



Use of solar thermal energy

- energy generation from solar radiation
- concentrating solar thermal energy
- different solar collectors in comparison





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Solar thermal energy, the use of a natural resource in technical education

The annual solar energy irradiated onto the continents is 1.08×10^{18} kWh. This corresponds to about 5,000 times the global demand for primary energy. It is obvious to use this solar energy technically. Solar thermal energy plays a special role in the use of solar energy. Applications in this field date back to pre-Christian times when burning mirrors or concave mirrors were used to focus light rays.

In addition to solar domestic hot water and heating water, the use of solar heat in large-scale energy generation processes and process engineering is becoming increasingly important today. The use of solar energy through solar thermal systems involves both practical aspects and extensive theoretical basics. Therefore, in our didactic concept for the area of solar thermal energy, we distinguish between the learning fields listed on the right.



E-learning from GUNT offers extensive multimedia educational material online for the laboratory experiments and thus supports technical training and engineering studies.

Basic knowledge

Solar thermal energy

Fundamentals of solar thermal energy use

ET 202
Principles of solar thermal energy
ET 202.01
Parabolic trough collector

Concentrating solar thermal energy

ET 203
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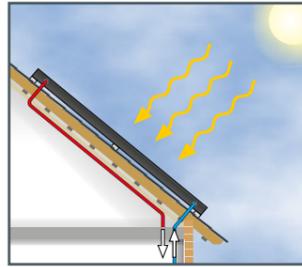
Solar thermal energy for domestic water heating

HL 313
Domestic water heating with flat collector
HL 314
Domestic water heating with tube collector
HL 313.01
Artificial light source

Solar thermal energy in modular systems for domestic supply

HL 320.03
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HL 320.04
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Central storage module with controller

Basic knowledge Solar thermal energy

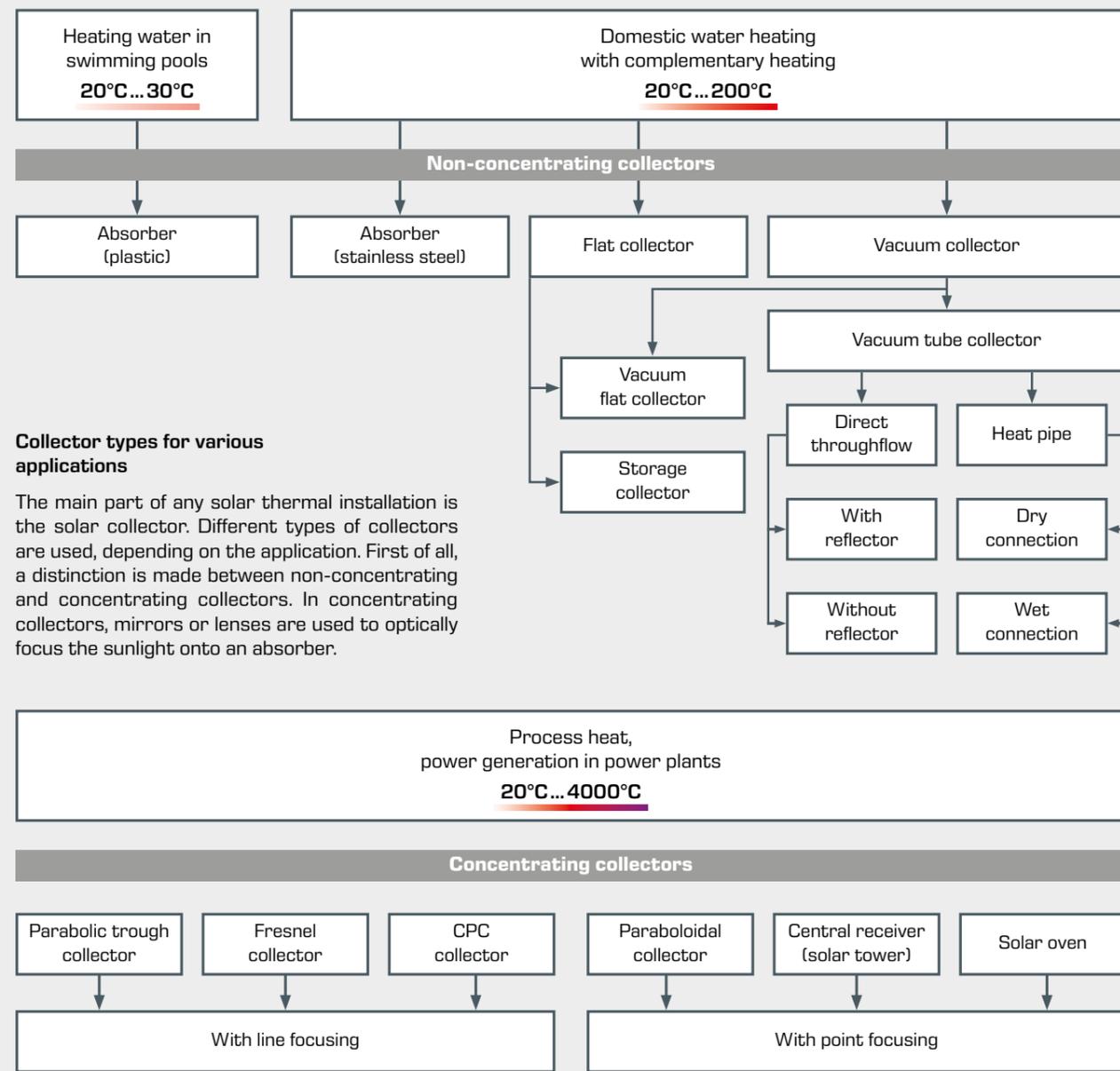


Solar thermal energy is defined as using solar power to provide heat. The heat can be used for heating in the home and for heating domestic water, as well as for process heat in industry and for steam generation in power stations and even for cooling.

