Renewables

THERMOMAX

A World Leader in Solar Thermal Collectors

Technical Design Guide

Energy to the Power of

Kingspan®
SOLAR

IMPORTANT

This document is not for use as a design tool, it is for guidance only. All solar systems should be fully designed by a competent engineer. Kingspan Group Plc or any of its companies do not take responsibility for any systems designed using the following details. For system design assistance, please contact our technical support team:

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Why Choose Kingspan Solar?

With over 25 years of experience, the Thermomax brand is firmly established as a world leader in solar thermal technology. Kingspan Solar offer quality, market-leading complete packages for all your solar requirements. Each package is custom designed for each specific application. Our premium quality solar panels and hot water storage cylinders are sized and specified to meet the requirements of each individual property. A number of accessories are also available to enhance the system.

For a list of the solar products and packages we sell, please go to pages 70 and 71.

Throughout this handbook various suggestions have been made for system design and installation. You are strongly advised to follow these suggestions, however, final design of any installation is left to the discretion of the installer.

Regulations and Standards

The solar water heating system should be installed in compliance with current building regulations, all local standards and health & safety regulations. These regulations are statutory documents and take priority over all recommendations within this document.

For installation and operating procedures, please refer to the Installation and Operating manuals provided with the product.

International Forum
Design Award
for Excellence in
Product Design

Thermomax products were
the first to receive the
European quality mark for
solar collectors -
The Solar Keymark.

Contents

What is Solar Energy?

Solar Energy – Ireland and UK's Largest Energy Resource

Solar radiation drives all natural cycles and processes on earth such as rain, wind, photosynthesis, ocean currents and several others that are important for life. From the very beginning of life, the overall world energy need has been based on solar energy. All fossil fuels (oil, gas, coal) are a result of solar energy.

The energy from the sun acting on the earth's surface, over a 15 minute period, is more then the earth's total energy requirement for a year. The amount of yearly global radiation on a horizontal surface may reach over 2,200 kWh/m^2 in sunny regions. In Northern Europe, the maximum values are 1,100 kWh/m^2 and are 943kWh/m^2 in London and
990 kWh/m^2 in Rosslare, Ireland.

The supply of solar radiation in UK and Ireland differs by a factor of 10 between summer and winter, e.g. Rosslare: 6.36 kWh/m^2/day in June; 0.64 kWh/m^2/day in December. Fig 1.

Global radiation comprises direct and diffuse radiation. As sunlight passes through the atmosphere, some of it is absorbed, reflected and scattered by air molecules, clouds and dust particles, this is known as diffuse radiation. The portion of radiation that hits the earth's surface without any change in direction is known as direct radiation. Fig 2.

In Ireland and UK, diffused radiation makes up between 40% (May) to 80% (December) of the total solar energy available in a year.

Month	Global Radiation (kWh/m^2/Day)	Mean Outside Temperature°C
January	0.7440	5.6000
February	1.5360	6.3000
March	2.9040	7.0000
April	4.4400	8.8000
May	5.5920	10.9000
June	6.3600	13.4000
July	5.7840	14.7000
August	4.6560	14.9000
September	3.5040	13.9000
October	1.9920	11.4000
November	1.0560	8.2000
December	0.6480	6.4000
Year	1195.7280	10.1250

Fig 1. Daily totals for irradiation in Rosslare, Ireland

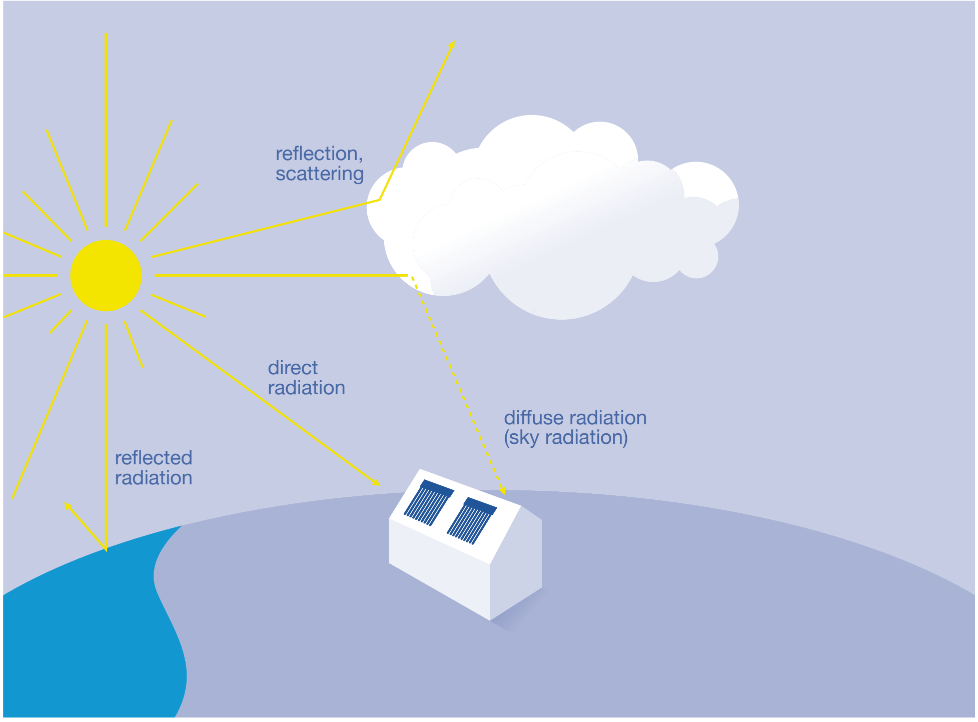


Fig 2. Diagram showing Global irradiation and its components

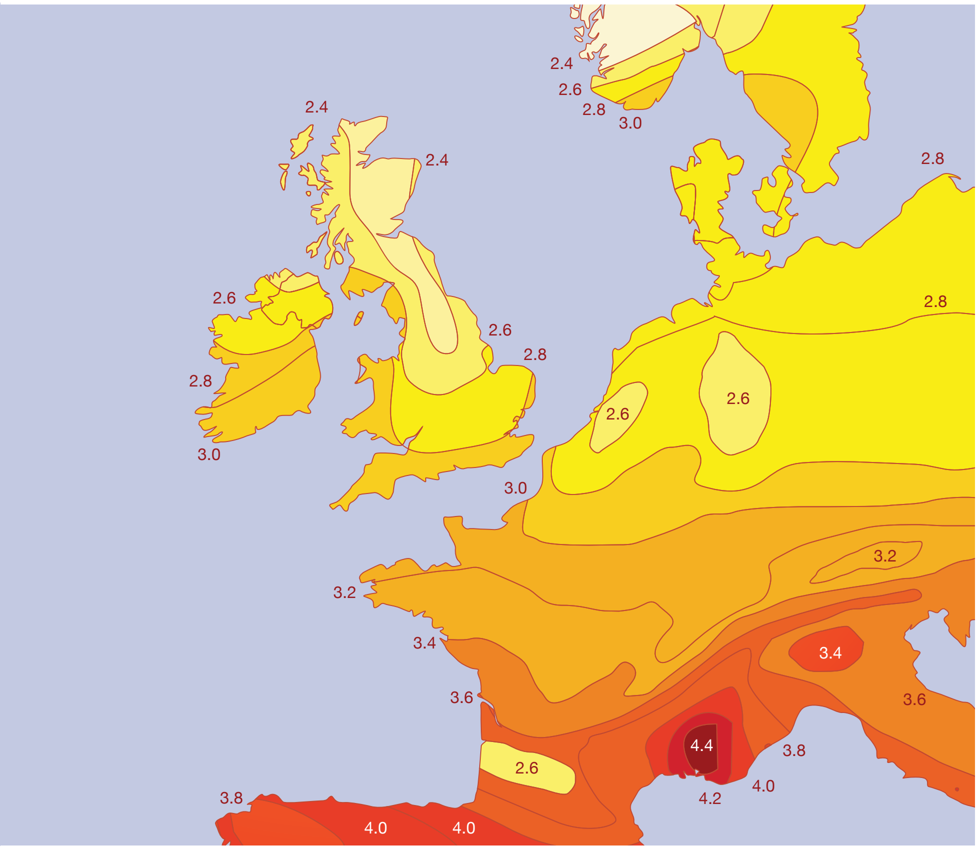


Fig 3. Diagram showing average daily solar radiation acting on 1m^2 in Northern Europe.
Surface inclined at 30°, measured in kWh

Influences on the Performance of the Solar System

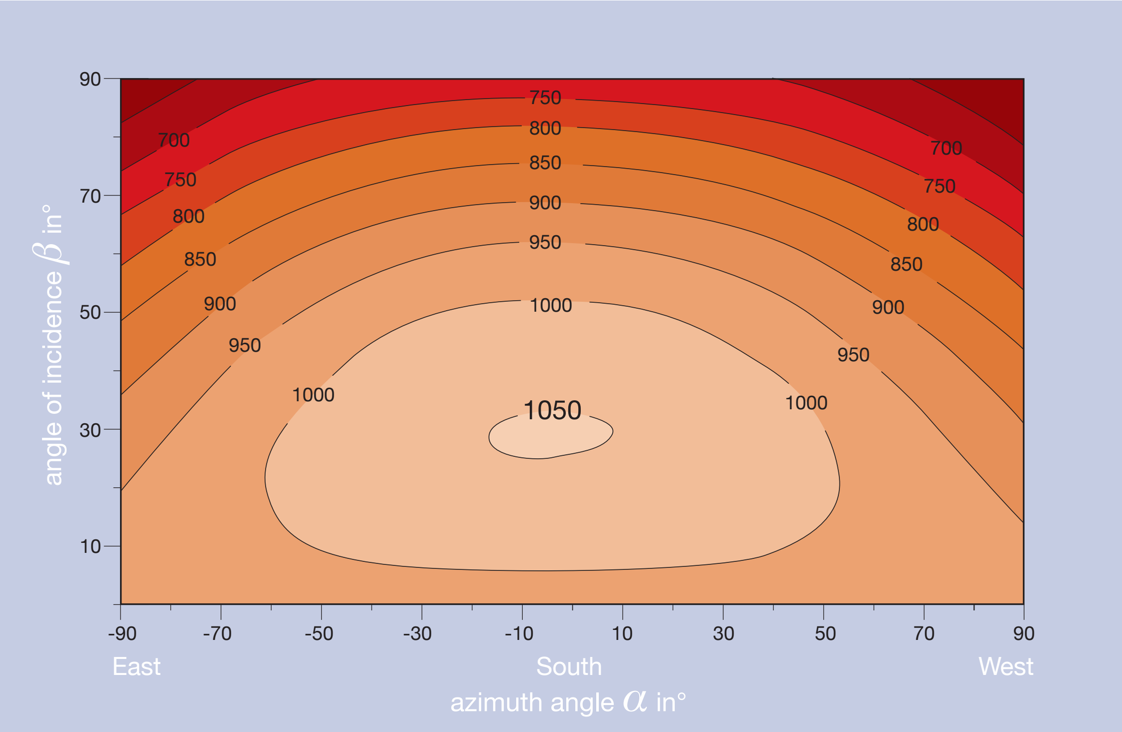


Fig 4. Diagram showing variations in solar energy gains due to changes in collector orientation

Azimuth (α):

The Azimuth angle is the angular distance between true south and the point on the horizon directly below the sun. The azimuth angle for south in solar applications is defined as β = 0°, west = 90°, east = -90°.

Please note that the solar system should always face the equator

Influences on the Performance of the Solar System

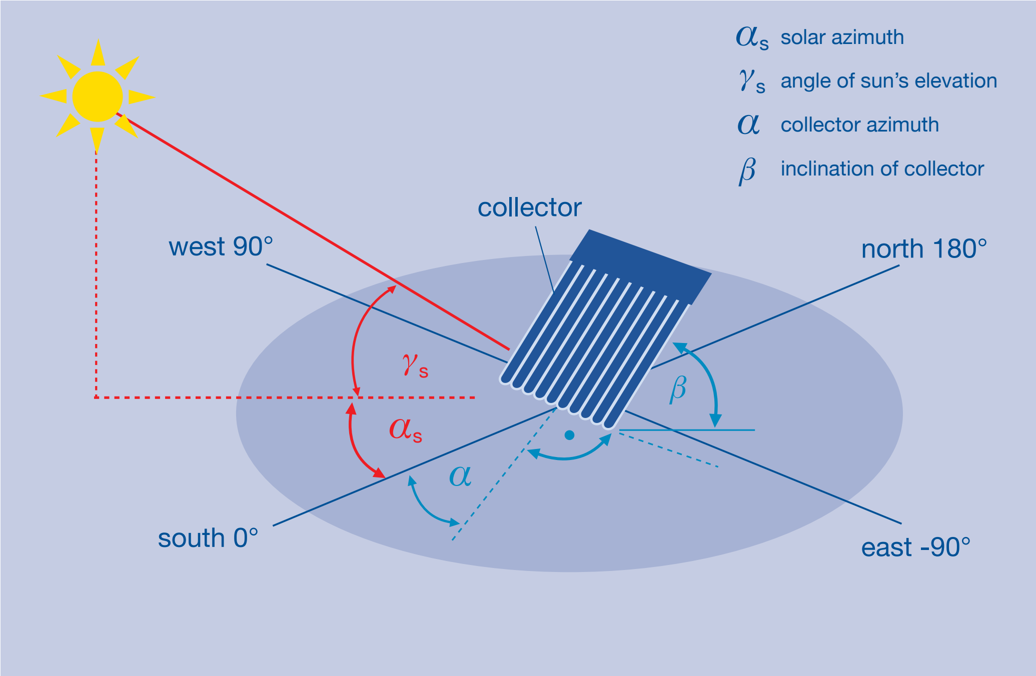


Fig 5. Angle descriptions in solar technology

The collector plane 'A' should be orientated as closely as possible to the south. Collectors can be productive in installations with azimuth angles 'α' up to 45°east or west of south with little variation in system performance, circa 1.5% reduction. Systems that deviate more then 45° will require additional collector area to compensate.

Sun's Height	γ_s	Horizon = 0°	Zenith = 90°	
Azimuth	α	South = 0°	East = -90°	West = 90°
Inclination	β	Horizon = 0°	Zenith = 90°	
Solar Azimuth	α_s	South =0°	East = -90°	West = 90°

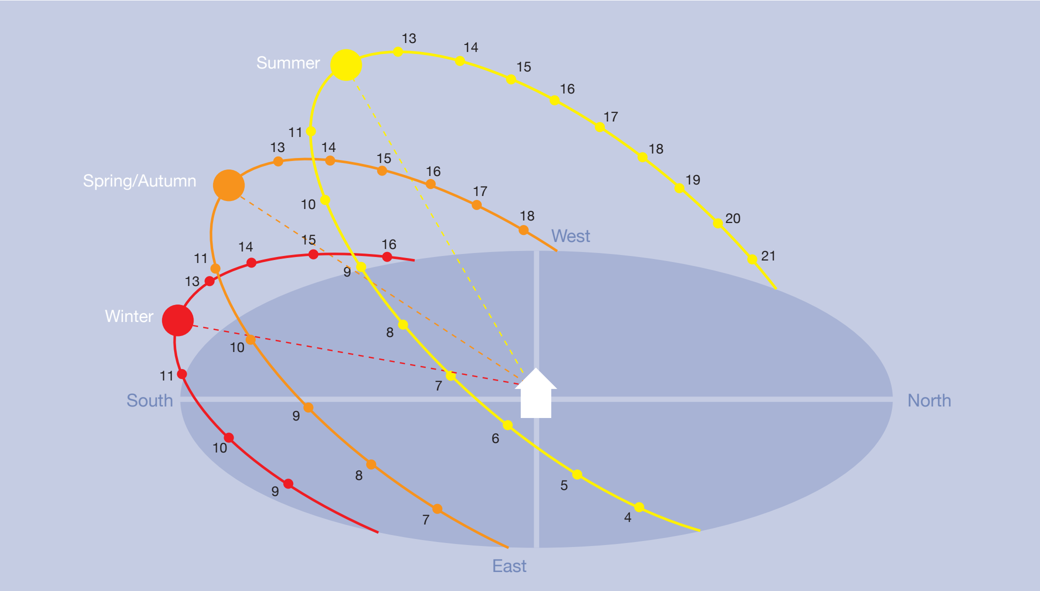


Fig 6. Diagram showing the sun's season trajectory

Influences on the Performance of the Solar System

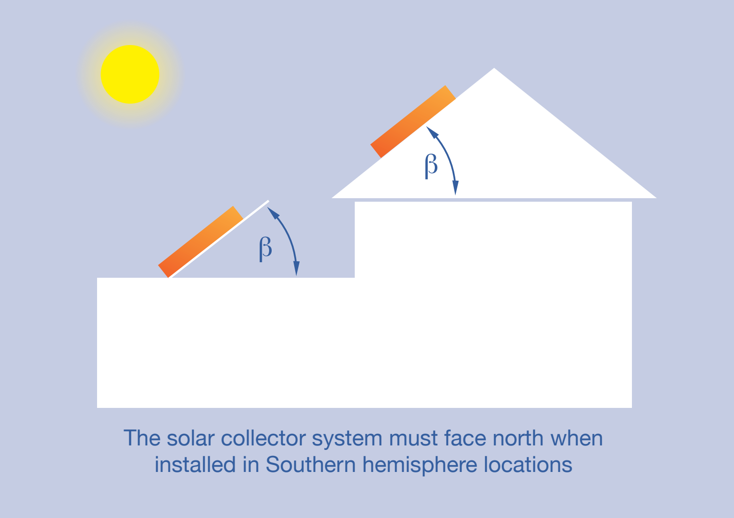


Fig 7. Diagram showing angle of inclination (β)

Angle of Inclination (β):

As the angle of incidence of the sun varies during the year (highest during summer), the maximum radiation yield of the collector can only be achieved if the collector surface is inclined at an angle to the horizontal.

City Location	Latitude (deg)	Angle of Incidence (deg)
Aberdeen	57.17	40.02
Belfast	54.60	38.22
Birr	53.08	37.16
Birmingham	52.47	36.73
Cork	51.85	36.30
Dublin	53.43	37.40
Glasgow	55.88	39.12
Liverpool	53.43	37.40
London	51.50	36.05
Northampton	52.23	36.56
Poole	50.73	35.51
Rosslare	52.25	36.58
York	53.97	37.78

Fig 8. Angle of inclination in relation to location

In Ireland, Dublin has latitude approximately 53.43°N, the optimum angle of inclination is approx 37.4°. As a rule of thumb, the collector should face the Equator and the optimum angle of inclination is approx 0.7 x latitude for domestic water heating. e.g. A European city with a latitude of 50° would require a $\beta = 50 \times 0.7 = 35°$. For space heating, the optimum angle of the collector is equal to the latitude.

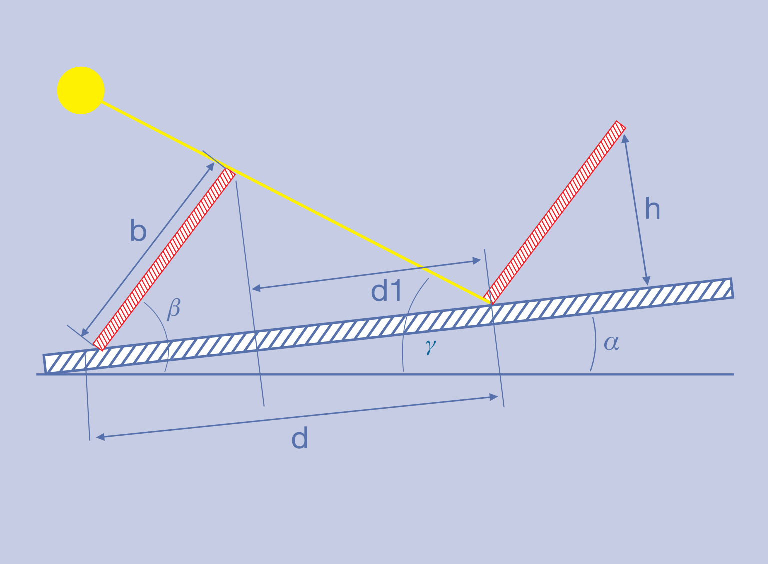
NB: The solar collector system must face north when installed in a Southern hemisphere location.

Influences on the Performance of the Solar System

Shading

Shading will reduce the overall performance of a solar system. During the planning stage of a solar system, consideration should be given to the location of the collectors with the aim of minimising the effects of shading from high buildings, trees, etc.

In addition, when dealing with larger systems with more than one row of collectors, sufficient space between the collector rows should be allowed for.



Reference	Value	Unit
b	2.00	m
h	1.20	m
Beta	37.00	°
Gamma	13.12	°
Gamma at	21.12.12:00	-

Results

Reference	Value	Unit
d	6.75	m
d1	5.16	m

Fig 9. Diagram showing minimum spacing between collectors, data used = Dublin, collectors at 37°

α = Roof pitch
β = Collector inclination + roof pitch
γ = Angle of sun above the horizon
b = Height of solar collector:
Thermomax collectors model DF100 = 1.996m
Thermomax collectors model HP100, HP200 = 2.005m
$d_1 = b \times \sin(\beta - \alpha) / \tan(\gamma - \alpha)$
$d = (b \times \cos(\beta - \alpha)) + d_1$
$h = \sqrt{} b^2 - d^2$

Influences on the Performance of the Solar System

Stagnation

Stagnation occurs when the solar loop does not transfer the energy from the collector during times when there is high solar radiation. Stagnation causes the absorber to heat up to very high temperatures.

The system should be designed so that the occurrence of stagnation should be eliminated or minimised as much as possible.

Typically, stagnation occurs where the solar collector has been over-sized or where the building has long periods of no hot water demand.

It should be noted that irreparable damage will be caused to systems that are exposed to long periods of stagnation. Later in this guide we will explore ways of protecting the solar system from stagnation, these include:

- Controllers with holiday functions
- How to size a solar system correctly
- Using a heat dump or radiator on the system

Collector Types

Kingspan Solar offer 2 types of solar collector: flat panel and evacuated tube collectors.

1) Thermomax FN and FS - Flat Panel Collectors

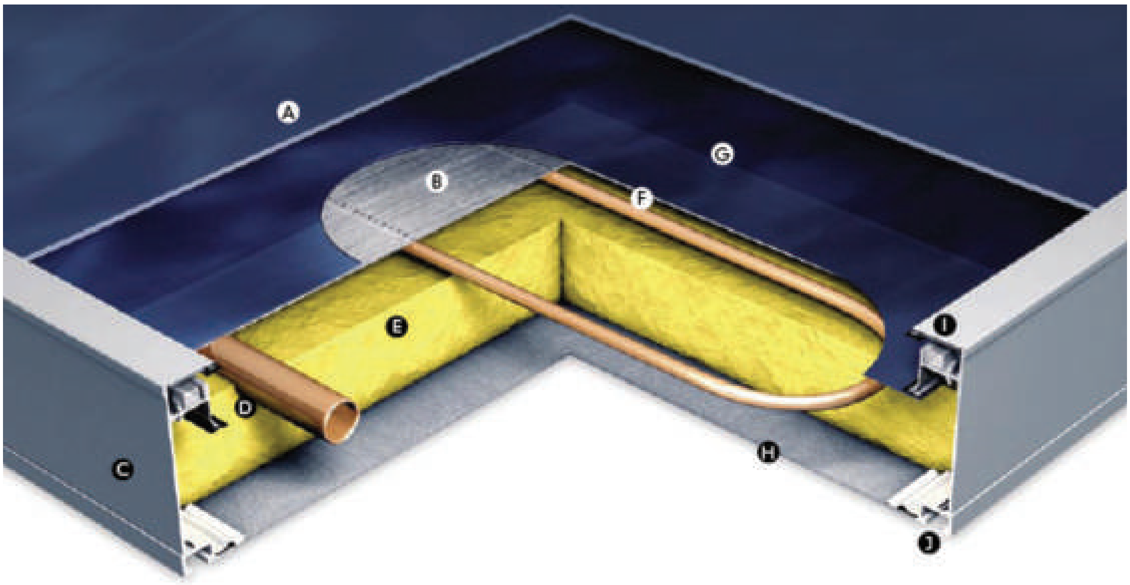


Fig 10. Cross section of flat panel collector

A) Solar glass
B) Cu or Al-absorber sheet
C) Powder-coated aluminium frame
D) Collector pipe
E) Mineral wool insulation
F) Meander tube
G) Higher selective absorber coating
H) Bottom plate made of aluminium
I) Secure glass fixing
J) Revolving groove for assembly

Thermomax FN and **FS** 2m^2 flat plate high performance solar collectors are one of the newest additions to the Kingspan Solar range. The rigorous prevention of thermal bridges allows the highest output levels. The secure glass mount featuring two separate sealing levels made of UV-resistant material guarantee ultimate product reliability and durability. The frame profiles are manufactured from a single piece of high-strength, corrosion-protected aluminium. They are available in anthracite.

