Each of these tubes contains a U-shaped copper tube Φ3/8'' fitted with copper fins to improve heat transmission properties. Each tube is connected to a heat conductive fluid input header, Φ18 size, and a similar output header, also Φ18. This fluid is circulating through the copper tubes.

The solar radiation incident on the outer glass tube - either directly or reflected - penetrates the interior through the vacuum. There, the selective surface absorbs heat and thus, the inner space of the tube is heated. The U shaped copper tube with the copper fins will then absorb heat and ultimately heat the heat transfer fluid circulating in the tube.

Due to their special construction and the dual glass tubes, VTS collectors offer the major benefit of developing high temperatures and preserving their high energy efficiency, irrespective of exterior conditions. Therefore, they are recommended for use in space heating applications or in installations with special requirements (e.g. cold climate, industrial facilities etc.)

Description - Characteristics

- The vacuum tubes are manufactured from borosilicate glass. The outer tube has a diameter d=47mm and is 1.8mm thick. Respectively, the inner tube has a diameter d=33mm and is 1.5mm thick. The inner tube surface towards the vacuum is specially treated to allow selective behavior.



- The entire assembly is mounted on a frame whose back is made from highly reflective aluminum. Its surface is parabolic shaped so that the radiation incident on the reflector, is routed to the vacuum tubes.

- The input / output collectors are Φ18 size insulated by glass wool and expanded polyurethane. They are covered by a black aluminum profile electrostatically painted.

- The vacuum between the tubes offers optimal insulation ($p<0.005Pa$) resulting in elimination of heat losses.

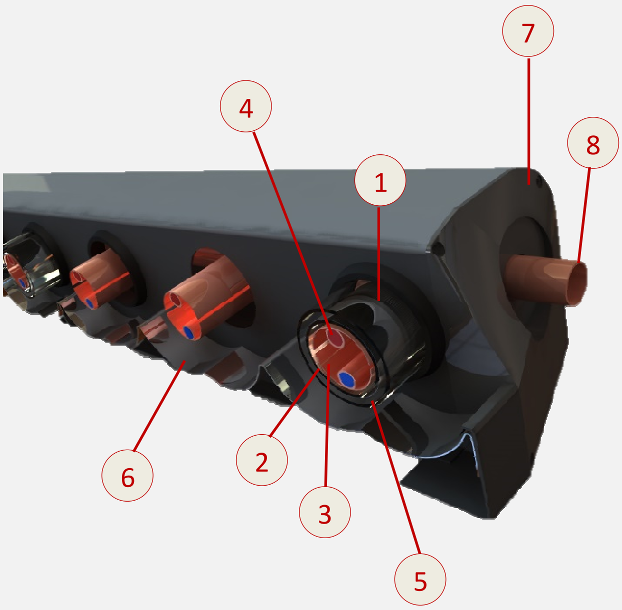
- The copper tubes are welded on the U-shaped copper tube using ULTRASONIC technology (high frequency welding). This method maximizes heat transfer from the U-tube to the heat transfer fluid in the copper tubes, and also ensures the resistance of the collector against potent thermal shocks.

- The operating pressure of the closed circuit of the collectors can be 6 or 10 bar, depending on the installation design, considering that collectors can withstand even higher pressures.

- Thanks to the specific design of the VTS collector, the installation and the series extension of the collector field is particularly easy, through the direct coupling of headers, without requiring additional pipes.

- In case of fault or accident, collector repairs are easily performed by simply replacing the individual pipe, without the need to purge the system.

- The Calpak VTS collectors are designed for installation on flat roofs and pitched tiled roofs, by using the corresponding bases that are available as accessories.



1. Outer Glass Tube
2. Inner glass tube with selective surface
3. Copper fins (with ultrasonic welded assembly)
4. U shaped copper tube
5. Air vacuum
6. Parabolic Aluminum Reflector
7. Header Aluminum Cover
8. Header Copper Tube

Technical Characteristics

			VTS 10	VTS 12	VTS 14	VTS 16
Number of vacuum tubes			10	12	14	16
Total surface area		m^2	1.79	2.13	2.48	2.86
Window surface		m^2	1.62	1.96	2.26	2.55
Absorber surface		m^2	1.64	1.99	2.30	2.65
Dimension: Length X Height X Thickness		mm	1,193 x 1,600 x 110	1,420 x 1,600 x 110	1,653 x 1,600 x 110	1,887 x 1,600 x 110
Active heat capacity (c)		kJ/ (m^2K)	4.9			
Weight (empty)		kg	29.5	35	41	47
Content of heat transfer fluid		l	2.1	2.5	2.9	3.3
Thermal efficiency, based on the window surface	**Output rate (η0)**	%	51			
	Heat transmission factor a1	$W/(m^2K)$	0.84			
	Heat transmission factor a2	$W/(m^2K^2)$	0.004			
Absorber Absorbency		%	> 92			
Absorber Emission		%	< 8			
Max. operating pressure		kPa/bar	1,000/10			
Standby temperature		°C	278			
Angle of incident solar radiation correction factor (50°)			1.14			
Annual energy performance in Athens (Tm=25°C)		kWh	1,491	1,804	2,080	2,347
Annual energy performance in Athens (Tm=50°C)		kWh	1,333	1,613	1,860	2,099

4. Calpak storage tanks

4.1. Domestic hot water tanks

Calpak floor standing tanks are used for water storage and heating, intended for vertical installations in boiler rooms or other sheltered spaces.

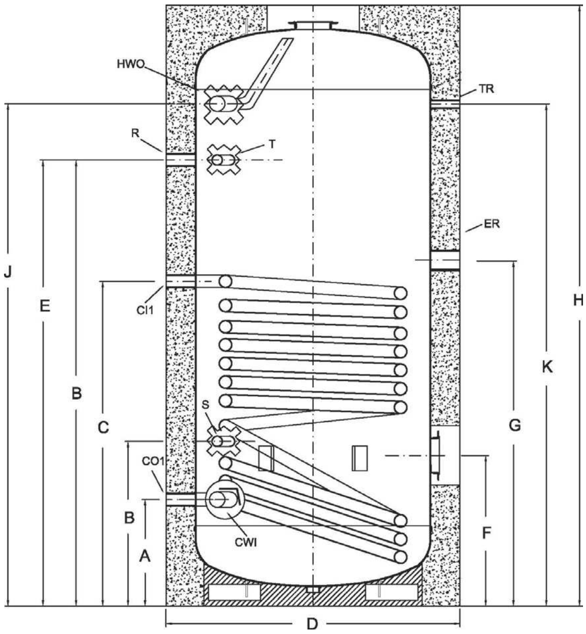
Depending on water heating (charge) mode, they can be supplied in 3 types:

1. ***Without coil :*** floor standing tank where water heating is exclusively carried out by an electric heating element. It can be also used to increase the storage volume of another existing installed tank.

2. ***Single coil :*** this floor standing tank in addition to heating by electric heating element, further contains a coil heat exchanger to allow water heating by a solar system or other alternative source of energy (e.g. boiler, heat pump), thus offering significant efficiency improvement.

3. ***Double coil :*** floor standing tank containing two coils heat exchangers and allowing coupling to solar systems and another ancillary source of energy. In this case, water is charged from both sources through the proper programming of the system, to ensure optimal performance and energy savings.

✓ CL1 Single coil domestic hot water tank (150lt - 800lt)



CL1: Single coil domestic hot water tank

Material: Sheet steel

Protection coating: Glass – enamel & magnesium anode protection

Insulation:

For tanks up to 500lt: Polyurethane foam 55 mm thick

For 800lt - 1.000lt tanks : Polyurethane foam 100 mm thick

Coil : DCP 1" tube

Welding : Automatic metal welding

Electric heating element : Upon request

Max. tank operating pressure: 10 bar

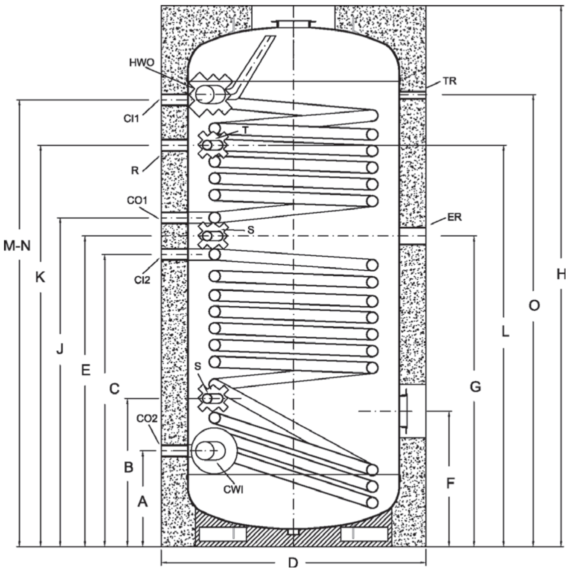
Max. water test pressure: 15 bar

Coil test pressure 25 bar

Maximum Operating Temperature: 95 °C

		CL1-150	CL1-200	CL1-300	CL1-500	CL1-800
	Tank capacity (lt)	139.3	196.4	277.7	455.2	757
D	Diameter (mm)	Ø560	Ø600	Ø630	Ø750	Ø1000
H	Overall height (mm)	1120	1400	1620	1700	1800
	Weight (kg)	61	85	111	141	228
	Coil capacity (lt)	5	6.4	9.9	12.2	15.20
CI1/CO1	S1 Coil, input / output	1"	1"	1"	1"	1"
	Coil surface (m^2)	0.78	0.986	1.55	1.92	2.39
R	Recirculation	¾"	¾"	¾"	1"	1"
CWI	Cold water inlet	1"	1"	1"	1"	1 ½"
HWO	Hot water outlet	1"	1"	1"	1"	1 ½"
	Cleaning flange - Anode	Ø170 & Ø140	Ø170 & Ø140	Ø170 & Ø140	Ø170 & Ø140	Ø170 & Ø170
A	Cold water inlet (mm)	245	245	240	195	305
J	Hot water outlet (mm)	880	1170	1360	1355	1435
C	S1 coil input (mm)	577	690	820	815	955
A	S1 coil output (mm)	245	235	220	205	305
B	Recirculation (mm)	465	545	620	615	1285
F	Cleaning flange (mm)	420	420	450	420	515
E	Thermostat (mm)	668	1070	1140	1115	1285
K	Thermometer (mm)	870	1160	1320	1310	1410
G	Electric heating element socket (mm)	660	785	930	930	1040
	Max. operating pressure (bar)	10	10	10	10	10

- CL2 Double coil domestic hot water tank (150lt - 1,000lt)

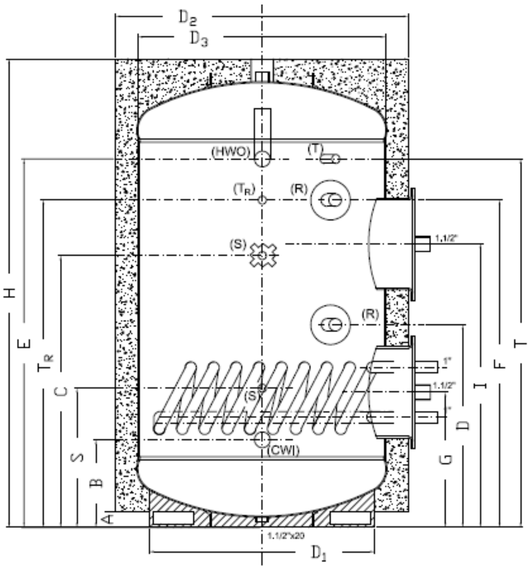


CL2 : Double coil domestic hot water tank

Material: Sheet steel
Protection coating: Glass – enamel & magnesium anode protection
Insulation:
For tanks up to 500lt: Polyurethane foam 55 mm thick
For 800lt - 1,000lt tanks : Polyurethane foam 100 mm thick
Coil : DCP 1" tube
Welding : Automatic metal welding
Electrical heating element : Upon request
Max. tank operating pressure: 10 bar
Max. water test pressure: 15 bar
Coil test pressure 25 bar
Maximum Operating Temperature: 95 °C

		CL2-150	CL2-200	CL2-300	CL2-500	CL2-800	CL2-1000
	Tank capacity (lt)	132.9	190	269.6	442.4	747.10	865.40
D	Diameter (mm)	Ø560	Ø600	Ø630	Ø750	Ø1000	Ø1000
H	Overall height (mm)	1,120	1,400	1,620	1,700	1,800	2,000
	Weight (kg)	70	100	130	170	250	276
	Coil capacity (lt)	8	11.4	16.2	19.8	23.80	31.70
CI1,CI2 /CO1,CO2	S1/S2 Coil, input / output	1"	1"	1"	1"	1"	1"
	S1/S2 Coil surface (m^2)	0.53/0.78	0.78/0.99	0.99/1.55	1.20/1.92	1.35/2.39	/1,973.02
R	Recirculation	¾"	¾"	¾"	1"	1"	1"
CWI	Cold water inlet	1"	1"	1"	1"	1 ½"	1 ½"
HWO	Hot water outlet	1"	1"	1"	1"	1 ½"	1 ½"
	Cleaning flange - Anode	Ø170 & Ø140	Ø170 & Ø140	Ø170 & Ø140	Ø170 & Ø140	Ø170 & Ø170	Ø170 & Ø170
A	Cold water inlet (mm)	235	235	245	195	305	290
N	Hot water outlet (mm)	880	1,155	1,380	1,370	1,435	1,670
J	S1 coil output (mm)	685	855	1,050	985	1,095	1,230
A	S2 coil output (mm)	235	230	225	200	305	280
M	S1 coil input (mm)	880	1,135	1,350	1,345	1,435	1,679
C	S2 coil input (mm)	565	685	820	820	955	1,055
K	Recirculation (mm)	780	1,010	1,245	1,155	1,285	1,507
E	Sensor (mm)	628	775	930	900	1,025	1 142.5
G	Electric heating element socket (mm)	630	770	930	910	1,025	1 142.5
B	Sensor (mm)	365	335	445	430	505	515
L	Thermostat (mm)	775	1,063	1,200	1,130	1,285	1,507
O	Thermometer (mm)	865	1,155	1,320	1,290	1,395	1,675
F	Cleaning flange	420	420	450	425	515	485
	Operating pressure (bar)	10	10	10	10	10	10

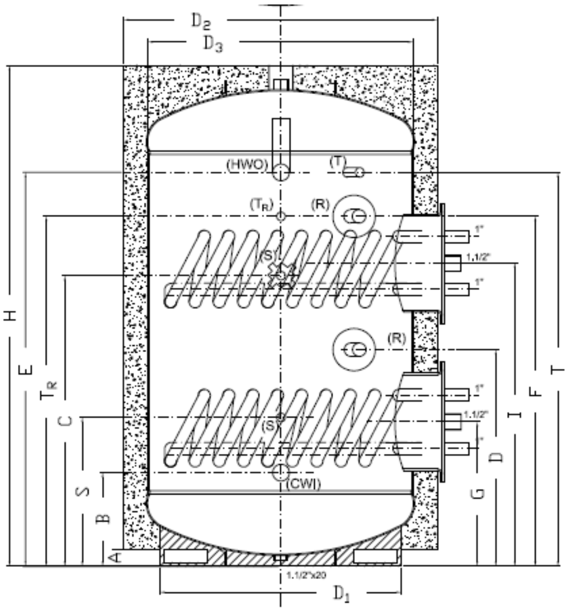
- CLD1 – Domestic hot water tank with detachable coil (1500lt - 7.000lt)



Inner tank material: **Steel**
Protection: **Epoxy resin coating**
Installation of magnesium anode
Coil material: **Steel**
Max. tank operating pressure: **10 bar**
Maximum Tank Operating Temperature: **95°C**
Coil withstand pressure: **25 bar**
Insulation : **Soft polyurethane, 100 mm thick**
Outer coating : **Soft colored PVC**
(Sheet steel upon request)
Electric heating element : **Upon request**

CLD1 : Floor standing hot water tank with one detachable coil

		CLD1-1500	CLD1-2000	CLD1-3000	CLD1 -4000	CLD1 -5000	CLD1 -7000
	Nominal Tank capacity (lt)	1500	2000	3000	4000	5000	7 000
	Actual tank capacity (lt)	1480	1940	2940	3960	4700	6950
D1	Tank base diameter (mm)	Ø1040	Ø1140	Ø1240	Ø1440	Ø1540	Ø1840
D2	Tank insulation diameter (mm)	Ø1300	Ø1400	Ø1500	Ø1700	Ø1800	Ø2100
D3	Tank diameter (mm)	Ø1100	Ø1200	Ø1300	Ø1500	Ø1600	Ø1900
H	Overall height (mm)	2000	2000	2500	2650	2750	3050
	Weight (kg)	445	515	670	875	950	1425
Coil s/ flange / ER	Flange / ER 1 (G)	520 (Ø508)	520 (Ø508)	530 (Ø620)	565 (Ø620)	565 (Ø620)	940 (Ø620)
	Flange / ER 2 (I)	1180 (Ø508)	1180 (Ø508)	1490 (Ø620)	1725 (Ø620)	1725 (Ø620)	1770 (Ø620)
	Flange / ER 3 (J)	--	--	--	--	--	--
CI1/CO1	S1 Coil, input / output	3.2m^2 / 5.4 m^2	3.2m^2 / 5.4 m^2	3.2m^2 / 5.4 m^2	3.2m^2 / 5.4 m^2	3.2m^2 / 5.4 m^2	3.2m^2 / 5.4 m^2
CI2/CO2	S2 Coil, input / output	--	--	--	--	--	--
Weights (kg)	Coils 3.2m^2 / 5.4m^2	78 / 109	78 / 109	78 / 109	78 / 109	78 / 109	78 / 109
R (F)	Recirculation	1495	1495	1980	2050	2050	2140
R (D)	Recirculation	840	840	1015	1030	1030	1240
CWI (B)	Cold water inlet	290	290	310	380	380	560
HWO (E)	Hot water outlet	1675	1675	2180	2245	2245	2340
F	Free supply	1495	1495	1980	2050	2050	2140
D	Free supply	840	840	1015	1030	1030	1240
T	Thermostat (mm)	1675	1675	2180	2245	2245	2340
T_R	Thermometer (mm)	1495	1495	1980	2050	2050	2140
S	Sensor (mm)	525	525	505	585	585	760



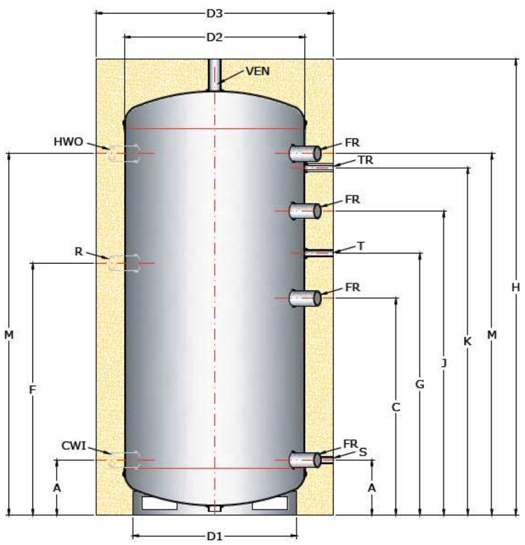
• CLD2 – Domestic hot water tank with two detachable coils (1500lt - 7,000lt)

Inner tank material: **Steel**
Protection: **Epoxy resin coating**
Installation of magnesium anode
Coil material: **Steel**
Max. tank operating pressure: **10 bar**
Maximum Tank Operating Temperature: **95°C**
Coil withstand pressure: **25 bar**
Insulation: **Soft polyurethane, 100 mm thick**
Outer coating: **Soft colored PVC**
(Sheet steel upon request)
Electric heating element: **Upon request**

CLD2: Floor standing hot water tank with two detachable coils

		CLD2-1500	**CLD2-2000**	**CLD2-3000**	**CLD2 -4000**	**CLD2 -5000**	**CLD2 -7000**
	Nominal Tank capacity (lt)	1500	2000	3000	4000	5000	7 000
	Actual Tank capacity (lt)	1480	1940	2940	3960	4700	6950
D1	**Tank base diameter (mm)**	Ø1040	Ø1140	Ø1240	Ø1440	Ø1540	Ø1840
D2	**Tank insulation diameter (mm)**	Ø1300	Ø1400	Ø1500	Ø1700	Ø1800	Ø2100
D3	**Tank diameter (mm)**	Ø1100	Ø1200	Ø1300	Ø1500	Ø1600	Ø1900
H	**Overall height (mm)**	2000	2000	2500	2650	2750	3050
	Weight (kg)	445	515	670	875	950	1425
Coils / flange / ER	**Flange / ER 1 (G)**	520 (Ø508)	520 (Ø508)	530 (Ø620)	565 (Ø620)	565 (Ø620)	940 (Ø620)
	Flange / ER 2 (I)	1180 (Ø508)	1180 (Ø508)	1490 (Ø620)	1725 (Ø620)	1725 (Ø620)	1770 (Ø620)
	Flange / ER 3 (J)	--	--	--	--	--	--
CI1/CO1	**S1 Coil, input / output**	3.2m^2 / 5.4 m^2	3.2m^2 / 5.4 m^2	3.2m^2 / 5.4 m^2	3.2m^2 / 5.4 m^2	3.2m^2 / 5.4 m^2	3.2m^2 / 5.4 m^2
CI2/CO2	**S2 Coil, input / output**	3.2m^2 / 5.4 m^2	3.2m^2 / 5.4 m^2	3.2m^2 / 5.4 m^2	3.2m^2 / 5.4 m^2	3.2m^2 / 5.4 m^2	3.2m^2 / 5.4 m^2
Weights (kg)	**Coils 3.2m^2 / 5.4m^2**	78 / 109	78 / 109	78 / 109	78 / 109	78 / 109	78 / 109
R (F)	**Recirculation**	1495	1495	1980	2050	2050	2140
R (D)	**Recirculation**	840	840	1015	1030	1030	1240
CWI (B)	**Cold water inlet**	290	290	310	380	380	560
HWO (E)	**Hot water outlet**	1675	1675	2180	2245	2245	2340
F	**Free supply**	1495	1495	1980	2050	2050	2140
D	**Free supply**	840	840	1015	1030	1030	1240
T	**Thermostat (mm)**	1675	1675	2180	2245	2245	2340
T_R	**Thermometer (mm)**	1495	1495	1980	2050	2050	2140
S	**Sensor (mm)**	525	525	505	585	585	760
C	**Sensor (mm)**	1150	1150	1485	1505	1505	1340

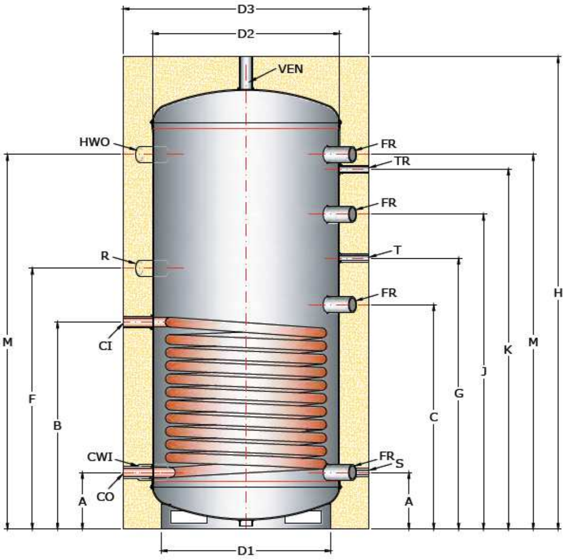
- CB0 Buffer tank – without coil (80lt - 2000lt)



Material: Sheet steel
Insulation:
For tanks up to 500lt: Polyurethane foam 55 mm thick
For 800lt - 1,000lt tanks : Polyurethane foam 100 mm thick
Welding : Automatic metal welding
Electric heating element : Upon request
Max. tank operating pressure: 4 bar
Max. water test pressure: 8 bar
Maximum Operating Temperature: 95 °C

		CB0-100	CB0-150	CB0-200	CB0-300	CB0-500	CB0-800	CB0-1000	CB0-1500	CB0-2000
	Tank capacity (lt)	96	136	196	298	492	746	882	1539	1831
D1	Tank base diameter (mm)	Ø318	Ø400	Ø430	Ø470	Ø580	Ø750	Ø750	Ø1040	Ø1140
D2	Tankl insulation diameter (mm)	Ø400	Ø450	Ø480	Ø520	Ø640	Ø800	Ø800	Ø1100	Ø1200
D3	Tank diameter (mm)	Ø500	Ø560	Ø600	Ø630	Ø840	Ø1000	Ø1000	Ø1300	Ø1400
H	Overall height (mm)	1000	1120	1400	1620	1700	1800	2000	2000	2000
	Weight (kg)	33	42	55	68	77	118	139	267	302
	Coil capacity (lt)	--	--	--	--	--	--	--	--	--
CI1/CO1	S1Coil, input / output	--	--	--	--	--	--	--	--	--
	Coil surface (m^2)	--	--	--	--	--	--	--	--	--
R (F)	Recirculation	590	620	750	920	935	980	1150	1200	1105
CWI (A)	Cold water inlet	230	260	250	220	235	280	320	340	395
HWO (M)	Hot water outlet	755	860	1140	1310	1325	1370	1660	1710	1615
J	Free supply	592	660	935	1105	1120	1165	1355	1425	1330
C	Free supply	392	460	625	795	810	855	1000	950	855
M	Free supply	755	860	1140	1310	1325	1370	1660	1710	1615
G (T)	Thermostat (mm)	455	560	785	955	970	1015	1235	1250	1010
K (TR)	Thermometer (mm)	655	760	1090	1260	1275	1320	1530	1710	1460
A (S)	Sensor (mm)	230	260	250	220	235	280	320	340	395
Max. operating pressure (bar)		4	4	4	4	4	4	4	4	4

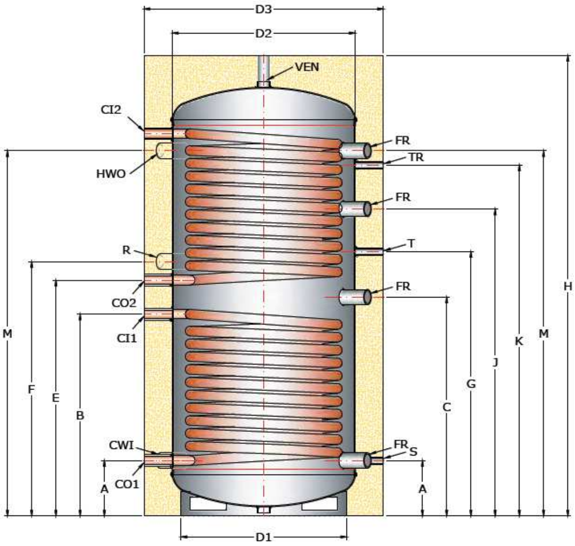
- CB1 Buffer tank - one coil (150lt - 2000lt)



Material: Sheet steel
Insulation:
For tanks up to 500lt: Polyurethane foam 55 mm thick
For 800lt - 1,000lt tanks : Polyurethane foam 100 mm thick
Welding : Automatic metal welding
Electric heating element : Upon request
Max. tank operating pressure: 4 bar
Max. water test pressure: 8 bar
COIL test pressure 25 bar
Maximum Operating Temperature: 95 °C

		CB1-200	CB1-300	CB1-500	CB1-800	CB1-1000	CB1-1500	CB1-2000
	Tank capacity (lt)	196	296	492	746	882	1539	1831
D1	Tank base diameter (mm)	Ø430	Ø470	Ø580	Ø750	Ø750	Ø1040	Ø1140
D2	Tank insulation diameter (mm)	Ø480	Ø520	Ø640	Ø800	Ø800	Ø1100	Ø1200
D3	Tank diameter (mm)	Ø600	Ø630	Ø840	Ø1000	Ø1000	Ø1300	Ø1400
H	Overall height (mm)	1400	1620	1700	1800	2000	2000	2000
	Weight (kg)	55	68	84.50	124.16	140.21	267.40	302.26
	Coil capacity (lt)	6.15	7.80	16.20	19.70	22.00	27.20	29.40
CI1 (B)/ CO1 (A)	S1 Coil, input / output	710/ 250	735/ 220	750/ 235	795/ 280	940/ 320	925/ 340	935/ 395
	Coil surface (m^2)	1.05	1.80	2.20	2.70	3.05	3.70	4.06
	Coil weight (kg)	18.70	27.60	33.35	45.04	56.03	57.16	60.32
R (F)	Recirculation	750	920	935	980	1150	1200	1105
CWI (A)	Cold water inlet	250	220	235	280	320	340	395
HWO (M)	Hot water outlet	1140	1310	1325	1370	1660	1710	1615
J	Free supply	935	1105	1120	1165	1355	1425	1330
C	Free supply	625	795	810	855	1000	950	855
M	Free supply	1140	1310	1325	1370	1660	1710	1615
G (T)	Thermostat (mm)	785	955	970	1015	1235	1250	1010
K (TR)	Thermometer (mm)	1090	1260	1275	1320	1530	1710	1460
A (S)	Sensor (mm)	250	220	235	280	320	340	395
Max. operating pressure (bar)		4	4	4	4	4	4	4
Max. operating pressure of coil (bar)		16	16	16	16	16	16	16
Max. operating temperature of coil (°C)		160	160	160	160	160	160	160

- CB2 Buffer tank – two coils (150lt - 2000lt)



Material: Sheet steel
Insulation:
For tanks up to 500lt: Polyurethane foam 55 mm thick
For 800lt - 1,000lt tanks : Polyurethane foam 100 mm thick
Welding : Automatic metal welding
Electric heating element : Upon request
Max. tank operating pressure: 4 bar
Max. water test pressure: 8 bar
Tank test pressure 25 bar
Maximum Operating Temperature: 95 °C

CB2: Buffer tank with one coil

		CB2-200	CB2-300	CB2-500	CB2-800	CB2-1000	CB2-1500	CB2-2000
	Tank capacity (lt)	196	296	492	746	882	1539	1831
D1	Tank base diameter (mm)	Ø430	Ø470	Ø580	Ø750	Ø750	Ø1040	Ø1140
D2	Tank insulation diameter (mm)	Ø480	Ø520	Ø640	Ø800	Ø800	Ø1100	Ø1200
D3	Tank diameter (mm)	Ø600	Ø630	Ø840	Ø1000	Ø1000	Ø1300	Ø1400
H	Overall height (mm)	1400	1620	1700	1800	2000	2000	2000
	Weight (kg)	55	68	84.50	124.16	140.21	267.40	302.26
	Coil capacity (lt)	6.15	7.80	16.20	19.70	22.00	27.20	29.40
CI1 (B)/ CO1 (A)	S1 Coil, input / output	710/ 250	735/ 220	750/ 235	795/ 280	940/ 320	925/ 340	935/ 395
CI2 (E)/ CO2 (L)	S2 Coil, input / output	830/ 1130	855/ 1370	870/ 1385	915/ 1430	1060/ 1680	1200/ 1605	1105/ 1560
	Coil surface (m^2) S1/S2	1.05/ 0.79	1.80/ 1.80	2.20/ 2.20	2.70/2.70	3.05/ 3.05	2.55/ 3.70	4.06/ 2.70
	Coil weight (kg) S1/S2	18.70/ 14.70	27.60/ 27.60	33.35/ 33.35	45.04/ 45.04	56.03/ 56.03	57.16/ 38.16	60.32/ 41.32
R (F)	Recirculation	750	920	935	980	1150	1200	1105
CWI (A)	Cold water inlet	250	220	235	280	320	340	395
HWO (M)	Hot water outlet	1140	1310	1325	1370	1660	1710	1615
J	Free supply	935	1105	1120	1165	1355	1425	1330
C	Free supply	625	795	810	855	1000	950	855
M	Free supply	1140	1310	1325	1370	1660	1710	1615
G (T)	Thermostat (mm)	785	955	970	1015	1235	1250	1010
K (TR)	Thermometer (mm)	1090	1260	1275	1320	1530	1710	1460
A (S)	Sensor (mm)	250	220	235	280	320	340	395
Max. operating pressure (bar)		4	4	4	4	4	4	4
Max. operating pressure of coil (bar)		16	16	16	16	16	16	16
Max. operating temperature of coil (°C)		160	160	160	160	160	160	160

5. Calpak gse – Fresh Water Tank

Calpak gse is Calpak's novel multipurpose tank through which hot water passes, with the possibility of connection to multiple charging sources. Its innovative construction technology allows the supply of domestic hot water at a large and stable flow, after being charged at a temperature exceeding the desired hot water temperature by only one degree, thus resulting in a more economical operation of energy sources (heat pump, boiler, solar collectors, etc.) and exerting less strain on the system. Furthermore, it may be used as buffer tank to assist space heating or even swimming pool heating.

The following are achieved thanks to the Calpak gse:

- ✓ **Top performance rate (n=99%) for an additional 25% in energy savings (see figure 1)**
- ✓ **Almost zero deviation between charging and supply temperature (ΔT=1) (see figure 2)**
- ✓ **Ultra fast ultratank charging, compared to traditional tanks (see figure 3)**
- ✓ **Legionella bacterium problem tackled, thanks to the stainless steel continuous flow alternator**
- ✓ **Long life span, minimum maintenance cost**
- ✓ Steady hot water supply at precise desirable temperature
- ✓ Easy installation or replacement of existing tank
- ✓ Easy system scalability with new energy sources
- ✓ Ideal use with heat pump and/or solar collectors
- ✓ Applicable in homes, hotels and commercial buildings

Calpak

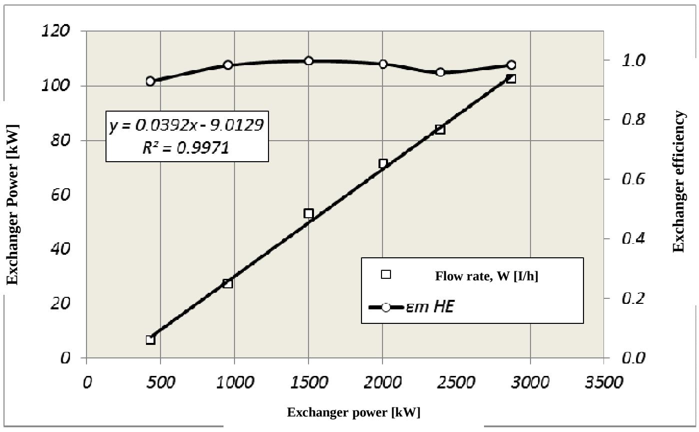


Figure 1- Source: NCSR "Demokritos"

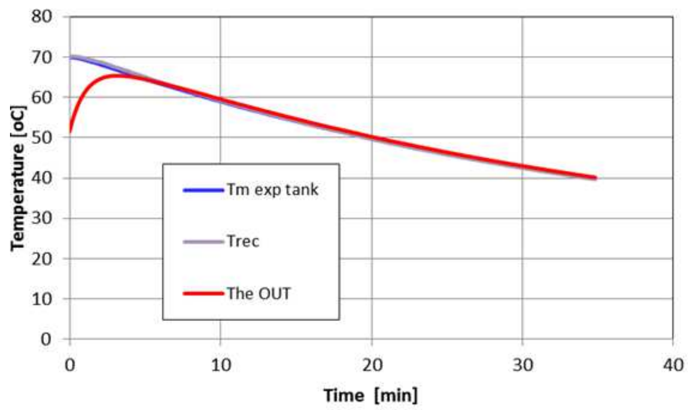


Figure 2- Source: NCSR "Demokritos"
Tm exp tank: tank average temperature
Trec: Hydraulic circuit temperature
The OUT: Hot water supply temperature

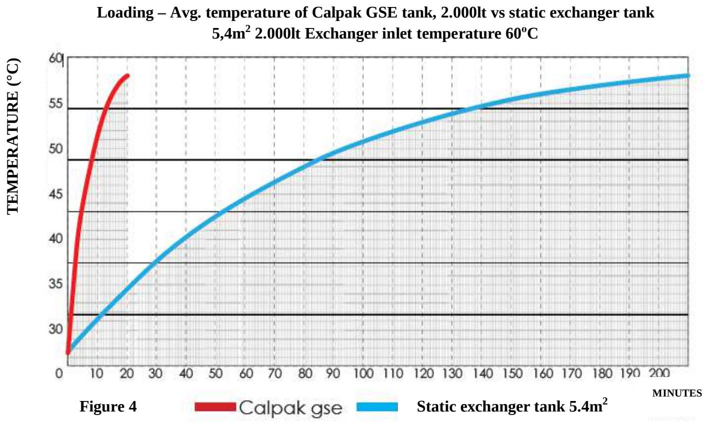


Figure 3

- Calpak gse description

The product comprises a thermally insulated steel tank filled with a heat transfer fluid (usually water), a heat exchanger, a counterflow circulator and a control unit with the respective temperature sensors.

In the conventional configuration of the product (Figure 1), we see the following:

- Side inlet (position E), for the supply of cold water to the stainless heat exchanger.
- Outlet of the stainless alternator on the upper part of the container for the supply of domestic hot water.
- Peripheral holes for the installation of temperature sensors and connection with hydraulic circuits of thermal sources (conventional boiler circuit, heat pump circuit, solar collectors circuit) and of electric heating element.
- Internal coil (top part) for the transmission of thermal energy.
- Counterflow circulator to forward the water of the coil and transfer thermal energy to the water.
- Control unit responsible for adjusting the temperature of the hot water to the desirable levels. This is achieved thanks to the automatic control of the operation of the counterflow circulator.
- Optional inner exchanger (bottom part) to allow connection with the solar field.

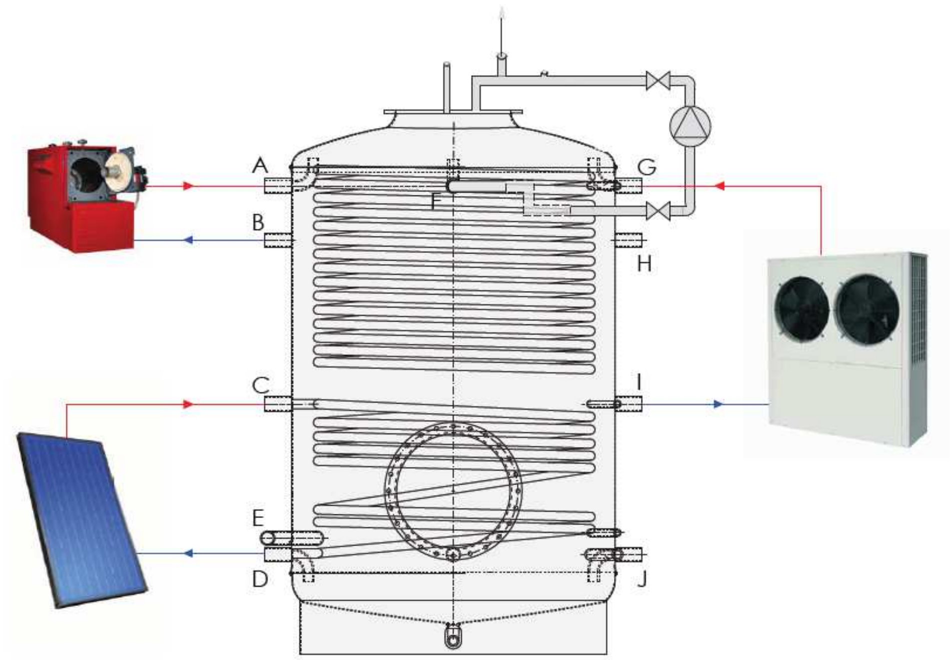
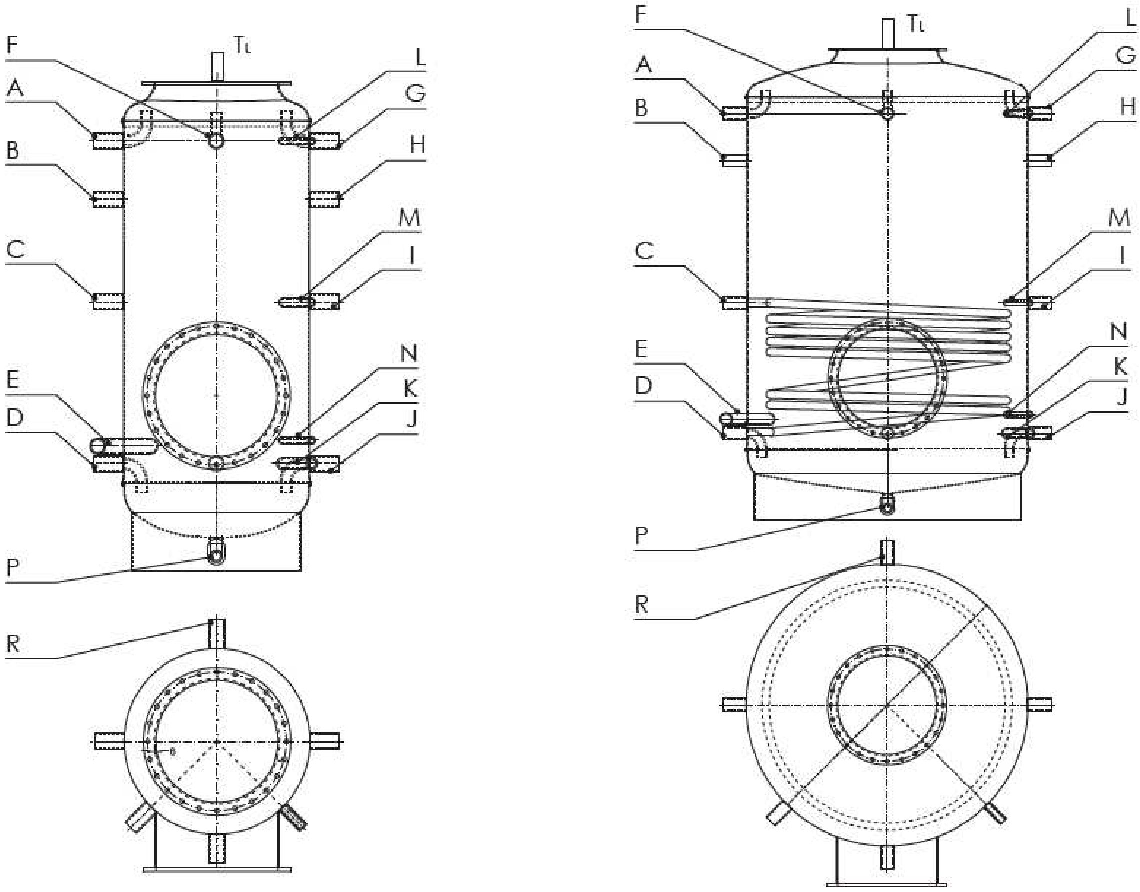


Figure 1

- Dimensions –Technical Characteristics Calpak gse

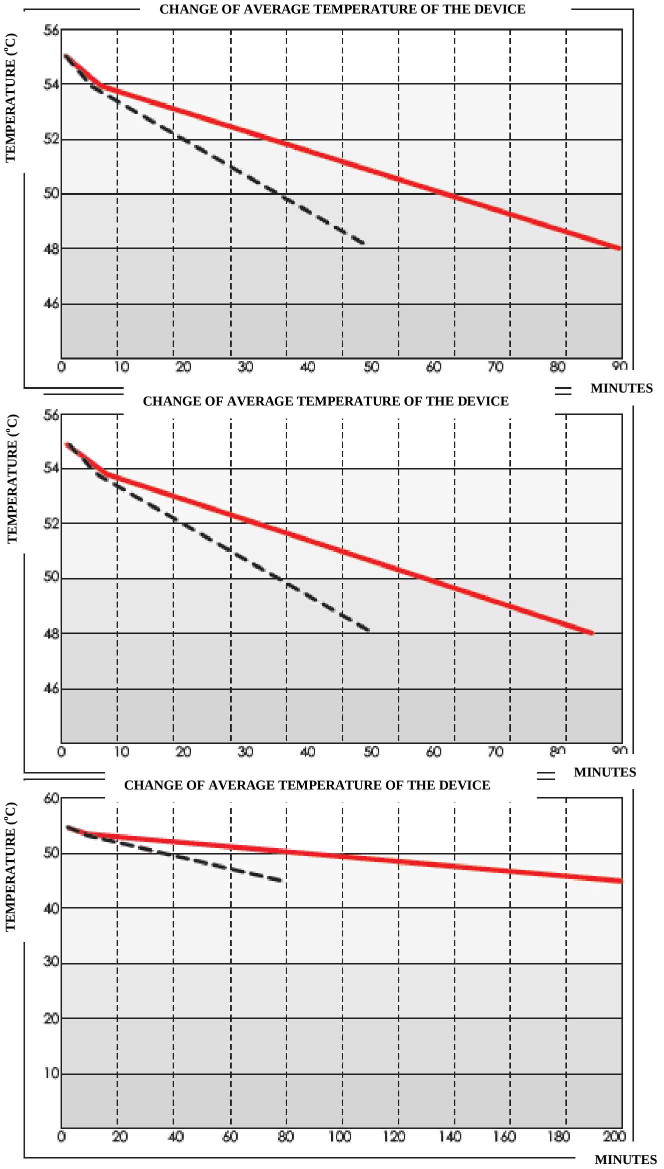


Conventional product configuration - Ultra tank gse/Ultra tank gse plus

DISTANCES	DESCRIPTION	Calpak gse 1,5 Dt1/500 (plus)	Calpak gse 1,5/3,0/4,5 Dt1/1000 (plus)	Calpak gse 1,5/3,0/4,5 Dt1/2000 (plus)
	NOMINAL CAPACITY (lt)	500	1000	2000
	NET CAPACITY (without the heat exchanger for the PLUS devices) (lt)	469.2 / (450.2)	883.6 / (855.6)	2027.6 / (1997.6)
	Diameter of the stainless speed-exchanger	DN40	DN40	DN40
	Max. operating pressure of the stainless speed-exchanger (bar)	10	10	10
	WEIGHT OF EMPTY TANK (kg) Calpak gse 1,5	159 / (193)	239/ (289)	402 / (459)
	WEIGHT OF EMPTY TANK (kg) Calpak gse 3,0	-	244/ (294)	407/ (464)
	WEIGHT OF EMPTY TANK (kg) Calpak gse 4,5	-	254/ (304)	417/ (474)
	CONTAINER HEIGHT (without the insulation)	1700	2100	2100
	CONTAINER HEIGHT	1800	2200	2200
	TOTAL CONTAINER HEIGHT (with the Speed Exchanger)	1950	2350	2350
	D exterior (Outside diameter of containers with insulation)	840	1000	1400
	Outer container diameter (without insulation)	640	800	1200
	Tank ventilation	✓	✓	✓
	Polyurethane insulation thickness (mm)	100	100	100
	Sheet thickness (mm)	2.5	3	4
	Capacity of charging heat exchanger (for PLUS devices) (lt)	-- / (9.5)	-- / (14)	-- / (15)
	Surface area of charging heat exchanger (for PLUS devices) (m^2)	-- / (1.90)	-- / (2.80)	-- / (3)
A	Free flow	1460	1550	1580
B	Free flow	1270	1550	1590
C	Free flow/(Inlet of heat exchanger of solar collectors in the “plus” model)	915	920	990
D	Free flow/(Outlet of heat exchanger of solar collectors in the “plus” model)	360	375	420
E	Cold water inlet	425	430	490
F	Counterflow pump suction	1460	1730	1780
G	Free flow	1460	1750	1780
H	Free flow	1270	1550	1580
I	Free flow	915	920	990
J	Free flow	360	375	420
K	Inlet of charging heat exchanger	360	375	430
L	Temperature sensor	1460	1730	1780
M	Temperature sensor	915	920	990
N	Temperature sensor	480	500	545
P	Outflow	✓	✓	✓
R	Heating element	320	380	430

- Usage and connections

Indicative charts on the coverage of peak demand in DHW at the desirable temperature compared to traditional tanks*



*Note: Calpak gse — Conventional tank with a 70% efficiency alternator

SCENARIO 1:

a. Hotel operating all year round, Category A & B. Climate zone A
b. 40 persons (60lt/person/day)
c. Water temperature = 48 °C, peak = 1.5 hour, concurrency = 50%, tank = 2000 lt
d. 16kW heat pump, source start-up and shutdown temperature: 54 °C and 55 °C respectively.
e. Month of reference: July

Duration of peak coverage by Calpak gse = 1:31:00
Duration of peak coverage by a conventional tank in the same conditions = 0:50:00

SCENARIO 2:

a. Hotel operating all year round, Category A & B. Climate zone A
b. 40 persons (60lt/person/day)
c. Water temperature = 48 °C, peak = 1.5 hour, concurrency = 35%, tank = 2000 lt
d. 16kW heat pump, source start-up and shutdown temperature: 54 °C and 55 °C respectively.
e. Month of reference: April

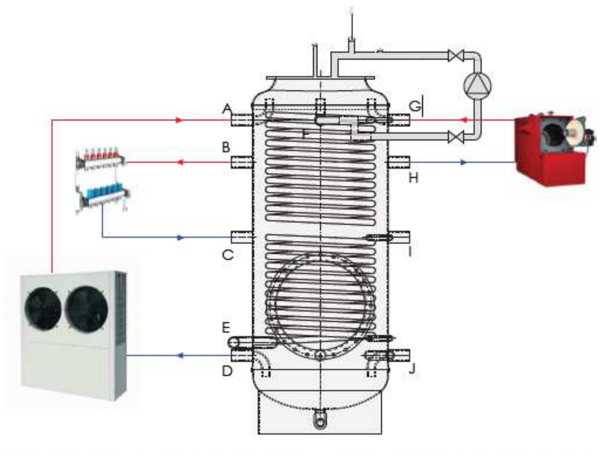
Duration of peak coverage by Calpak gse = 1:27:00
Duration of peak coverage by a conventional tank in the same conditions = 0:51:00

SCENARIO 3:

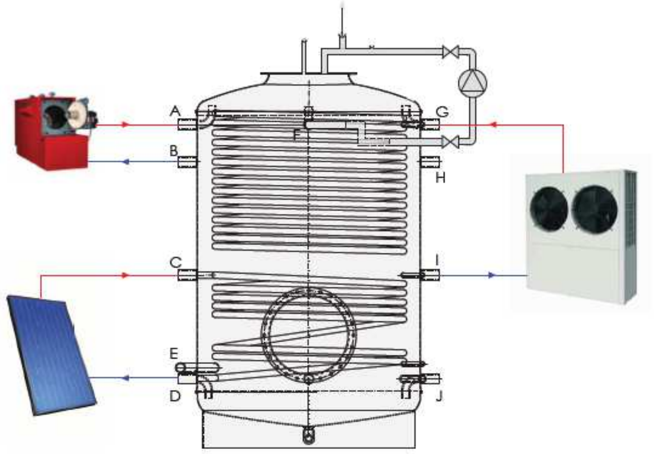
a. Hotel operating all year round, Category A & B. Climate zone A
b. 40 persons (60lt/person/day)
c. Water temperature = 45 °C, peak = 1.5 hours, concurrency = 50%. tank = 2000 lt
d. 16kW heat pump, source start-up and shutdown temperature: 54 °C and 55 °C respectively.
e. Month of reference: July

Duration of peak coverage by Calpak gse = 3:24:00
Duration of peak coverage by a conventional tank in the same conditions = 1:20:00

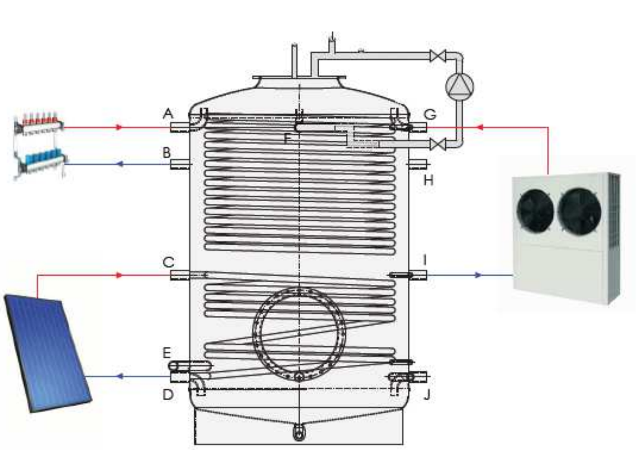
Illustrative usage examples



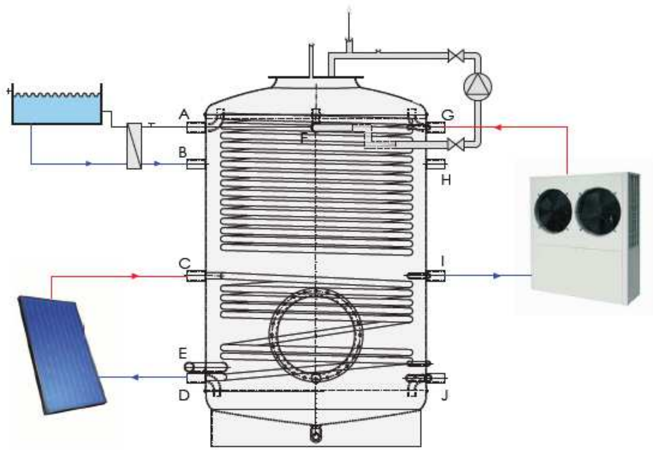
Use A: Underfloor heating and hot water heating using a heat pump and a boiler



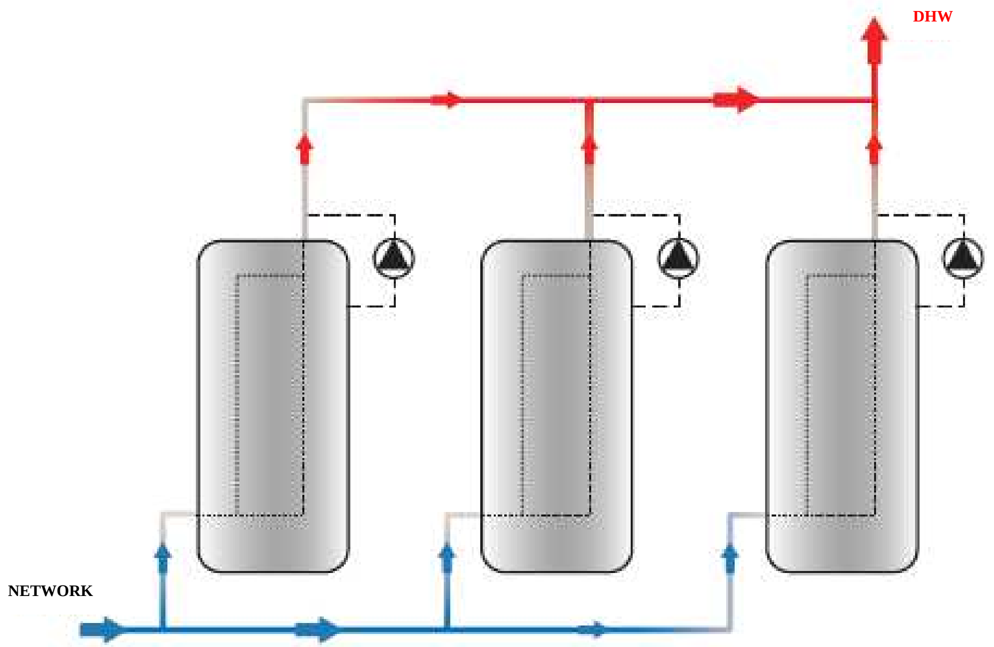
Use B: Heating water with Calpak M4 solar panels, a heat pump and a boiler



Use C: Underfloor heating and hot water heating using Calpak M4 solar panels and a heat pump



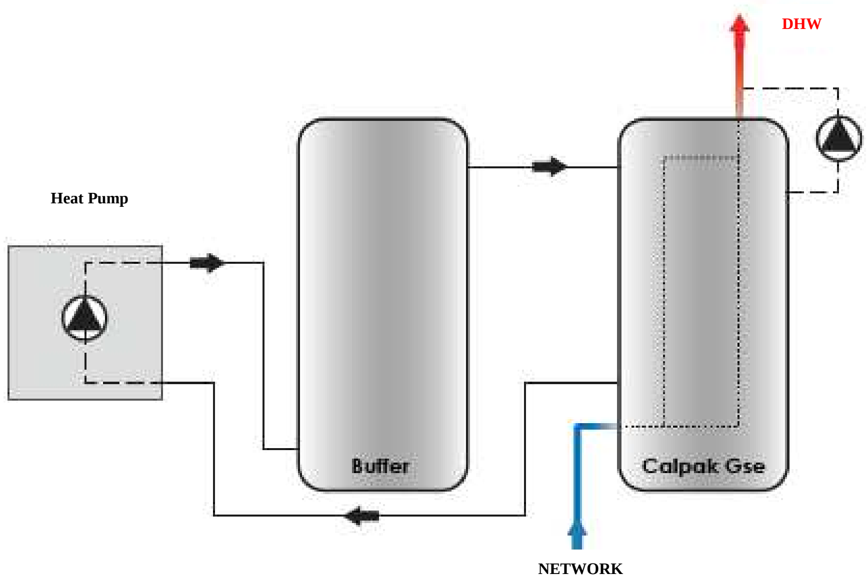
Use D: Heating a swimming pool using Calpak M4 solar panels and a heat pump



Comments:
1. The recommended reverse-return pipe connection layout requires the calculation of suitable pipe cross sections.
2. The counterflow check takes place separately for each Calpak gse ultratank, with a separate controller CFA and separate sensors.