Thermomax FN is designed specifically for the Northern European climate, it is ideal for both domestic and commercial use. The new collector housing contains a laser-welded copper absorber with 4 connectors. With an optimised aperture area, the Thermomax FN offers high efficiency and elegant design, as well as simple and flexible installation. Innovative ventilation and drainage design allows the collector to dry out very quickly so it is not adversely affected by wet conditions.

Thermomax FS is specifically designed for the Southern European climate and ideal for domestic use. The new collector housing contains laser-welded Cu or Al absorbers with 2 connectors. The Thermomax FS has a 75mm profile, as compared to conventional collector heights of up to 95mm.

Collector Types

2) Thermomax DF and HP Evacuated Tube Collectors

Vacuum tube collectors perform extremely well when compared to unglazed and glazed collectors, particularly in Northern European countries. Thermomax solar vacuum collectors are the premium product on the market, acknowledged as the most efficient method of generating solar hot water even in cold, wet and windy conditions. This is due to the low thermal losses from the collector.

By creating a vacuum of 10^{-6} bar within the tube, thermal losses caused by conduction and convection are eliminated, this enables the collector to be very effective in utilising low amounts of radiation (diffused radiation).

The tube is made from glass with unique properties that gives it good transmissibility with low reflection losses and good durability.

High absorption of solar energy is achieved by using an absorber. The main assembly parts of the absorber are the absorber plate and the heat transfer tube.

The absorber plate is coated with a special high efficiency selective coating that ensures maximum radiation absorption and minimum thermal radiation losses.

Thermomax offer 3 models of evacuated tube collectors:
DF100
HP100
HP200

Collector Types

(1) The DF100 Collector

This collector is a direct flow type collector. The heat medium to be heated is passed down through the collector tube within a coaxial heat exchanger.

This product can be installed on a pitched or horizontal surface, and the tube can be rotated 25° to compensate for installations that deviate from south. As this collector is a fully pumped unit there is no minimum angle of inclination for the collector.

DF100 collectors are available in 3 sizes:

10 Tube = 1.08m^2 aperture area
20 Tube = 2.16m^2 aperture area
30 Tube = 3.23m^2 aperture area

Up to a maximum of 5 x 30 tubes collectors can be joined together in series with a flow rate of 15 Ltrs/min.

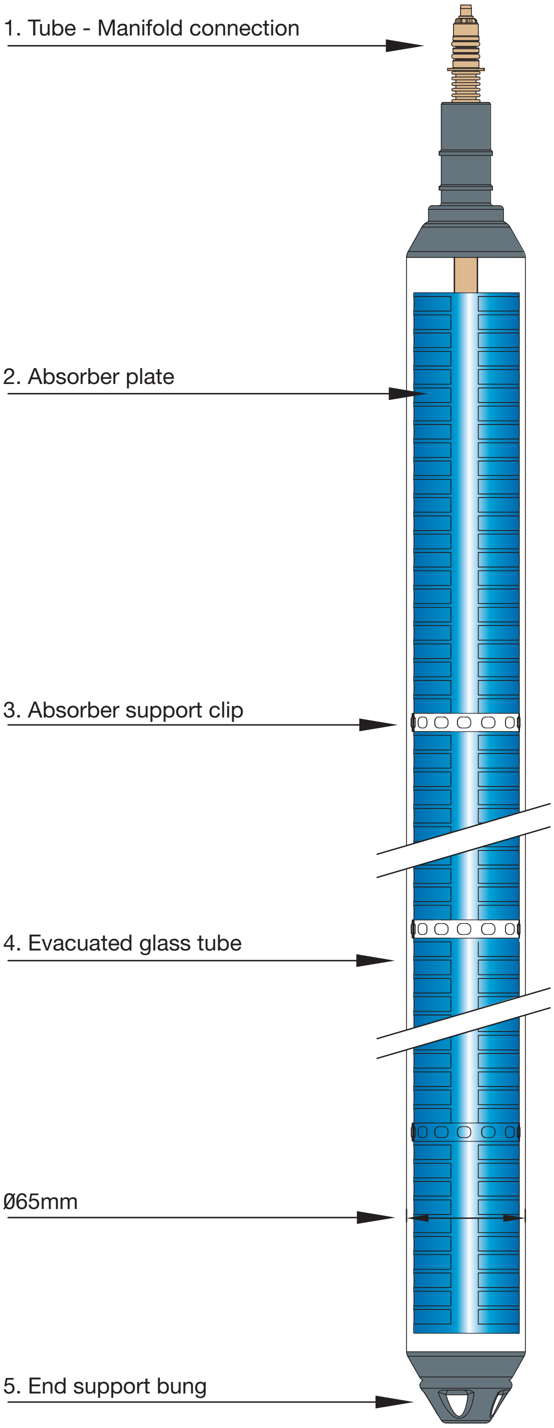


Fig 11. DF100 collector elements

Collector Types

(2) The HP100 Collector

This collector is a ‘wet’ heat pipe product. In this collector, the heat pipe is attached to the back of the absorber plate. Evaporator fluid is contained within the heat pipe. The energy absorbed by the absorber causes the fluid to change from a fluid state to a vapour state and the vapour rises to the condenser bulb. The condenser is connected directly into the HP100 manifold where the solar system solution is passed directly across the condenser.

The condenser releases the latent heat of evaporation to the solar system solution and condenses, the condensate returns to the heat pipe and the cycle is repeated.

HP100 collectors are available in 2 sizes:

20 Tube = 2.16m^2 aperture area
30 Tube = 3.24m^2 aperture area

Up to a maximum of 6 x 30 tubes collectors can be joined together in series with a flow rate of 18 Ltrs/min.

The Kingspan HP range of collectors contain a unique safety device. A temperature limiter is fitted within the condenser bulb, this limiter has two rated temperatures, 95°C or 130°C. When activated the limiter prevents the condensate from entering the heat pipe from the condenser, in turn preventing unwanted conduction of energy through the system from the collectors.

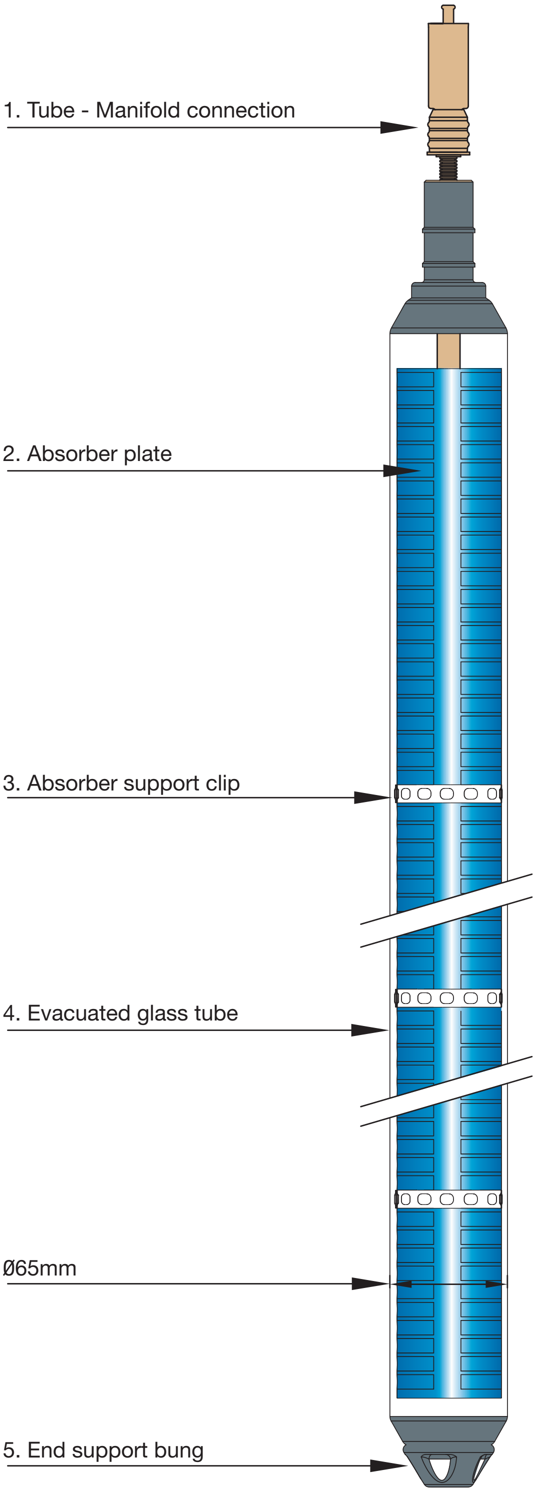


Fig 12. HP100 collector elements

Collector Types

(3) The HP200 Collector

This collector is a ‘dry’ heat pipe product. In this collector, the heat pipe is attached to the back of the absorber plate. Evaporator fluid is contained within the heat pipe.

The energy absorbed by the absorber causes the fluid to change from a fluid state to a vapour state and the vapour rises to the condenser bulb.

The condenser is connected directly into the manifold via a dry pocket. Within the manifold the solar system solution is passed across the dry pocket that houses the condenser.

The condenser releases the latent heat of evaporation to the solar system solution and condenses, the condensate returns to the heat pipe and the cycle is repeated.

Due to the dry connection the HP200 tubes can be replaced without the need of draining down the solar system.

HP200 collectors are available in 3 sizes:

10 Tube = 1.08m^2 aperture area
20 Tube = 2.16m^2 aperture area
30 Tube = 3.24m^2 aperture area

Up to a maximum of 4 x 30 tubes collectors can be joined together in series with a flow rate of 12 Ltrs/min.

The Kingspan HP range of collectors contain a unique safety device. A temperature limiter is fitted within the condenser bulb, this limiter has two rated temperatures, 95°C or 130°C. When activated the limiter prevents the condensate from entering the heat pipe from the condenser, in turn preventing unwanted conduction of energy through the system from the collectors.

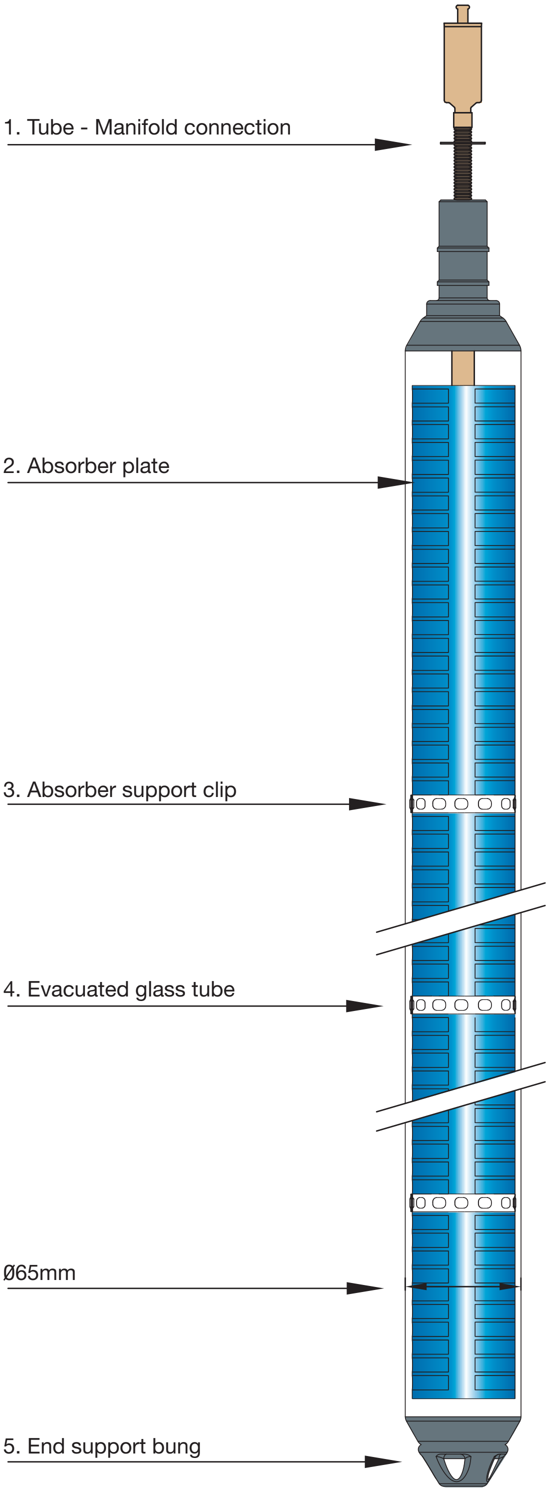
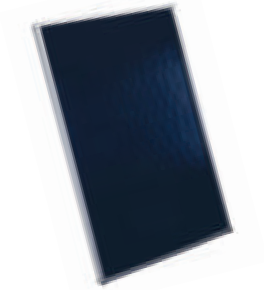


Fig 13. HP200 collector elements

Collector Types

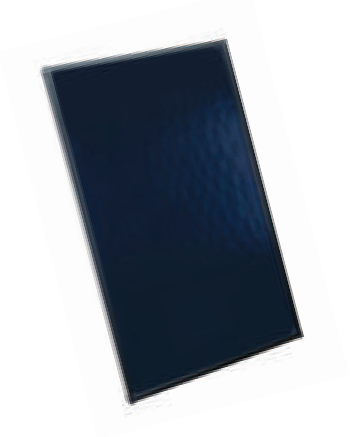
Kingspan Solar - Thermomax Solar Collector Range

THERMOMAX FN Flat Panel



Collector Type	Flat Panel
Model	FN 2.0
Gross Area (m^2)	2.15
Aperture Area (m^2)	2
Dimensions	W - 1150mm H - 1870mm D - 95mm
Weight (kg) (Dry)	35

THERMOMAX FS Flat Panel



Collector Type	Flat Panel
Model	FS 2.0
Gross Area (m^2)	2.15
Aperture Area (m^2)	2
Dimensions	W - 1150mm H - 1870mm D - 75mm
Weight (kg) (Dry)	34

THERMOMAX Evacuated Tube Collectors

Product	Collector Type	Model	Gross Area (m^2)	Aperture Area (m^2)	Dimensions			Weight (kg) (Dry)
					W(mm)	H(mm)	D(mm)	
Thermomax DF100	Direct Flow Vacuum	10 Tube	1.44	1.02	709	2127	97	25
		20 Tube	2.83	2.153	1418	2127	97	55
		30 Tube	4.245	3.228	1996	2127	97	81
Thermomax HP100	Wet Heat Pipe	20 Tube	2.843	2.157	1418	2005	97	50
		30 Tube	4.28	3.237	2127	2005	97	76
Thermomax HP200	Dry Heat Pipe	10 Tube	1.4	1.079	709	2005	97	25
		20 Tube	2.843	2.157	1418	2005	97	50
		30 Tube	4.265	3.229	2127	2005	97	75

Fig 14. Collector types

Collector Efficiencies

All solar collector systems have the sun as a common energy source. The performance depends therefore on the conversion of the solar radiation into useful thermal energy and to transfer it to the hot water system.

The ability to convert solar energy into thermal energy is expressed by the optical efficiency of the system η^0.

It is accepted practice within the European solar industry to quote efficiencies based upon the aperture area of the collector and the SEI (Harp) database utilises the performance figures based upon the aperture area.

	Aperture				Absorber			
Model	Area (m^2)	η_0	a1 (W/m^2K)	a2 (W/m^2K^2)	Area (m^2)	η_0	a1 (W/m^2K)	a2 (W/m^2K^2)
DF100-2m^2	2.153	0.773	1.43	0.0059	2.004	0.830	1.53	0.0063
DF100-3m^2	3.228	0.779	1.07	0.0135	3.020	0.832	1.14	0.0144
HP100-2m^2	2.158	0.758	1.02	0.0099	2.006	0.815	1.10	0.1060
HP100-3m^2	3.237	0.739	1.00	0.0074	3.009	0.795	1.07	0.0080
HP200-2m^2	2.157	0.738	1.17	0.0082	2.010	0.792	1.25	0.0088
HP200-3m^2	3.229	0.727	0.85	0.0093	3.021	0.778	0.91	0.0100

Fig 15. Results obtained when the products were tested according to EN12975-2:2006

The efficiency of the collectors are compared by using the following formula:

$$\eta(T_m) = \eta_0 - a_1 T_m - a_2 G T_m^2$$

$$T_m = (t_m - t_a)/G$$

Collector Efficiencies

Compare $\eta(T_m) = \eta_0 - a_1 T_m - a_2 G T_m^2$ $T_m = (t_m - t_a)/G$

Collector Make	Type	η_o	a1	a2	G	I ambient
			W/(m²K)	W/(m²K)	W/m²	°C
HP200 - 30	Tubes	0.727	0.85	0.0093	800	20
HP100 - 30	Tubes	0.739	1	0.0074	800	20
DF100 - 30	Tubes	0.779	1.07	0.0135	800	20
FN 2.0	Flat Panel	0.775	3.73	0.0152	800	20

Collector Efficiency and Performance Calculator

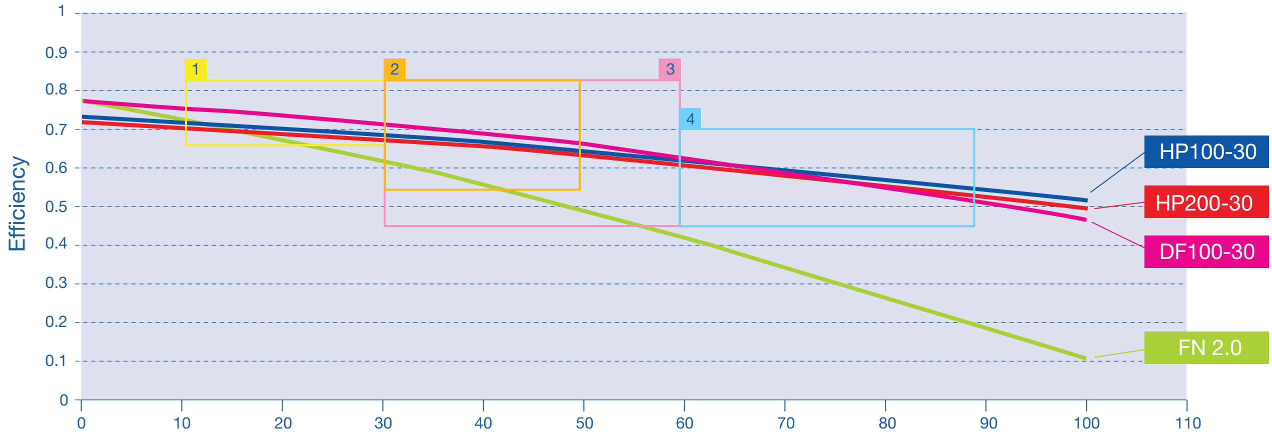


Fig 16. Collector efficiency graph

1 = Solar heated DHW at low coverage
2 = Solar heated DHW at high coverage
3 = Solar heated DHW with solar assisted central heating
4 = Process applications, e.g. solar assisted cooling, desalination etc.

System Sizing

When sizing a solar system for domestic hot water, we typically will size the system to achieve an annual solar fraction of between 55 – 60%.

A correctly sized domestic system would see the following solar contribution over a year:

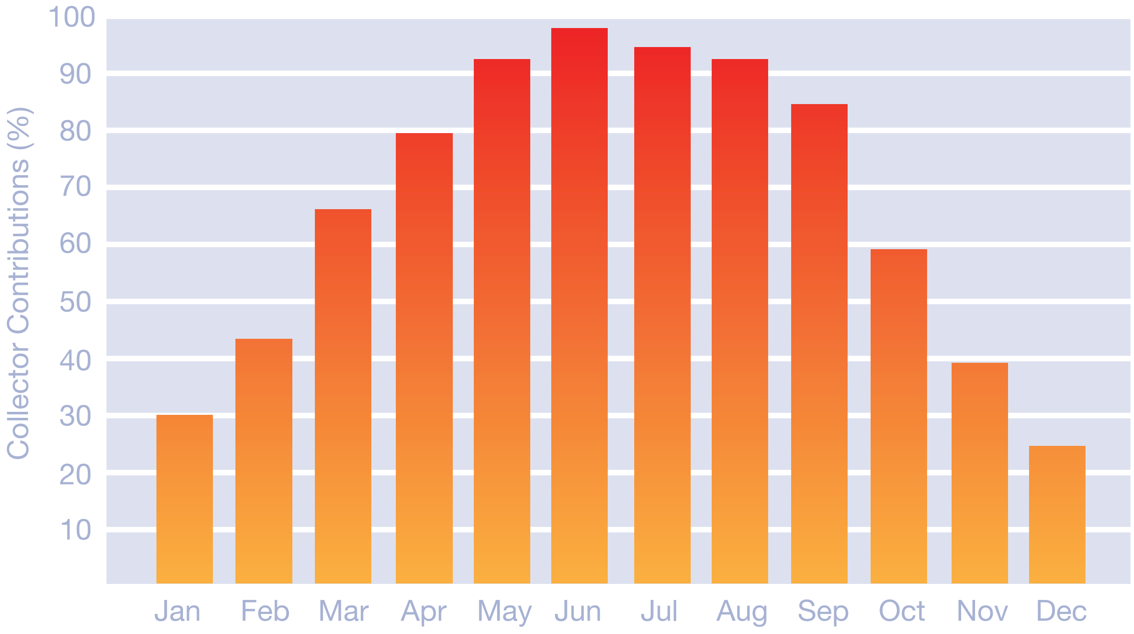


Fig 17. Annual solar collective contribution

It should be noted that minimising the risk of stagnation must be considered when sizing a solar system. The system must not be oversized.

The following diagram outlines the steps involved in correctly sizing a solar system:

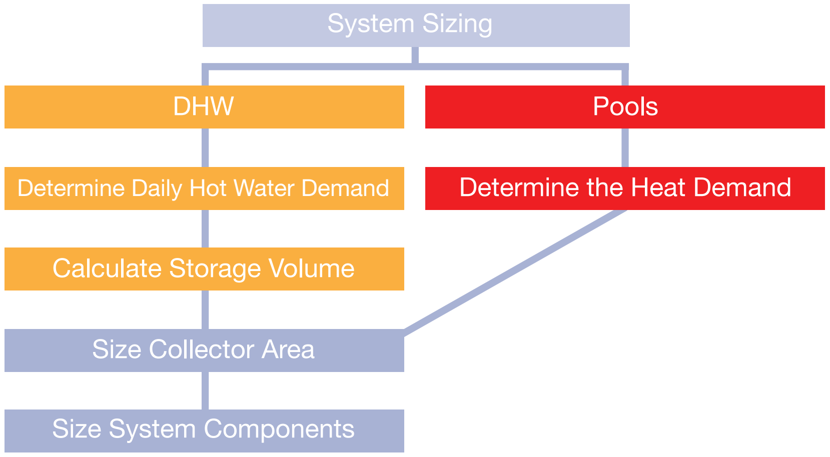


Fig 18. Steps to size a solar system

System Sizing

(a) Determine the Daily Hot Water Demand
Ideally the hot water demand value should be provided through proper metering, however, where this is not possible, the daily demand should be estimated using the following tables:

Standard Consumption	Hot water requirement per day and person at a temperature of 60°C
Low demand	10-20 Ltr
Medium demand	20-40 Ltr
High demand	40-80 Ltr

Fig 19. Domestic hot water requirement

Consumption Type	Hot water requirement per day and person at a temperature of 60°C (Ltr)	
	Average	From - To
Retirement home	45	30 - 65
Kitchen - breakfast	2	2 - 3
Kitchen - noon/evening	5	4 - 8
Swimming pool - public/private	40/20	
Sauna - public/private	70/35	
Hospital	80	60 - 120
Sports facilities - total		35 - 50
Sports facilities - showers	25	20 - 30
Hotel (** - ***)	50	30 - 80
Hotel (**** - *****)	80	80 - 150
Guest house, inn	30	20 - 50
Holiday house	40	30 - 50
Camping site	20	15 - 35
Youth hostel, holiday hostel	20	15 - 30
Student hall of residence	25	15 - 60

Fig 20. Typical domestic hot water demand

Example: Sizing a flat panel collector for a 4 person domestic household
From Fig 19, medium demand = 40 Ltr/person/day
Total daily demand = 40 x 4 = 160 Ltr/day

System Sizing

(b) Calculate the Hot Water Heat Requirement

The amount of energy to heat the daily hot water demand (Q_{HW}) is calculated using the formula:

$$Q_{HW} = Volume\ of\ Daily\ DHW\ x\ Cw\ x\ (\Delta T)$$

Volume of Hot Water = From Fig 19
Cw = Specific heat capacity of water (1.16 Wh/kgK)
ΔT = Temperature difference between cold water temperature and desired water temperature

Continuing example of 4 person domestic household:

$$Q_{HW} = 160\ x\ 1.16\ Wh/kgK\ x\ (60\text{-}10) = 9280Wh = 9.28kWh$$

Therefore the heat requirement = 9.28 kWh/day

(c) Calculate the Storage Volume

For domestic solar systems typically the storage volume of the cylinder should be equal to 2 times the daily hot water demand.

To correctly size the storage volume the following formula should be used:

$$Vcyl = \frac{2.Vn.P.\,(Th - Tc)}{(Tdhw - Tc)}$$

Vcyl = Minimum volume of cylinder (Ltr)
Vn = DHW demand per person/day (Ltr)
P = Number of people
Th = Temperature of hot water at outlet (°C)
Tc = Temperature of cold water
Tdhw = Temperature of stored water

System Sizing

Again, continuing the example of the 4 person domestic household:

$$V_{cyl} = \frac{2.40.4.(45-10)}{(60 - 10)} = 224\ Ltr$$

The cylinder size is rounded up to the nearest available size, in this case = 250 Litres

(d) Sizing the Collector Area

To size the required collector area the following formula is used:

$$A_R = \frac{ED}{SC}$$

Expanding this formula:

$$A_R = \frac{No.\ of\ Days\ x\ Q_{HW}\ x\ Solar\ Fraction}{Yearly\ Solar\ Irradiation\ x\ Av.\ System\ Eff.}$$

The yearly solar irradiation value can be seen in the table below:

Location	Annual Irradiation (kWh/m²a)	Mean Outside Temperature (°C)	Longitude (°)	Latitude (°)
Belmullet	913	9.8	9.00	54.23
Birr	900	9.3	7.90	53.08
Casement	948	9.7	6.43	53.30
Claremorris	912	8.9	8.98	53.72
Clones	900	8.8	7.23	54.18
Connaught	910	7.8	8.82	53.90
Cork	976	9.4	8.48	51.85
Dublin	949	9.5	6.23	53.43
Kilkenny	976	9.4	7.27	52.67
Mulingar	922	9.1	7.37	53.53
Roches Point	975	10.4	8.25	51.80
Rosslare	990	10.1	6.33	52.25
Valentia	983	10.7	10.25	51.93

Fig 21. Annual irradiation values for Ireland

Alternatively, for more information go to the PVGIS web page:
http://re.jrc.ec.europa.eu/pvgis/apps/radmonth.php?lang=en&map=europe

System Sizing

System Efficiency

The system efficiency is strongly dependent on the solar fraction of the system. When there is a high solar fraction the system efficiency is lower.

High solar fractions result in a higher return temperature to the solar collector, the effect of this is that less solar irradiation can be absorbed by the collector, hence reducing the system efficiency.

In undersized systems with small collector areas, the solar fraction is low but the system efficiency is high. In oversized systems with large collector areas the solar fraction is high but the system efficiency is low.

The counter effect of the 2 variables can be seen in Fig 22 below:

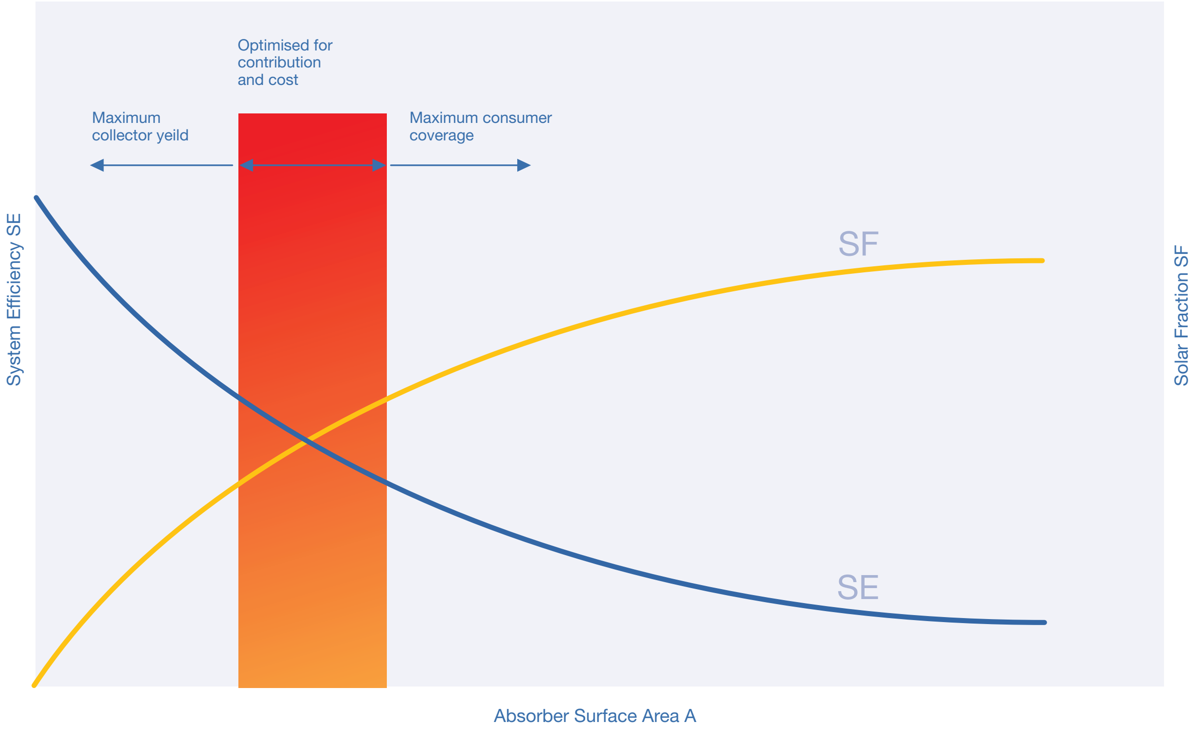


Fig 22. Relationship between solar fraction and system efficiency

Returning to the example of the 4 person domestic household:

$$A_R = \frac{365 \times 9.28 \text{ (from (b) page 21) } \times 60}{949 \text{ (Dublin) } \times 55}$$

A_R (collector area) = 3.89m^2 flat panel collector

Nearest size = 2 x 2m^2 collectors = 4m^2

System Sizing

To simplify the selection of collector area, the following graphs have been created to quickly determine the correct collector size for UK and Ireland.

If the same daily DHW demand was required using an evacuated tube collector, from Fig 24 below we would see a collector area of 3m^2 for a solar fraction of 60%.

Important

For Thermomax evacuated tube collectors we recommend a minimum cylinder storage of 100 Ltrs per m^2 of collector area, in this case:

System sized as 3m^2 of tube, therefore the cylinder volume should not be less than 3 x 100 Ltrs = 300 Ltrs.

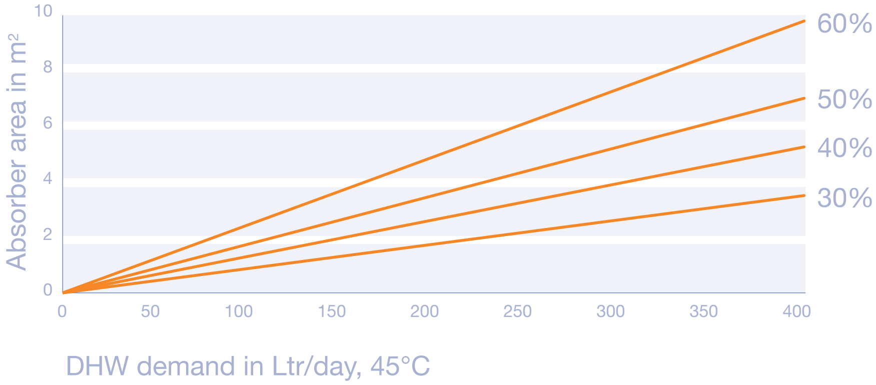


Fig 23. Thermomax FN 2.0 flat panel collectors

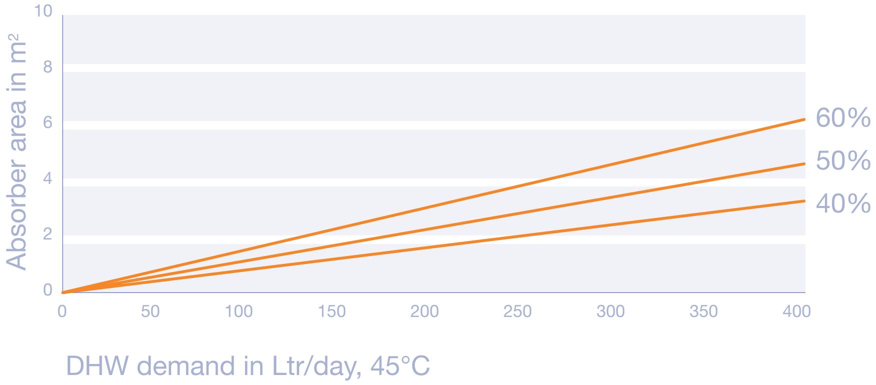


Fig 24. Thermomax DF & HP evacuated tube collectors

System Sizing

System Flow Rates

The specific flow rate per tube (V_T) lies in the range of $0.1 \leq V_T \leq 0.25$ (Ltr/min/tube). We recommend that a minimum flow rate of 60 Ltr/hour/m^2 is used for pipe sizing.

Collection Area (m^2)	Flow Rate (Ltr/min)
2	2.0 - 5.0
3	3.0 - 7.5
4	4.0 - 10.0
5	5.0 - 12.5
6	6.0 - 15.0
7	7.0 - 17.5
8	8.0 - 20.0
9	9.0 - 22.5

Fig 25. Flow rate as function of collector area

The volumetric flow rate should be sized to ensure that it is large enough to cool the solar collector sufficiently, this will result in higher system efficiencies.

To calculate the flow rate we use the following formula:

$$m = \frac{Q}{\mathrm{Cgw}\ .\Delta\Theta}$$

m = Volumetric flow rate
Q = Solar irradiance x collector efficiency W/m^2
Cgw = Specific heat capacity of solar liquid. (Tyfocor LS = 0.98 Wh/kg K)
$\Delta\Theta$ = 10 K

$$m = \frac{1000 \text{ x } .779 \text{ (DF100 - 30Tube)}}{0.98 \text{ x } 10}$$

m = 79 Ltrs/m^{2}h
m for 30 tubes = 3.95 Ltrs/min

System Sizing

Pipework and Pipework Sizing

Suitable Materials

The following piping materials are suitable for use in a solar system:

- Black steel pipe (a.k.a. gun barrel)
- Copper tubing
- Stainless steel tubing

Insulation

The insulation has to be UV stable where exposed to the sunlight and has to be resistant to high temperatures in excess of 170°C. To prevent high heat losses through the pipework it is recommended to use insulation with a minimum thickness equal to half the pipe diameter and an U value in [W/(mK)] of $U \leq 0.035$ [W/(mK)].

It should be noted that REIA recommend an insulation thickness equal to 100% of the internal diameter.

Unsuitable Materials

We do not recommend the use of the following material to be used in solar systems:

- Plastic pipes (PEX)
- Multi-layer aluminium / plastic pipes (ALU-PEX)
- Galvanised metal pipes

Suitable Fittings

- Compression fittings
- Press fittings (with gasket rated for temperatures above 150°C)
- Brazed fittings
- Fittings supplied with solar stainless steel tubing, i.e. Waterway, Aeroline etc.

Note: The use of solder ring fittings on copper pipework is not recommended.

On long pipework, runs allowances should be made for expansion in the pipework, please see Fig 26 below.

Temperature Raise (°C)	Steel Pipe Expansion (mm/m)	Copper Expansion (mm/m)
50	0.48	0.66
100	1.08	1.49
120	1.32	1.83

Fig 26. Pipe expansion due to temperature

System Sizing

Pipework Sizing

For pipe sizing we recommend a minimum flow rate of 60 Ltrs/hr/m^2 is used.
i.e. a DF100-30 tube system = 60 Ltrs/hr x 3m^2 = flow rate = 180 Ltrs/hour.

In order to minimise the pressure drop through the solar pipework, we recommend that the flow velocity through the solar pipework should not exceed 1 m/s.

Ideally flow velocities between 0.4 and 1m/s should be used, resulting in a pressure drop of between 1 and 2.5 mbar/m pipe length.

The required internal diameter of the pipework can be sized using the following equation:

$$\phi i = 4.6\sqrt{\frac{Vs}{\nu}}$$

Where:
ϕi = Internal diameter (mm)
Vs = System flow rate (Ltr/min)
ν = Velocity of fluid (m/s)

Example:
DF100, 30 tube collector

$$\phi i = 4.6\sqrt{\frac{3}{1}}$$

= 8mm internal pipework

Pipework with an outside diameter of less than 15mm should never be used, in this example we would increase pipe size from 8mm to 13mm (= 15mm OD pipe with a 1mm wall thickness).

Fig 27 below shows recommended pipe sizing for typical domestic systems.

Collector Area (m^2)	Flow Rate Ltr/hr	Pipe Diameter Copper External (mm)	DF100 (mbar)	Collector Pressure Drop HP100 (mbar)	HP200 (mbar)
2	120	15 x 1	8.54	1.18	4.11
3	180	15 x 1	12.57	2.87	10.47
4	240	15 x 1	17.08	2.36	8.22
5	300	22 x 1	21.11	4.05	14.58
6	360	22 x 1	25.14	5.74	20.94
8	240	22 x 1	33.68	6.92	25.05

Fig 27. Typical domestic pipe sizing

System Sizing

Pump Sizing

To size the solar pump correctly the system flow rate and the total pressure drop across the solar system should be known.

From previous we know the minimum flow rate should be 60Ltr/hr/m^2.

The pressure drop across the collectors can be estimated from the following graphs:

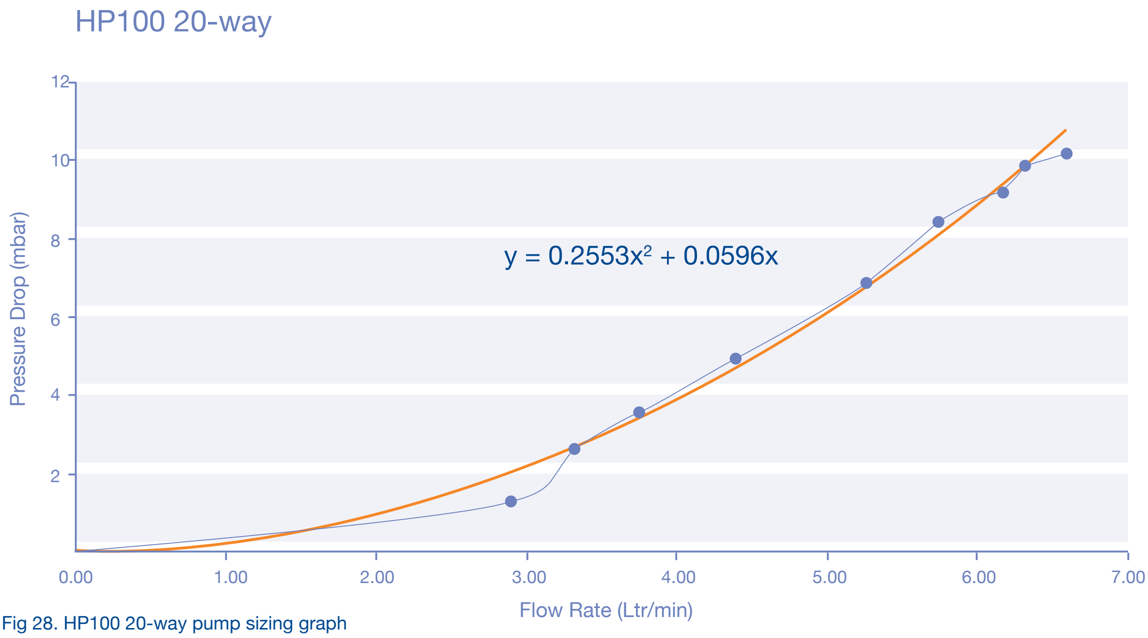


Fig 28. HP100 20-way pump sizing graph

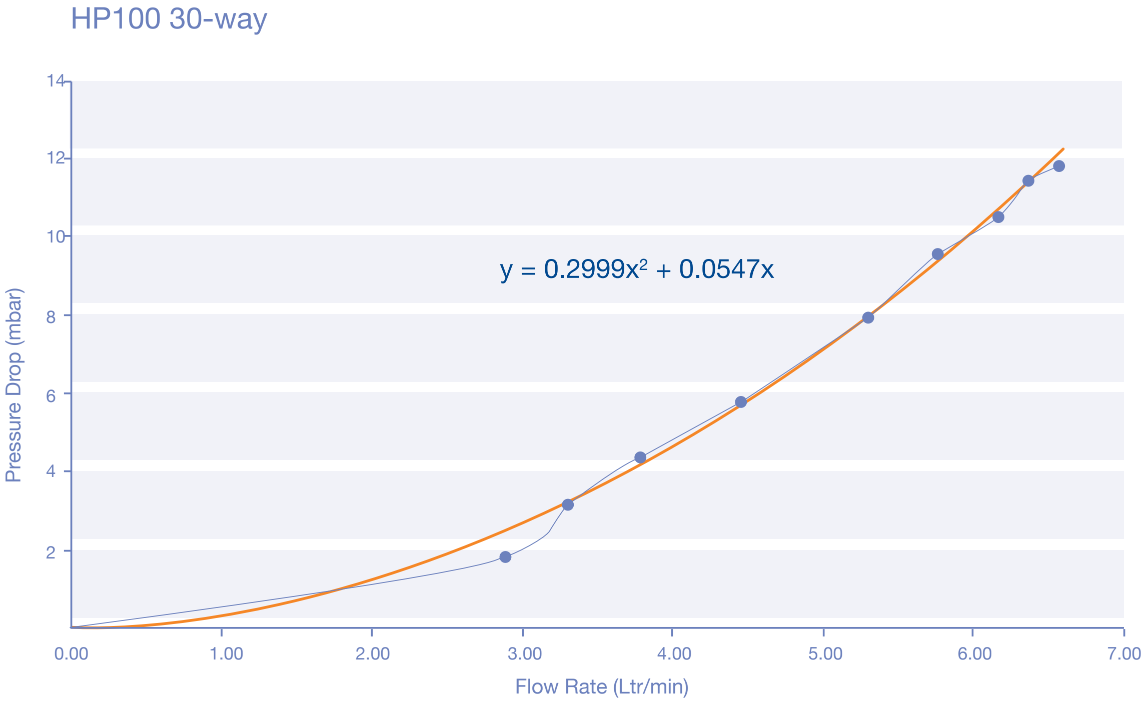


Fig 29. HP100 30-way pump sizing graph

System Sizing

HP200 20-way

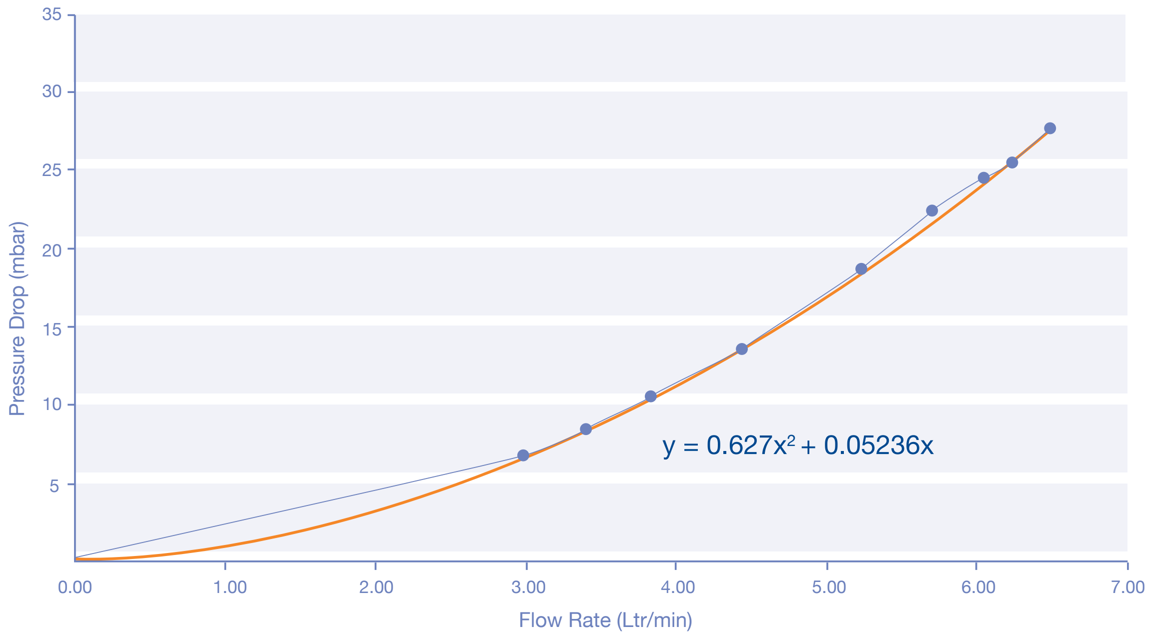


Fig 30. HP200 20-way pump sizing graph

HP200 30-way

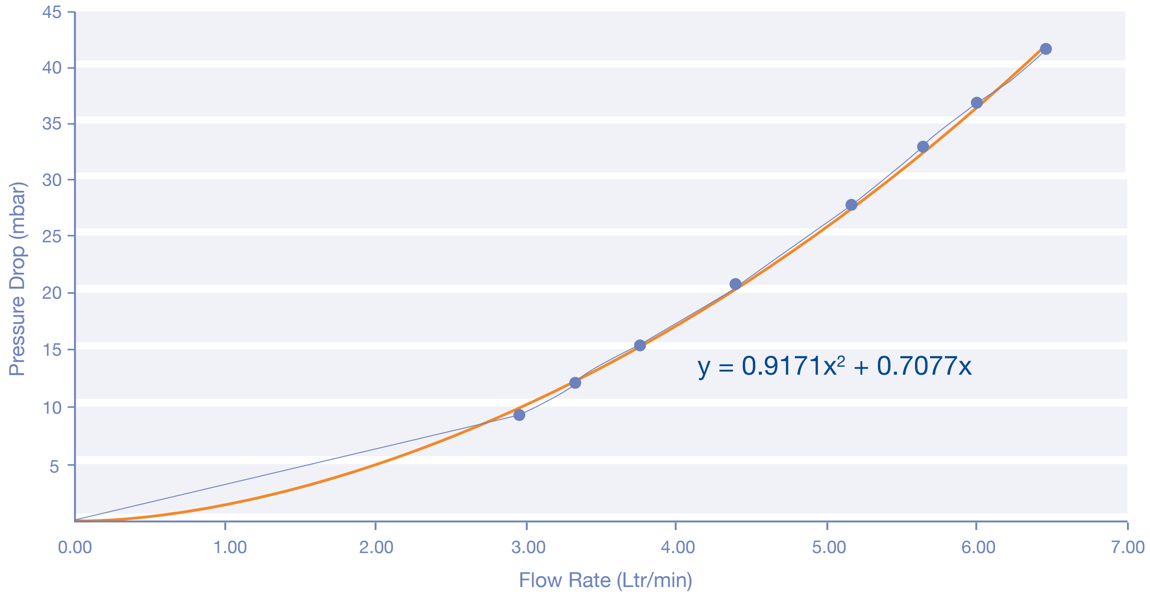


Fig 31. HP200 30-way pump sizing graph

System Sizing

DF100 20-way

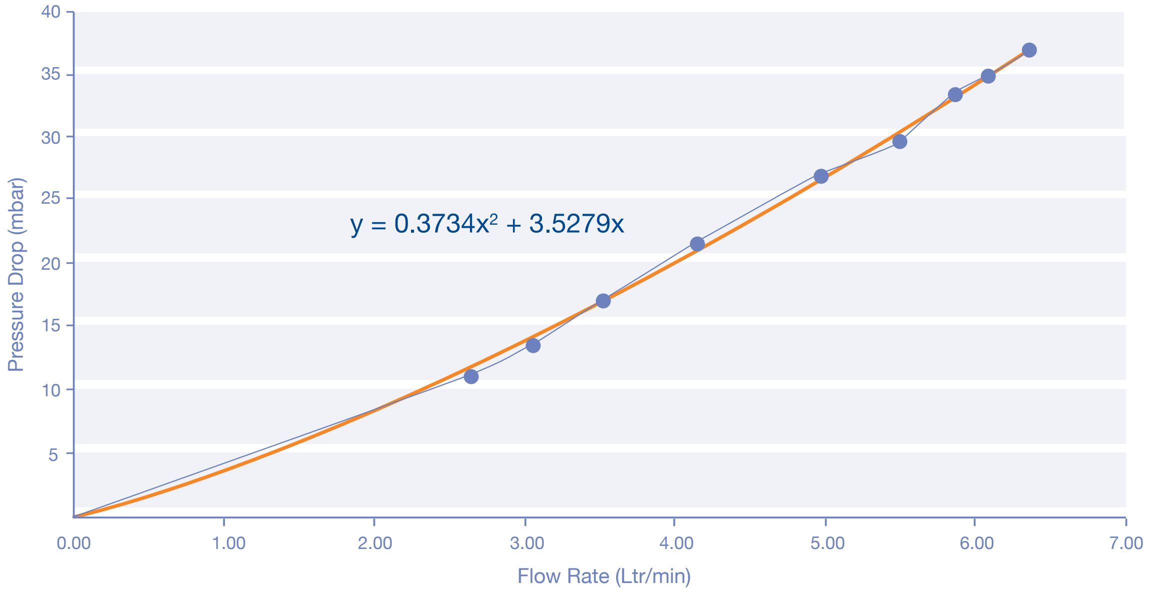


Fig 32. DF100 20-way pump sizing graph

DF100 30-way

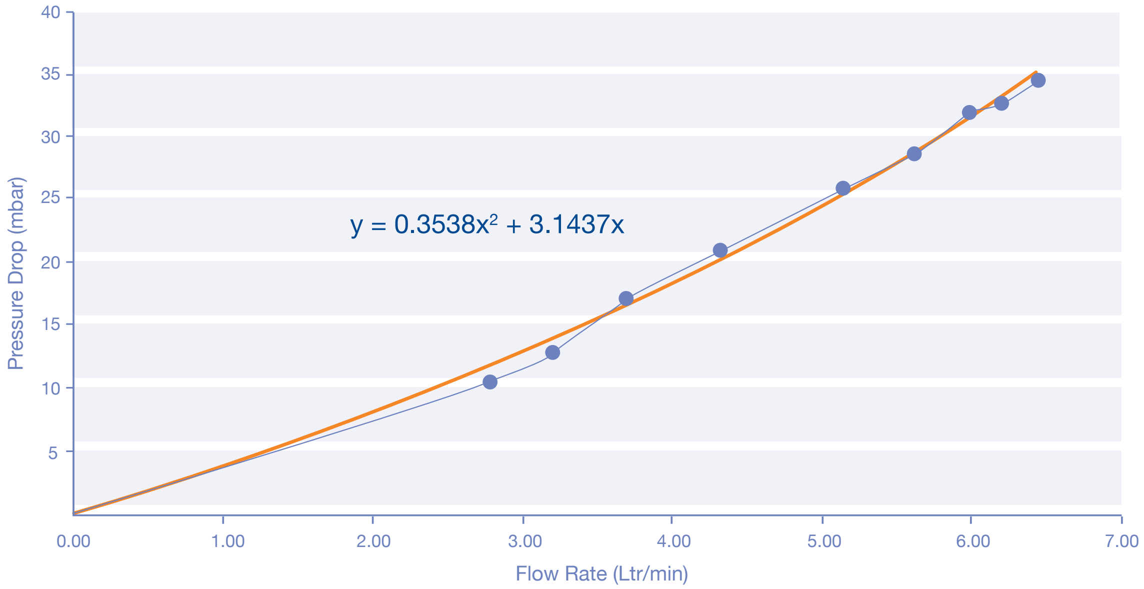


Fig 33. DF100 30-way pump sizing graph

System Sizing

For system flow rates higher then those shown on the previous graphs, i.e. for large collector areas, the following formula can be used:

Collector	Equation
DF100 20-way	$\Delta P = 0.37q^2 + 3.53q$
DF100 30-way	$\Delta P = 0.35q^2 + 3.14q$
HP100 20-way	$\Delta P = 0.255q^2 - 0.06q$
HP100 30-way	$\Delta P = 0.3q^2 + 0.055q$
HP200 20-way	$\Delta P = 0.637q^2 + 0.52q$
HP200 30-way	$\Delta P = 0.917q^2 + 0.708q$

Fig 34. Formula for calculating collector pressure drops

ΔP = collector pressure drop (mbar)
q = flow rate (Ltrs/min)

The total pressure drop of the index run =
$\Delta P_s = (n_{20} \times \Delta P_{c20}) + (n_{30} \times \Delta P_{c30}) + \Delta P_p + \Delta P_{he}$

Where:

ΔP_s = Total pressure drop on index run (mbar)
n_{20} = Number of 20 tubes in series on index run
ΔP_{c20} = Pressure drop on tube 20 collector (mbar) (see Fig 27 or 34)
n_{30} = Number of 30 tubes in series on index run
ΔP_{c30} = Pressure drop on tube 20 collector (mbar) ((see Fig 27 or 34)
ΔP_p = Pressure drop on index run pipework (mbar)
ΔP_{he} = Pressure drop on heat exchanger (mbar)

Units

1m (water) ≈ 100mbar
1 Ltr/min = 0.06 m^3/hr

System Sizing

Kingspan solar offer 3 standard pump kits, larger units are available upon request.

The flow rate as calculated previously should be plotted on the pump performance graphs below. Particular attention should be given to the residual head of the pump (y-axis), and this figure should be greater then the ΔP_S as calculated before.

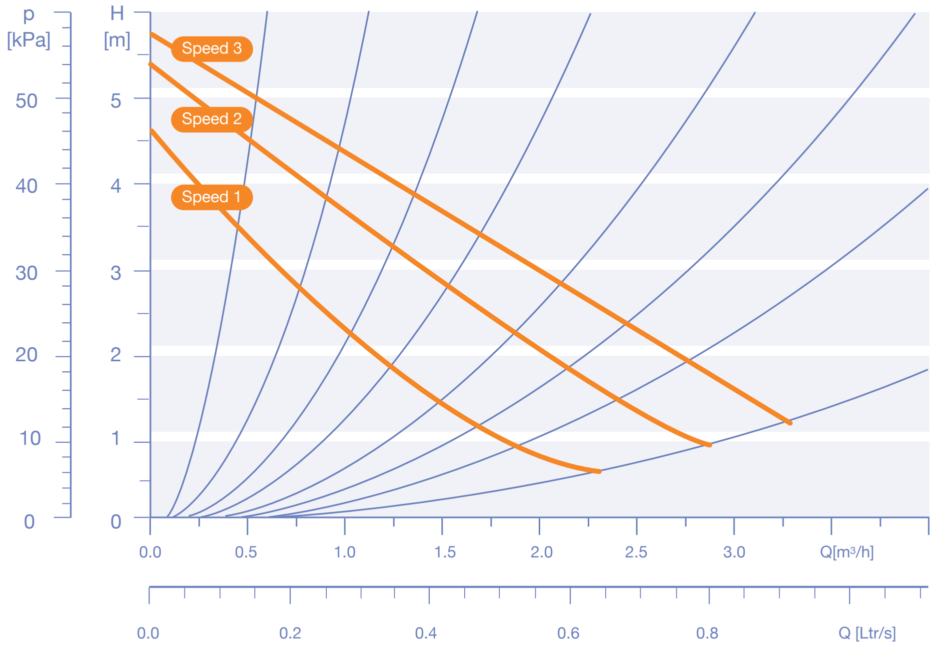


Fig 36. Graph for pump kit KSP0019 and KSP0025

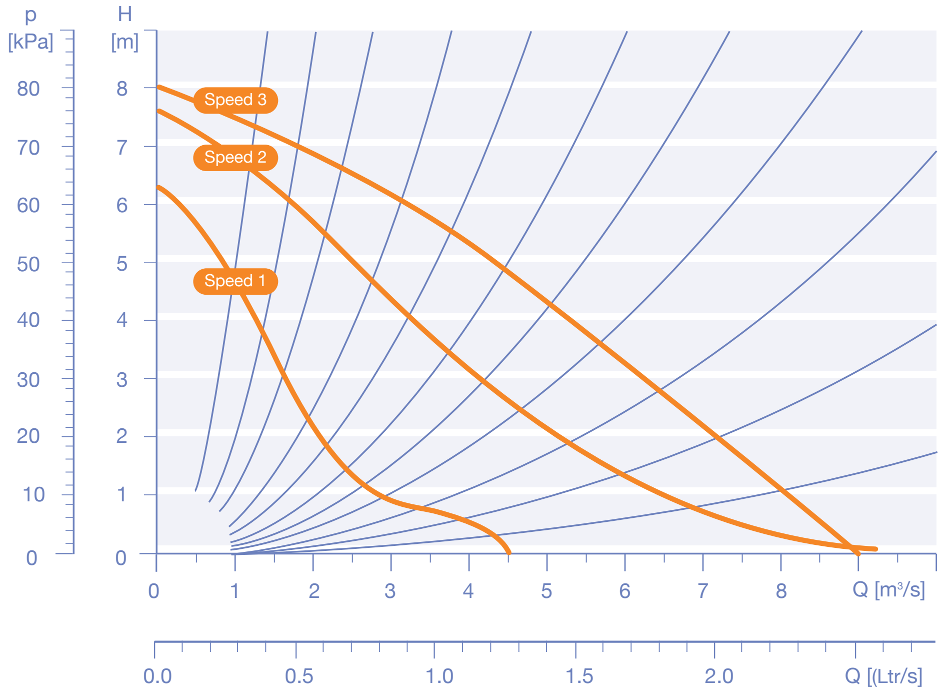


Fig 37. Graph for pump kit KSP0020

System Sizing

Expansion Vessel Sizing

The function of an expansion vessel in a solar system is to absorb the volume increase in the solar liquid when it is heated and return it back to the system when it cools down. Care should be taken to ensure the expansion vessel is sufficiently large enough to accommodate the content of the collector when steam forms (stagnation), this is to ensure that no heat transfer medium can escape from the safety valve.

To size the expansion vessel we use the following equation:

$$V_{EV} = (V_V + V_D + \beta V_T)\left(\frac{P_e + 1}{P_e - P_0}\right)$$

Where:

V_V = Safety seal (minimum volume of fluid in EV)
V_D = Collector volume (Ltr) in case of stagnation
β = Expansion coefficient of heat transfer fluid
V_T = Total system volume
P_e = Pressure relief valve rating – 10%
P_0 = Minimum functioning pressure of system

Kingspan Solar recommend the following values

V_v = Safety seal of expansion vessel = 3 litres
V_D = Collector volume (from Fig 38 overleaf) + 10%
β = Tyfocor LS, from 20 - 120°C = 7.15%, for sizing we recommend 8.5%
P_0 = Initial cold fill of system, this should be 1 bar + 0.1bar / m static height
P_e = Safety valve rating typically 6 bar – 10% = 5.4bar
V_T = Volume of collectors + volume of pipework

In Fig 39, examples of recommended expansion vessel sizes are shown.

System Sizing

Collector Volumes

Model	Size	Capacity (Ltrs)
HP100	20 Tube 30 Tube	1.2 1.7
HP200	20 Tube 30 Tube	1.1 1.7
DF100	20 Tube 30 Tube	3.8 5.6
FN 2.0	Flat Panel	1.7

Fig 38. Collector volumes

Expansion Vessel Sizing

Model	Collector Area (m^2)	System Volume (Ltrs)	Static Height	Vessel Size
HP100	2	17	5	18
	3	17	5	18
	4	18	5	18
	5	19	5	18
HP200	2	17	5	18
	3	17	5	18
	4	18	5	18
	5	19	5	18
DF100	2	19	5	18
	3	20	5	25
	4	22	5	25
	5	24	5	35

Fig 39. Expansion vessel sizing recommendations

System Sizing

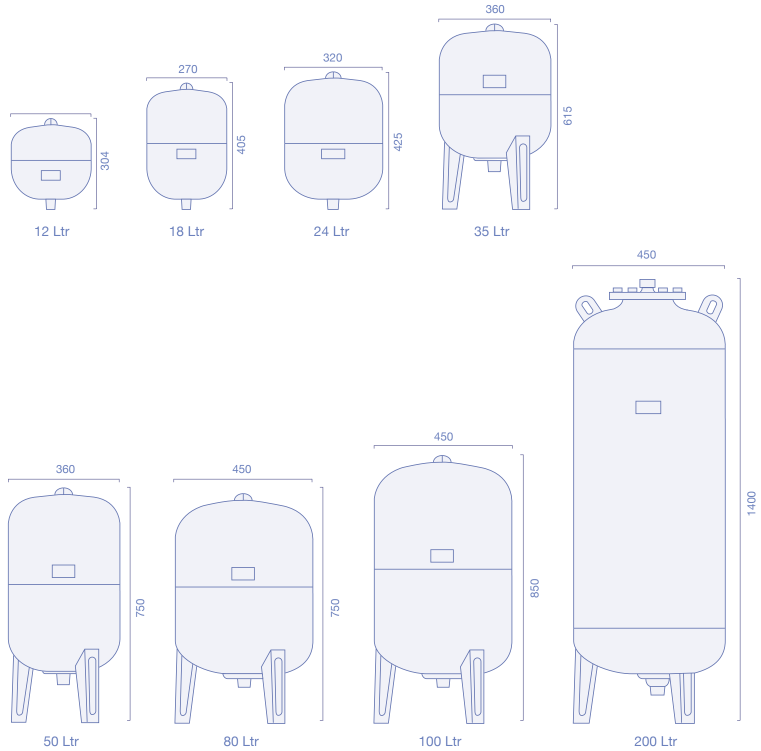


Fig 40. Expansion vessel dimensions (in mm)

Capacity (Ltrs)	Diameter (mm)	Height (mm)	Connection (in)
12	270	304	¾
18	270	405	¾
24	320	425	¾
35	360	615	1
50	360	750	1
80	450	750	1
100	450	850	1
200	485	1400	1½

IMPORTANT NOTE:
Commissioning Expansion Vessels:

Before filling the system, the gas side of the expansion vessel must be set 0.3 bar lower then the cold fill pressure of the solar system. The cold fill pressure should be approximately equal (not less than) to 1 bar + 0.1 bar/m static height. The safety seal (volume of fluid in the expansion vessel) should be 3 litres.

System Sizing

Cooling Vessel Sizing

The VDI 6002 directive recommends a cooling vessel "...when the contents of the piping between the collectors' field and the expansion vessel is lower than 50% of the reception capacity of the expansion vessel".

The cooling vessel is also known as a 'temperature reducing vessel', 'stagnation vessel' or a 'stratification vessel'.

The cooling vessel loop

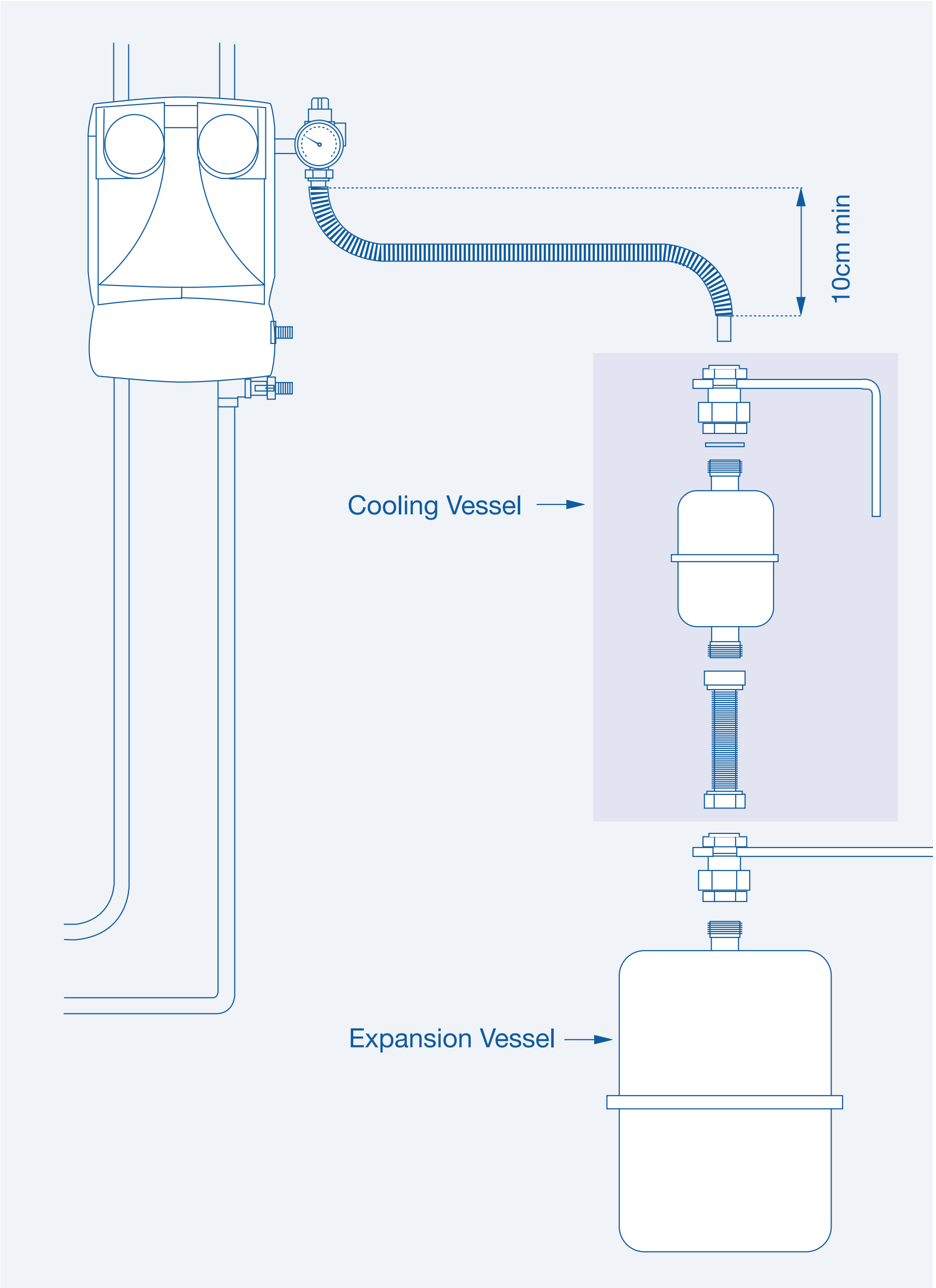


Fig 41. Cooling vessel loop

System Sizing

A long period of high temperature fluid in the expansion vessel has the effect of shortening its useful life – ultimately causing premature failure of the diaphragm. To avoid this situation, a cooling vessel should be installed on the system when using DF100, FN 2.0 or FS 2.0 collectors.

To assist with the cooling function of this vessel, the pipework from the pump station to the cooling vessel and to the expansion vessel must not be insulated. The expansion vessel and cooling vessel also must not be insulated.

There are no regulations regarding the sizing of cooling vessels, however we recommend the following method is used.

The volume of the cooling vessel = $V_{CV} = (0.5 \times V_{EVS}) - V_S$

Where

Vcv = Volume of cooling vessel
V_{EVS} = Usable expandable volume
V_{SL} = Volume of simple length of pipework (distance from vessel to solar collector)

We recommend the following sized vessels to be used with our collectors:

Cooling Vessel Sizing

Model	Collector Area (m^2)	System Volume (Ltrs)	Static Height	Vessel Size	Cooling Vessel Size
DF100	2	19	5	18	5
	3	20	5	25	8
	4	22	5	25	8
	5	24	5	35	12

Fig 42. Cooling vessel sizing for DF100

Stagnation Prevention

As mentioned previously the occurrence of stagnation in a solar system should be avoided.

Continuous temperatures in excess of 170°C will cause the degrading of the Tyfocor solar solution and degrade its inhibitor properties, this is evident by the solution turning a brown colour (see solution on left in picture below).

The continuous high temperatures will also cause damage to the collectors, pump station and expansion vessels on the system.

Fig 43. The effect of stagnation on Tyfocor solution

The solution on the right is the delivered state of the Tyfocor solution, the beaker on the left contains a solution that has been in stagnation for long periods above 170°C.

We recommend that the solution is tested every year and, based on the results of this test, replaced as required. The solution should be tested using a refractometer and ph test paper. This kit is available from our sales office.

Stagnation in a solar system can be caused by a number of reasons such as:

- Oversized systems – correct sizing methods have been addressed in previous chapters
- Undersized expansion vessel – correct sizing methods have been addressed in previous chapters
- Poor set up of the system – it is essential that all solar systems are installed and commissioned by fully trained and technically competent installers who fully understand the requirements of a high performance solar thermal system
- Air locks or leaks in the system
- Prolonged periods of low hot water demand. Using our range of control panels this can be overcome by using a heat dissipation function, this is explained in greater detail on the following pages

Stagnation Prevention

Control Strategies for Reduction of Stagnation

Our range of Thermomax SC100, SC200 and SC300 solar control panels contain the following strategies.

Please note: that we recommend the installation of a thermostatic mixing valve with all solar systems. It is important that they are installed for options 1 and 2 to prevent accidental scalding owing to high temperatures.