Illustrative connection of multiple Calpak gse units

Recommended Calpak gse connection with external buffer (extension of discharge time)

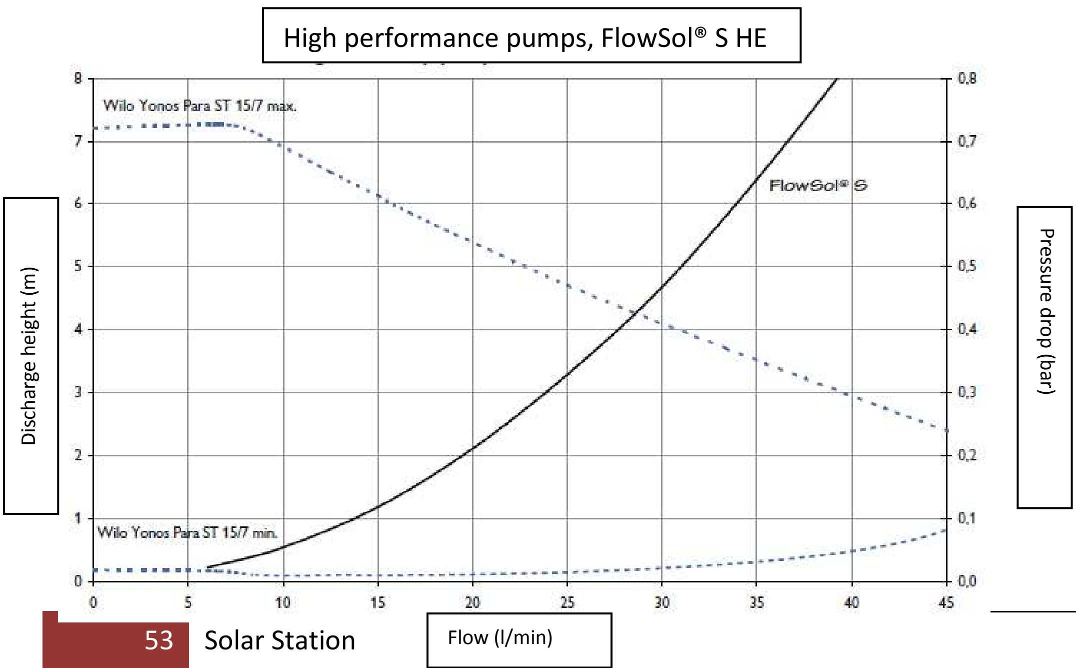


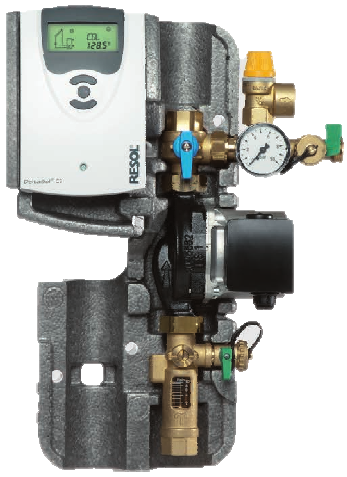
Indicative suggested configuration

6. Solar Station

6.1. FlowSol S HE & Controller DeltaSol CS plus

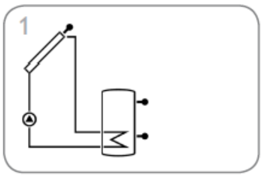
Circulation Pump:
Wilo ST 15/6 ECO or ST 15/7 ECO (surcharge) :Wilo Yonos PARA ST 15/7.0-PWM2
(Pump power consumption: 23W)
Safety valve: 6 bar
Manometer: 0 ... 10 bar
Flow meter: 1 ... 13 l/min
Non-return valve: Opening pressure 40 mbar, adjustable
Connection for Expansion Tank: ¾'' ET, flat sealing
Extraction of safety valve:¾'' IT
Solar pipe connections:¾'' IT
Maximum temperature: 95 °C
Maximum pressure: 6 bar
Medium: Water with 50 % glycol (maximum)
Dimensions: approximately 430 × 223 × 193 mm (with insulation)
Distance axis/wall: 67 mm
Material: Reinforcements: brass
Packings: AFM 34
Insulation: EPP foam



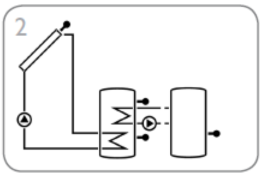


Controller Deltasol SL

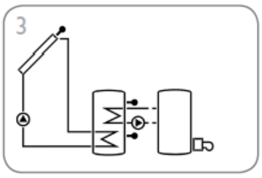
Supported layouts:



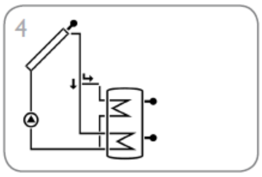
Standard solar system (page 8)



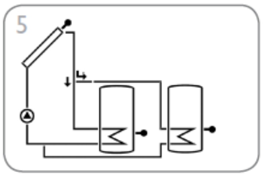
Solar system with heat exchange (page 11)



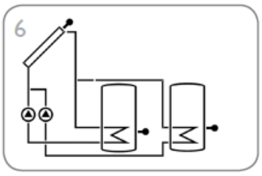
Solar system with backup heating (page 17)



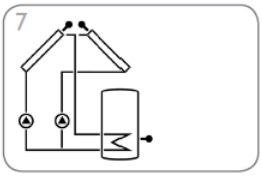
Solar system with store loading in layers (page 22)



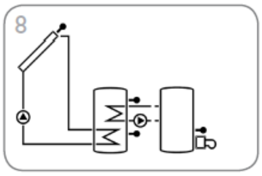
Solar system with 2 stores and valve logic (page 25)



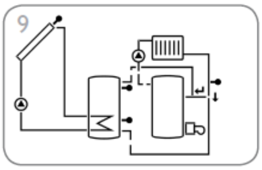
Solar system with 2 stores and pump logic (page 28)



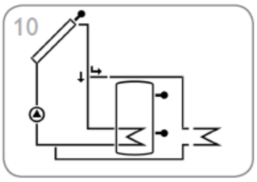
Solar system with east-/west collectors and 1 store (page 31)



Solar system with backup heating by solid fuel boiler (page 34)



Solar system with heating circuit return preheating (page 40)



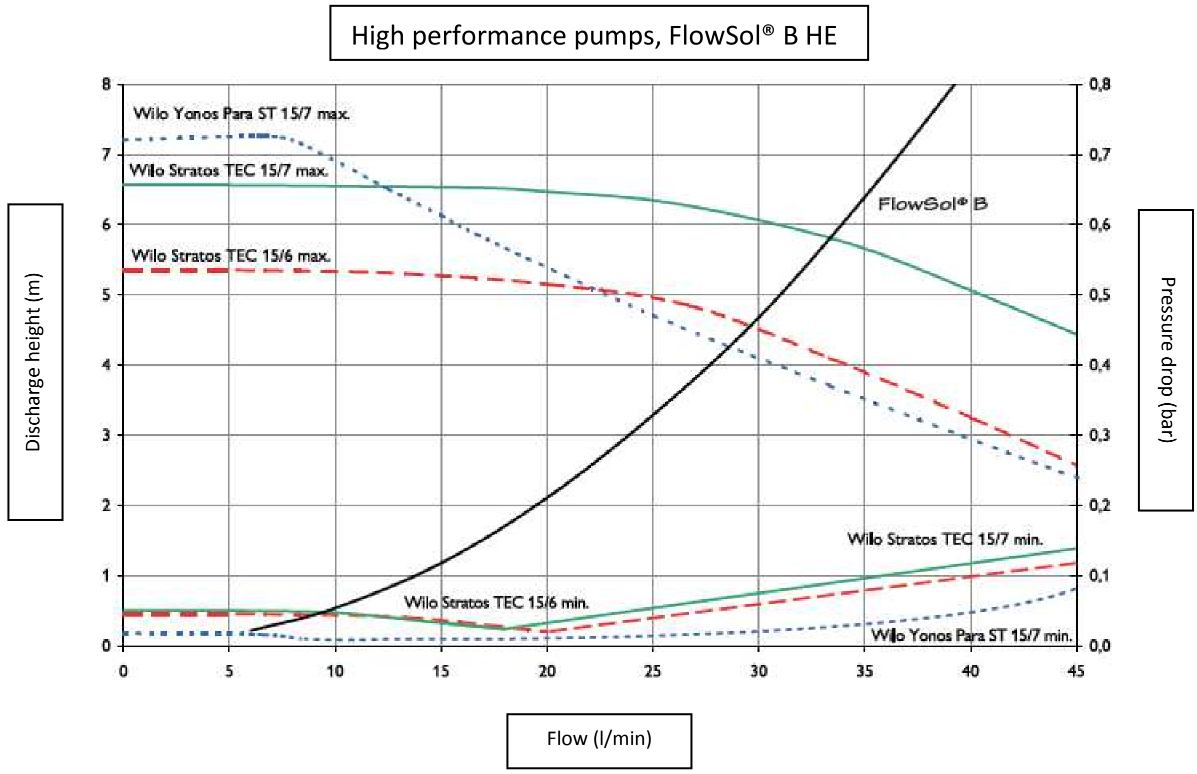
Standard solar system with heat dump (page 43)

Rule of Thumb

Connect Deltasol CS plus or SL controller to the internet
with the ***DL2 Datalogger***
to obtain full remote control of your solar system from the computer, the tablet or your cell phone!

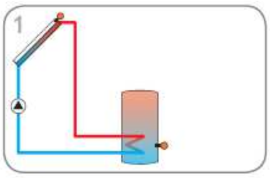
6.2. FlowSol B HE & Controller DeltaSol SL

Circulation Pump:
Wilo Yonos Para 15/1-7 PWM2
Safety valve: 6 bar
Manometer: 0 ... 10 bar
Flow meter: 1 ... 13 l/min
Non-return valve: Opening pressure 20 mbar, adjustable
Connection for Expansion Tank: ¾'' ET, flat sealing
Extraction of safety valve:¾'' IT
Solar pipe connections:¾'' IT
Peak intake / return temperature: 120° C/ 95 °C
Maximum pressure: 6 bar
Medium: Water with 50 % glycol (maximum)
Dimensions:
approximately 481 × 320 × 190 mm (with insulation)
Distance axis/wall: 67 mm
Material: Reinforcements: brass
Packings: AFM 34
Insulation: EPP foam

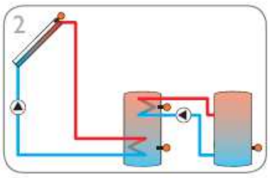


Controller DeltaSol SL

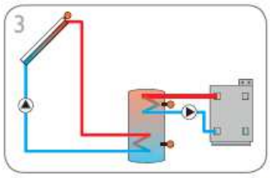
Supported layouts:



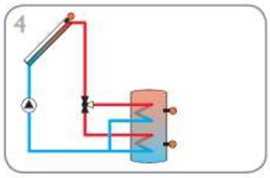
Solar system with 1 store (page 9)



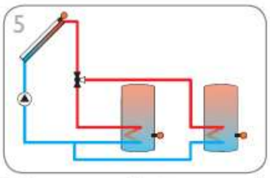
Solar system with 2 stores and heat exchange (page 10)



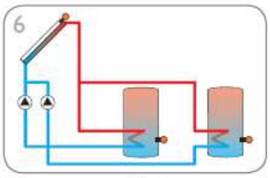
Solar system with 1 store and after-heating (page 11)



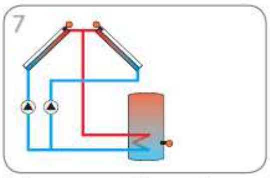
Solar system with 1 store and 3-port valve for store loading in layers (page 12)



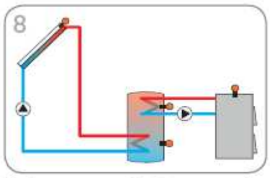
Solar system with 2 stores and valve control (page 13)



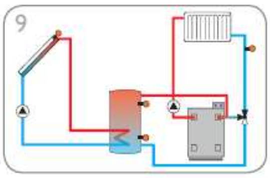
Solar system with 2 stores and pump control (page 14)



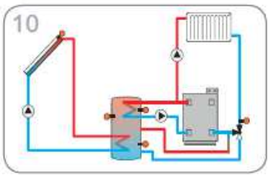
Solar system with east-/west collectors (page 15)



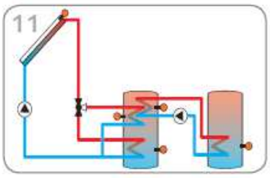
Solar system with 1 store and solid fuel boiler (page 16)



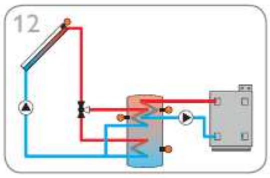
Solar system with 1 store and return preheating (page 17)



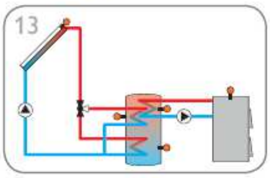
Solar system with 1 store, return pre-heating and afterheating (page 18)



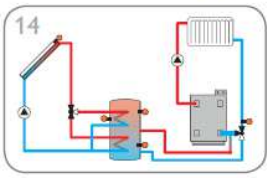
Solar system with store loading in layers and heat exchange (page 19)



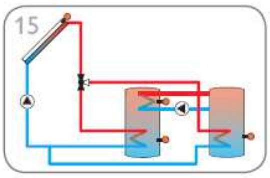
Solar system with store loading in layers and afterheating (page 20)



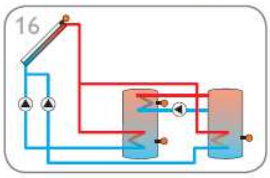
Solar system with store loading in layers and solid fuel boiler (page 21)



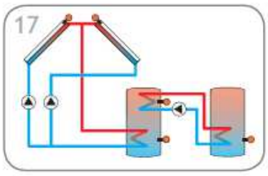
Solar system with store loading in layers and return preheating (page 22)



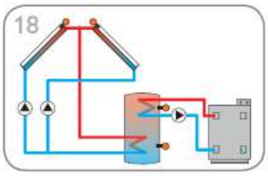
Solar system with store loading in layers and heat exchange (page 23)



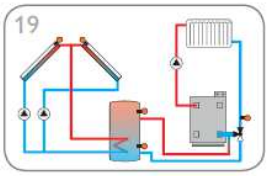
Solar system with 2 stores and heat exchange (page 24)



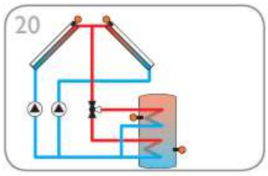
Solar system with 2 stores and heat exchange (page 25)



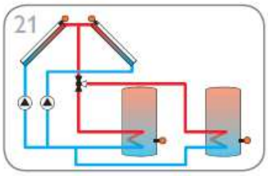
Solar system with east-/west collectors and thermostatic afterheating (page 26)



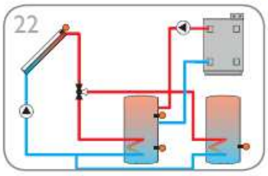
Solar system with east-/west collectors and return preheating (page 27)



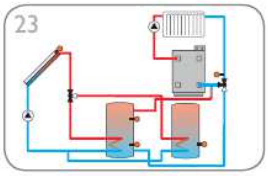
Solar system with east-/west collectors and store loading in layers (page 28)



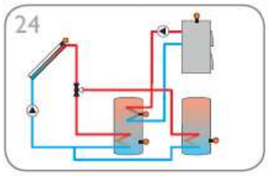
Solar system with with east-/west collectors, 2 stores and valve control (page 29)



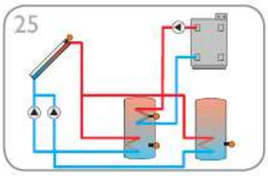
Solar system with 2 stores, valve control and afterheating (page 30)



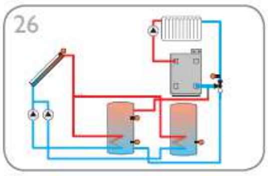
Solar system with 2 stores, valve control and return preheating (page 31)



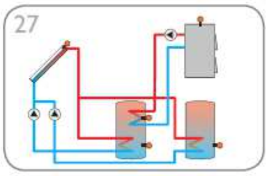
Solar system with 2 stores, valve control and solid fuel boiler (page 32)



Solar system with 2 stores, pump control and afterheating (page 33)



Solar system with 2 stores, pump control and return preheating (page 34)

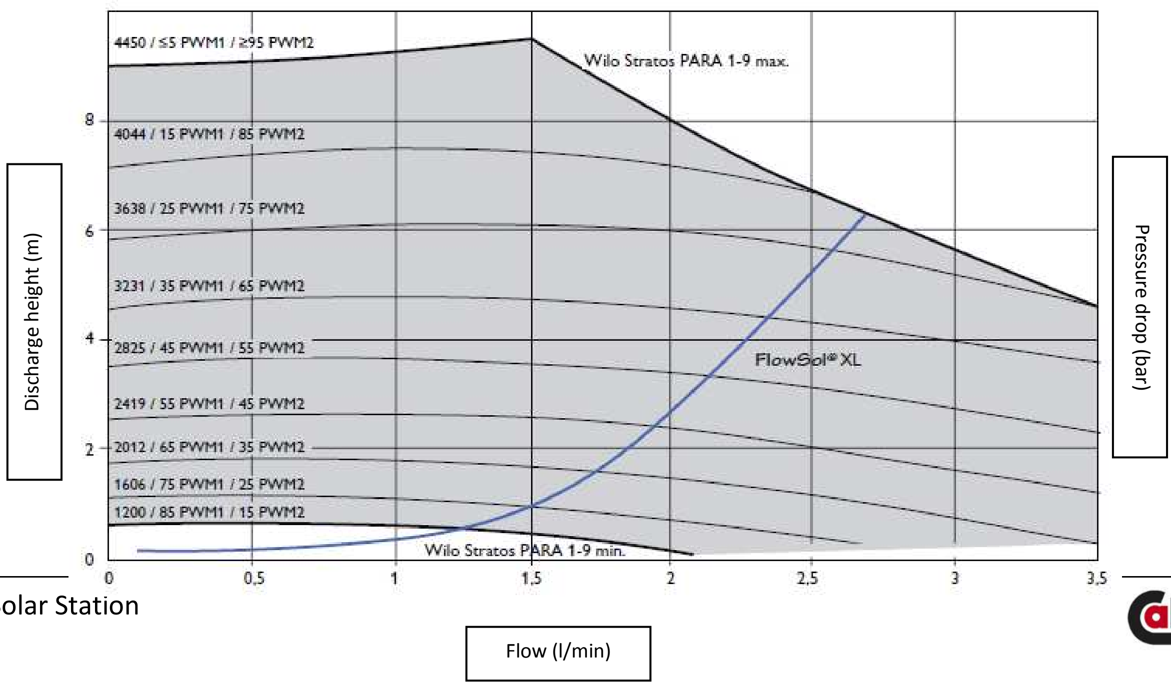


Solar system with 2 stores, pump control and solid fuel boiler (page 35)

6.3. FlowSol XL with Controller DeltaSol BX plus (programmable)

Circulation Pump: Wilo Stratos PARA 15/1-9
(Pump power consumption: 45W)
Safety valve: 6 bar
Manometer: 0 ... 10 bar
Flow meter:5 ... 35 l/min
For low flow systems (0.2 l/min/m^2)
with total collective surface to 100m^2
For high flow systems (0.5 l/min/m^2)
with total collective surface to 50m^2
Ball valves at intake and return
with non - return valves and thermometer:
Non-return valve: Opening pressure 20 mbar, adjustable
Thermometer: 0...160^o C
Connection for Expansion Tank: 1'' ET, flat sealing
Extraction of safety valve: 1'' IT
Solar pipe connections: 1'' IT
Peak intake / return temperature: 120^o C/ 95 °C
Maximum pressure: 6 bar
Medium: Water with 50 % glycol (maximum)
Dimensions:
approximately 470 × 380 × 220 mm (with insulation)
Distance axis/wall: 73 mm
Material: Reinforcements: brass
Packings: AFM 34
Insulation: EPP foam

High performance pumps, FlowSol® XL



7. Equipment Installation

General

- ### Safety measures

1. Always use certified tools and protective devices.
2. In case of installation close to power lines, current should be disconnected.
3. Always use protective glasses, boots, gloves and mask, according to the applicable safety regulations.

- ### Transportation and Handling

Tanks and collectors are packaged with expanded polystyrene and film; they should remain packaged throughout the storage and transportation processes. The collectors should be stored in vertical position to prevent damage. **During installation, collectors should remain covered until the system is filled and commissioned**.

- ### Lightning Protection

Connect the collector's metallic part to the lightning protection system - if existing - otherwise connect it to the earthing rod. For further information consult an expert.

Thermal influences from lightning currents are considered to be negligible (annex E, paragraph E 5.10 EN 12976-2 standard).

Mechanical loads applied to solar system parts due to lightning strikes are especially low and their effect on strength and stability is considered negligible (annex E, paragraph E 5.11 EN 12976-2 standard).

- ### Heat transfer fluid

The Calpak Fluid is a medical propylene/glycol-based heat transfer fluid. It is non-toxic and suitable for use in solar systems due to its antifreeze and anti-corrosion properties. It should be always used diluted in water, otherwise corrosion may occur. The portion of heat transfer fluid in the overall water volume is determined according to the minimum potential local ambient temperature. It can be calculated from the following table:

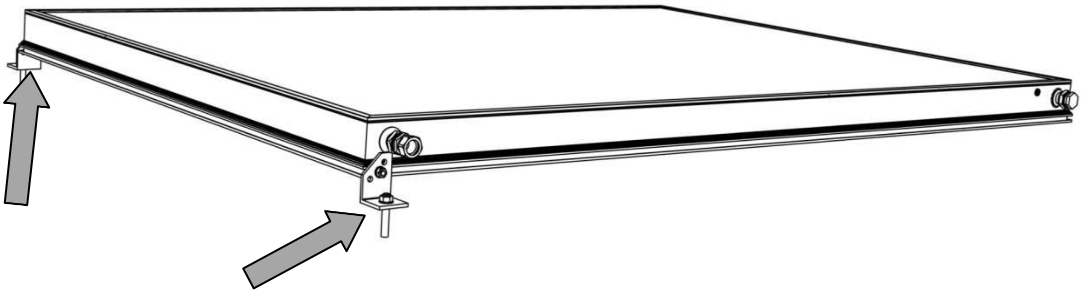
Ambient Temperature (°C)	-10	-15	-20	-25	-30	-35
Percentage in water solution (%)	25	33	40	45	50	53

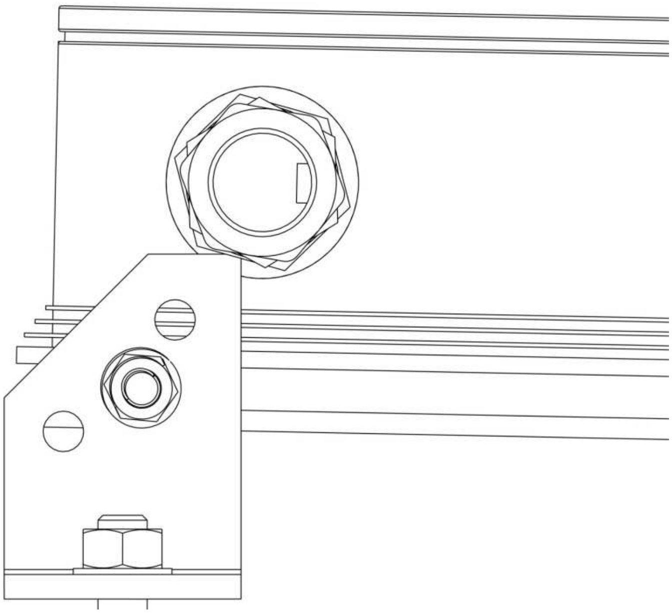
- Permissible snow load & wind pressure

Collectors are tested in accordance with EN 12975-2 standard. From these tests, it was accepted that collectors may sustain a snow load [pressure] equal to 2400 Pa without any damage.

7.1. M4 Collector installation

- M4 Collector installation on flat roof

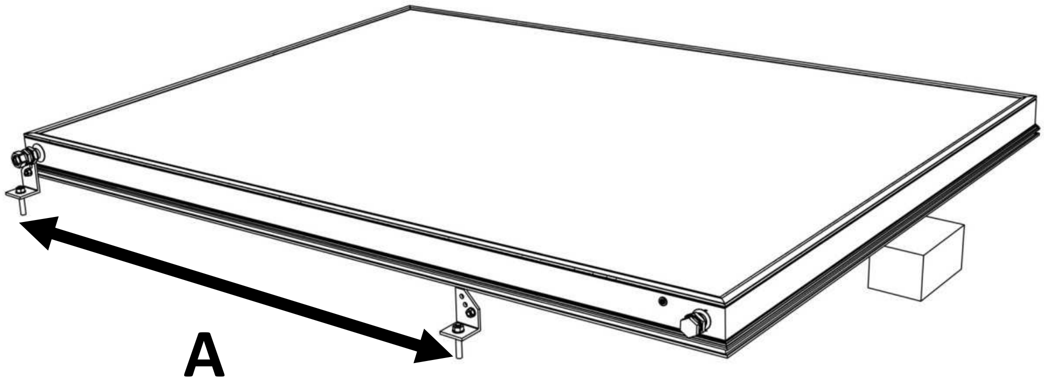


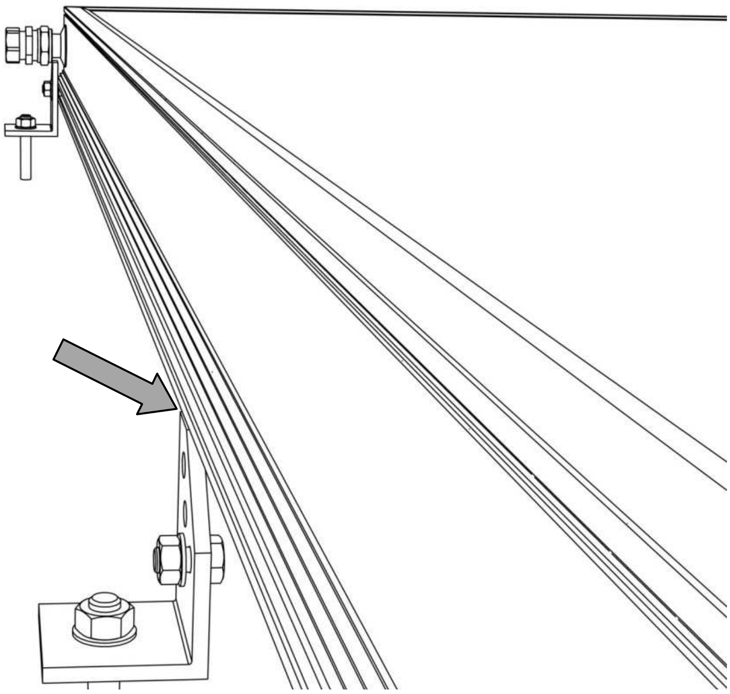


STEP 1

Place the collector on the flat roof and connect the collector footings as shown in the following figure. Tighten screws as necessary without excessive play, just to allow collector rotation in relation to the footings. Mount footings on flat roof. Follow the recommendations listed in Chapter III regarding system orientation and position. Use adequately long screws to allow sufficient encasing of uprights in the concrete mass of the flat roof (not on the surface of insulation or on light concrete). Use suitable sealant to prevent the intrusion of moisture from the holes on the flat roof.

CAUTION: DO NOT REMOVE THE PROTECTIVE COVER FROM THE COLLECTOR GLASS!



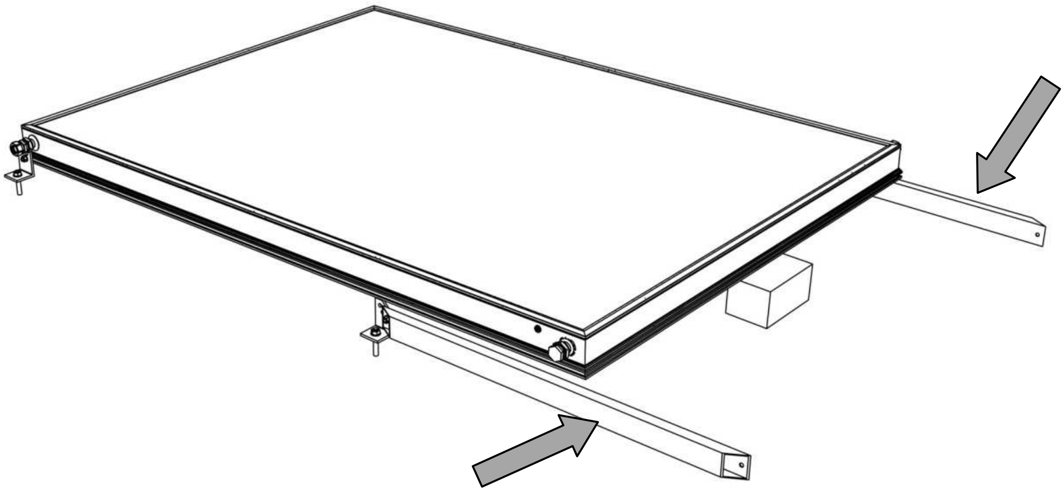


STEP 2

Use a small object on the top side of the collector to lift it just enough to place the footings of the braces, at a distance equal to A [between anchoring bolt holes] according to table 1. To ensure proper installation, the footing of the brace and the collector must be aligned, as shown in the following figure.

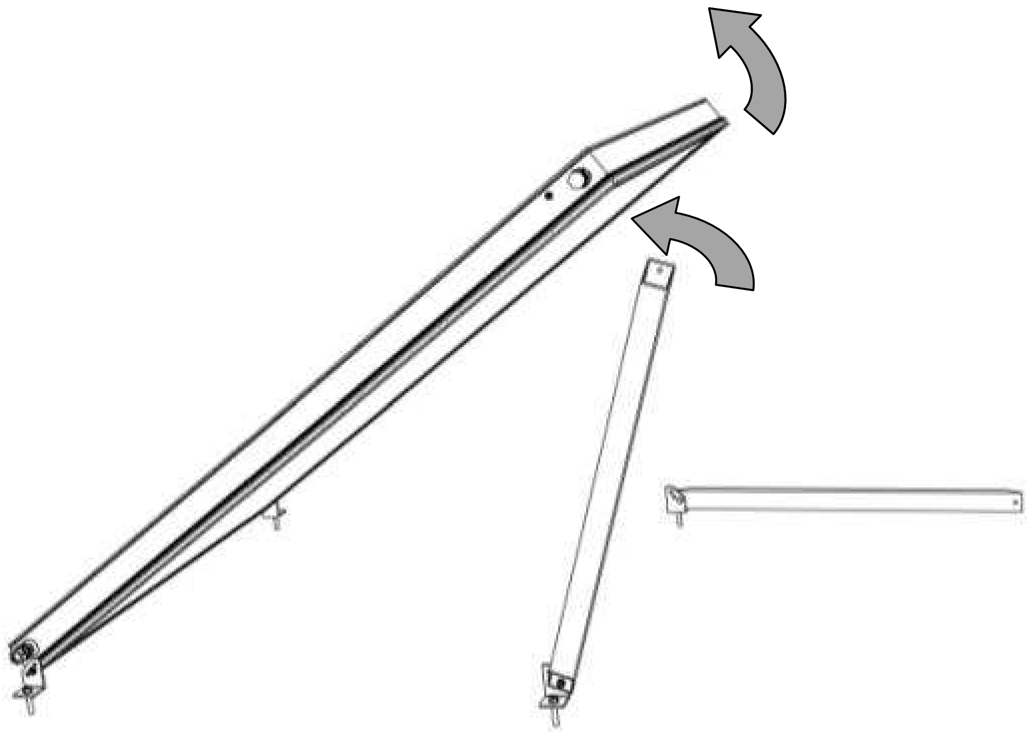
TABLE 1

COLLECTOR	2	2.1	2.5	2.6	2.6H	3	3H
DISTANCE A [MM] 45 DEGREES	1240	972	1350	1240	697	1240	972
DISTANCE A [MM] 30 DEGREES	1765	1390	1965	1765	1007	1765	1390



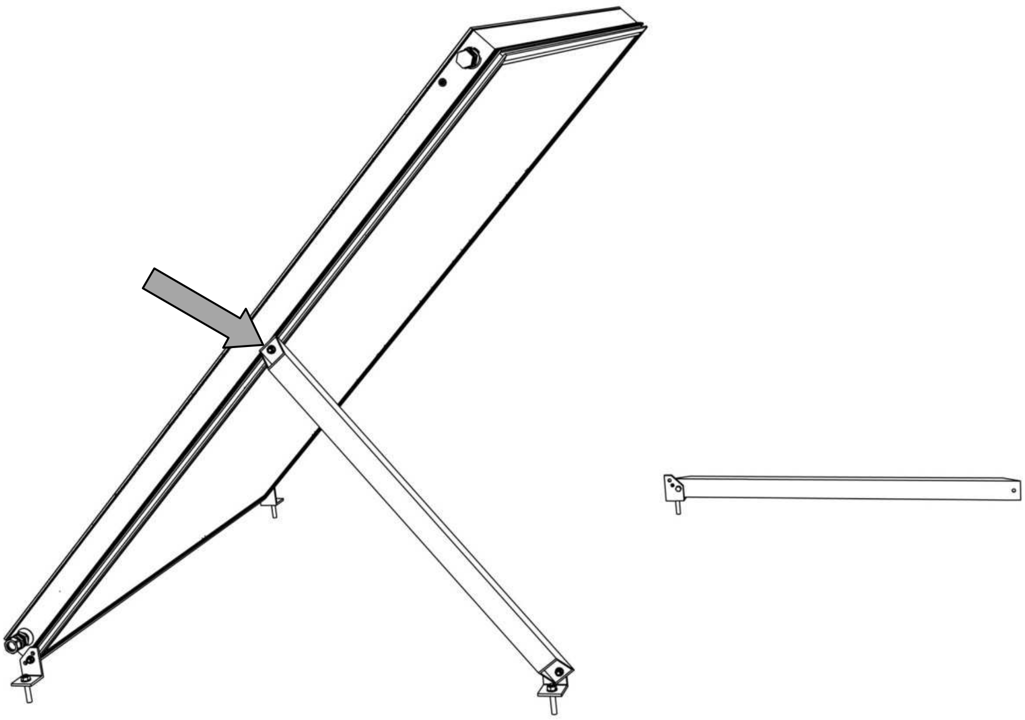
STEP 3

Connect both braces on the footings. Tighten screws sufficiently without excessive play, just to allow brace rotation.



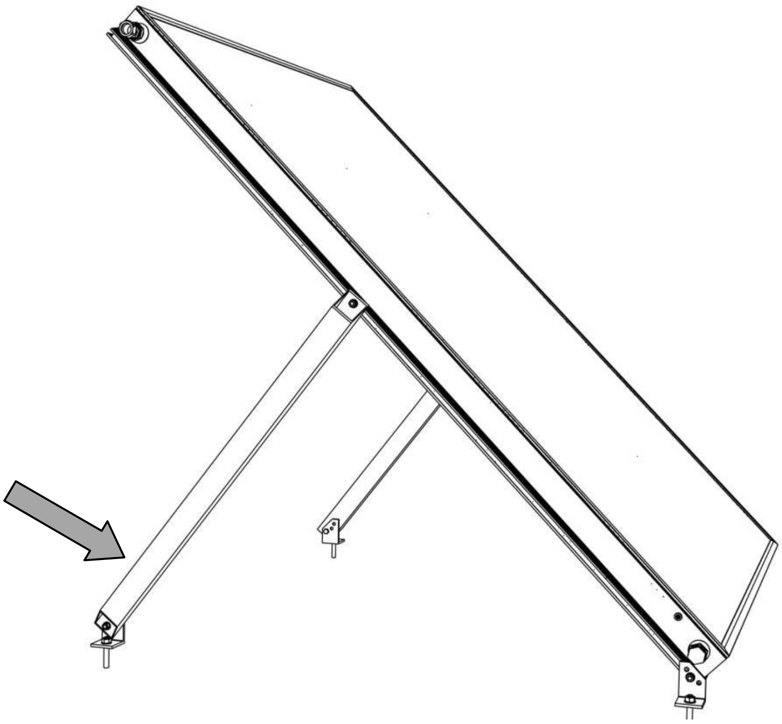
STEP 4

Lift the collector from the top, together with one brace.



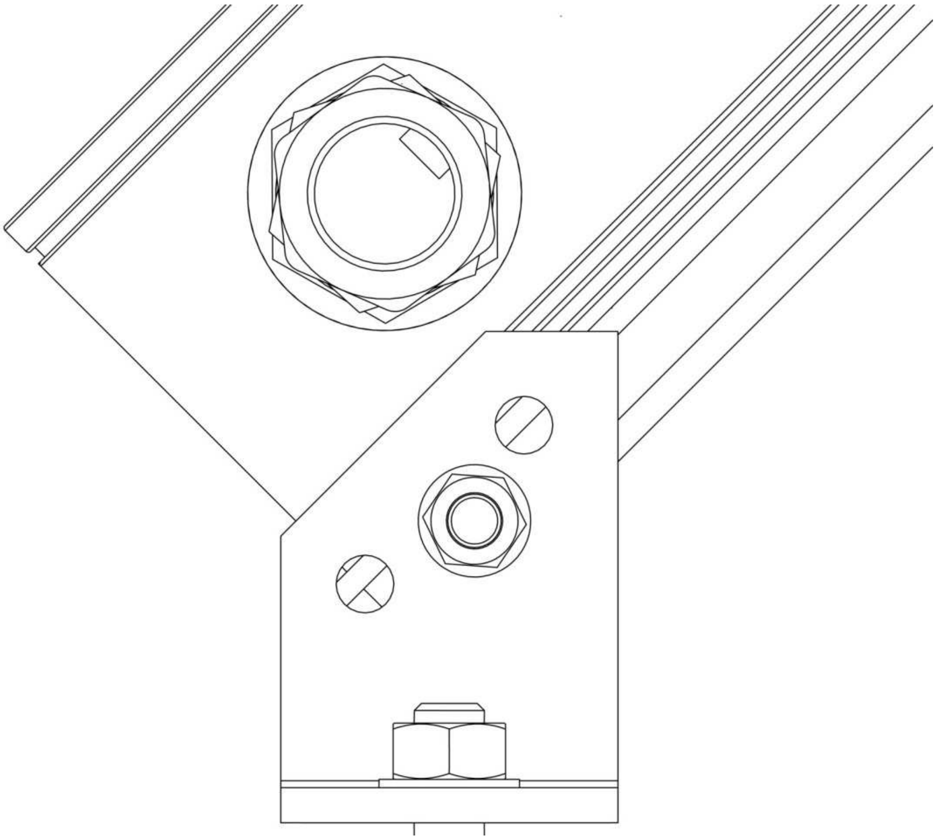
STEP 5

Connect the top of the brace with the collector’s retaining screw. Do not fully tighten the screw.



STEP 6

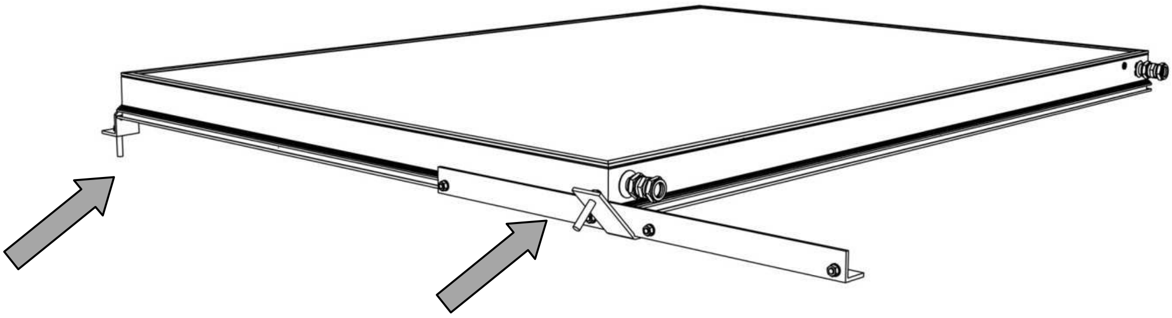
Connect the other brace. Do not fully tighten the screw holding the collector.

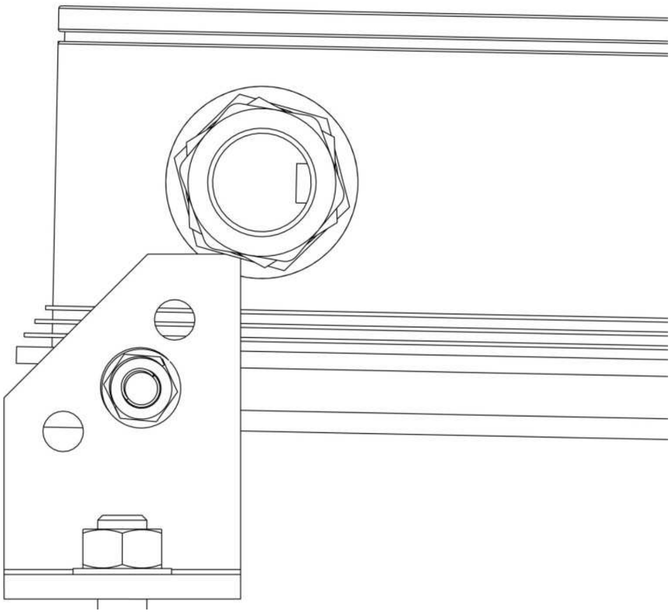


STEP 7

Make sure that the collector is installed at the preferred inclination. The collector support footings can be used as guides, as their cap is truncated at a 45 degree angle. Moreover, the angle between the retaining screw, the bottom hole and the horizontal plane is 30 degrees. Ensuring that the inclination of the collector is right, you may secure all 6 screws [4 screws retaining the collector and 2 screws at the bottom of braces.

- Installation of M4 collector array on flat roof



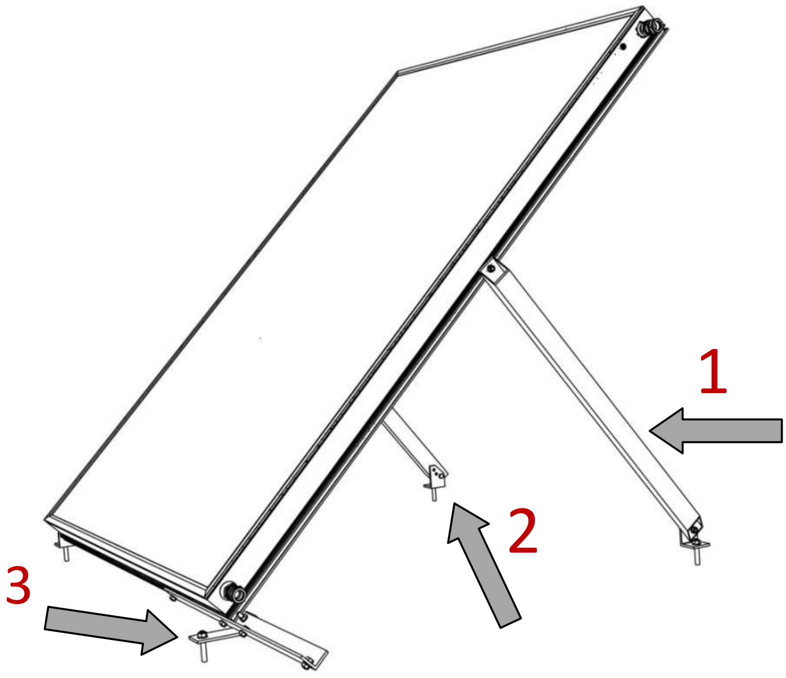


STEP 1

Install the first collector on the floor of the flat roof and connect the suport footing to the side that corresponds to the end of the array, as shown in the above figure. Tighten the screw as necessary without excessive play, just to allow collector rotation in relation to the footing. Mount the footing on flat roof. Follow the recommendations listed in Chapter III regarding system orientation and position. Use adequately long screws to allow sufficient encasing of uprights in the concrete mass of the flat roof (not on the surface of insulation or on light concrete). Use suitable sealant to prevent the intrusion of moisture from the holes on the flat roof.

CAUTION: DO NOT REMOVE THE PROTECTIVE COVER FROM THE COLLECTOR GLASS!

Connect a bottom joint at the side where the next collector will be installed. Tighten the collector's retaining screws but do not place it on the floor of the flat roof.



STEP 2

Follow Steps 2-7 of Chapter VII to mount the braces and to regulate collector inclination. Mount the bottom joint on the flat roof.

STEP 3

Connect a top joint at the top of the collector.

STEP 4

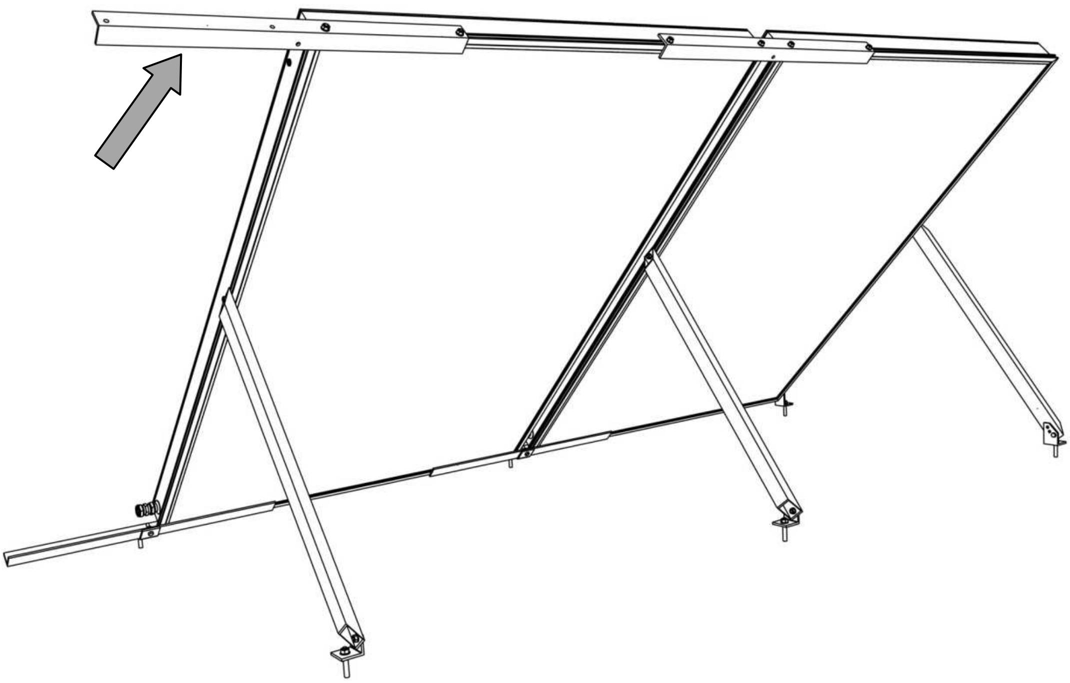
Install the next bottom joint at a distance equal to collector width. Make sure that both joints are aligned.

STEP 5

Place the next collector on the joints. Locate the screws and tighten them sufficiently so that the new collector can be dragged towards the one previously installed. Tighten the hydraulic fittings between absorbers and then tighten the collector retaining screws.

STEP 6

Install the brace. Before tightening the screws, make sure that the edge of the collector is at the correct inclination.

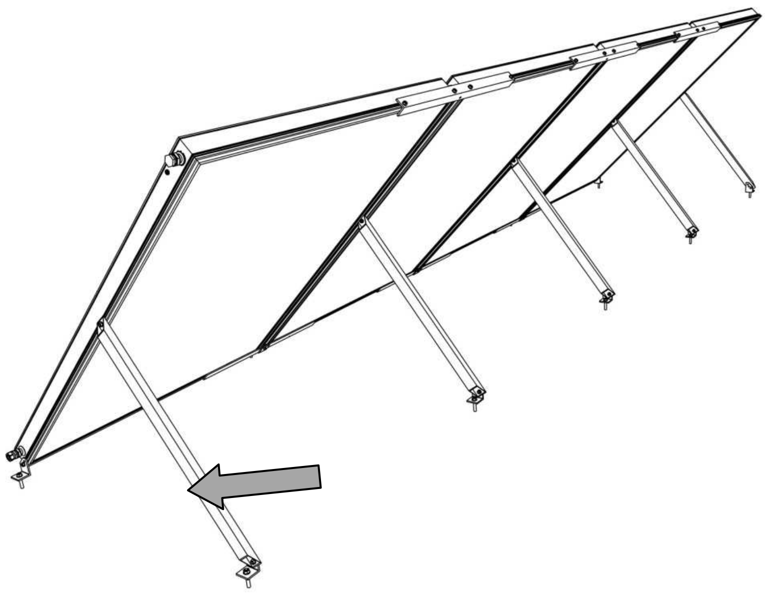


STEP 7

Install the bottom joint.

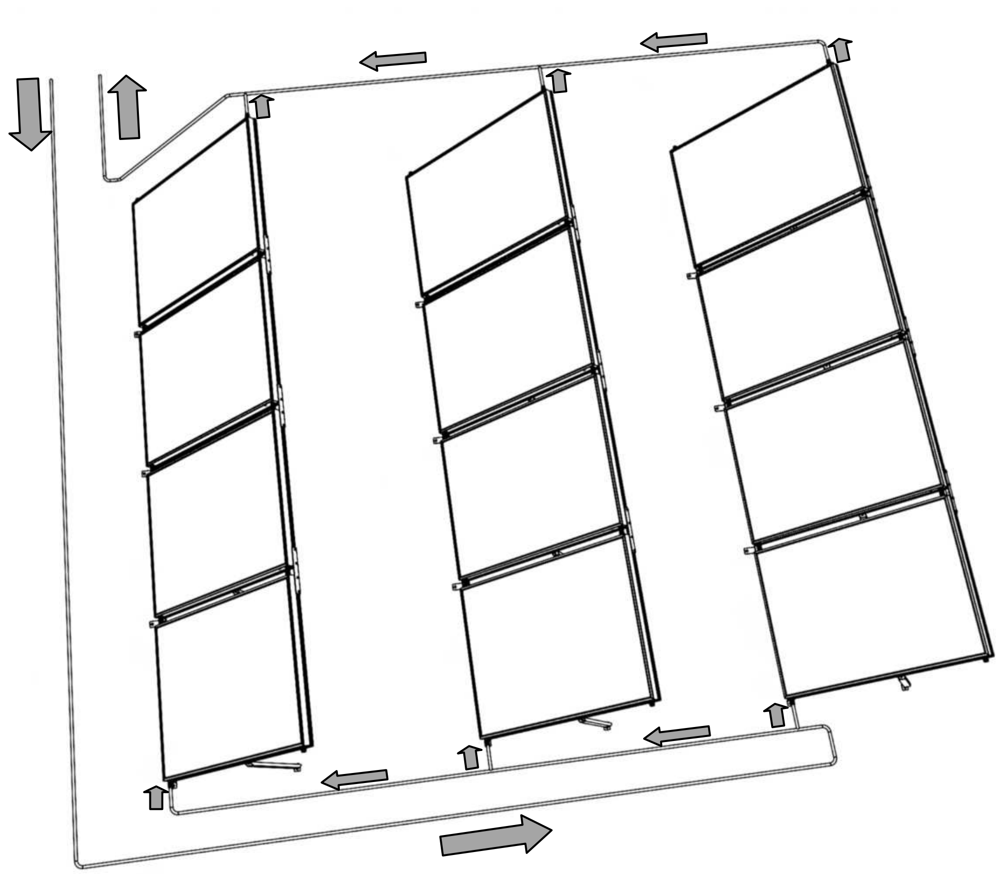
STEP 8

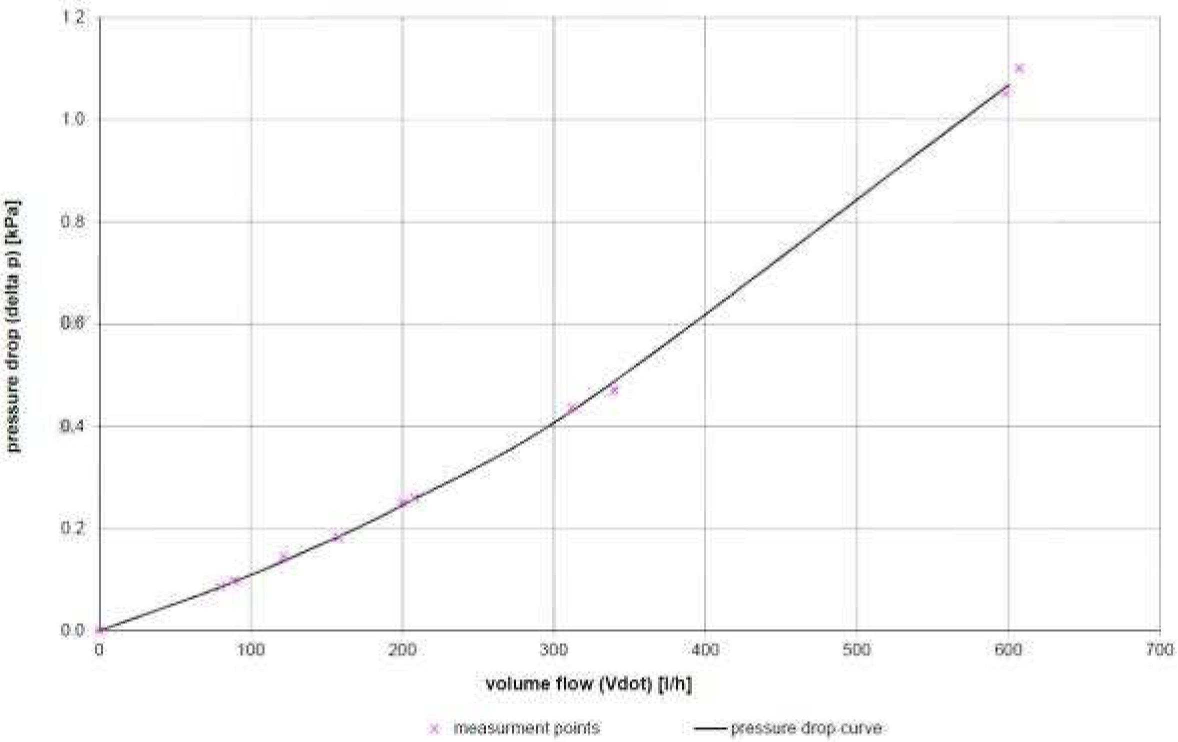
Continue with the installation of as many collectors as necessary, following steps 4-7. The last collector should have a mounting footing connected, before installation on joints. First tighten the collector retaining screws to the joints and then, install the footing on the flat roof floor.



STEP 9

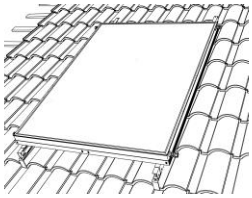
Install the last brace.





1.2
1.0
0.8
0.6
0.4
0.2
0.0
pressure drop (delta p) [kPa]
0
100
200
300
400
500
600
700
volume flow (Vdot) [l/h]
measurment points
pressure drop curve

- M4 Collector installation on sloping roof



CAUTION: Check with the building constructor whether the roof can withstand the load of an operational system or contact the competent authorities.