(1) Heat Dissipation Through an Emitter Option A

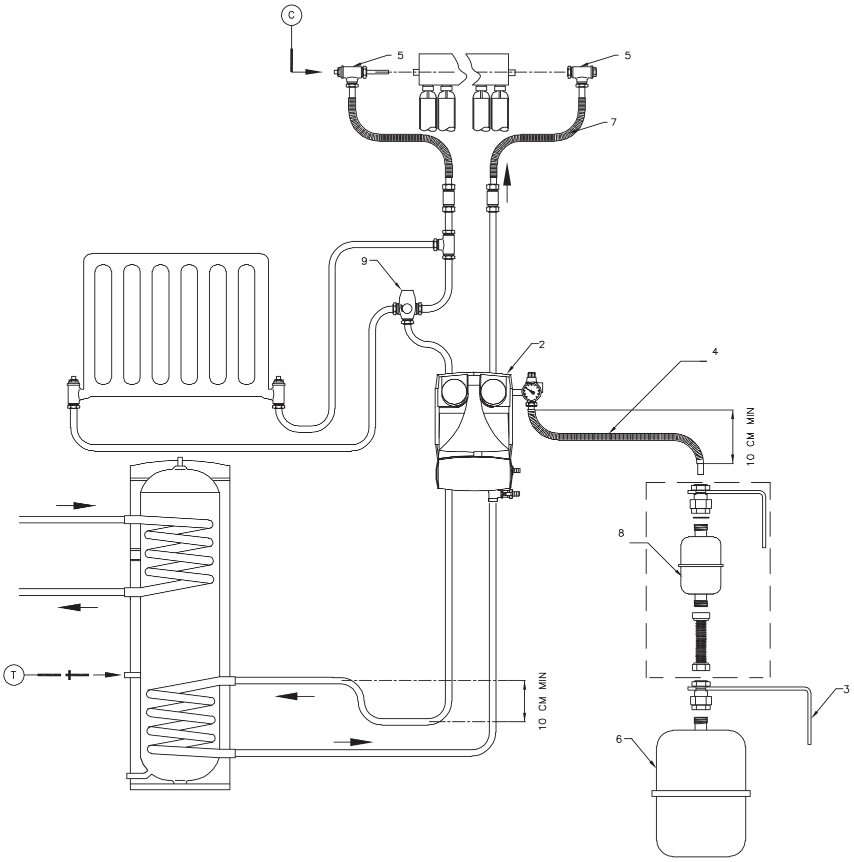
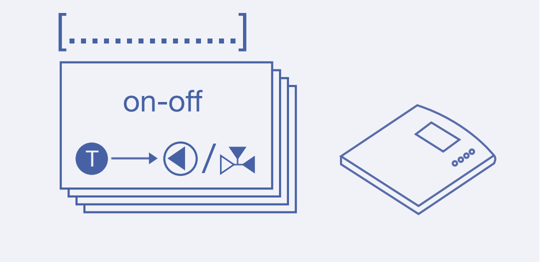


Fig 44. Heat dissipation Option A

Thermostat Display: 3.7



Stagnation Prevention

A radiator/ emitter is installed with a 3 port diverting valve on the solar side of the cylinder. In our control panel function 3.7 should be enabled ‘thermostat function’.

This function allows the controller to control the 3 port valve supplying the radiator depending on a predefined temperature difference.

When the temperature in the cylinder exceeds the defined ‘on’ value (typically 80°C), the output is switched on until the temperature difference falls below the ‘off’ value (typically 60°C).

This cycle will continue until the collector temperature has been reduced.

Heat Dissipation Through an Emitter Option B

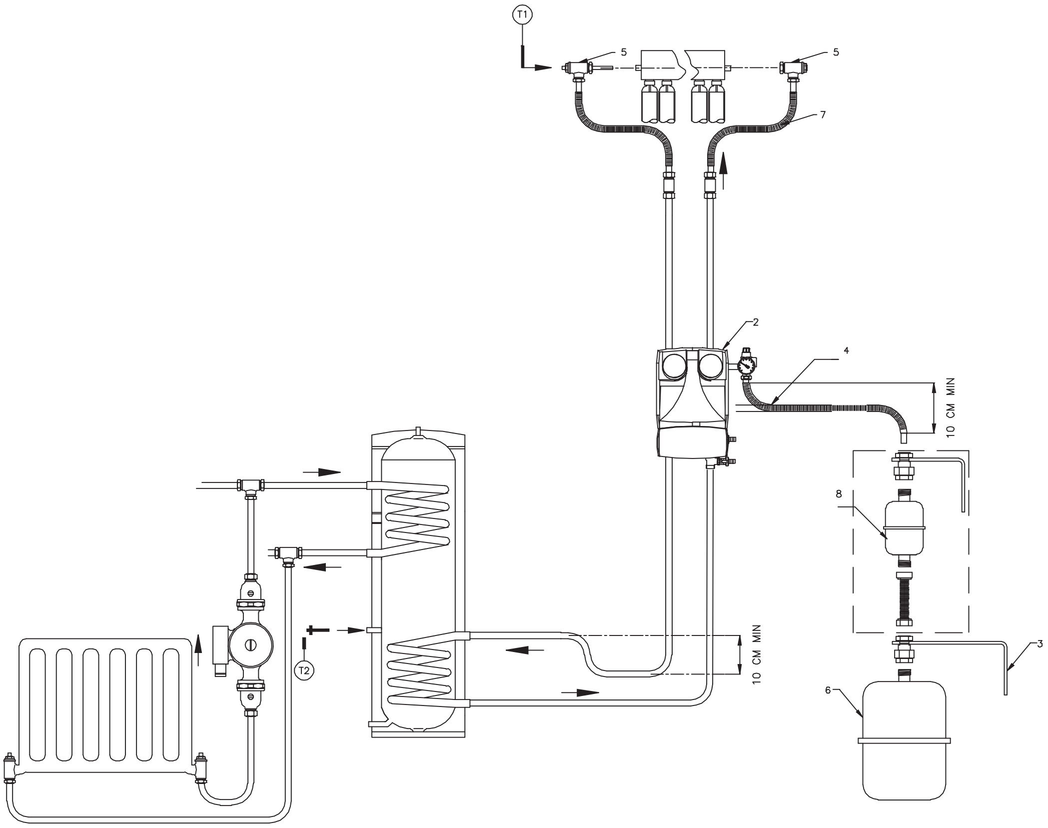
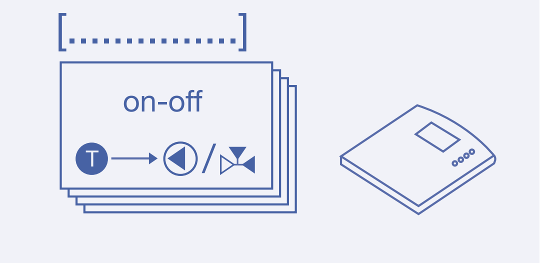


Fig 45. Heat dissipation Option B

Stagnation Prevention

Thermostat Display: 3.7



A radiator / emitter is installed with a circulating pump on the heating side of the cylinder. In our control panel function 3.7 should be enabled ‘thermostat function’.

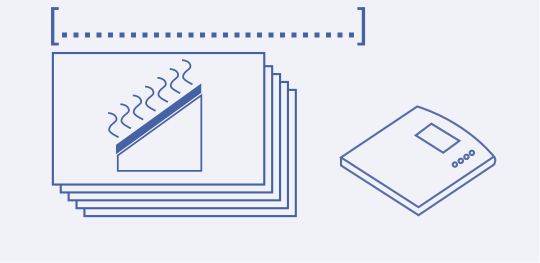
This function allows the controller to control the circulator supplying the radiator depending on a predefined temperature difference.

When the temperature in the cylinder exceeds the defined ‘on’ value (typically 80°C), the output is switched on until the temperature difference falls below the ‘off’ value (typically 60°C).

This cycle will continue until the collector temperature has been reduced.

(2) Stagnation Reduction Function

Stagnation Reduction Display: 2.9



In our control panel function 2.9 ‘Stagnation Reduction Function’ should be enabled.

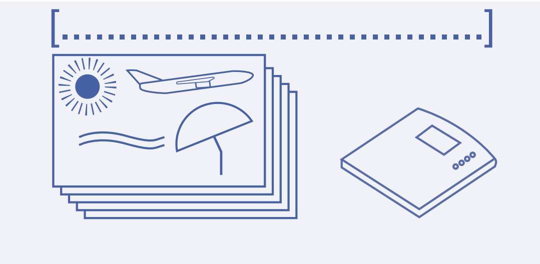
This function delays the end of the storage tank’s loading phase in order to reduce, or even to avoid, the system’s stagnation times at high temperatures.

This function causes the pump to be stopped repeatedly, and only briefly switched on again when high collector temperatures arise. With higher collector temperatures, the efficiency decreases significantly, thus loading takes longer. This delays the beginning of any stagnation time.

Stagnation Prevention

(3) Holiday Function / Re-cooling

Holiday Function/Re-cooling Display: 2.10



In our control panel function 2.10 ‘Holiday Function/ Re-cooling’ should be enabled.

This function is better for preventing stagnation in flat panel collectors rather than evacuated tube collectors due to the higher heat losses.

This function is typically enabled when the household is on holiday. When the holiday function is activated, and the temperature in the storage tank reaches 10 K below the set maximum storage tank temperature, the controller attempts to systematically unload the lower part of the storage tank, until the set minimum storage tank temperature is reached.

Solar Air Conditioning

Solar Assisted Air Conditioning Systems

In solar assisted air conditioning systems solar energy collected by solar thermal is used to drive the cooling process.

The maximum cooling load of any building typically coincides with the period when the maximum solar radiation is available.

Considerable savings can be achieved when using solar systems rather then normal electrical consumption of a mechanical compressor.

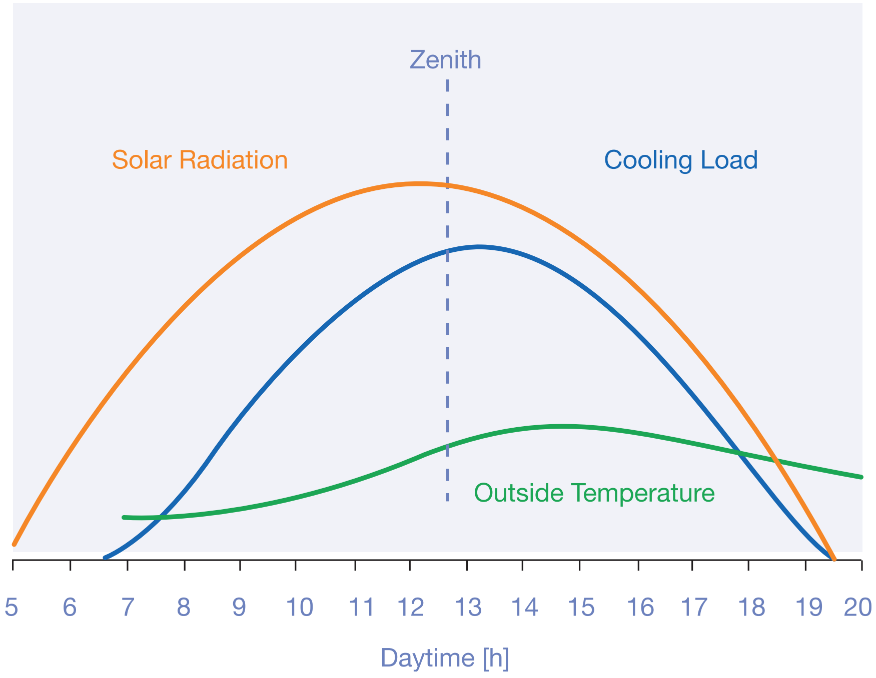


Fig 46. Effects of cooling load and solar radiation on typical day

There are two main systems used for solar assisted air conditioning systems:

1. Closed Systems – Thermal driven chiller (absorption or adsorption)
2. Open Systems (desiccant)

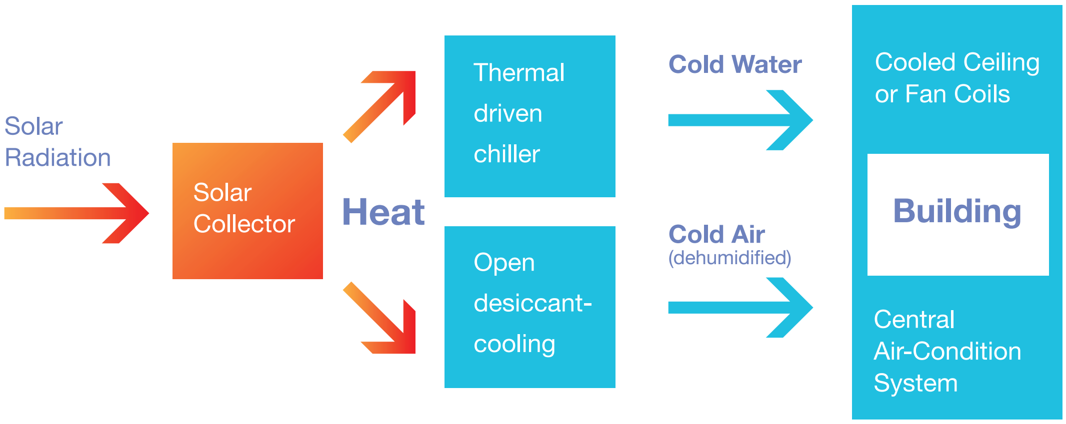


Fig 47. Solar assisted air conditioning systems

Solar Air Conditioning

For the purpose of this technical guide, we will be briefly describing the 2 variants of the closed systems.

For full design and specification details please see our ‘Kingspan Climate’ Solar Air Conditioning technical guide.

Closed Systems

Closed systems are thermally driven chillers normally referred to as absorption chillers and adsorption chillers. These units provide chilled water used to supply air handling units or fan coil units.

Absorption

Absortion chillers work in a similar process to that of a mechanical compressor system i.e. the key components being an evaporator and a condenser.

In the absorption process a vapourising liquid extracts heat at low temperature, the vapour is then compressed to a high pressure using a thermal driven compressor which consists of an absorber and generator. The pressure of the liquid is reduced by expansion through a throttle valve, and the cycle is repeated. Absorption cycles are based on the fact that the boiling point of a mixture is higher than the corresponding boiling point of a pure liquid.

The steps of the absorption cycle are:

1. The refrigerant evaporates in the evaporator, thereby extracting heat from a low temperature heat source. This results in the useful cooling effect.

2. The refrigerant vapour flows from the evaporator to the absorber, where it is absorbed in a concentrated solution. The latent heat of condensation and mixing heat must be extracted by a cooling medium, so the absorber is usually water-cooled using a cooling tower to keep the process going.

3. The diluted solution is pumped to the components connected to the driving heat source (i.e. generator), where it is heated above its boiling temperature, the refrigerant vapour is then released at high pressure. The concentrated solution flows back to the absorber.

4. The desorbed refrigerant condenses in the condenser, whereby heat is rejected. The condenser is usually water-cooled using a cooling tower to reject ‘waste-heat.’

5. The refrigerant flows back to the evaporator through an expansion valve, the pressure of the refrigerant condensate is reduced by the valve.

Solar Air Conditioning

A simple air conditioning diagram below.

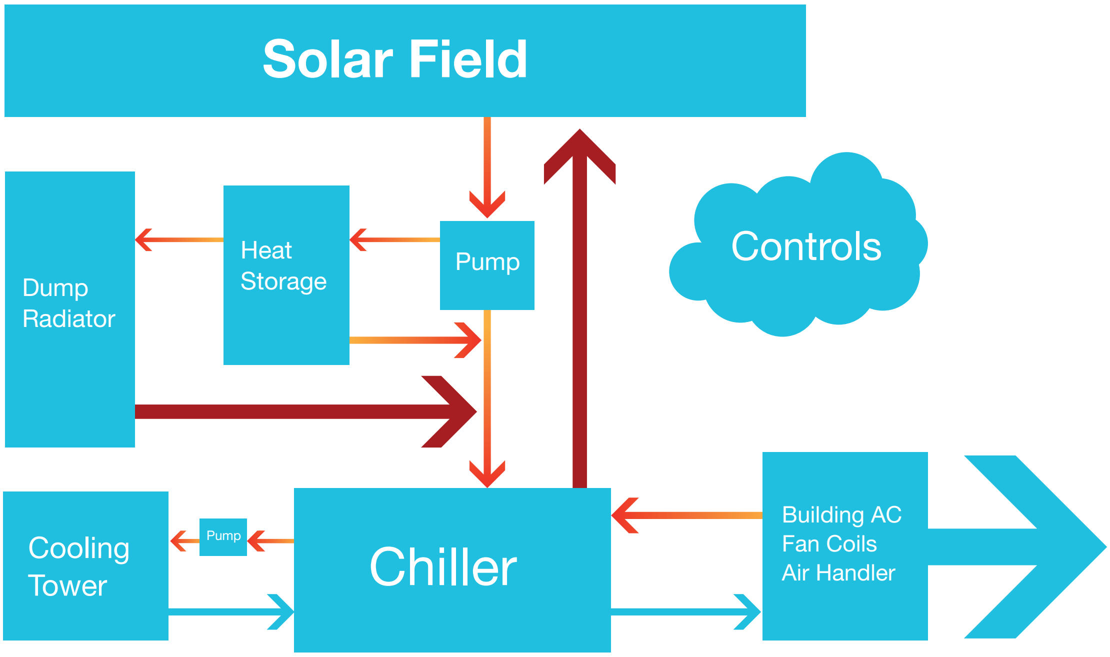


Fig 48. Air conditioning process

For solar-assisted air-conditioning systems with common solar collectors, single-effect LiBr (Lithium Bromide) absorption chillers are the most commonly used because they require a comparatively low temperature heat input. However, due to the higher performance of the Thermomax evacuated tube collectors, double-effect chillers can be driven by solar when they are used.

Adsorption

Adsorption chillers use solid sorption materials instead of liquid solutions as above. The most common systems use water as refrigerant and silica gel as sorbent, however more recently zeolith is being adopted. Adsorption units consist of two main components (see figure 49) – one evaporator and one condenser.

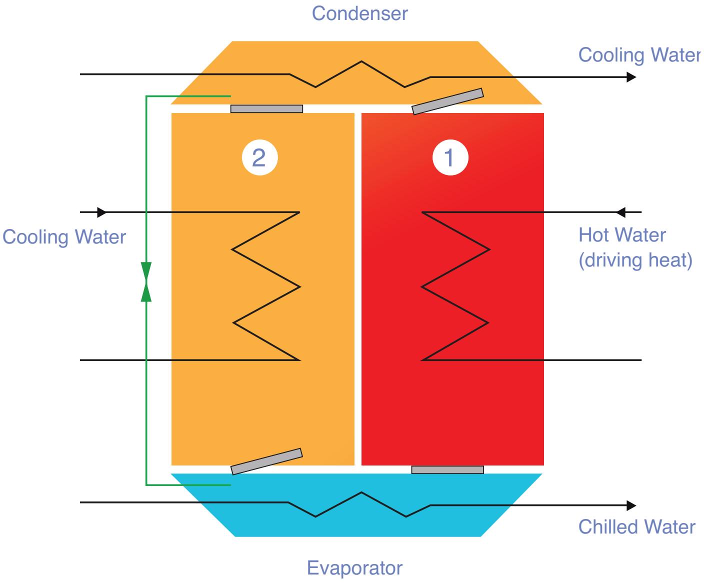


Fig 49. Components of an adsorption chiller

Solar Air Conditioning

While the sorbent in the first compartment is regenerated using hot water from the external heat source, e.g. the solar collector, the sorbent in the second compartment adsorbs the water vapour entering from the evaporator. Compartment 2 has to be cooled in order to enable a continuous adsorption.

Owing to the low pressure conditions in the evaporator, the refrigerant in the evaporator is transferred into the gas phase by taking up the evaporation heat from the chilled water loop and thereby producing the useful ‘cold’. If the sorption material in the adsorption compartment is saturated with water vapour to a certain degree, the chambers are switched over in their function.

For more information on solar assisted cooling, please see our Kingspan Climate brochure or contact our sales office.

Collector Fixings

Fixing Options for Solar Collectors

Shown below are examples of our standard roof fixings. Please refer to our installation manual for instructions and full details of our complete range of collector fixings.

Sloping Roof Kit Vertical Part CO590

A	Attach lower brackets to roof.	A1 x 2
B	Secure side rails to lower bracket.	B1 x 2
D	Attach upper bracket to roof.	D1 x 2
E	Secure side rails to upper brackets.	E1 x 2
I	Locate manifold on side rails.	I1 x 1
J	Locate support rails on side rails.	J1 x 2

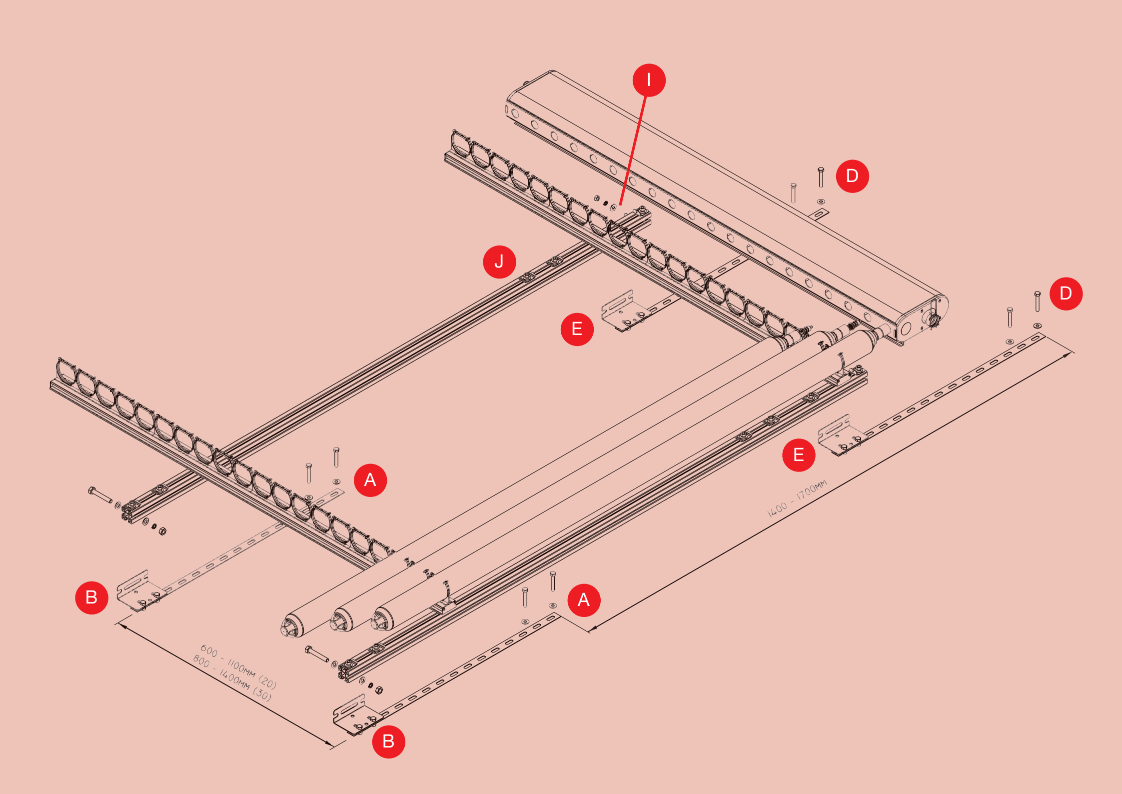


Fig 50. Standard Sloping Roof Kit

Collector Fixings

Horizontal Roof Kit Part C0593

A	Attach brackets to roof at distance shown.	A4 x 4
D	Secure side rails to brackets.	D3 x 2
H	Locate locking pin positions and drill holes.	H x 3
I	Locate manifold on side rails.	I3 x 1
J	Locate support rails on side rails.	J2 x 2