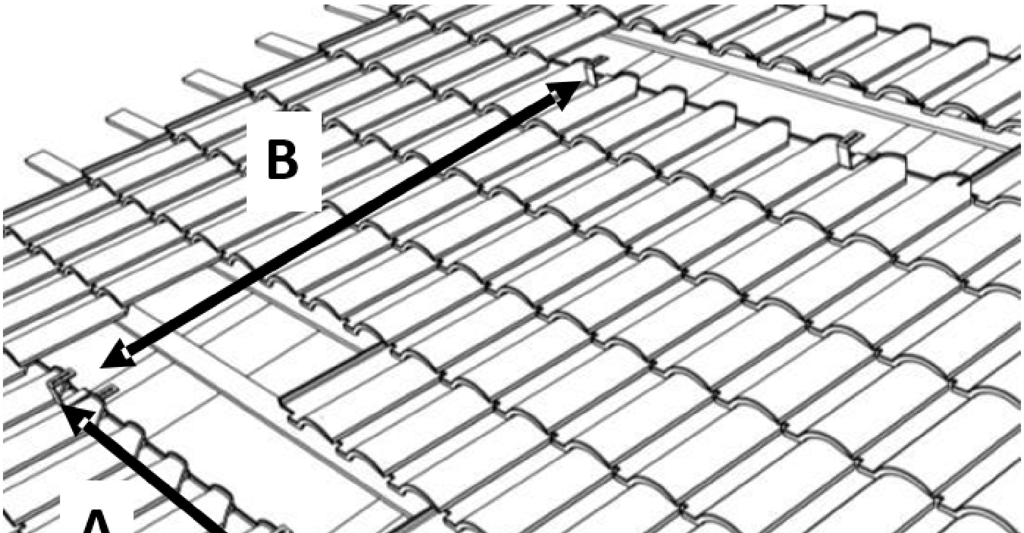


FIGURE 1

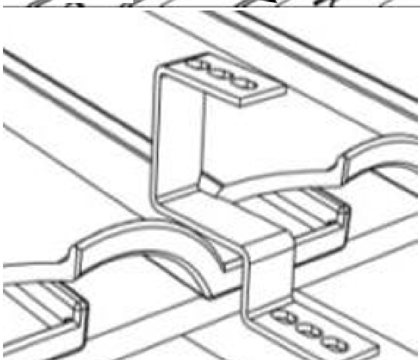


FIGURE 2

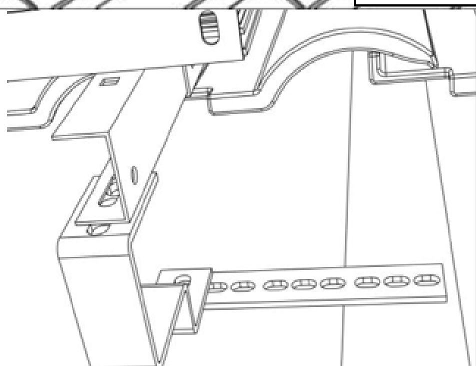


FIGURE 3

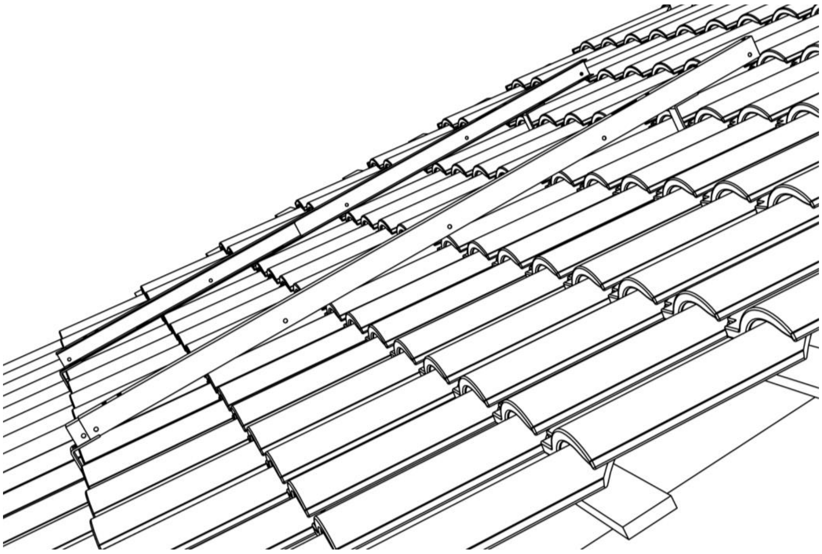
STEP 1

Remove the tiles found at the topmost and the lowermost end of the area where the system will be installed. Install - using suitable screws - 4 AGG brackets (or AT – triangular or AR – special anchor bolt, if necessary) on the vertical beams of the roof, ref. the above figure (fig. 2). Make sure that distances A and B (fig. 1) between any holes on the top of brackets, are in accordance with the following table. You may leverage the fact that each bracket includes 3 holes to adapt the system on different tile sizes. In case the AGG brackets are not matching the roof beams, use the additional 20cm extender for AGG brackets (fig. 3).

TABLE 1

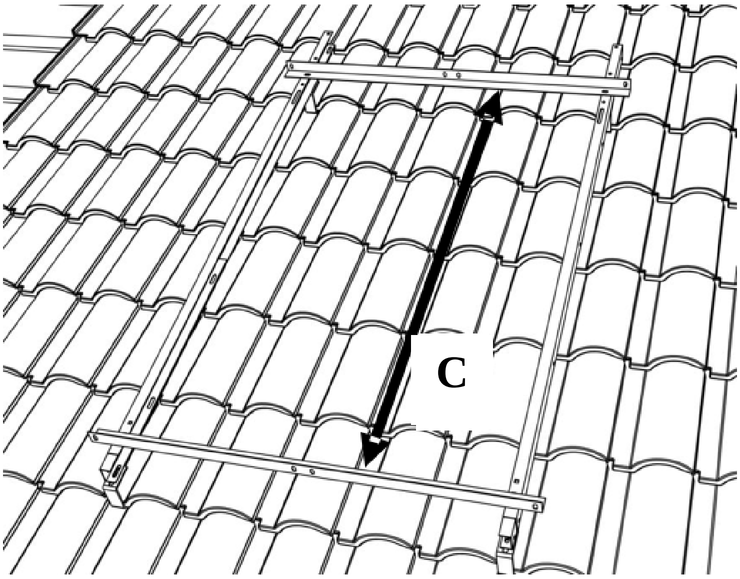
COLLECTOR (S)	M4-200	M4-210	M4-260	M4-260H	M4-300	M4-300H	2x M4-200	2x M4-210	2x M4-260
DISTANCE A [MM]	940	940	940	940	940	940	1160	1160	1160
DISTANCE B [MM]	2000	1930	2050	1700	2050	1770	2000	1930	2050

Note: Dimension B can be extended to 700 mm so that AGG parts can be mounted on the end point of roof tiles.



STEP 2

Replace roof tiles and install the two longitudinal parts of the sloping roof support on AGG brackets, provided that the latter are regulated at the necessary length.

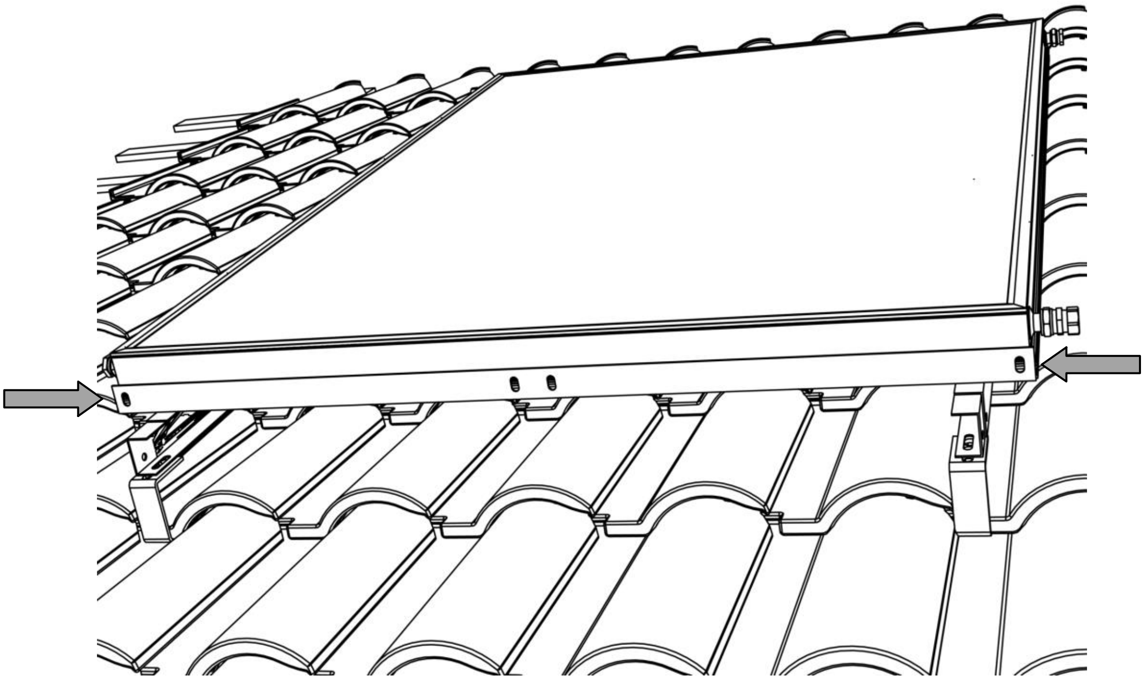


STEP 3

Install the 2 beams with L profile, supporting the collector(s). The distance C between the two vertical parts of beams shall comply with table 2 so that the collector fits between them. Only tighten the bottom beam and slide the top beam by a few cm upwards to facilitate collector installation.

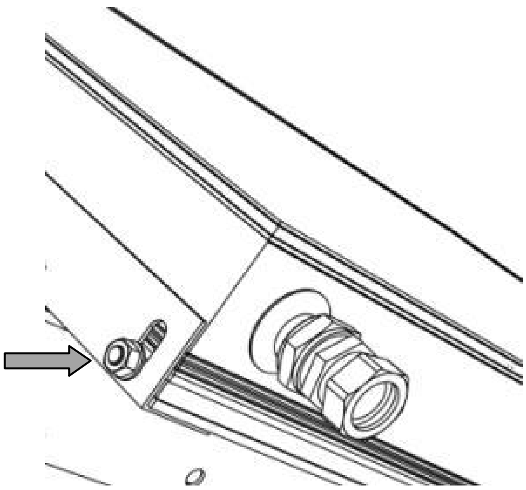
TABLE 2

COLLECTOR (S)	M4-200	M4-210	M4-260	M4-260H	M4-300	M4-300H	2x M4-200	2x M4-210	2x M4-260
DISTANCE C [MM]	2070	1711	2121	1244	2011	1514	2070	1711	2121



STEP 4

Locate the collector(s) on the sloping roof support assembly. Tighten the lower clamping screws.



STEP 5

Slide the top support beam towards the collector and tighten the collector's clamping screws. Tighten the beam's clamp screws on the sloping roof support.

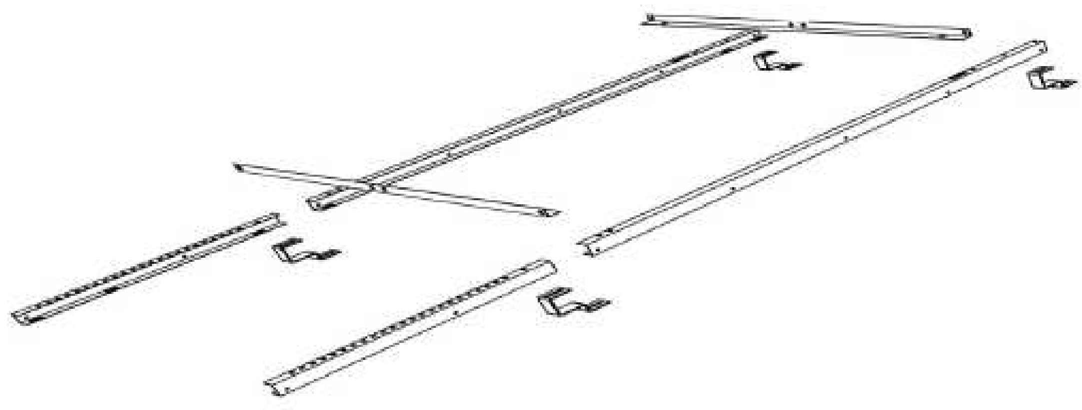
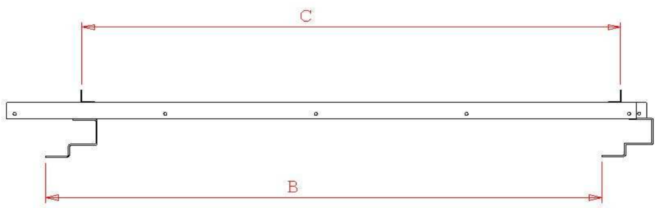
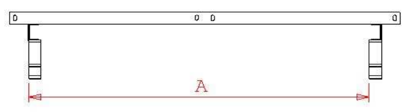


Figure 1: Parts of the sloping roof system.





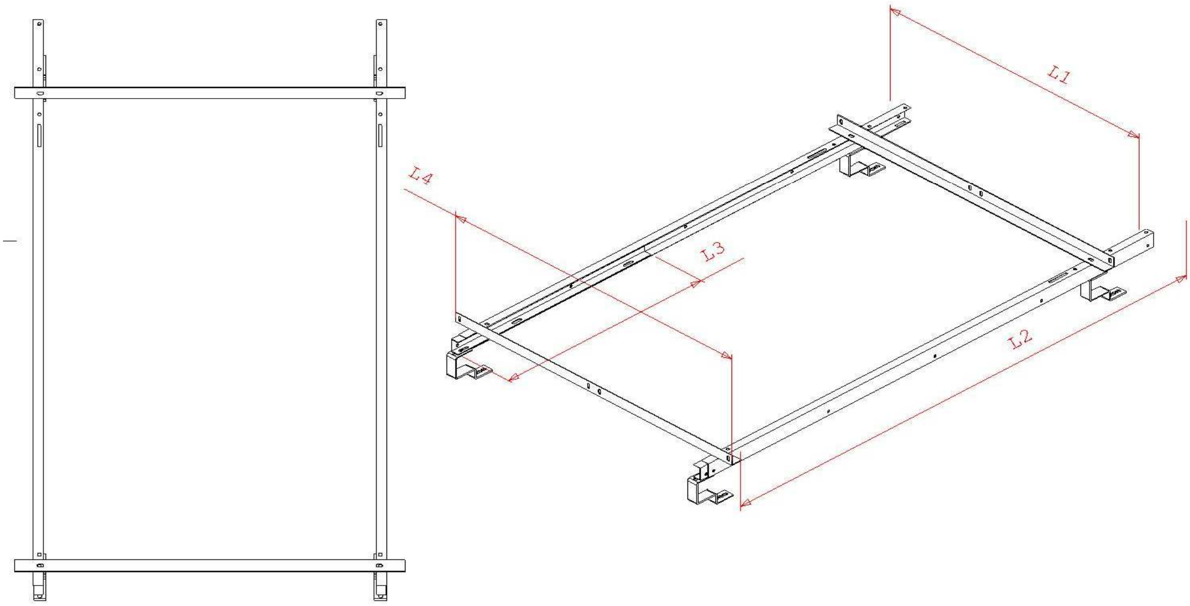


Figure 2: Installation dimensions and sloping roof support dimensions.

COLLECTOR (S)	M4-200	M4-210	M4-260	M4-260H	M4-300	M4-300H	2x M4-200	2x M4-210	2x M4-260
DISTANCE A [MM]	940	940	940	940	940	940	1160	1160	1160
DISTANCE B [MM]	2000	1930	2050	1700	2050	1770	2000	1930	2050
DISTANCE C [MM]	2070	1711	2121	1244	2011	1514	2070	1711	2121

7.2. VTS Collector Installation

- VTS Collector installation on flat roof

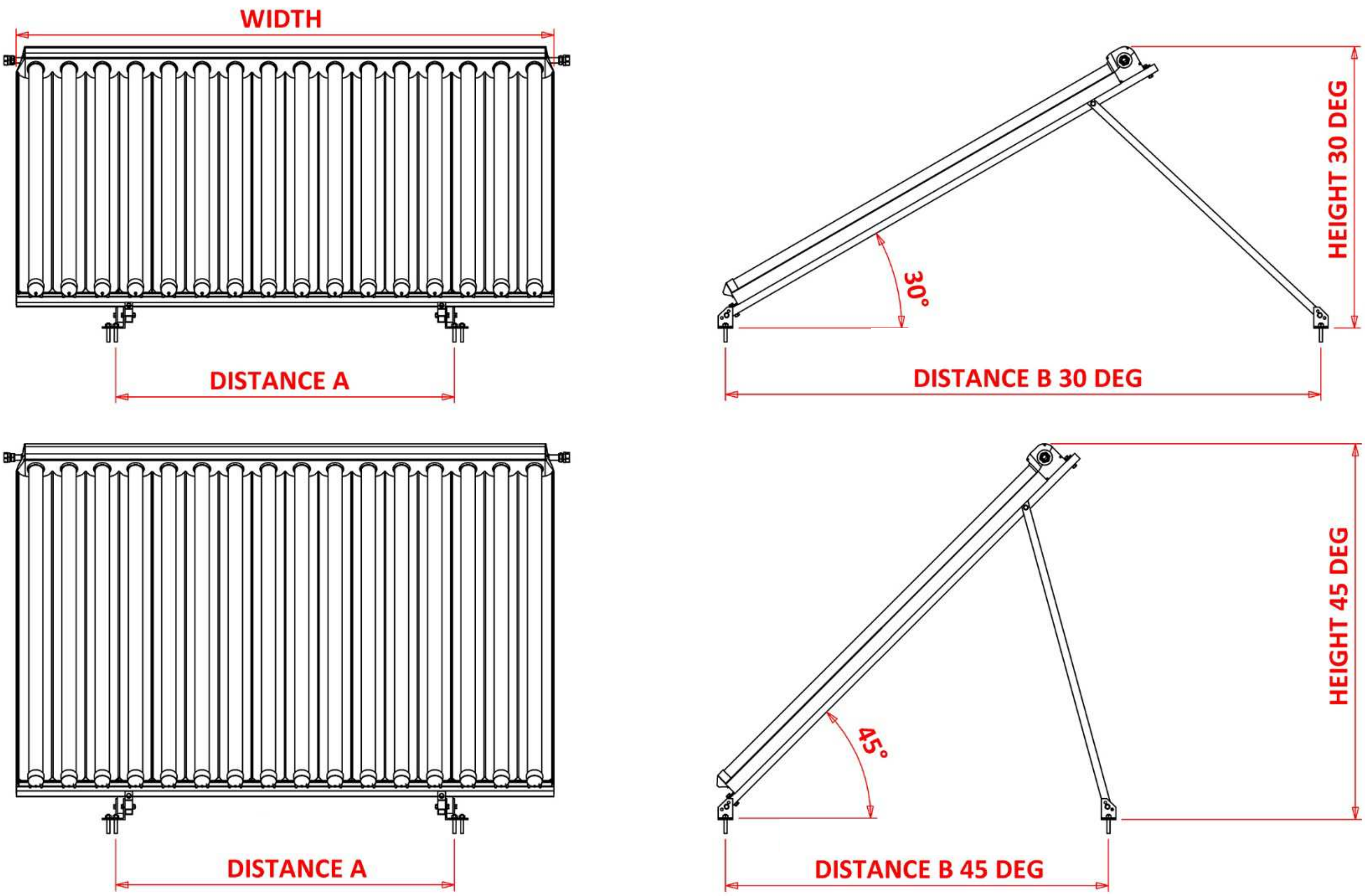


DIAGRAM 1: SYSTEM DIMENSIONS

COLLECTOR	SYSTEM WIDTH [mm]	DISTANCE A [mm]	SYSTEM HEIGHT 45 DEGREES [mm]	DISTANCE B 45 DEGREES [mm]	SYSTEM HEIGHT 30 DEGREES [mm]]	DISTANCE B 30 DEGREES [mm]
10T	1119	960	1244	1267	932	1970
12T	1339	960	1244	1267	932	1970
14T	1559	1120	1244	1267	932	1970
16T	1779	1120	1244	1267	932	1970

TABLE 1: MAIN OUTER DIMENSIONS OF SYSTEM & INSTALLATION CLEARANCES

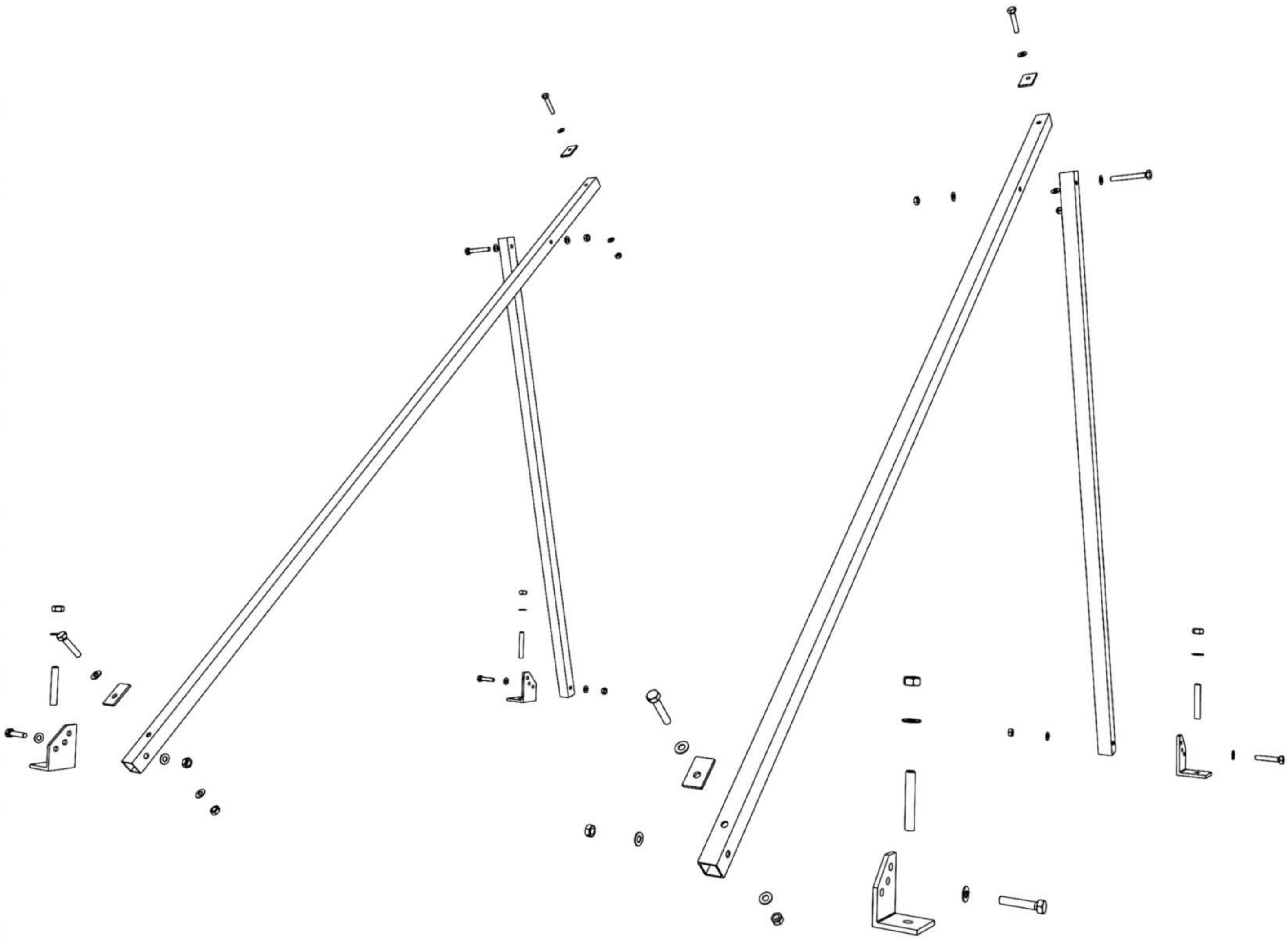
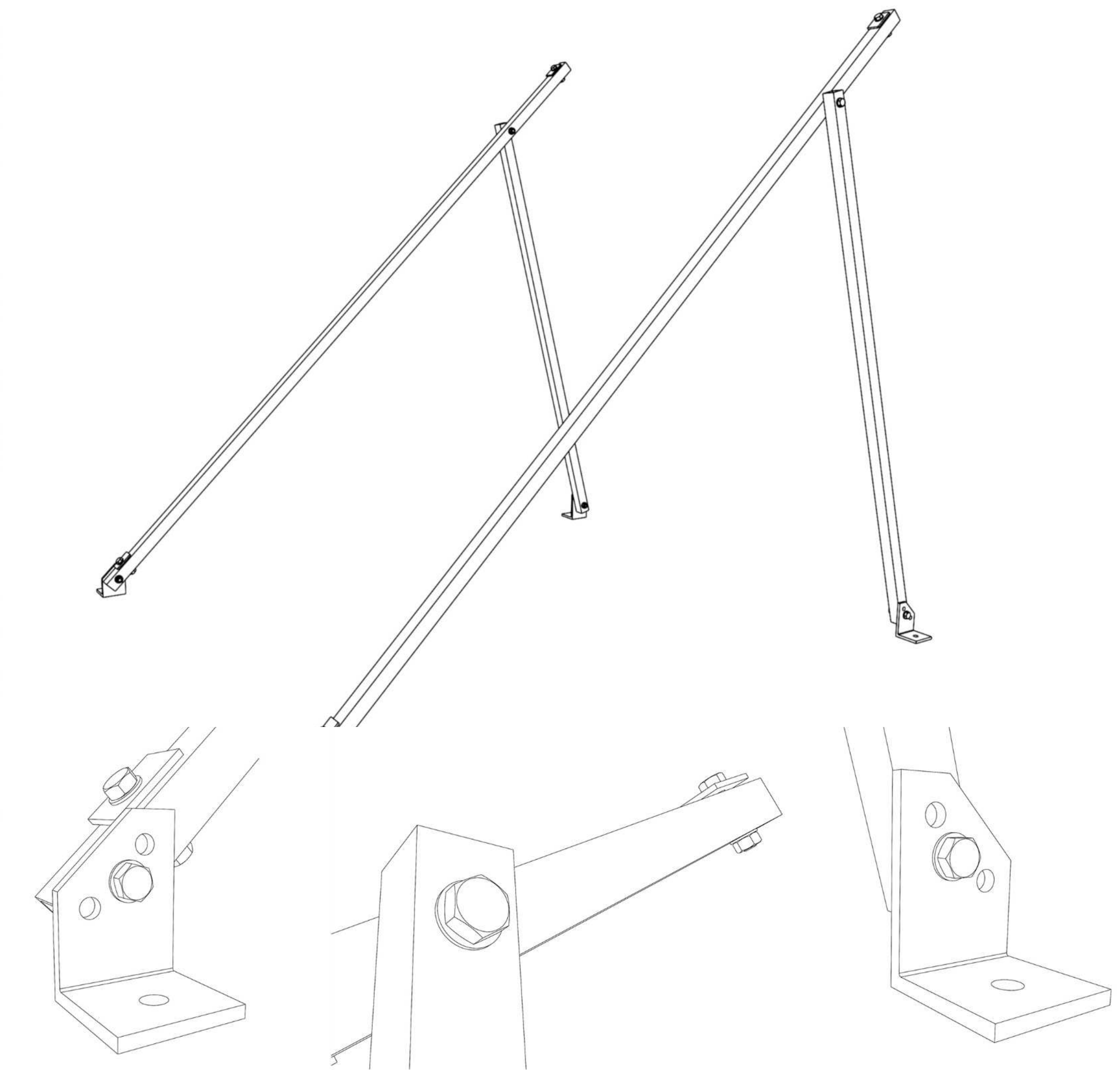
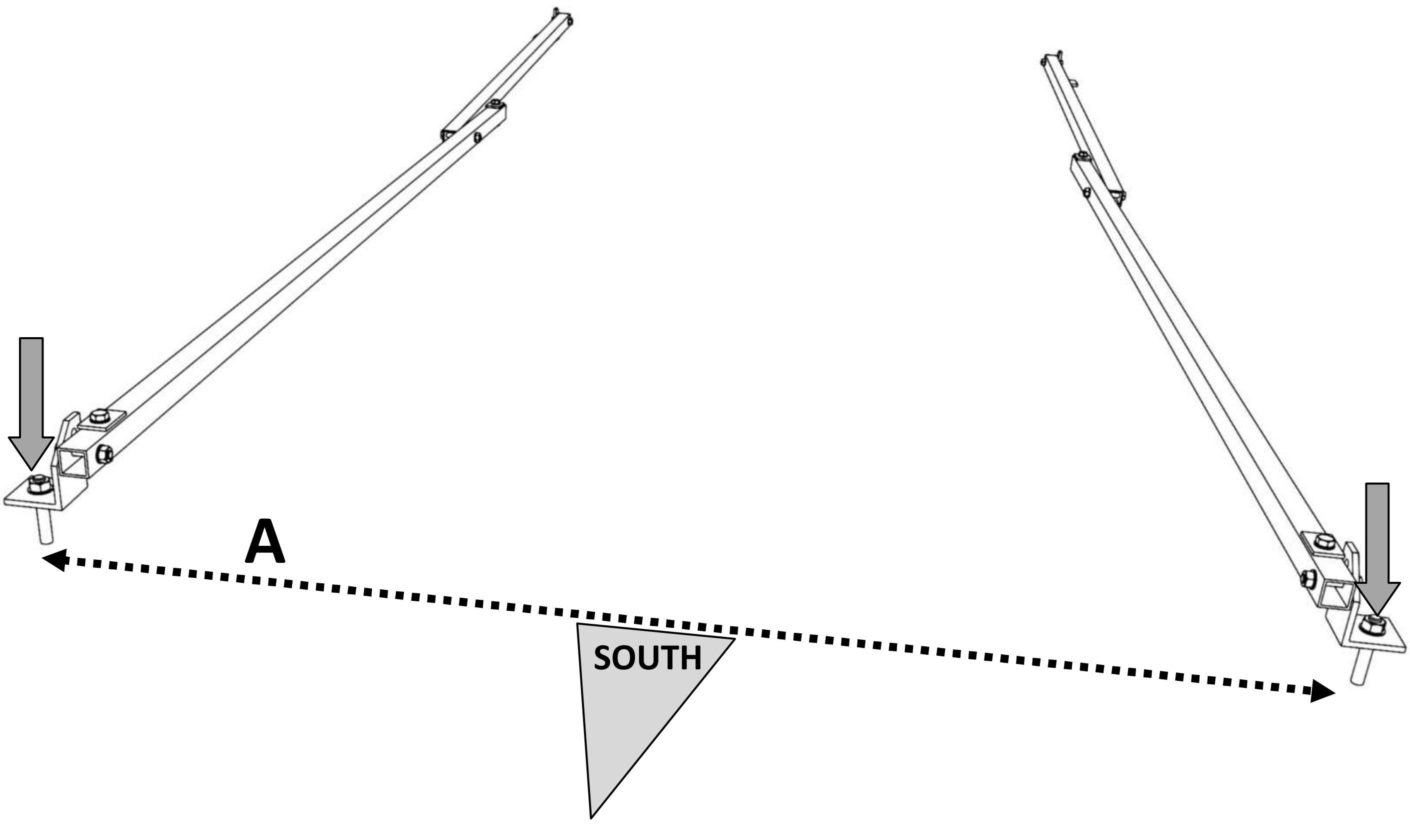


DIAGRAM 2: COLLECTOR SUPPORT PARTS



STEP 1

Assemble the support as per the above mentioned figures. Pay attention to using the right parts. Refer to Diagram 2. The left and the right side are identicals. **Do not fully tighten** the screws.