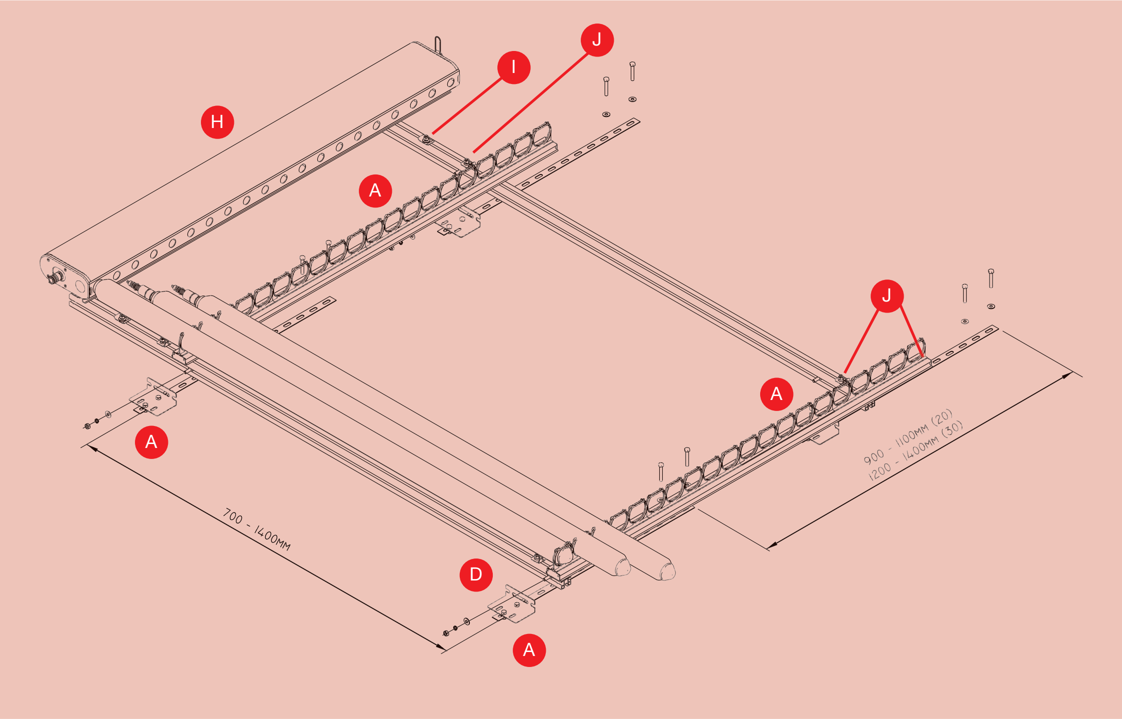


Fig 51. Horizontal Roof Kit

‘A’ Frame Kit, 35-55° Part C0599

A	Attach front brackets to surface at distance shown.	A5 x 2
B	Attach rear brackets to surface at distance shown.	B4 x 2
C	Expand A-Sections.	x 2
D	Secure side rail to front bracket.	D2 x 2
E	Secure rear strut to rear bracket.	E3 x 2
F	Adjust and secure side brace.	F2 x 2
G	Attach and secure rear brace.	G2 x 1
I	Locate manifold on side rails.	I2 x 1
J	Locate support rails on side rails.	J1 x 2

Collector Fixings

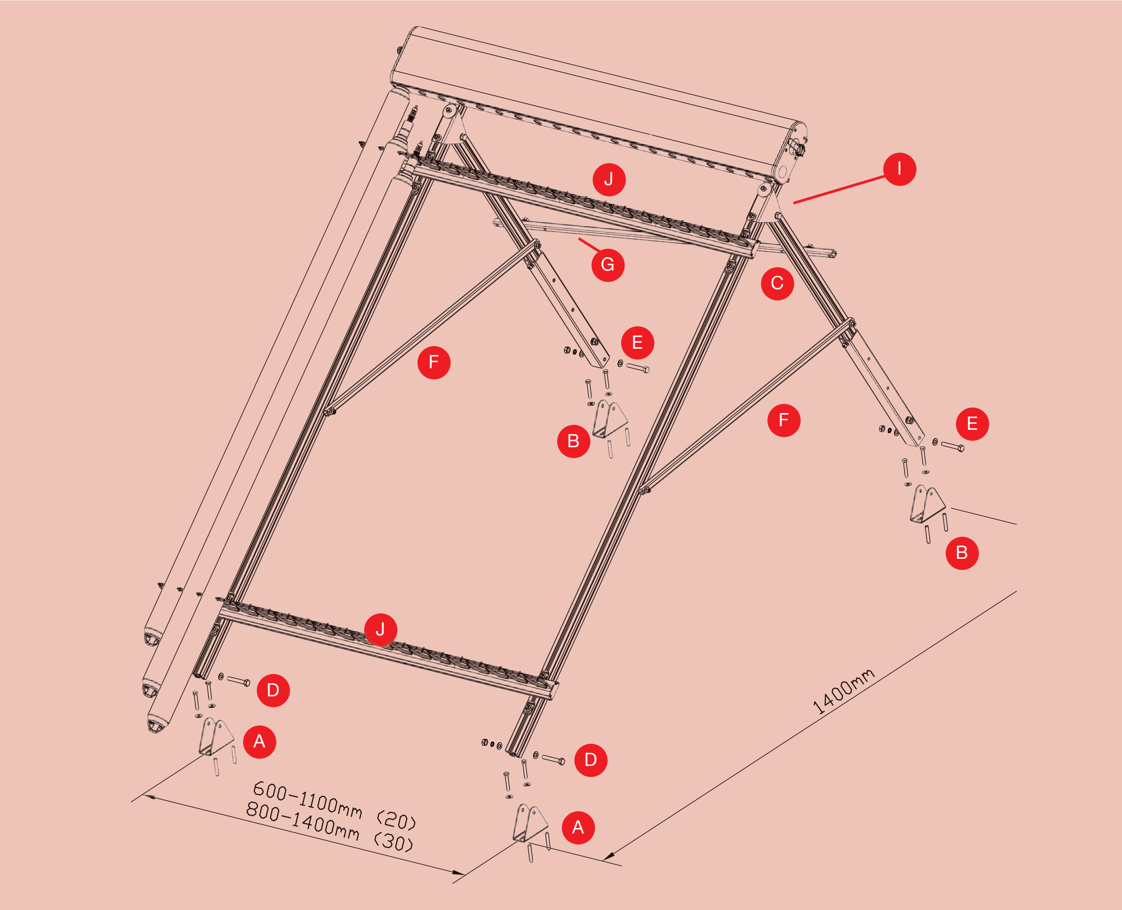


Fig 52. 'A' Frame Kit, 35-55°

Stress and maximum load on the substance on flat roofs to DIN 1055

25°	Prevention of Collector Slippage						Prevention of Collector Lifting					
	Weight Per Foot (kg)						Weight Per Foot (kg)					
	10 Tube Collector		20 Tube Collector		30 Tube Collector		10 Tube Collector		20 Tube Collector		30 Tube Collector	
Height Above Ground (m)	A	B	A	B	A	B	A	B	A	B	A	B
8	76	102	76	102	116	155	26	65	26	65	41	100
8 to 20	129	178	129	178	195	269	57	125	51	125	80	191

Stress and maximum load on the substance on flat roofs to DIN 1055

45°	Prevention of Collector Slippage						Prevention of Collector Lifting					
	Weight Per Foot (kg)						Weight Per Foot (kg)					
	10 Tube Collector		20 Tube Collector		30 Tube Collector		10 Tube Collector		20 Tube Collector		30 Tube Collector	
Height Above Ground (m)	A	B	A	B	A	B	A	B	A	B	A	B
8	102	171	102	171	156	256	73	73	73	73	111	111
8 to 20	177	287	177	287	266	430	137	137	137	137	206	206

Collector Fixings

NoteDF100 Collectors Only

Individual tubes can be rotated up to 25° to achieve an improved angle of inclination

Façade and Flat On Roof Fixing Kit Part C0595

A	Attach brackets to surface at distance shown.	A5 x 4
D	Attach side rails to brackets.	D4 x 2
I	Locate manifold on side rails.	I1 x 1
J	Locate support rails on side rails.	J1 x 2

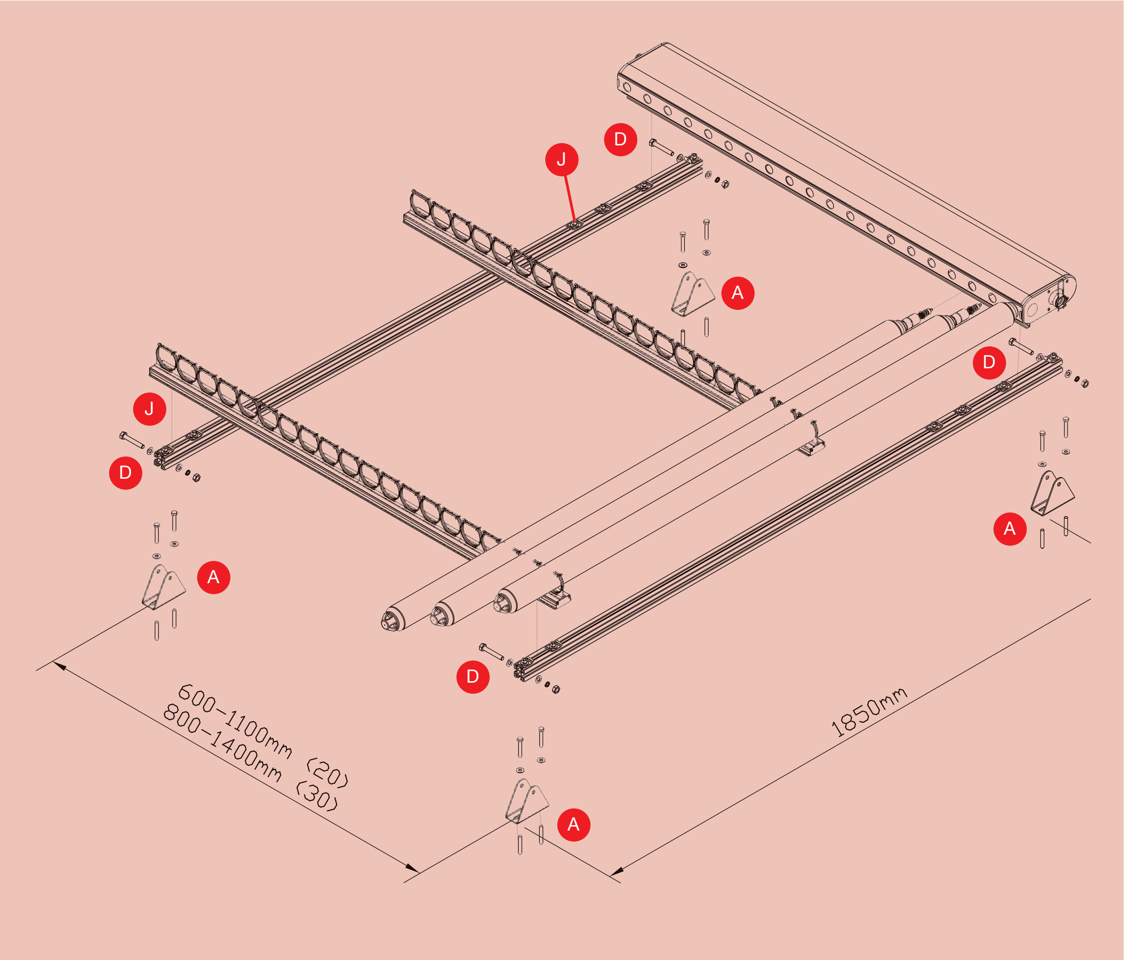


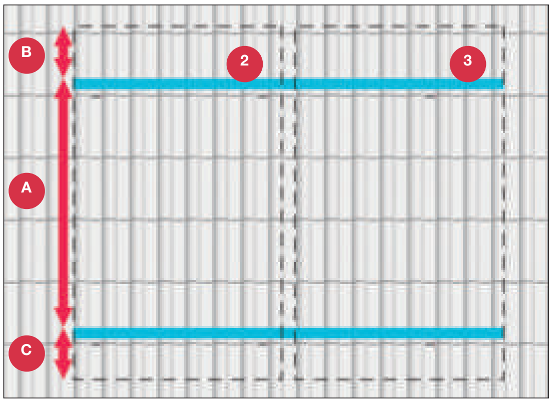
Fig 53. Façade and Flat On Roof Fixing Kit

Stress and maximum load on the substance on flat roofs to DIN 1055

FLAT	Prevention of Collector Slippage						Prevention of Collector Lifting					
	Weight Per Foot (kg)						Weight Per Foot (kg)					
	10 Tube Collector		20 Tube Collector		30 Tube Collector		10 Tube Collector		20 Tube Collector		30 Tube Collector	
Height Above Ground (m)	A	B	A	B	A	B	A	B	A	B	A	B
8	22	26	22	26	33	39	15	18	15	18	22	27
8 to 20	44	46	44	46	65	69	31	32	31	32	46	49
20 to 100	66	67	66	67	98	101	48	48	48	48	72	73

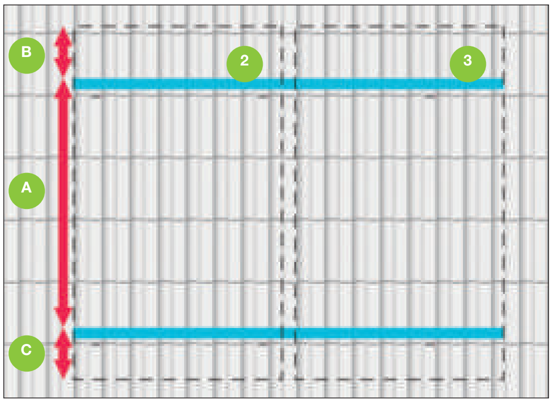
Collector Fixings

NoteFN and FS 2.0 Flat Panel Collectors Only



On Roof Fixing Kit for FN 2.0
Part KFP0002

For vertical installation, the rails (2/3) are installed horizontally. The distance A between the rails must be between 1.2 m and 1.6 m. The distances B and C from the rails to the outer edge of the collector have to be between 150 mm and 350 mm. Up to 10 collectors can be connected in series (1 basic kit and 9 extension kits).



On Roof Fixing Kit for FS 2.0
Part KFP0009

For vertical installation, the rails (2/3) are installed horizontally. The distance A between the rails must be between 1.2 m and 1.6 m. The distances B and C from the rails to the outer edge of the collector must be between 150 mm and 350 mm. Up to 3 collectors can be connected in series (1 basic kit and 2 extension kits).

Fig 54. Flat Panel On Roof Fixing Kits

Schematics

Arrangement of Collectors and Schematics

As previous, the maximum number of collectors that can be connected in series with a flow rate of 60 Ltr/hr/m^2 are:

DF100 = 5 collectors
HP200 = 4 collectors
HP100 = 6 collectors
FN 2.0 = 10 collectors
FS 2.0 = 3 collectors

We recommend that the ‘Tichelman system’ or ‘Reverse Return System’ is used when arranging banks of collectors onto a solar system. This type of arrangement ensures the length of the flow pipework to the collector is equal to the length of the return pipework, creating hydraulic balancing without the need for regulating valves.

Shown below is an example of 10 DF100 collectors installed on one system using a ‘Tichelman’ pipe arrangement.

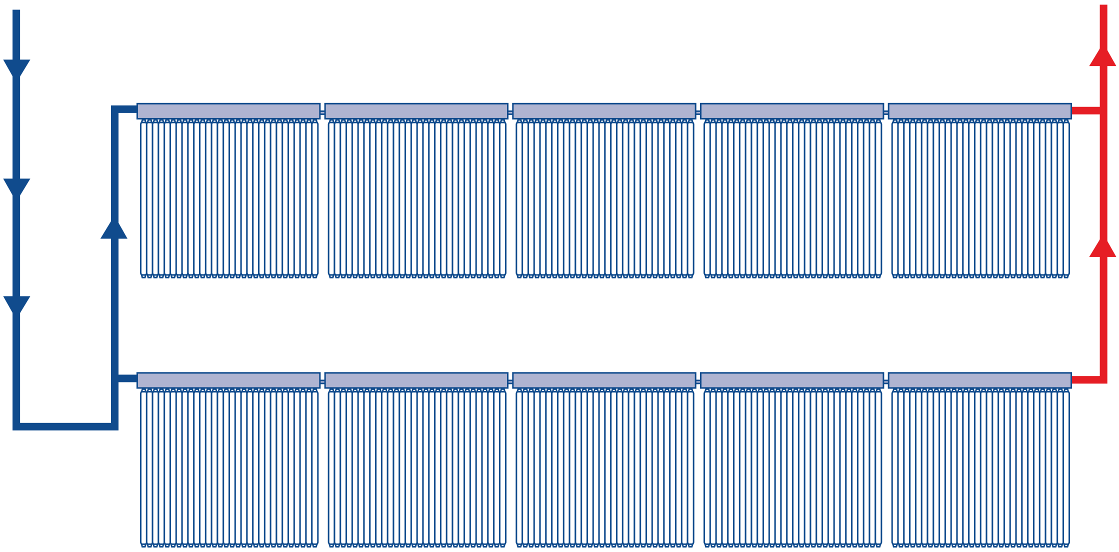


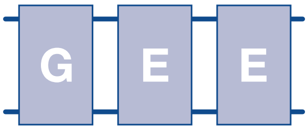
Fig 59. Tichelman pipe arrangement of DF100 collectors

Schematics

With our Thermomax FN range of flat panel collectors in series, we use a flexible interconnection between each collector.

G = Basic kit
E = Extension kit

3 x FN 2.0 Collectors



4 x FN 2.0 Collectors

10 x FN 2.0 Collectors

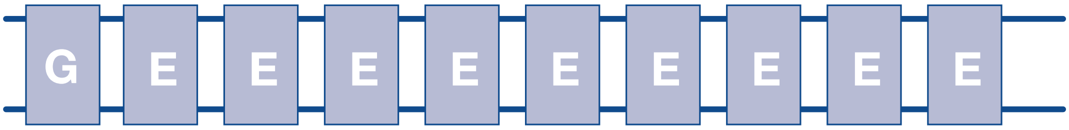
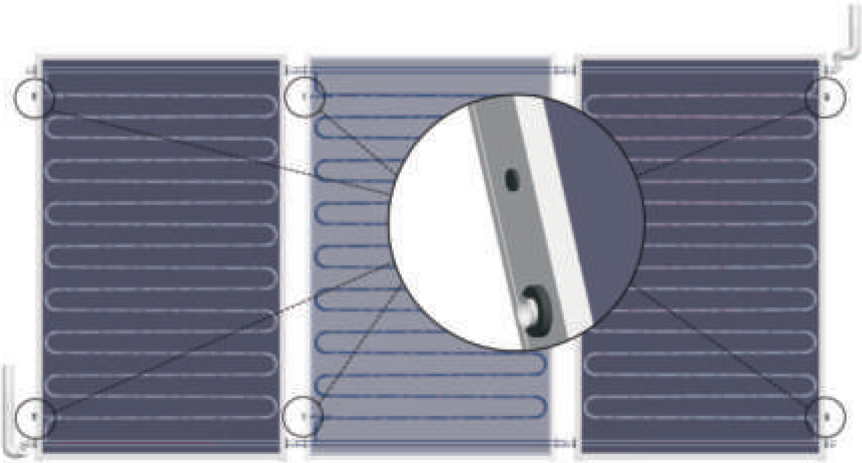


Fig 60. Series of FN 2.0 collectors using flexible interconnection



Important: To ensure the full flow-through of the collector array, the position of the immersion sleeves have to be observed. When connecting collectors in series please note the last collector should be rotated 180.

Schematics

When using DF or HP solar collectors, the return from the cylinder / heat exchanger should always be connected to the left hand side of the manifold (when viewing the collectors from the front).

The flow from the collector to the cylinder is always connected to the right hand side of the manifold.

The collector sensor pocket must always be fitted to the right hand side of the manifold.

Schematics

On the following pages we show the most common type of solar installations. Please refer to our install manuals before attempting any installation.

For further schematics to be used on commercial or industrial applications, please contact our technical support team.

NOTE: System numbers refer to the pre-loaded systems numbers within the Thermomax SC100, SC200 and SC300 solar controllers.

Schematics

Domestic and Industrial Systems

System 1 - One storage tank
Suitable controllers: SC100 / SC200 / SC300

Description of the solar function: The solar circuit pump R1 is switched on as soon as the switch-on temperature difference between collector array A1 (T1) and storage tank B1 (T2) is reached. When the switch-off temperature difference between collector array A1 (T1) and storage tank B1 (T2) or a safety limit is reached, the solar circuit pump R1 is switched off again.

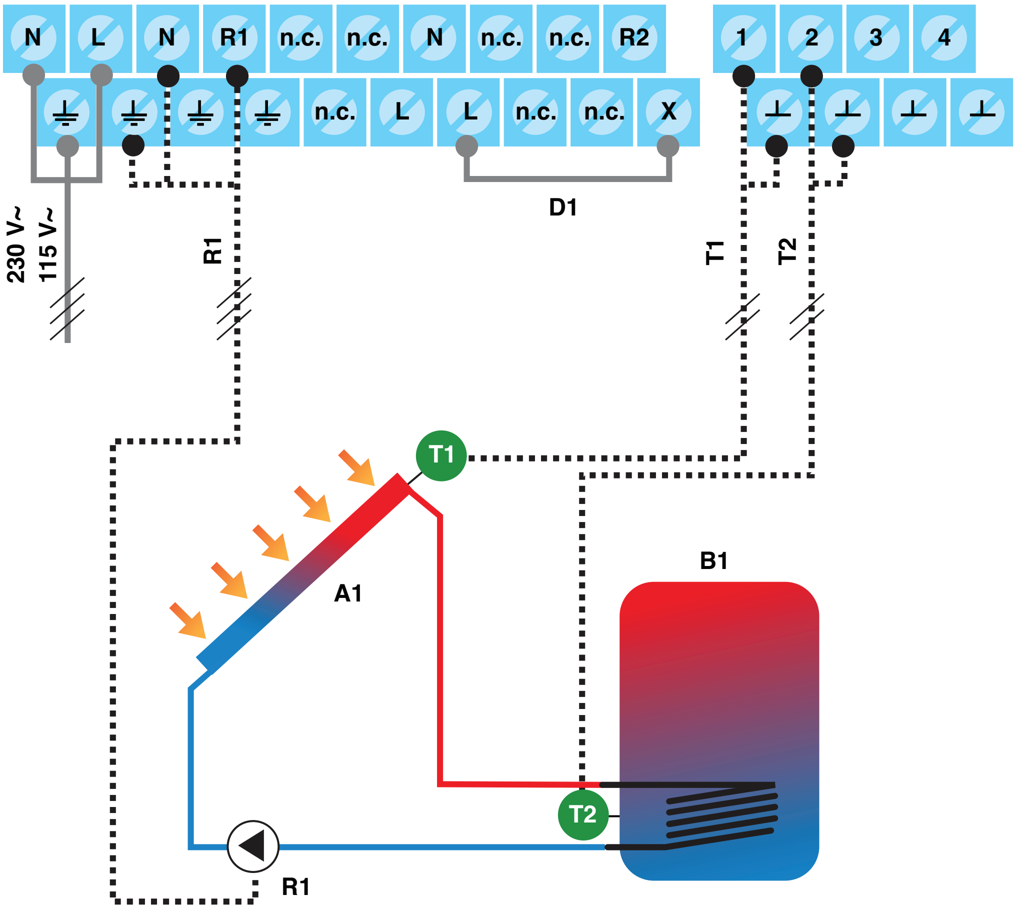


Fig 61. Terminal layout

Schematics

Hydraulic schematic variances between each collector type :

DF100 (Direct Flow Tube) collectors (standard using dual stream pump)

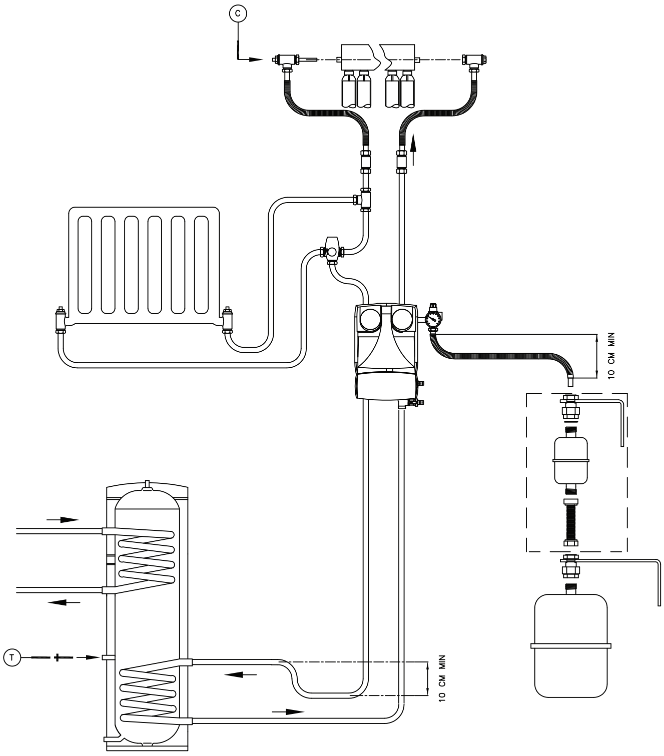


Fig 62.

FN 2.0 Flat panel collectors (standard using dual stream pump)

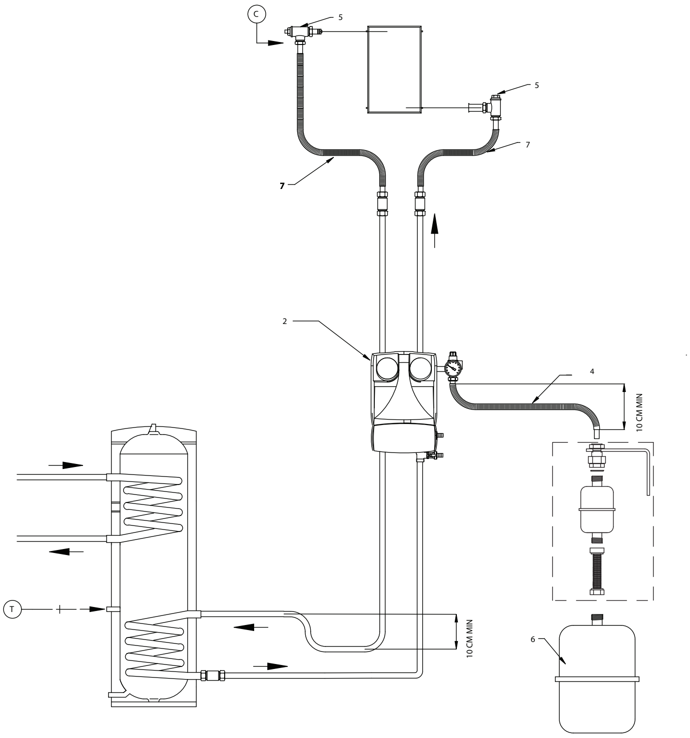


Fig 63.

Schematics

HP collectors (standard using dual stream pump)

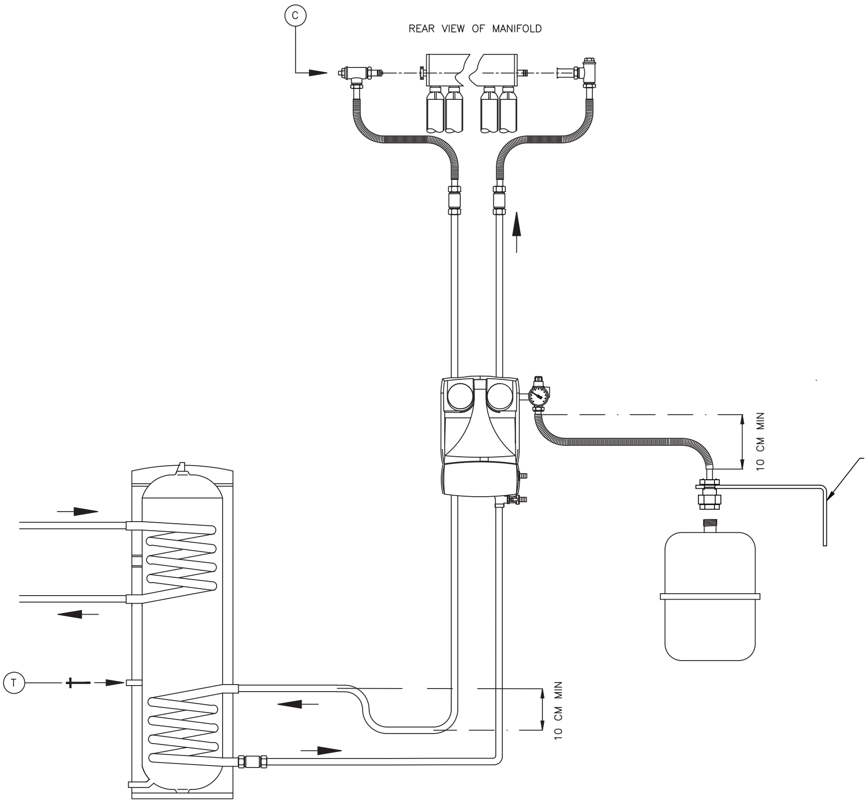


Fig 64.

Schematics

FN 2.0 Flat panel collectors (standard using dual stream pump)

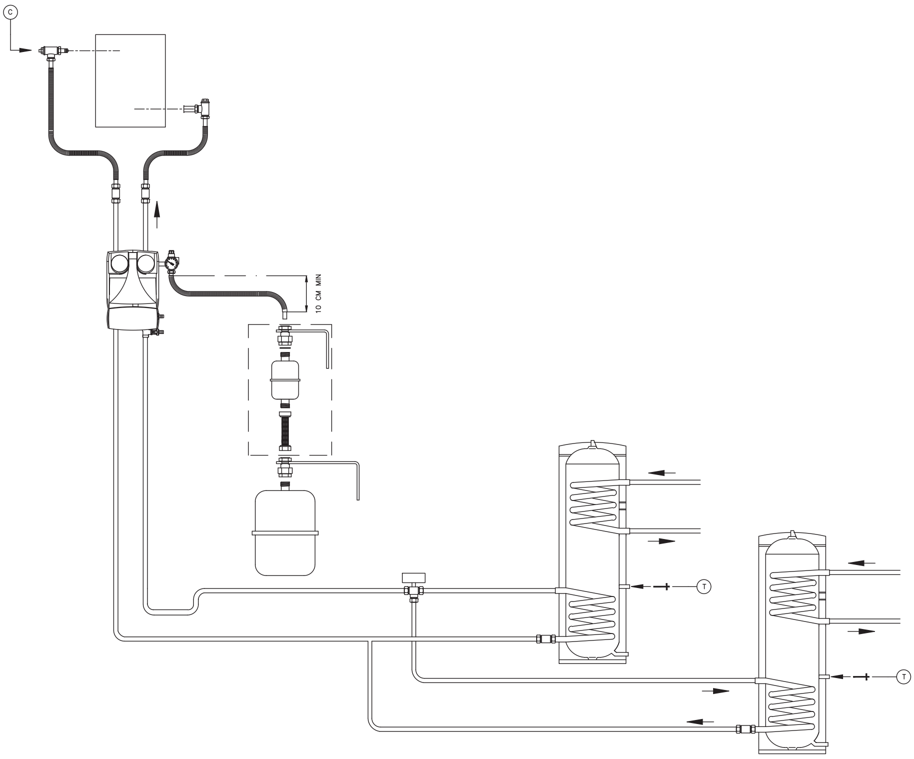


Fig 65.

Schematics

System 7 - Two storage tanks
Suitable controllers: SC200 / SC300

Description of the solar function: When the switch-on temperature difference between the collector array A1 (T1) and one of the two storage tanks B1, B2 (T2, T3) is exceeded, the solar circuit pump R1 is switched on and the switching valve R2 is set to the correct position depending on the storage tank to be loaded. Both storage tanks B1, B2 are loaded one after the other, according to the priority control, until either the relevant switch-off temperature difference between the collector array A1 (T1) and storage tanks B1, B2 (T2, T3) is reached, or a safety limit is reached.

NOTE:
When no voltage is on the system, the switching valve R2 must be set to storage tank B1.

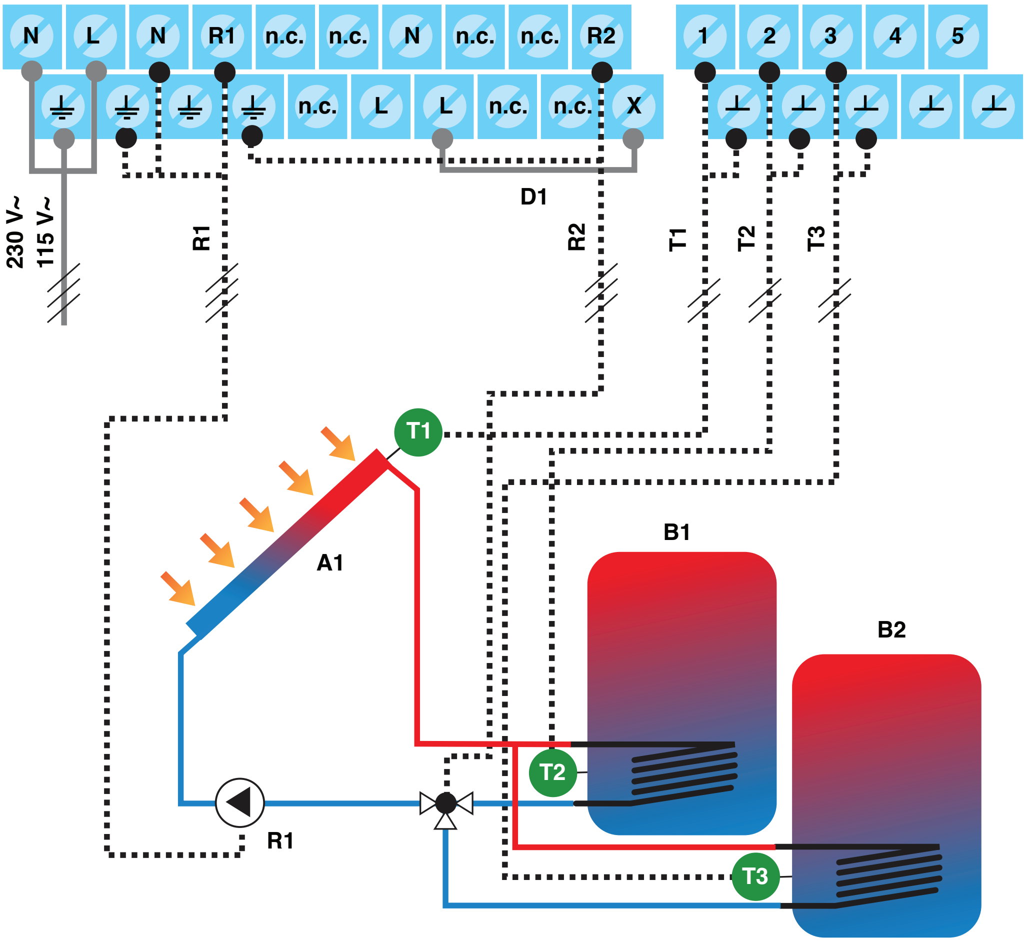


Fig 65. Terminal layout

Schematics

DF100 (Direct Flow Tube) collectors (standard using dual stream pump)

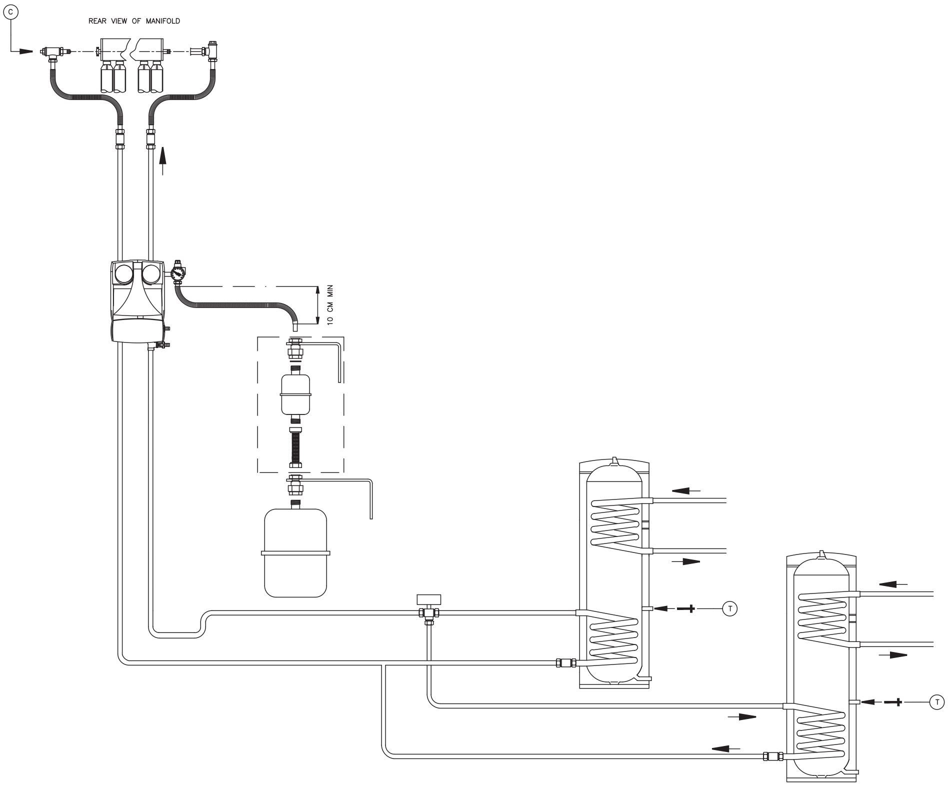


Fig 66.

Schematics

HP collectors (standard using dual stream pump)

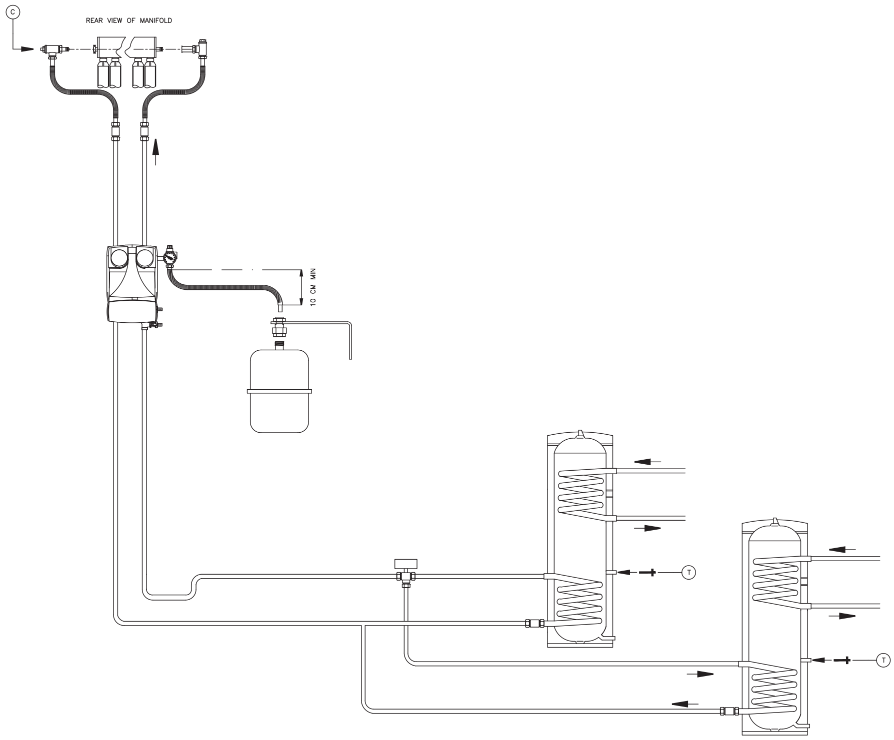


Fig 66.

System - East/West system – 2 collectors, one storage tank
Suitable controllers: SC200 / SC300
System 5 = SC200
System 8 = SC300

Schematics

Description of the solar function: When the switch-on temperature difference between the storage tank B1 (T3) and one or the other of the collector arrays A1, A2 (T1, T2) is reached, then either solar circuit pump R1 for collector array A1 (T1), or solar circuit pump R2 for collector array A2 (T2) is switched on, depending on where the temperature difference occurs. When the switch-on temperature difference is reached for both collector arrays A1, A2 (T1, T2), then both pumps R1, R2 are switched on. When the switch-off temperature difference between the collector array A1, A2 (T1, T2) and the storage tank B1 (T3) or a safety limit is reached, the solar circuit pumps R1, R2 are switched off again.

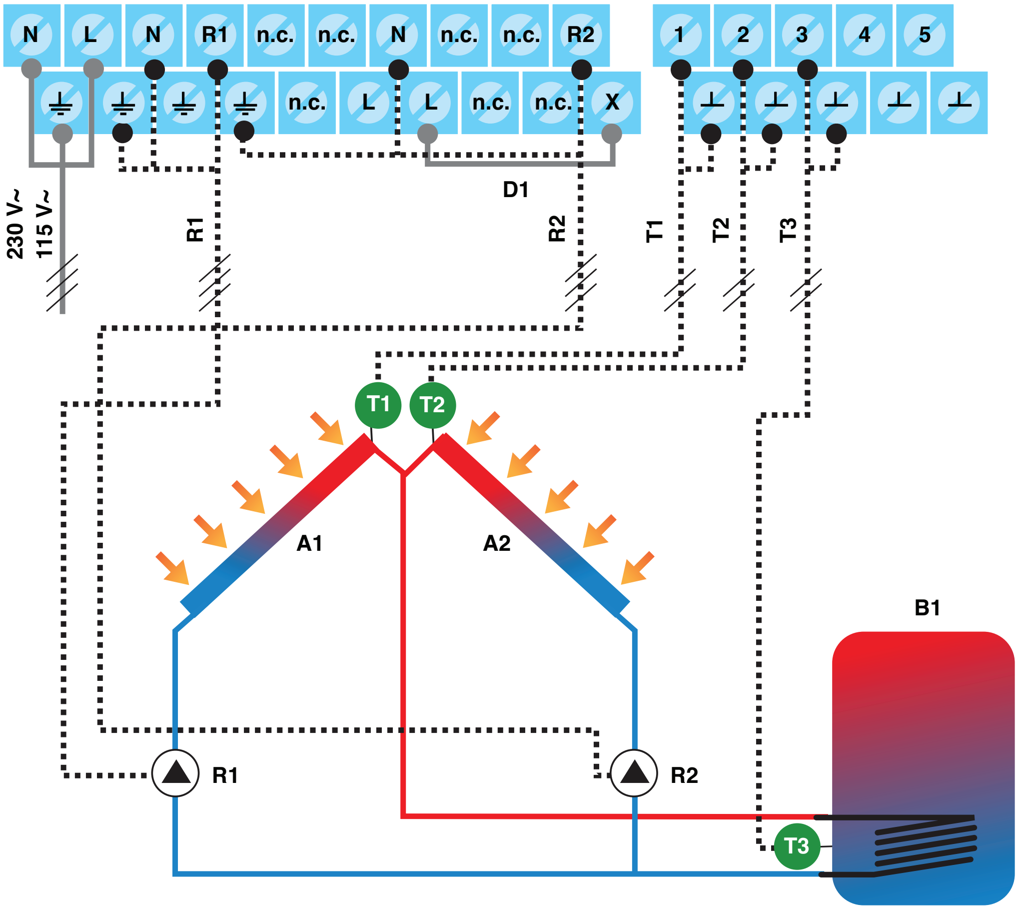


Fig 69. Terminal layout

Schematics

HP collectors - East/West system

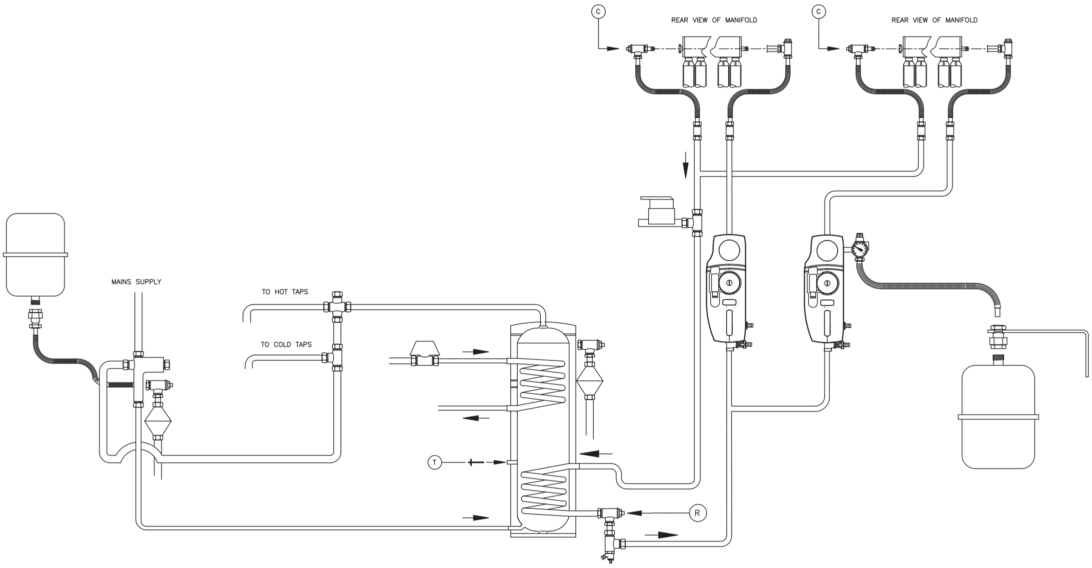


Fig 70.

Product Test Reports

Technical Specification

Thermomax evacuated tube solar thermal collectors.

EN12975-2: Certified Efficiencies

	Aperture				Absorber			
Model	Area (m^2)	η_0	a1 (W/m^2K)	a2 (W/m^2K^2)	Area (m^2)	η_0	a1 (W/m^2K)	a2 (W/m^2K^2)
DF100-2m^2 **DF100-3m^2**	2.153 3.228	0.773 0.779	1.43 1.07	0.0059 0.0135	2.004 3.020	0.830 0.832	1.53 1.14	0.0063 0.0144
HP100-2m^2 **HP100-3m^2**	2.158 3.237	0.758 0.739	1.02 1.00	0.0099 0.0074	2.006 3.009	0.815 0.795	1.10 1.07	0.1060 0.0080
HP200-2m^2 **HP200-3m^2**	2.157 3.229	0.738 0.727	1.17 0.85	0.0082 0.0093	2.010 3.021	0.792 0.778	1.25 0.91	0.0088 0.0100

	Gross Dimensions		
Model	Length (mm)	Width (mm)	Height (mm)
DF100-2m^2 **DF100-3m^2**	1996 1996	1418 2127	97 97
HP100-2m^2 **HP100-3m^2**	2005 2005	1418 2127	97 97
HP200-2m^2 **HP200-3m^2**	2005 2005	1418 2127	97 97

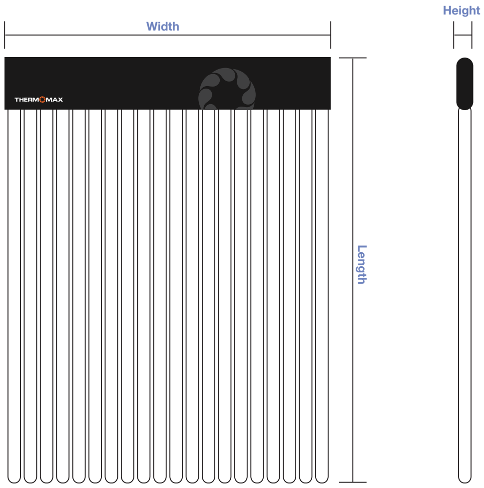


Fig 71. Product dimensions

Institut für Solarenergieforschung GmbH Hameln / Emmerthal

Test Centre for Solar Thermal Components and Systems

ISFH

Am Ohrberg 1 · 31860 Emmerthal · Germany

1. Summary

Company:	**Thermomax Ltd.** Balloo Crescent Bangor, BT 19 7UP United Kindom	Report no.: Report date:	107-06/D 02.11.2006
Type:	**DF 100 30**	Serial no.: Year of production:	MB 08631 2006

The following results were obtained from a test of the thermal performance of a solar collector according to **EN 12975-2:2006**. They apply to the collector described more precisely in the test report no. 107-06/D and to the tests and procedures described herein.