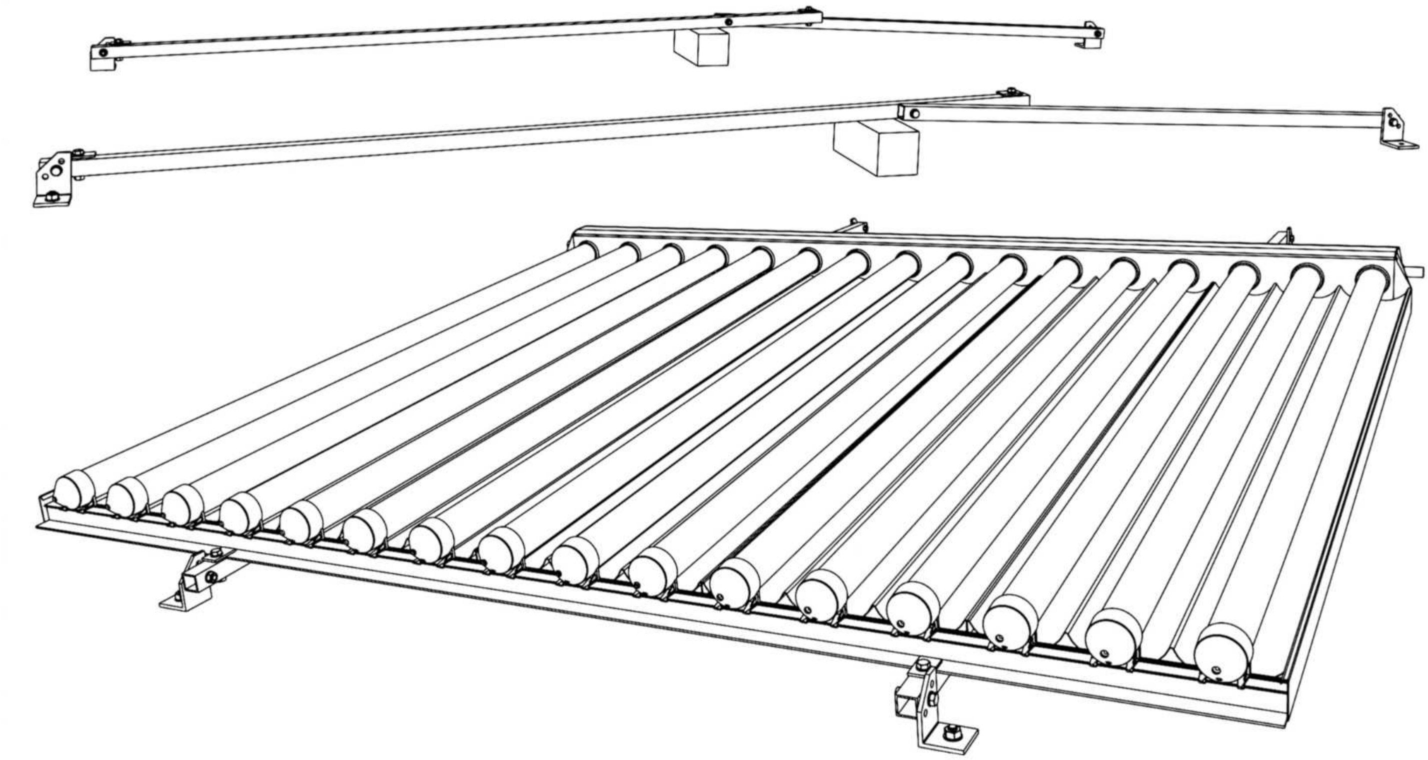


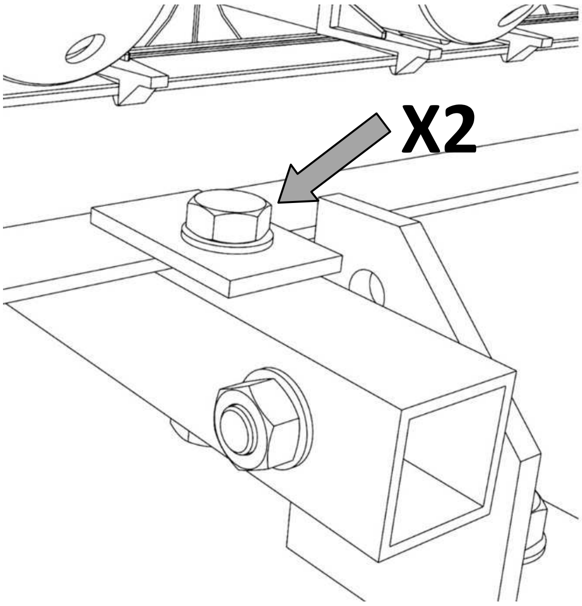
STEP 2

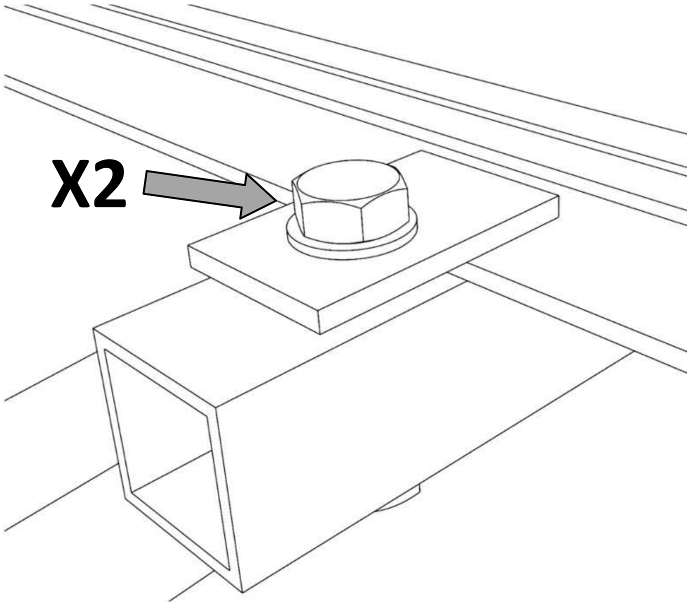
Lay the support on the floor of the flat roof and place it at the installation location. Follow the recommendations listed in Chapter II regarding system orientation and position. Install the front clamping screws at A distance between centres, according to Table 2. Use adequately long screws to allow sufficient encasing of uprights in the concrete mass of the flat roof (not on the surface of insulation or on light concrete). Use suitable sealant to prevent the intrusion of moisture from the holes on the flat roof.

COLLECTOR	6T	7T	8T	9T	10T	12T	14T	16T
DISTANCE A [mm]	520	630	740	850	960	960	1120	1120

TABLE 2: INSTALLATION ON FLAT ROOF, DISTANCE A





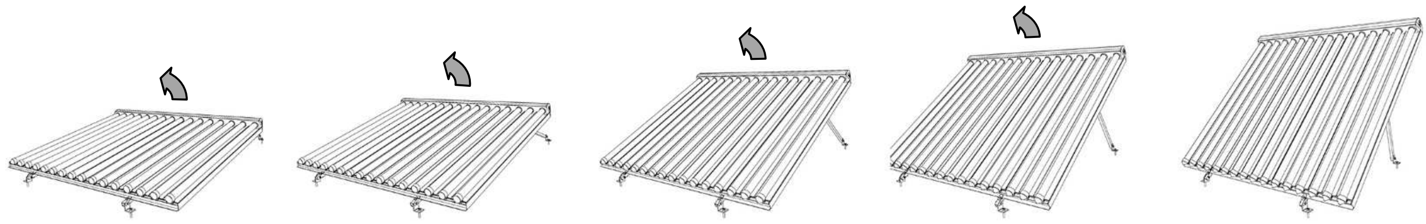


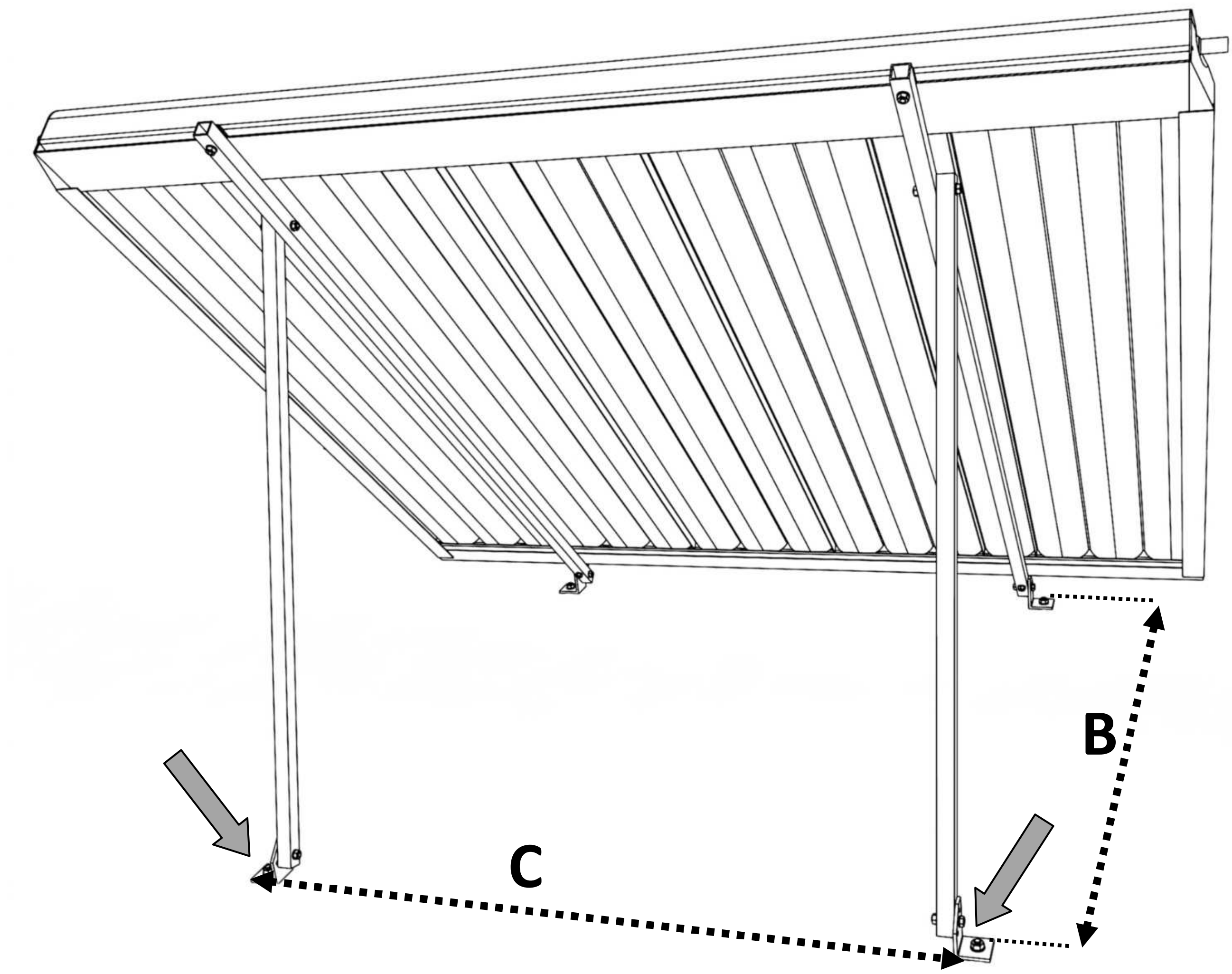
STEP 3

Place 2 spacers under the support, as shown in the figure [e.g. 2 timber planks 75X75X200 mm.] Carefully place the collector in position, on top of the support. Make sure that mount beams are parallel between them and tighten the collector's 4 clamping screws.

CAUTION: DO NOT REMOVE THE PROTECTIVE COVER FROM THE COLLECTOR !

CAUTION: 2 PERSONS MUST BE EMPLOYED FOR COLLECTOR TRANSPORTATION AND HANDLING. ALWAYS USE ONLY THE SPECIAL HANDLING STRAPS !





STEP 4

Carefully lift the collector until it reaches the preferred inclination. Drill on the flat roof and mount the rear mounting screws. Use adequately long screws to allow sufficient encasing of uprights in the concrete mass of the flat roof (not on the surface of insulation or on light concrete). Use suitable sealant to prevent the intrusion of moisture from the holes on the flat roof.

Make sure that the two braces are parallel between them.

Tighten the remaining 6 screws of the support.

NOTE: In case it is not possible to calculate the collector's inclination, you may obtain distance A for 45 and 30 degrees on page 6. Distance C is 50 mm. Higher than distance A.

- Installation of VTS collector array

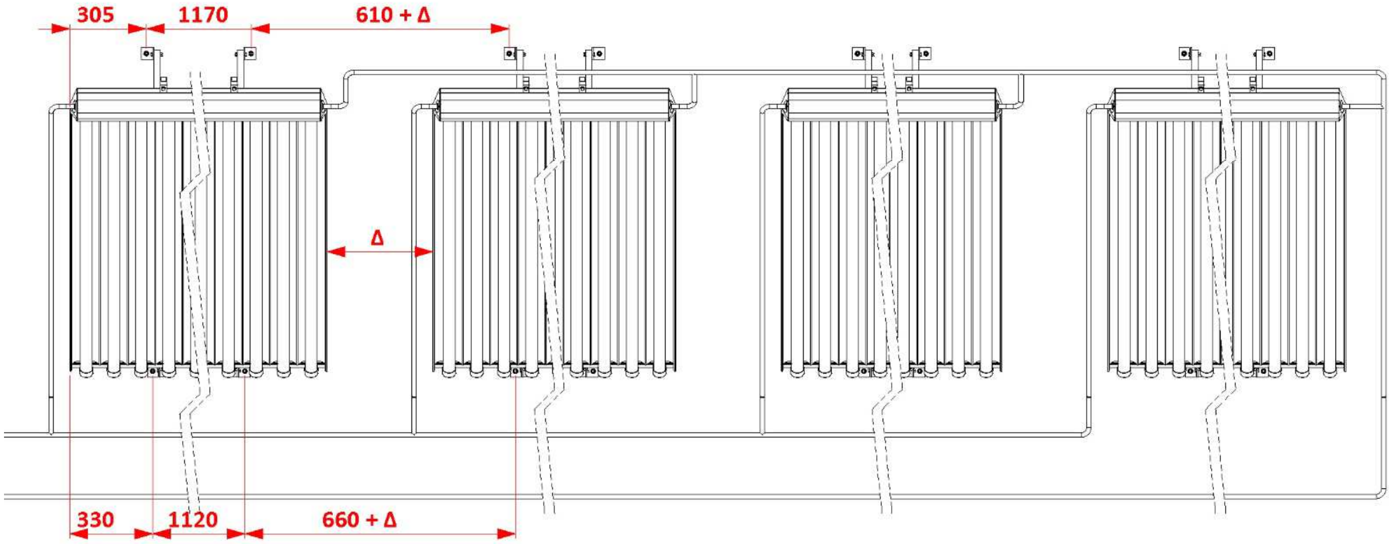


DIAGRAM 3, TRANSVERSE DISTANCES OF THE ARRAY

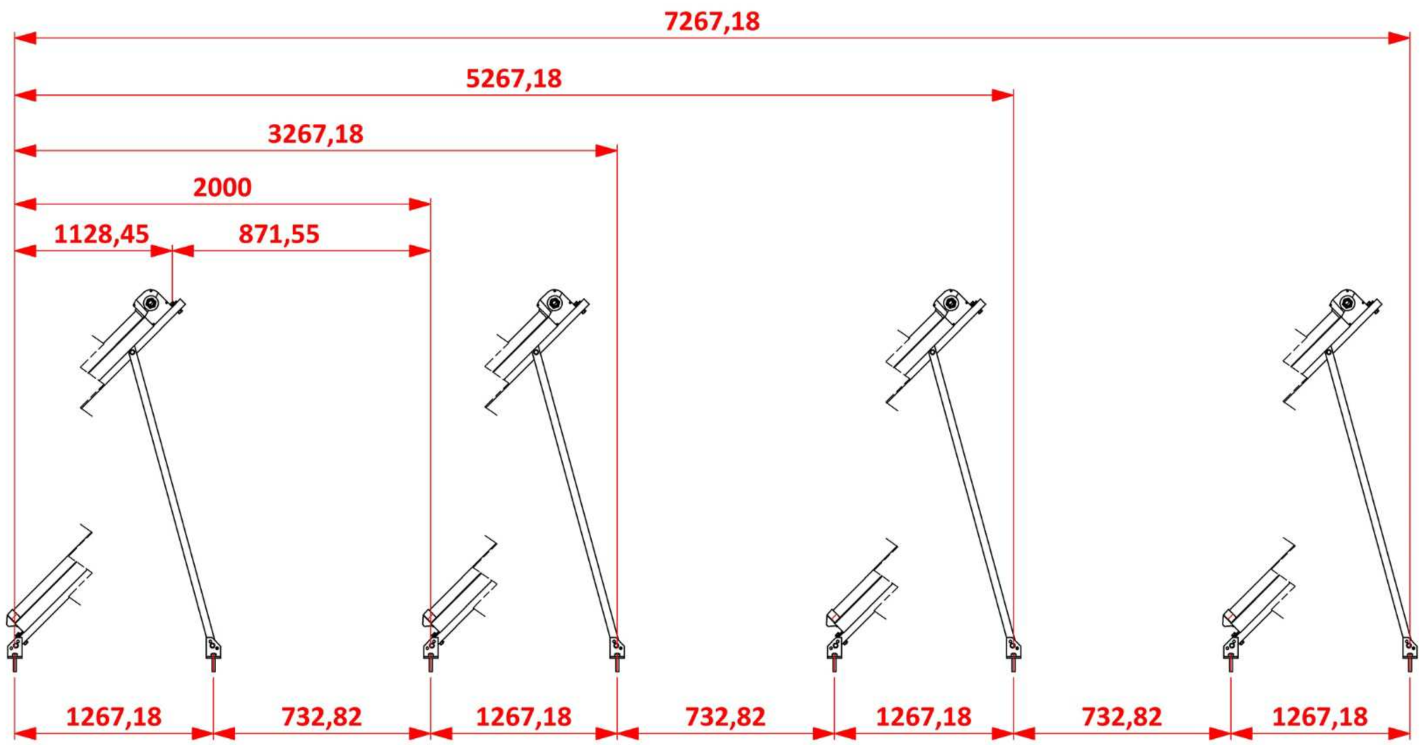
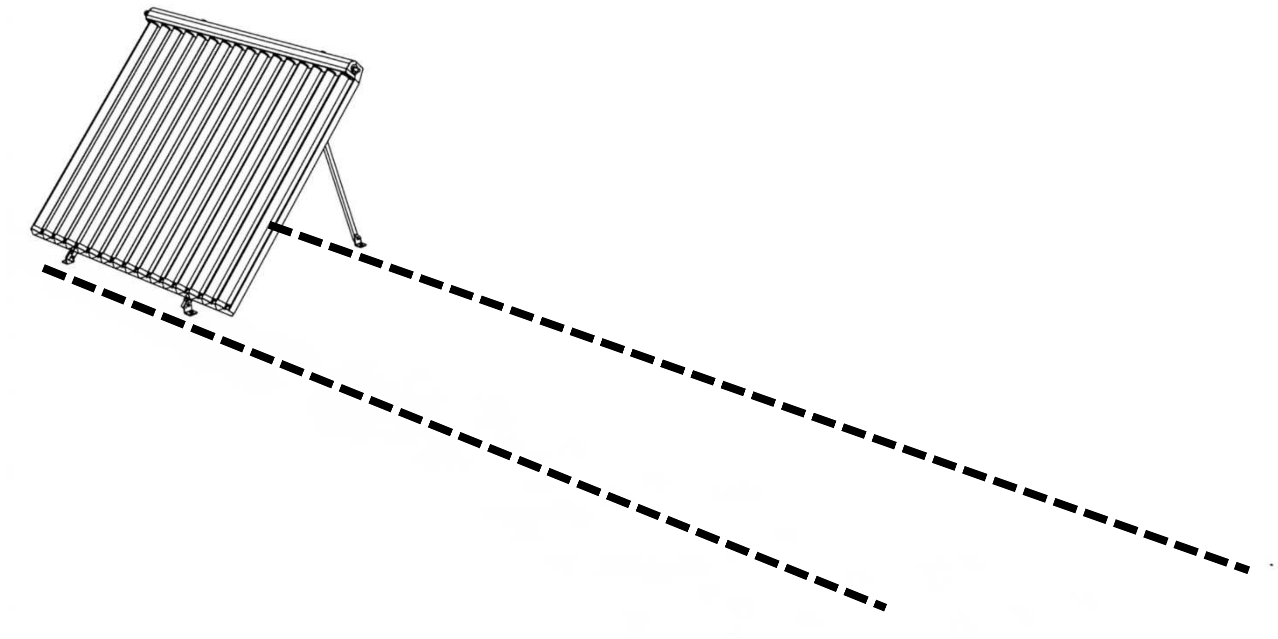


DIAGRAM 4, LONGITUDINAL DISTANCES OF THE 4X4 ARRAY



STEP 1

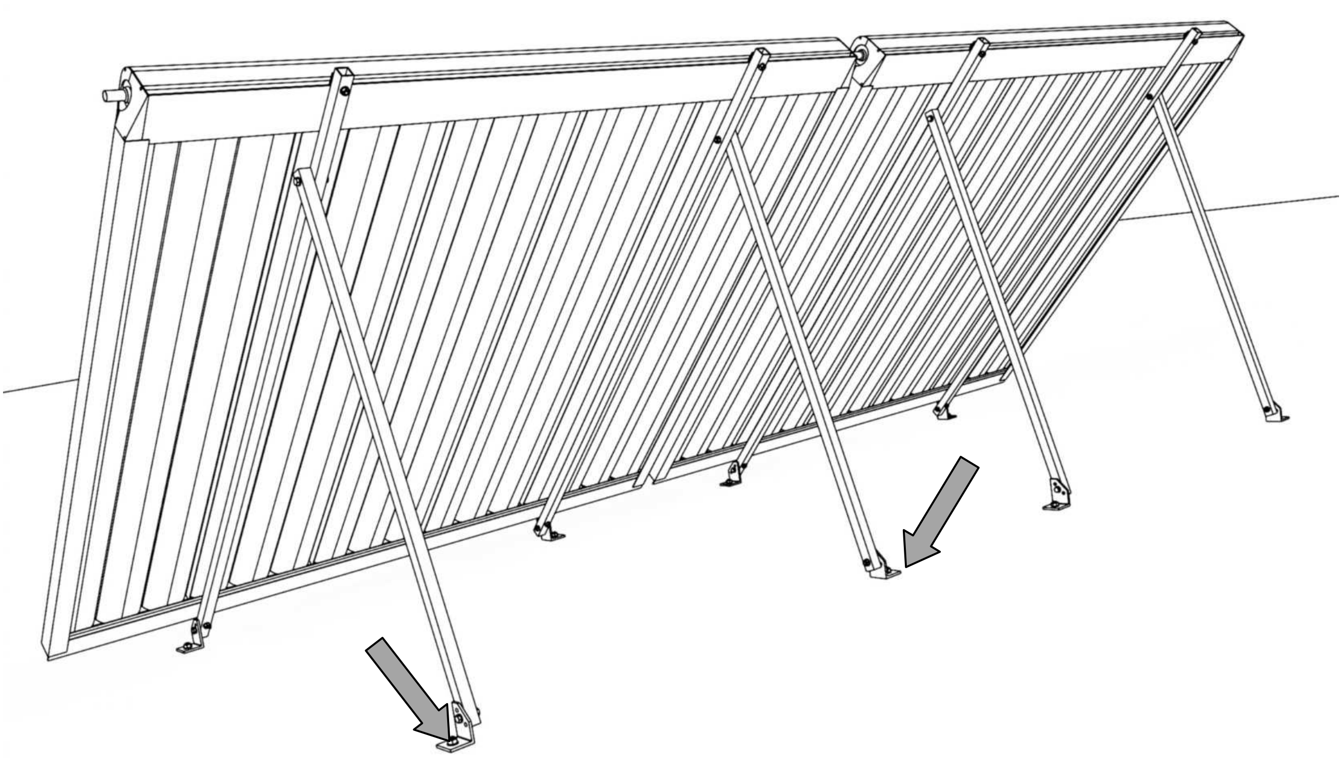
Position the array according to the dimensions shown in Diagrams 3 and 4. Locate the first collector of the array, according to steps 1-4 of single collector installation. To facilitate the performance of the next steps, mark on the flat roof floor the 2 lines on which holes will be arranged to install the next mounts.

STEP 2

Install the support of the next collector, according to steps 1 and 2. Refer to Diagram 3 regarding correct spacing between mounting holes.