Description of the collector

Type	evacuated tubular collector	Aperture area	3.228 m²
Length/Width/Height	1996 / 2127 / 97 mm	Absorber area	3.020 m²
Max. operation pressure	8 bar	Gross area	4.245 m²
Weight, empty	81.4 kg	Recommended flow rate	60..150 kg/m²h
Heat transfer fluid	Polypropylene	Thickness of absorber sheet	0.12 mm
		Number of tubes	30

Test results

Coefficients of efficiency
(determined outdoor)

$$\eta = \eta_0 - a_1 \cdot (t_m - t_a)/G - a_2 \cdot (t_m - t_a)^2/G$$

Based on:	aperture area	absorber area
η_0 =	0.779	0.832
a_1 =	1.07 W/m²K	1.14 W/m²K
a_2 =	0.0135 W/m²K²	0.0144 W/m²K²

Incident angle modifier
(determined outdoor)

proj. angle of incidence θ	0°	10°	20°	30°	40°	50°	60°
$K_{\theta b,trans}(\theta_{trans})$	1.00	1.01	1.04	1.07	1.07	1.02	0.90
$K_{\theta b,long}(\theta_{long})$	1.00	1.00	0.99	0.98	0.96	0.92	0.86
$K_{\theta d}$ =					0.90		

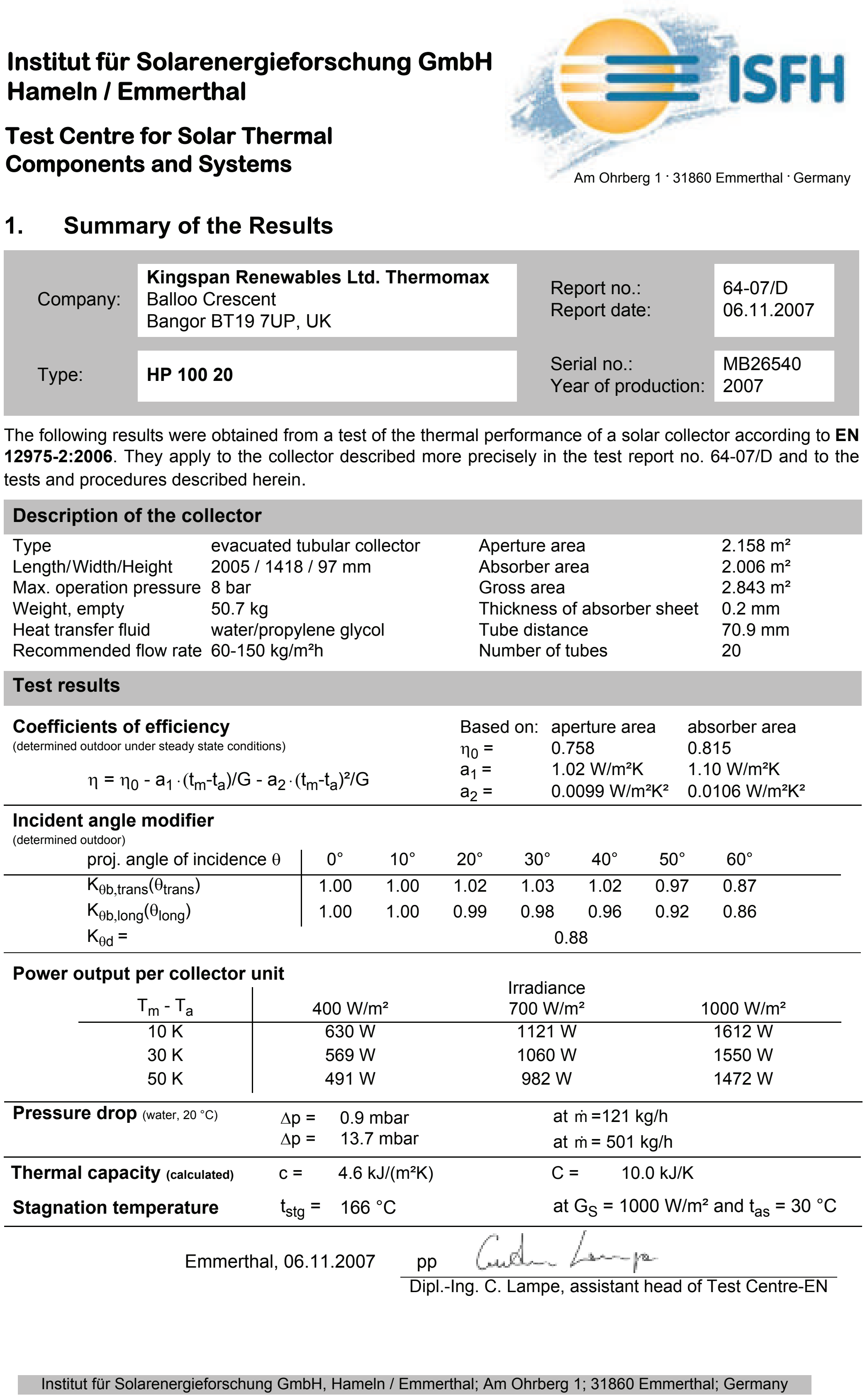
Power output per collector unit

	Irradiance		
$T_m - T_a$	400 W/m²	700 W/m²	1000 W/m²
10 K	967	1721	2475
30 K	863	1617	2371
50 K	724	1478	2233

Peak power per collector unit		**2514 W_{peak}**	at G = 1000 W/m² and $t_m - t_a$ = 0 K
Pressure drop (water, 20 °C)	Δp = Δp =	1.2 mbar 5.9 mbar	at $\dot{m}$ = 70.5 kg/h at $\dot{m}$ = 210.4 kg/h
Thermal capacity **(calculated)**	c =	9.2 kJ/(m²K)	C = 29.6 kJ/K
Stagnation temperature	t_{stg} =	286 °C	at G_S = 1000 W/m² and t_{as} = 30 °C

Emmerthal, 02.11.2006 pp

Dipl.-Ing. C. Lampe, deputy head of Test Centre-EN



Institut für Solarenergieforschung GmbH
Hameln / Emmerthal

Test Centre for Solar Thermal
Components and Systems

Am Ohrberg 1 · 31860 Emmerthal · Germany

1. Summary of the Results

Company:	**Kingspan Renewables Ltd. Thermomax** Balloo Crescent Bangor BT19 7UP, UK	Report no.: Report date:	64-07/D 06.11.2007
Type:	**HP 100 20**	Serial no.: Year of production:	MB26540 2007

The following results were obtained from a test of the thermal performance of a solar collector according to **EN 12975-2:2006**. They apply to the collector described more precisely in the test report no. 64-07/D and to the tests and procedures described herein.

Description of the collector

Type	evacuated tubular collector	Aperture area	2.158 m²
Length/Width/Height	2005 / 1418 / 97 mm	Absorber area	2.006 m²
Max. operation pressure	8 bar	Gross area	2.843 m²
Weight, empty	50.7 kg	Thickness of absorber sheet	0.2 mm
Heat transfer fluid	water/propylene glycol	Tube distance	70.9 mm
Recommended flow rate	60-150 kg/m²h	Number of tubes	20

Test results

Coefficients of efficiency
(determined outdoor under steady state conditions)

$$\eta = \eta_0 - a_1 \cdot (t_m - t_a)/G - a_2 \cdot (t_m - t_a)^2/G$$

Based on:	aperture area	absorber area
η_0 =	0.758	0.815
a_1 =	1.02 W/m²K	1.10 W/m²K
a_2 =	0.0099 W/m²K²	0.0106 W/m²K²

Incident angle modifier
(determined outdoor)

proj. angle of incidence θ	0°	10°	20°	30°	40°	50°	60°
$K_{\theta b,trans}(\theta_{trans})$	1.00	1.00	1.02	1.03	1.02	0.97	0.87
$K_{\theta b,long}(\theta_{long})$	1.00	1.00	0.99	0.98	0.96	0.92	0.86

$K_{\theta d}$ = 0.88

Power output per collector unit

	Irradiance		
$T_m - T_a$	400 W/m²	700 W/m²	1000 W/m²
10 K	630 W	1121 W	1612 W
30 K	569 W	1060 W	1550 W
50 K	491 W	982 W	1472 W

Pressure drop (water, 20 °C)

Δp = 0.9 mbar at $\dot{m}$ =121 kg/h

Δp = 13.7 mbar at $\dot{m}$ = 501 kg/h

Thermal capacity **(calculated)** c = 4.6 kJ/(m²K) C = 10.0 kJ/K

Stagnation temperature t_{stg} = 166 °C at G_S = 1000 W/m² and t_{as} = 30 °C

Emmerthal, 06.11.2007 pp

Dipl.-Ing. C. Lampe, assistant head of Test Centre-EN

Institut für Solarenergieforschung GmbH, Hameln / Emmerthal; Am Ohrberg 1; 31860 Emmerthal; Germany

Institut für Solarenergieforschung GmbH Hameln / Emmerthal

Test Centre for Solar Thermal Components and Systems

ISFH
Am Ohrberg 1 · 31860 Emmerthal · Germany

1. Summary of the Results

Company:	**Kingspan Renewables Ltd. Thermomax** Balloo Crescent Bangor BT19 7UP, UK	Report no.: Report date:	62-07/D 06.11.2007
Type:	**HP 100 30**	Serial no.: Year of production:	MB25813 2007

The following results were obtained from a test of the thermal performance of a solar collector according to **EN 12975-2:2006**. They apply to the collector described more precisely in the test report no. 62-07/D and to the tests and procedures described herein.

Description of the collector

Type	evacuated tubular collector	Aperture area	3.237 m²
Length/Width/Height	2005 / 2127 / 97 mm	Absorber area	3.009 m²
Max. operation pressure	8 bar	Gross area	4.280 m²
Weight, empty	75.5 kg	Thickness of absorber sheet	0.2 mm
Heat transfer fluid	water/propylene glycol	Tube distance	70.9 mm
Recommended flow rate	60-150 kg/m²h	Number of tubes	30

Test results

Coefficients of efficiency
(determined outdoor under steady state conditions)

$$\eta = \eta_0 - a_1 \cdot (t_m - t_a)/G - a_2 \cdot (t_m - t_a)^2/G$$

Based on:	aperture area	absorber area
η_0 =	0.739	0.795
a_1 =	1.00 W/m²K	1.07 W/m²K
a_2 =	0.0074 W/m²K²	0.0080 W/m²K²

Incident angle modifier
(determined outdoor)

proj. angle of incidence θ	0°	10°	20°	30°	40°	50°	60°
$K_{\theta b,trans}(\theta_{trans})$	1.00	1.01	1.02	1.03	1.01	0.94	0.80
$K_{\theta b,long}(\theta_{long})$	1.00	1.00	0.99	0.98	0.96	0.92	0.86
$K_{\theta d}$ =	0.88						

Power output per collector unit

	Irradiance		
$T_m - T_a$	400 W/m²	700 W/m²	1000 W/m²
10 K	922 W	1639 W	2356 W
30 K	838 W	1555 W	2272 W
50 K	735 W	1452 W	2169 W

Pressure drop (water, 20 °C)
Δp = 1.0 mbar at $\dot{m}$ =120 kg/h
Δp = 15.4 mbar at $\dot{m}$ = 501 kg/h

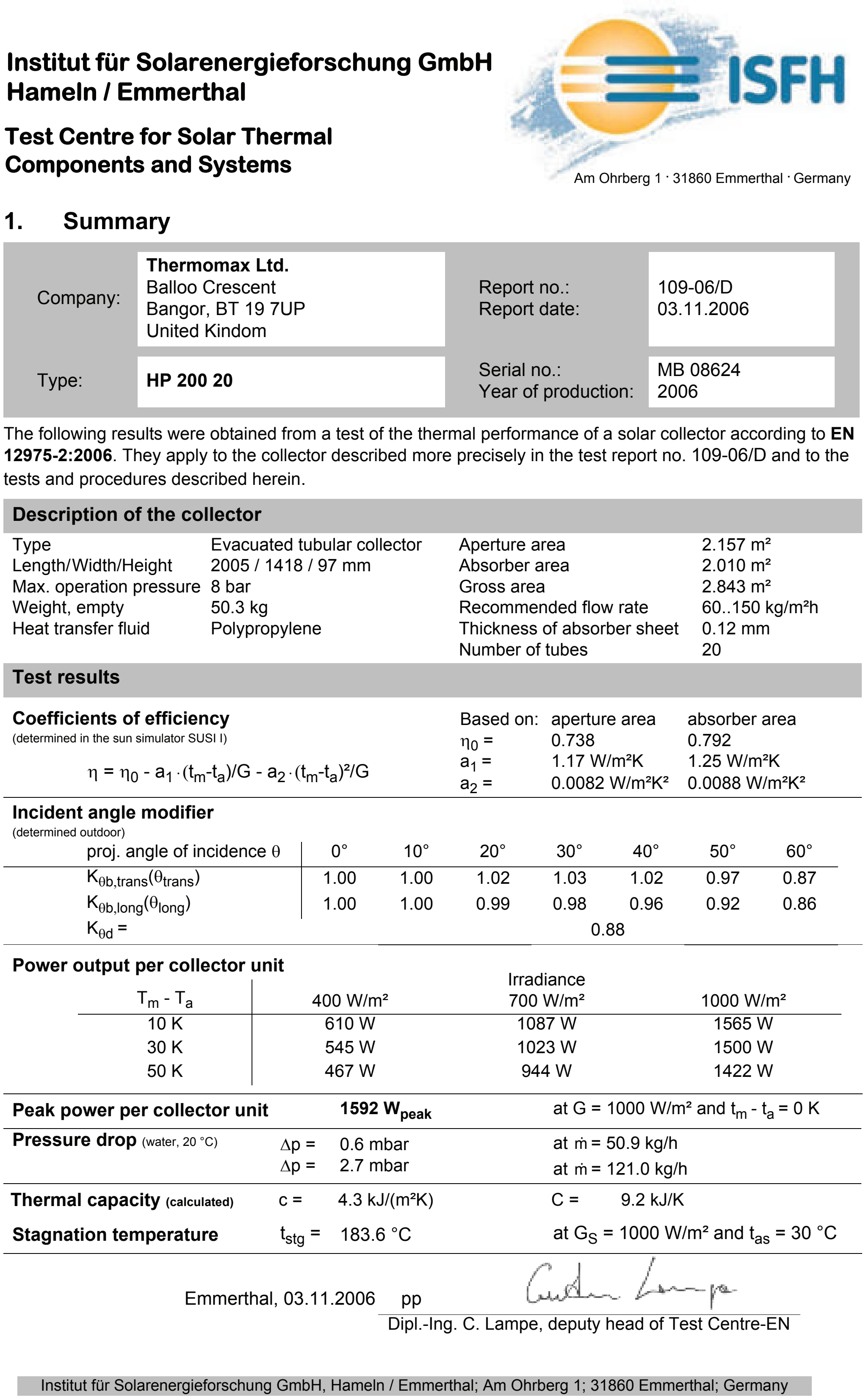
Thermal capacity (calculated) c = 4.6 kJ/(m²K) C = 14.9 kJ/K

Stagnation temperature t_{stg} = 166 °C at G_S = 1000 W/m² and t_{as} = 30 °C

Emmerthal, 06.11.2007 pp

Dipl.-Ing. C. Lampe, assistant head of Test Centre-EN

Product Test Reports



Institut für Solarenergieforschung GmbH
Hameln / Emmerthal

Test Centre for Solar Thermal
Components and Systems

Am Ohrberg 1 · 31860 Emmerthal · Germany

1. Summary

Company:	**Thermomax Ltd.** Balloo Crescent Bangor, BT 19 7UP United Kindom	Report no.: Report date:	109-06/D 03.11.2006
Type:	**HP 200 20**	Serial no.: Year of production:	MB 08624 2006

The following results were obtained from a test of the thermal performance of a solar collector according to **EN 12975-2:2006**. They apply to the collector described more precisely in the test report no. 109-06/D and to the tests and procedures described herein.

Description of the collector

Type	Evacuated tubular collector	Aperture area	2.157 m²
Length/Width/Height	2005 / 1418 / 97 mm	Absorber area	2.010 m²
Max. operation pressure	8 bar	Gross area	2.843 m²
Weight, empty	50.3 kg	Recommended flow rate	60..150 kg/m²h
Heat transfer fluid	Polypropylene	Thickness of absorber sheet	0.12 mm
		Number of tubes	20

Test results

Coefficients of efficiency
(determined in the sun simulator SUSI I)

$$\eta = \eta_0 - a_1 \cdot (t_m - t_a)/G - a_2 \cdot (t_m - t_a)^2/G$$

Based on:	aperture area	absorber area
η_0 =	0.738	0.792
a_1 =	1.17 W/m²K	1.25 W/m²K
a_2 =	0.0082 W/m²K²	0.0088 W/m²K²

Incident angle modifier
(determined outdoor)

proj. angle of incidence θ	0°	10°	20°	30°	40°	50°	60°
$K_{\theta b,trans}(\theta_{trans})$	1.00	1.00	1.02	1.03	1.02	0.97	0.87
$K_{\theta b,long}(\theta_{long})$	1.00	1.00	0.99	0.98	0.96	0.92	0.86

$K_{\theta d}$ = 0.88

Power output per collector unit

$T_m - T_a$	Irradiance 400 W/m²	 700 W/m²	 1000 W/m²
10 K	610 W	1087 W	1565 W
30 K	545 W	1023 W	1500 W
50 K	467 W	944 W	1422 W

Peak power per collector unit **1592 W_{peak}** at G = 1000 W/m² and $t_m - t_a$ = 0 K

Pressure drop (water, 20 °C)
Δp = 0.6 mbar at $\dot{m}$ = 50.9 kg/h
Δp = 2.7 mbar at $\dot{m}$ = 121.0 kg/h

Thermal capacity **(calculated)** c = 4.3 kJ/(m²K) C = 9.2 kJ/K

Stagnation temperature t_{stg} = 183.6 °C at G_S = 1000 W/m² and t_{as} = 30 °C

Emmerthal, 03.11.2006 pp Carsten Lampe
Dipl.-Ing. C. Lampe, deputy head of Test Centre-EN

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Institut für Solarenergieforschung GmbH
Hameln / Emmerthal

Test Centre for Solar Thermal Components and Systems

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1. Summary

Company:	**Thermomax Ltd.** Balloo Crescent Bangor, BT 19 7UP United Kindom	Report no.: Report date:	110-06/D 03.11.2006
Type:	**HP 200 30**	Serial no.: Year of production:	MB 08617 2006

The following results were obtained from a test of the thermal performance of a solar collector according to **EN 12975-2:2006**. They apply to the collector described more precisely in the test report no. 110-06/D and to the tests and procedures described herein.

Description of the collector

Type	Evacuated tubular collector	Aperture area	3.229 m²
Length/Width/Height	2005 / 2127 / 97 mm	Absorber area	3.021 m²
Max. operation pressure	8 bar	Gross area	4.265 m²
Weight, empty	75.1 kg	Recommended flow rate	60..150 kg/m²h
Heat transfer fluid	Polypropylene	Thickness of absorber sheet	0.12 mm
		Number of tubes	30

Test results

Coefficients of efficiency
(determined outdoor)

$$\eta = \eta_0 - a_1 \cdot (t_m - t_a)/G - a_2 \cdot (t_m - t_a)^2/G$$

Based on:	aperture area	absorber area
η_0 =	0.727	0.778
a_1 =	0.85 W/m²K	0.91 W/m²K
a_2 =	0.0093 W/m²K²	0.0100 W/m²K²

Incident angle modifier
(determined outdoor)

proj. angle of incidence θ	0°	10°	20°	30°	40°	50°	60°
$K_{\theta b,trans}(\theta_{trans})$	1.00	1.00	1.02	1.03	1.01	0.94	0.80
$K_{\theta b,long}(\theta_{long})$	1.00	1.00	0.99	0.98	0.96	0.92	0.86
$K_{\theta d}$ =				0.88			

Power output per collector unit

	Irradiance		
$T_m - T_a$	400 W/m²	700 W/m²	1000 W/m²
10 K	909 W	1614 W	2319 W
30 K	830 W	1535 W	2240 W
50 K	727 W	1432 W	2137 W

Peak power per collector unit **2349 W_{peak}** at G = 1000 W/m² and $t_m - t_a = 0$ K

Pressure drop (water, 20 °C) Δp = 0.8 mbar at $\dot{m}$ = 50.3 kg/h
Δp = 4.4 mbar at $\dot{m}$ = 130.0 kg/h

Thermal capacity (calculated) c = 4.2 kJ/(m²K) C = 13.6 kJ/K

Stagnation temperature t_{stg} = 183.6 °C at G_S = 1000 W/m² and t_{as} = 30 °C

Emmerthal, 03.11.2006 pp

Dipl.-Ing. C. Lampe, deputy head of Test Centre-EN

Product List

Kingspan Solar offer a complete range of renewable energy products for both domestic and commercial applications. Our complete solar package solutions include initial advice, professional design specifications and technical assistance through to a network of fully trained Kingspan Solar Accredited Installers who are kept up to date with the latest regulations and available grants.

Our range of products consist of:

THERMOMAX

THERMOMAX | FN

THERMOMAX | FS

High quality flat panel (Thermomax FN/FS or Marvel) or our world leading solar vacuum tube collectors (Thermomax) are supplied as part of the total package. Flat panel collectors are available for on-roof or in-roof. Our Heat Pipe and Direct Flow vacuum tube solar collectors are available for on-roof installation.

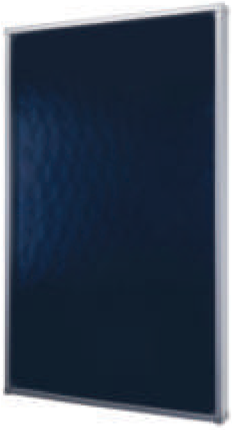
- **Range Tribune Cylinder - from 60 to 300 Ltr. Direct or Indirect. High quality, 'Duplex' stainless steel**
- **Solar Controller**
- **Pump Station**
- **Expansion Vessel**
- **Glycol – Antifreeze**
- **Roof Kit**

We also offer a range of stainless steel or copper cylinders with volumes from 90 to 1500 litres for vented or unvented applications.

SOLAMAX

powered by MITSUBISHI HEAVY INDUSTRIES, LTD.

New generation of Thin film photovoltaic panels. Tandem technology guarantees high energetic yields. Factors that often hamper performance including widespread radiation, partial overshadow or less than perfect orientation are overcome in most cases. With tandem technology these factors have little effect on performance. In most cases, Tandem technology guarantees yields of up to 10% more than silicone crystalline products.



Kingspan Climate

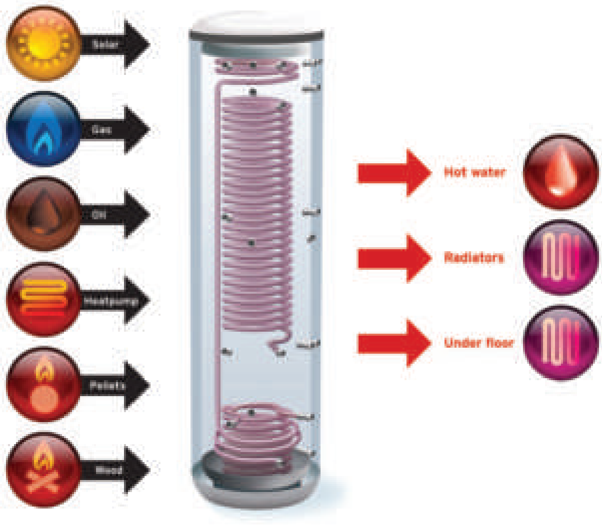
This silent solar powered cooling/heating system is perfect for hotter Mediterranean-style climates. The Kingspan Climate package includes the ClimateWell, premium quality Thermomax vacuum tube collectors, controllers and a Kingspan cylinder. Compact and incredibly cheap to run, the Kingspan Climate can also provide heating for domestic water and swimming pools.

Kingspan AEROMAX

Aeromax heat pumps use natural heat from the air outside to provide central heating (underfloor heating or traditional radiators) and/or hot water for your home. Highly efficient, the units are compact and easy to install. Incredibly quiet, they require virtually no maintenance. Offered with complete package solutions and can be coupled with the highly efficient Range Tribune HE renewable energy cylinder to maximise efficiency benefits.

Kingspan ENERGICENTER

This integrated energy store can combine multiple renewable and traditional methods of heat inputs (such as solar, wood pellets, heatpump, gas or oil), to offer an integrated central energy system. Compact in size, this single tank system results in minimum space requirement. Along with robust and well-established technology, it can be integrated at any stage into any heating system. Offering optimal contribution of renewable energy to both space heating and water heating.



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