STEP 3

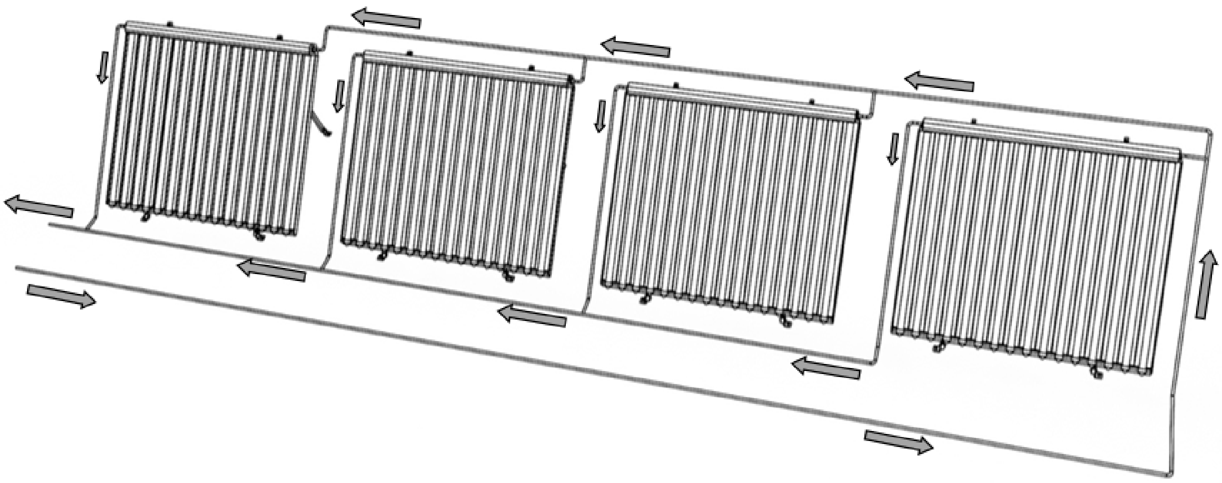
Install the second collector on its support, according to Step 3. **Do not fully tighten the screws on the 4 collector support plates.**

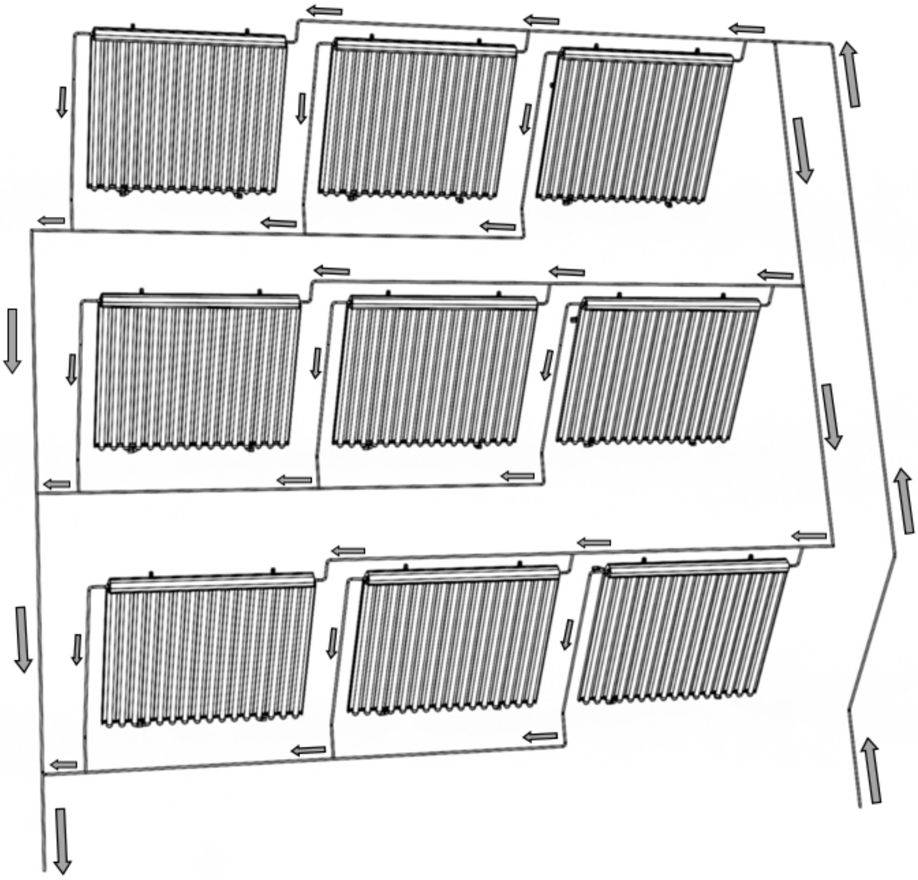


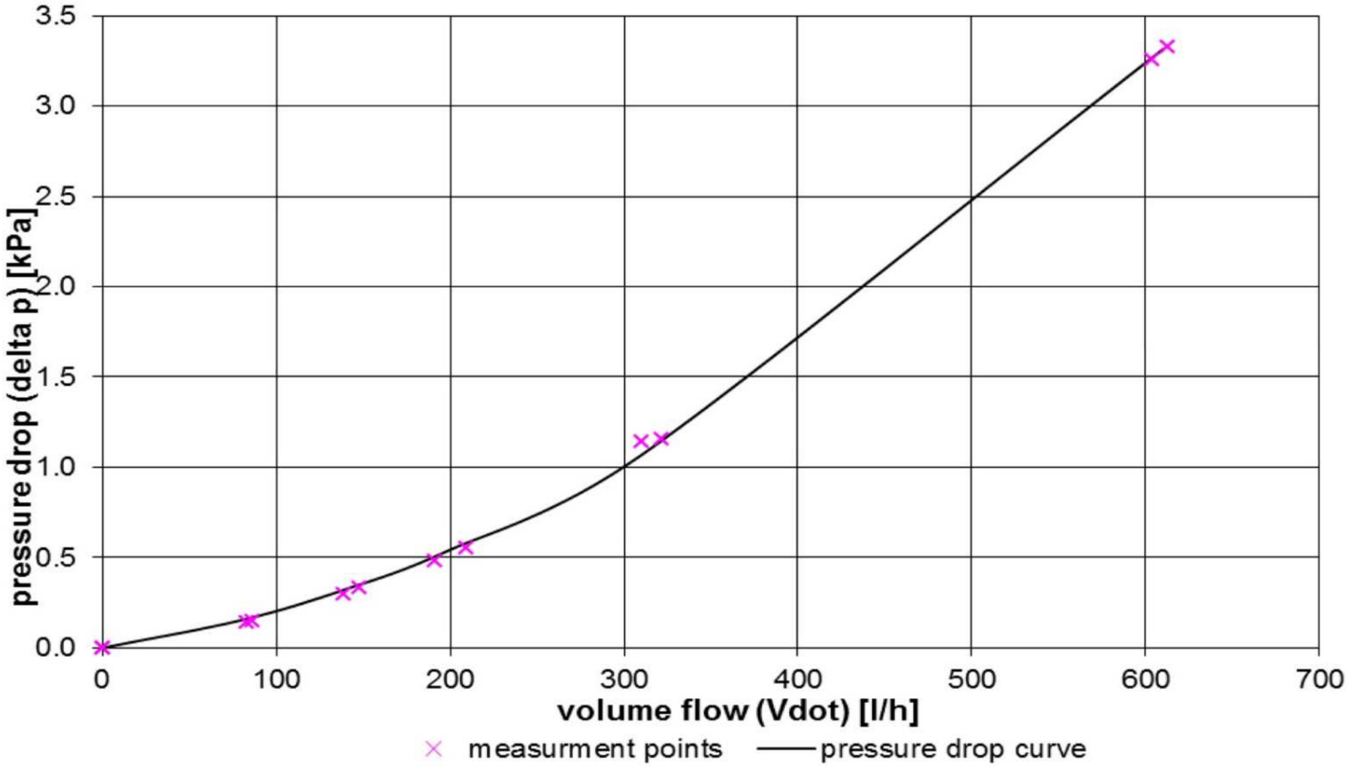
STEP 4

Complete the 2nd collector installation procedure according to Step 4.

- Installation of VTS arrays







3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
pressure drop (delta p) [kPa]
0
100
200
300
400
500
600
700
volume flow (Vdot) [l/h]
measurment points
pressure drop curve

- VTS Collector installation on sloping roof

CAUTION: Check with the building constructor whether the roof can withstand the load of an operational system or contact the competent authorities.

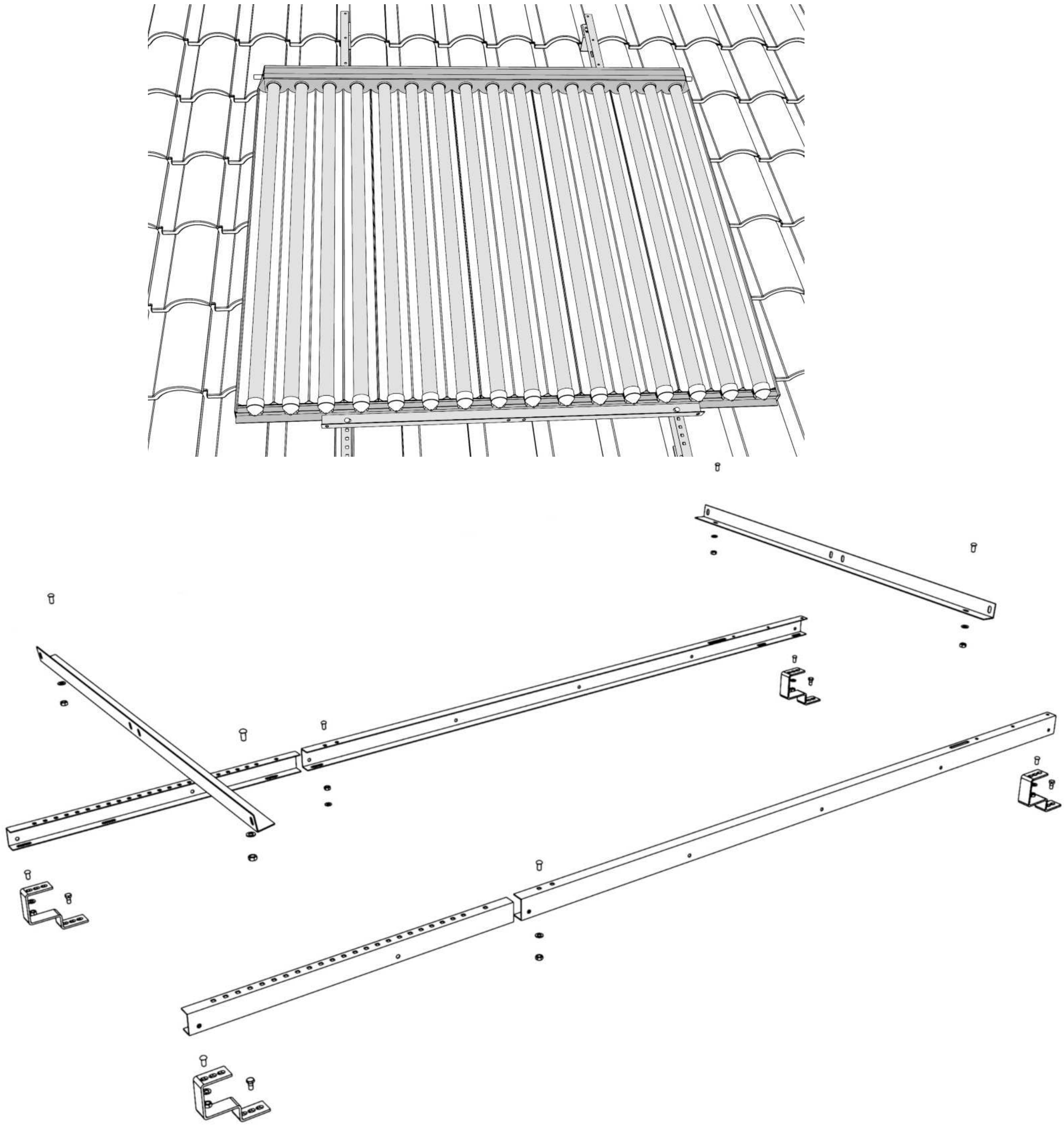


DIAGRAM 5: PARTS OF THE COLLECTOR'S SLOPING ROOF SUPPORT

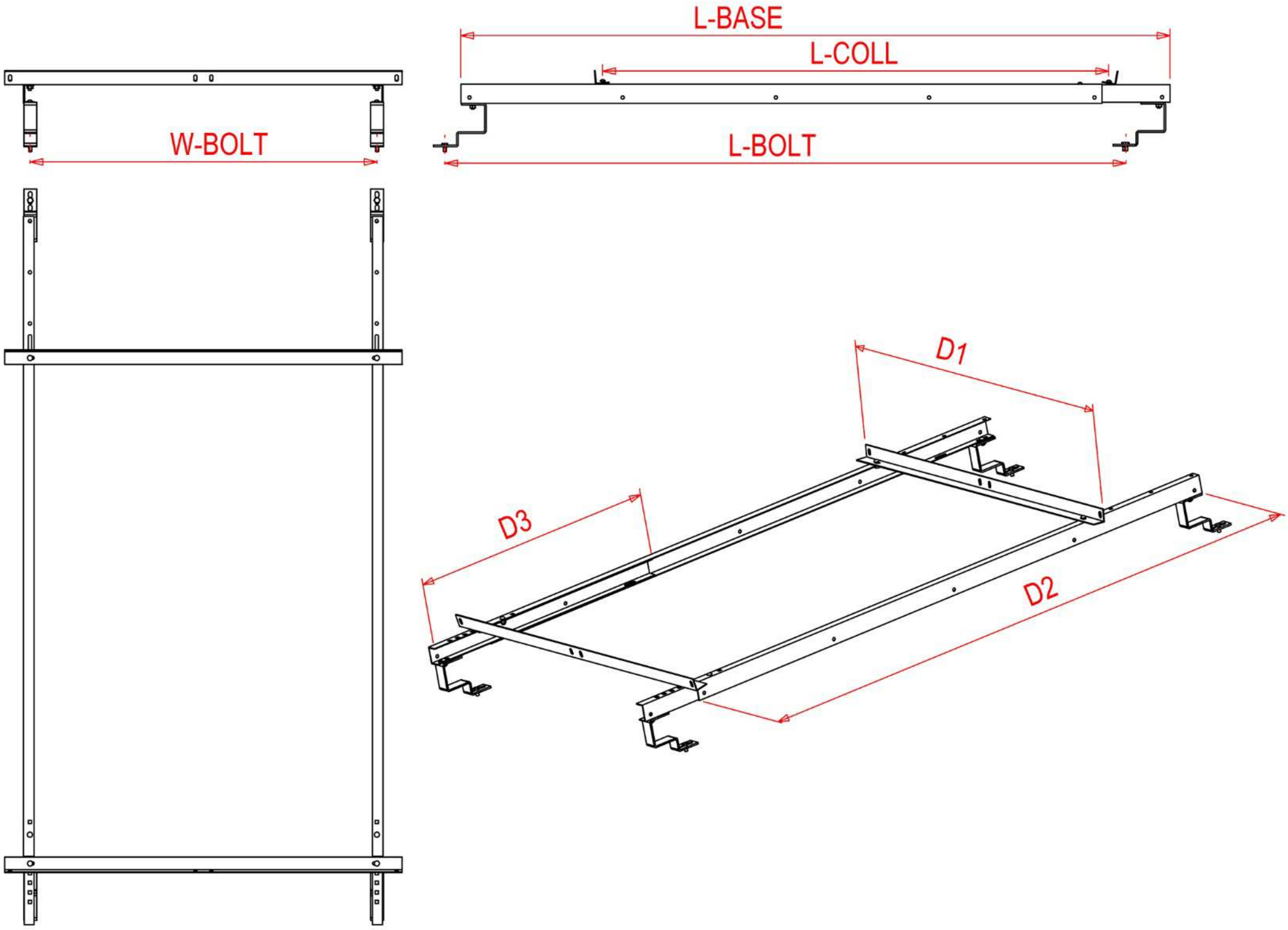
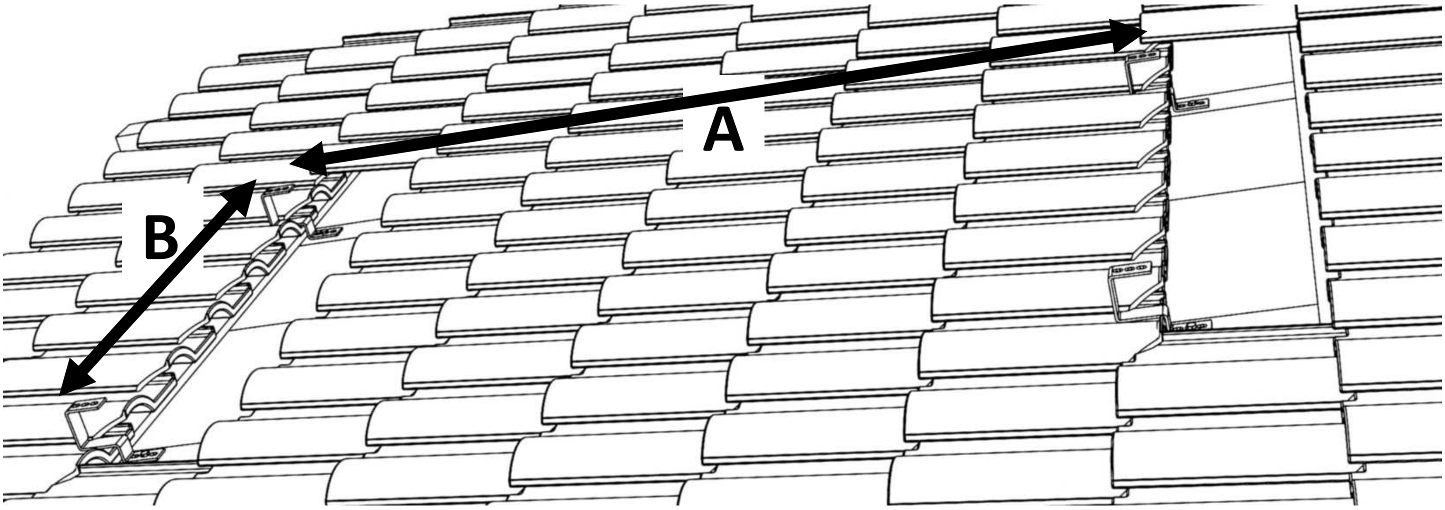


DIAGRAM 6: INSTALLATION DIMENSIONS AND SLOPING ROOF SUPPORT DIMENSIONS

COLLECTOR	COLLECTOR DIMENSIONS			INSTALLATION DIMENSIONS			
	D1	D2	D3	W-BOLT	L-BOLT	L-COLL	L-BSE
10 VTS	1240	2000	866	1082	2126	1579	2213
12 VTS	1240	2000	866	1082	2126	1579	2213
14 VTS	1240	2000	866	1082	2126	1579	2213
16 VTS	1240	2000	866	1082	2126	1579	2213

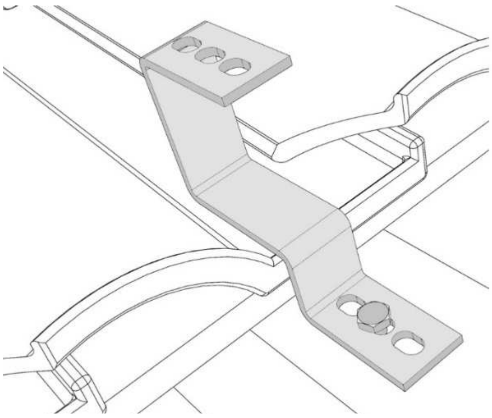
TABLE 3: INSTALLATION DIMENSIONS AND SLOPING ROOF SUPPORT DIMENSIONS.

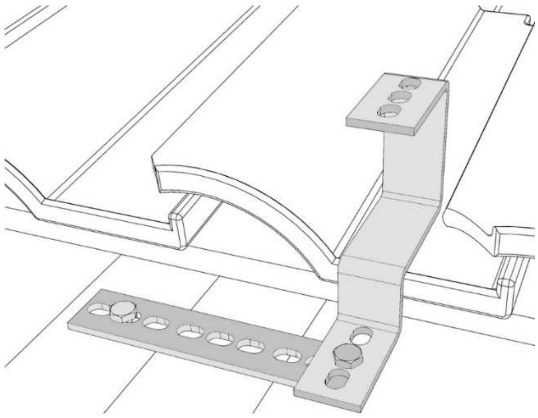


STEP 1

Remove the tiles found at the topmost and the lowermost end of the area where the system will be installed. Install - using suitable screws - 4 AGG brackets (or AT – triangular or AR – special anchor bolt, if necessary) on the vertical beams of the roof, ref. the above figure. Make sure that distances A and B between any holes on the top of brackets, are in accordance with the following table. You may leverage the fact that each bracket includes 3 holes to adapt the system on different tile sizes. In case the AGG brackets are not matching the roof beams, use the additional 20cm extender for AGG brackets [lower right figure].

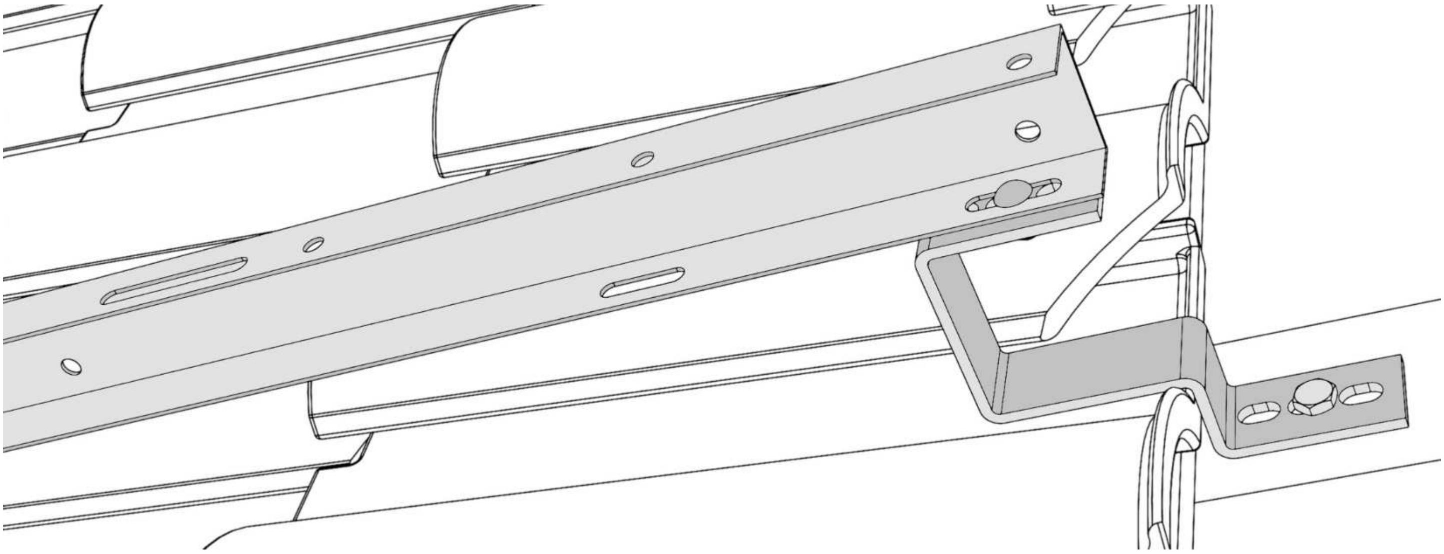
Depending on tile size, distance A may change.

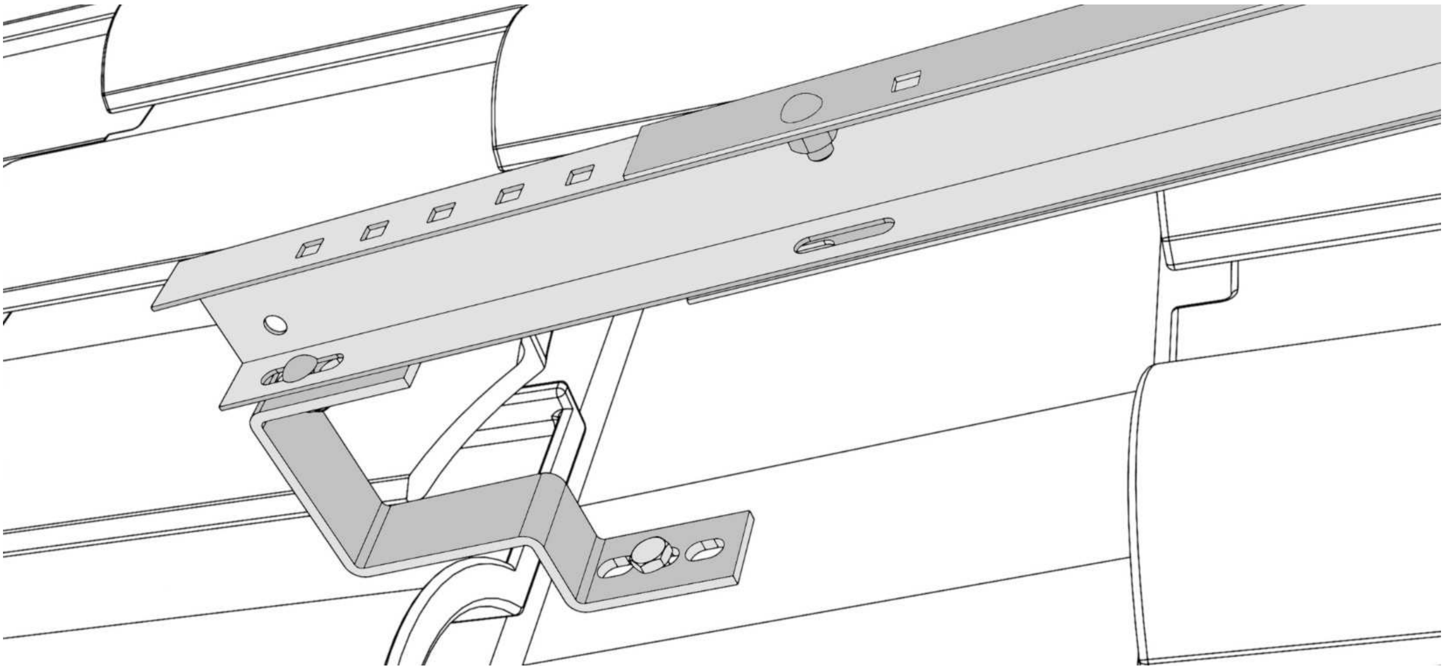


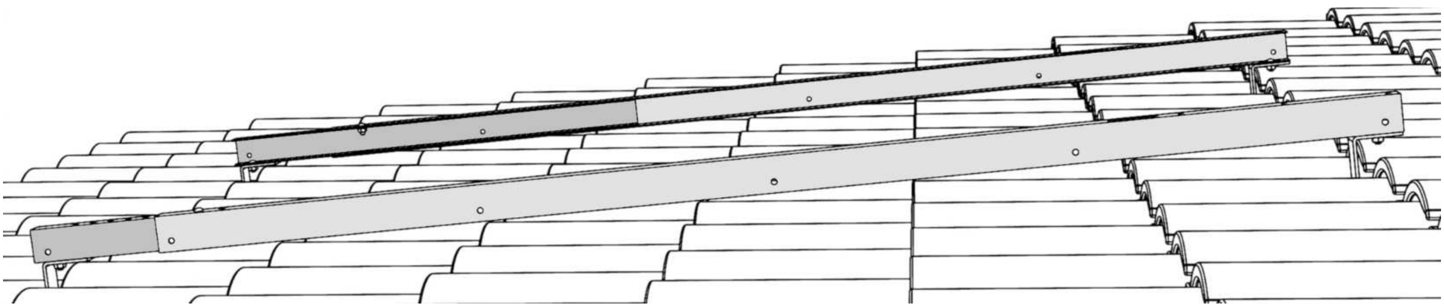


COLLECTOR	10T	12T	14T	16T
DISTANCE A [MM]	2120	2120	2120	2120
DISTANCE B [MM]	1081	1081	1081	1081

TABLE 4: INSTALLATION ON SLOPING ROOF, DISTANCES A AND B

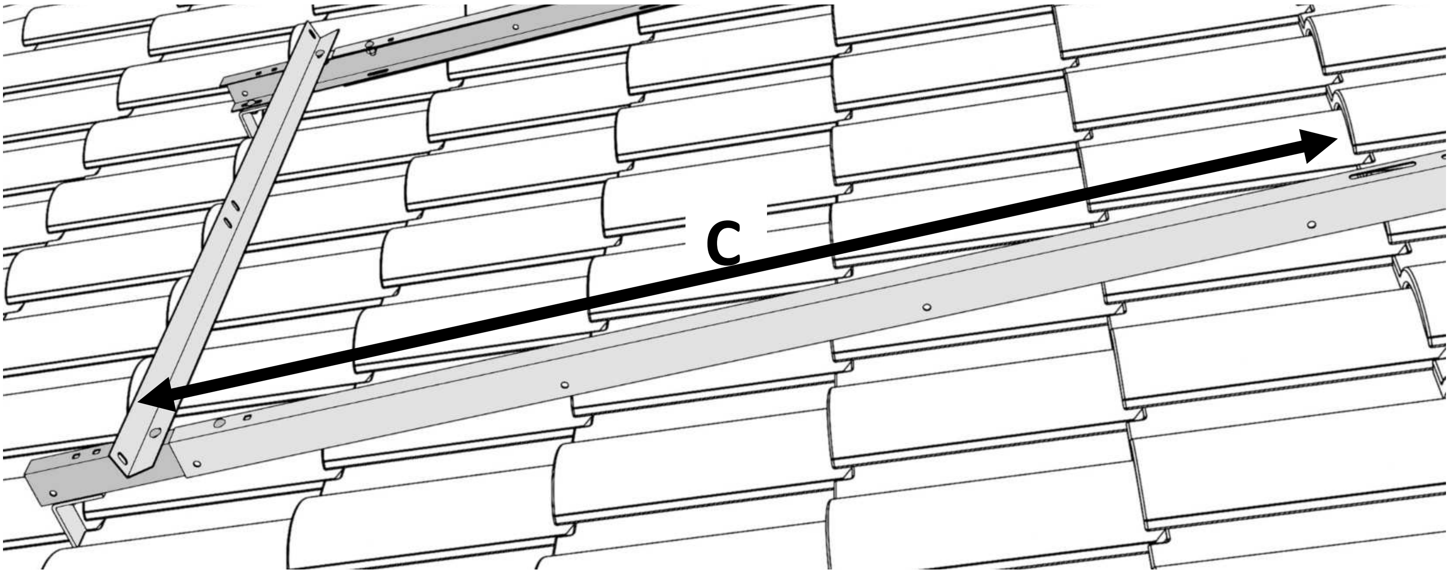






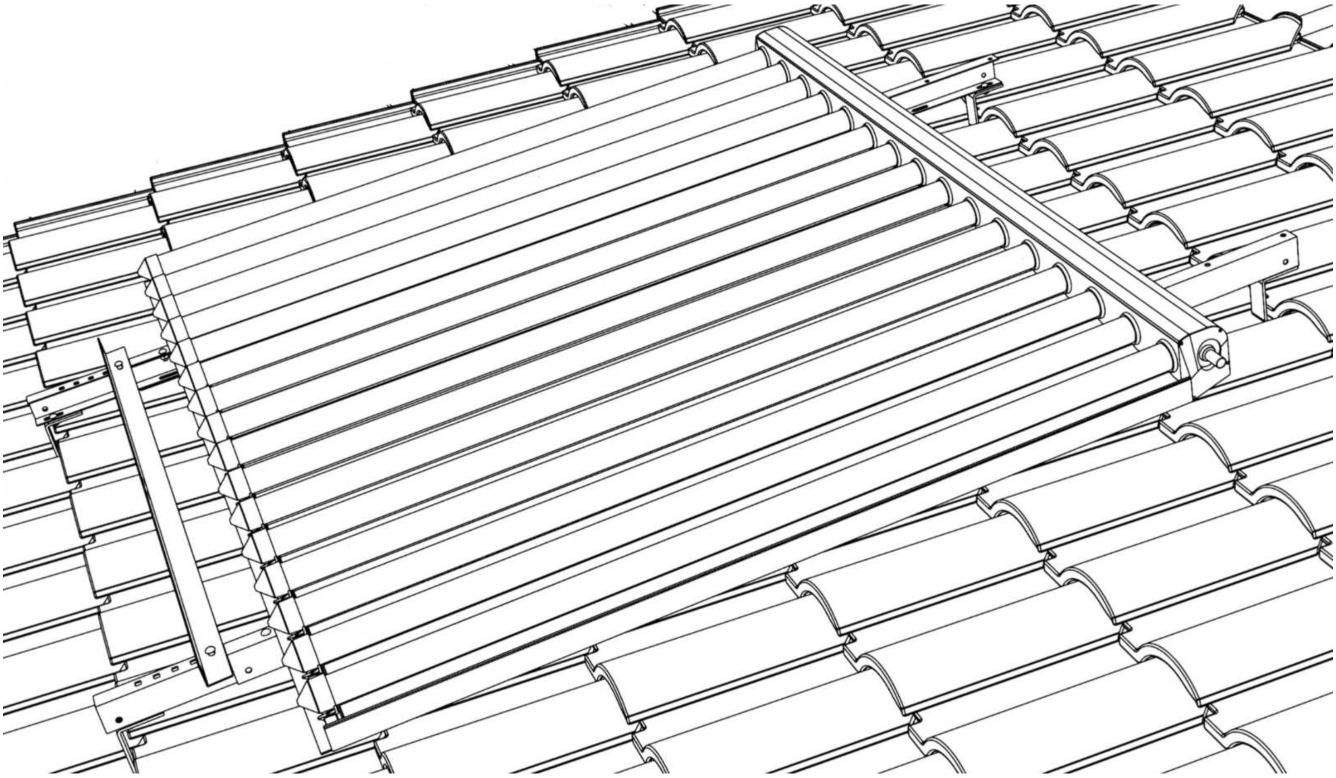
STEP 2

Replace roof tiles and install the two longitudinal parts of the sloping roof support on AGG brackets, provided that the latter are regulated at the necessary length.



STEP 3

Install the transverse beam at the bottom of the mount. Make sure that **Distance C** between the centre of the lower hole and the bottom centre of the slot is **1570 – 1580** mm. Do not tighten the screws.

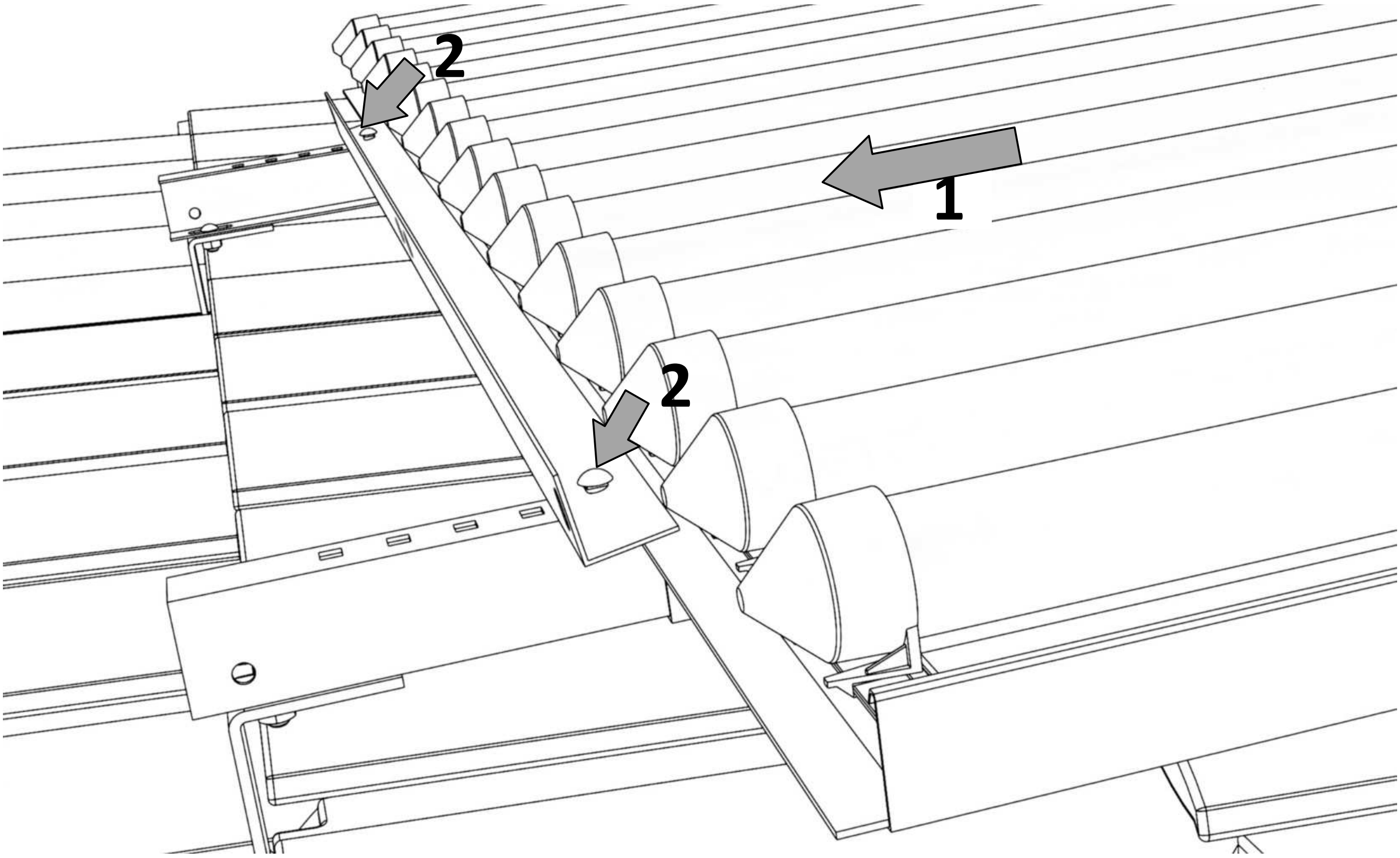


STEP 4

Carefully place the collector on beams of the mount.

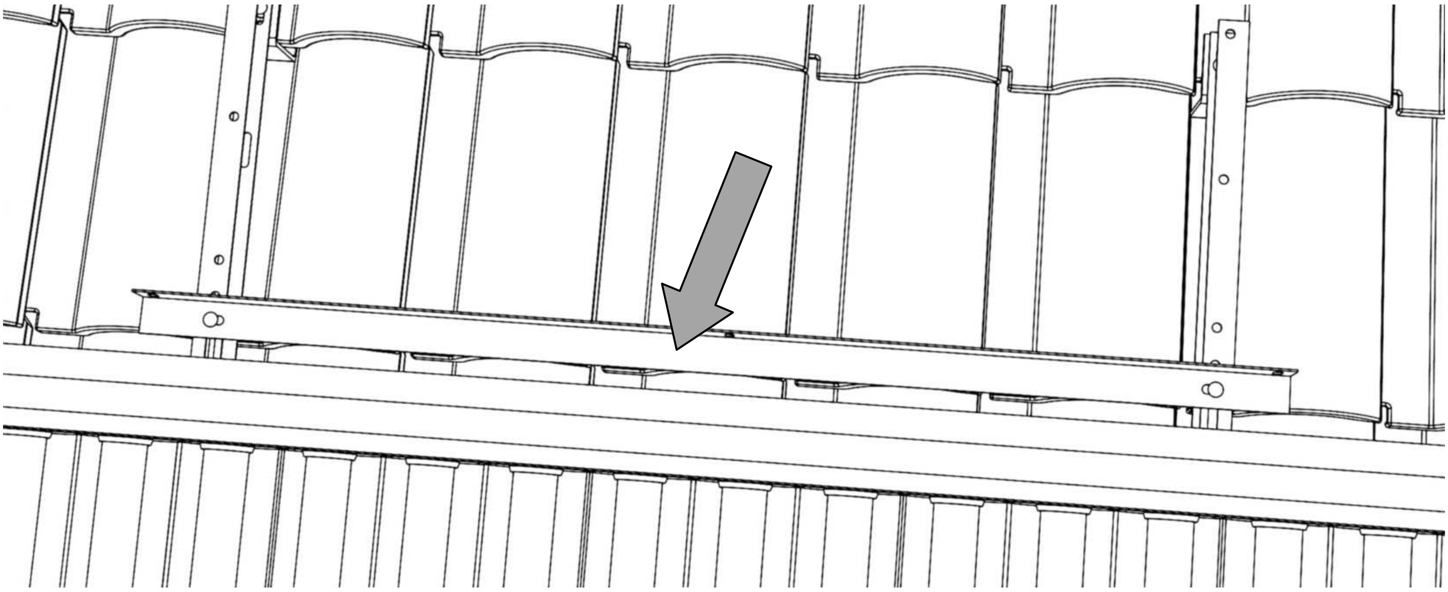
CAUTION: DO NOT REMOVE THE PROTECTIVE COVER FROM THE COLLECTOR !

CAUTION: 2 PERSONS MUST BE EMPLOYED FOR COLLECTOR TRANSPORTATION AND HANDLING. ALWAYS USE ONLY THE SPECIAL HANDLING STRAPS !



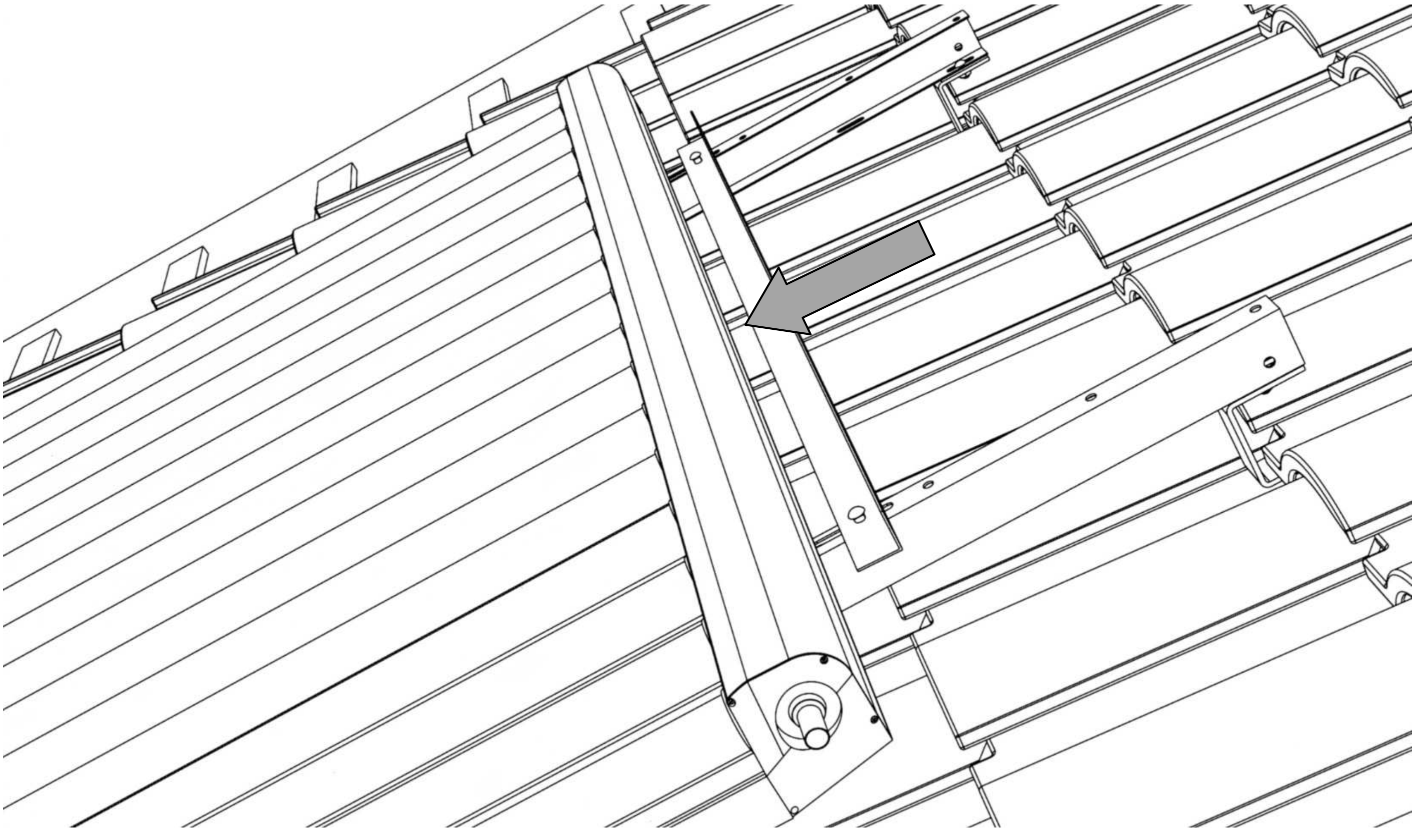
STEP 5

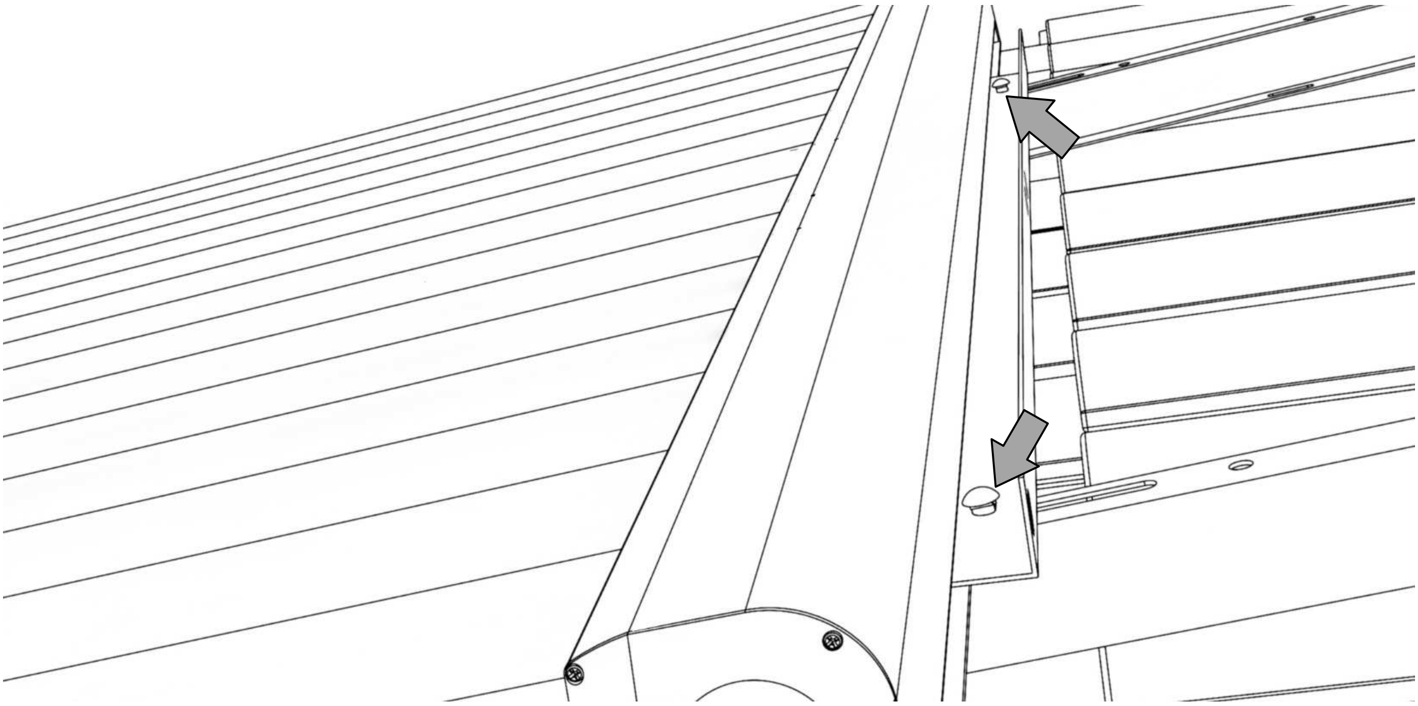
Slide the collector to the bottom of the support until it contacts the clamping screws. The transverse beam should be above the support edge of the collector. Make sure that the collector is symmetrically placed and tighten the screws.



STEP 6

Install the transverse beam on the top of the support in suitable slots.



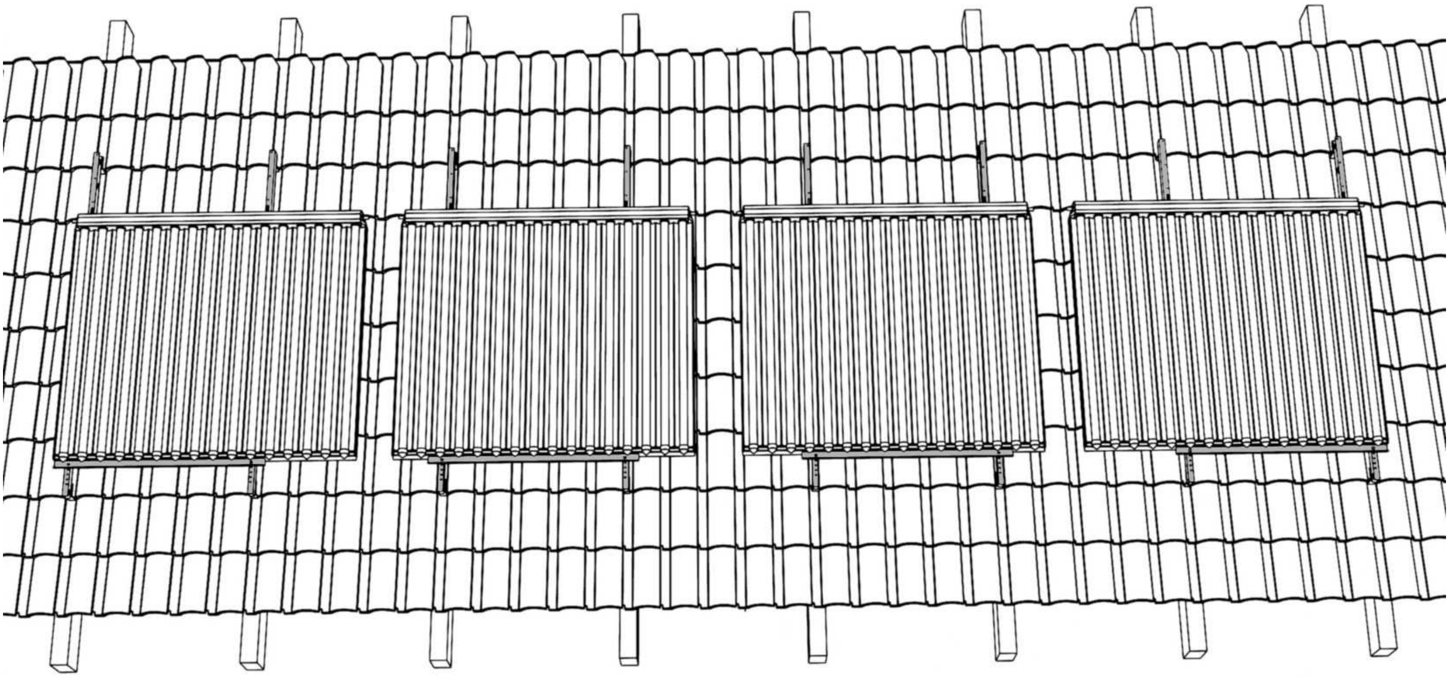


STEP 7

Slide the transverse beam to the collector until the screws contact the edge of the collector. Ensure that the beam is above the top support edge of the power and tighten the screws.

Make a final tightening check on all system screws.

- Installation of VTS collector array on sloping roof



The installation of a collector array on sloping roof will be performed according to the same procedure as a single unit, as each collector requires a separate mounting system. Depending on spacing among roof beams, it may be necessary to relocate horizontally the collector to reduce spaces between them. In case the AGG brackets are not matching the roof beams, use the additional 20cm extender for AGG brackets.

Before installation implementation, calculate the distances between supports and collectors.

8. Annex

8.1. Preliminary study form for forced circulation solar systems

	SPECIAL FORM FOR PRELIMINARY STUDY OF CENTRAL SOLAR SYSTEMS				
INTERESTED PARTY DETAILS					
Full Name					
Address					
Telephone					
FAX					
E-mail					
INSTALLATION DETAILS					
Installation region:					
Application	**DHW generation**	**DHW generation and supplementing space heating**	**Swimming pool heating**	**DHW generation and swimming pool heating**	**DHW generation and supplementing space heating and heating**
Building type	**Single family home**	**Multiple residence block**	**Hotel**	**Industry**	**Other**
Tenants served on a daily basis					
or					
Total daily DHW requirement					
DHW Temperature					
Collector installation site	**Flat roof**			**Sloping roof**	
available surface area (m2)					
Orientation					
Inclination (°)					
Distance between solar collector and boiler room (m)					
ADDITIONAL INFORMATION					
DHW recirculation	**Yes**	**No**			
Recirculation operating hours					
Length of recirculation pipework (single line, m)					
Main source of energy	**Oil-fired Boiler**	**Gas-fired Boiler**	**Heat Pump**	**Electrical heating element**	**Other**
Output (KW)					
A DHW tank is available?	**Yes**	**No**			
Volume of existing DHW tank					

	SPECIAL FORM FOR PRELIMINARY STUDY OF CENTRAL SOLAR SYSTEMS				
IN CASE OF HOTEL					
Hotel profile	Holidays	Urban	All inclusive		
Hotel guest profile	Mixed profile	Camping	Students / young people	Elderly/ Nursery home	No specific profile
Number of hotel rooms					
Operation period	12 months	9 months	Summer	Winter	
% occupancy rate	Jan – Mar	Apr – Jun	Jul – Sep	Oct - Dec	
SWIMMING POOL HEATING					
Swimming pool surface (m2)					
Average swimming pool depth (m)					
Swimming pool type	Indoor	Outdoor			
A swimming pool cover is available	Yes	No			
Operation period (months)	Yes	No			
Is the swimming pool emptied in the winter?	Yes	No			
Is the pool also heated at night?	Yes	No			
Number of users / day					
Desirable swimming pool temperature					
SPACE HEATING					
Heating type	High temperature radiators	Underfloor	Fan coils		
Surface of heated spaces (m2)					
Main source of energy	Oil-fired Boiler	Gas-fired Boiler	Heat Pump		
Output (Kw)					

8.2. Preliminary study form for Calpak gse Fresh Water Tank

CALPAK gse PRELIMINARY STUDY FORM		
Details of Interested Person		
Full name		
Address		
Telephone		
FAX		
Email		
Category Selection		
Basic building category		
Building subcategory		
Climate zone		
System Information		
Number of units		*persons*
Desirable hot water temperature, Th		*[°C]*
Duration of peak time		*[h]*
Demand rate during peak time		*[%Vd]*
Total capacity of the device		*[lt]*
Distribution Network Information		
Distribution network		
Sufficiency of insulation in the distribution network		
Area of distribution network		
Device Information		
Device installation location		
Information on Energy Source Location		
Location where the energy source is installed		
Sufficiency of insulation of the primary network		
Energy Source Information		
Energy source type A		
Thermal power of energy source A		kw
Discharging time		
Temperature of source ignition body Ton		[°C]
Temperature of source shutdown body Toff		m
Month of reference		

CALPAK gse PRELIMINARY STUDY FORM		
Details of Interested Person		
Full name		
Address		
Telephone		
FAX		
Email		
Category Selection		
Basic building category		
Building subcategory		
Climate zone		
System Information		
Number of units		*persons*
Desirable hot water temperature, Th		*[^{o}C]*
Duration of peak time		*[h]*
Demand rate during peak time		*[%Vd]*
Total capacity of the tank		*[lt]*
Distribution Network Information		
Distribution network		
Sufficiency of insulation in the distribution network		
Area of distribution network		
Tank Information		
Tank installation location		
Information on Energy Source Location		
Location where the energy source is installed		
Sufficiency of insulation of the primary network		
Energy Source Information		
Energy source type A		
Thermal power of energy source A		kw
Discharging time		
Temperature of source ignition body Ton		[^{o}C]
Temperature of source shutdown body Toff		m
Month of reference		