Typical applications for solar thermal collectors:

- heating water in swimming pools
- low-temperature heat for heating rooms
- domestic water heating
- process heat (concentrated solar power)
- electricity generation (concentrated solar power)

Collector types



Collector types for various applications

The main part of any solar thermal installation is the solar collector. Different types of collectors are used, depending on the application. First of all, a distinction is made between non-concentrating and concentrating collectors. In concentrating collectors, mirrors or lenses are used to optically focus the sunlight onto an absorber.

Flat collector

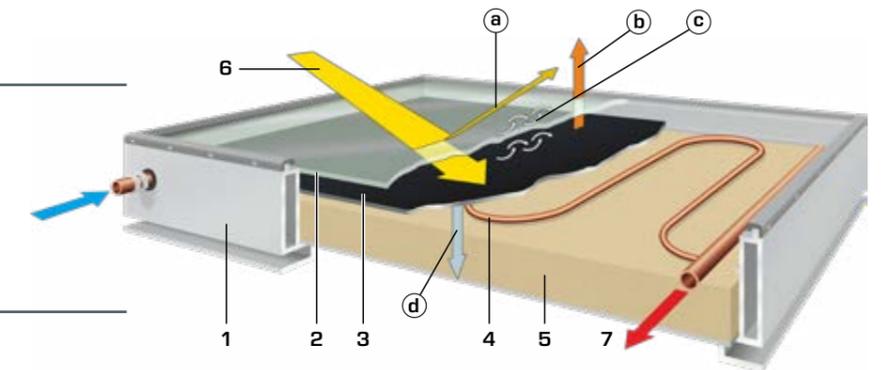
A widely used non-concentrating solar collector type is the flat collector. It represents a balanced compromise between a simple, cost-effective design and efficiency.

The back is insulated against heat loss. The copper tube can be fed through the collector in different ways. The absorber may be made of copper, aluminium, or steel. The absorber's dark colour is caused by the selective coating. The glass cover is made of high-quality, low-iron solar glass with a low absorption factor.

In the design, a compromise is sought between good heat transfer through turbulent flow and a low pressure loss. The flat collector is mainly used for hot water preparation and heating support.

Design

- 1 collector frame
- 2 solar glass cover
- 3 absorber
- 4 copper tube as heat transfer fluid
- 5 thermal insulation
- 6 incident solar radiation
- 7 generated heat at the collector outlet



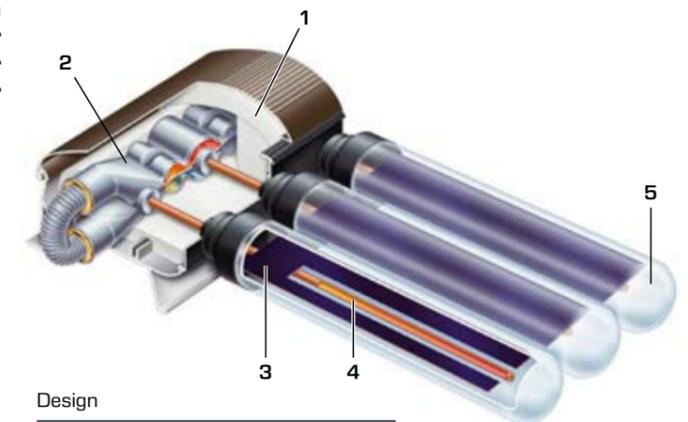
Main losses

- a losses through reflection
- b thermal radiation losses
- c losses through convection
- d losses through heat conduction

Tube collector

While flat collectors are simple in design, tube collectors are made up of technically more complex individual components. The use of double-walled, airless glass tubes (vacuum tubes) prevents heat loss through convection. The glass tubes contain absorbers that are provided with a spectrally selective coating. In so-called heat pipe collectors, the heat transfer from the absorber to the solar circuit takes place through evaporation and condensation of an evaporation liquid in a sealed transfer pipe. The generated heat is transferred to the heat transfer fluid in the solar circuit and from there reaches the consumer or the storage tank.

The efficiency of tube collectors is up to 30 percent higher than that of flat collectors. One advantage of direct-flow tube collectors with a circumferential absorber is that they absorb light from all sides and thus also make better use of diffuse scattered light.



Design

- 1 thermal insulation
- 2 tubular heat exchanger outside the heat transfer fluid, dry connection
- 3 absorber
- 4 heatpipe
- 5 glass tube (vacuum)



Tube collectors mounted at an optimised angle of incidence on a flat roof

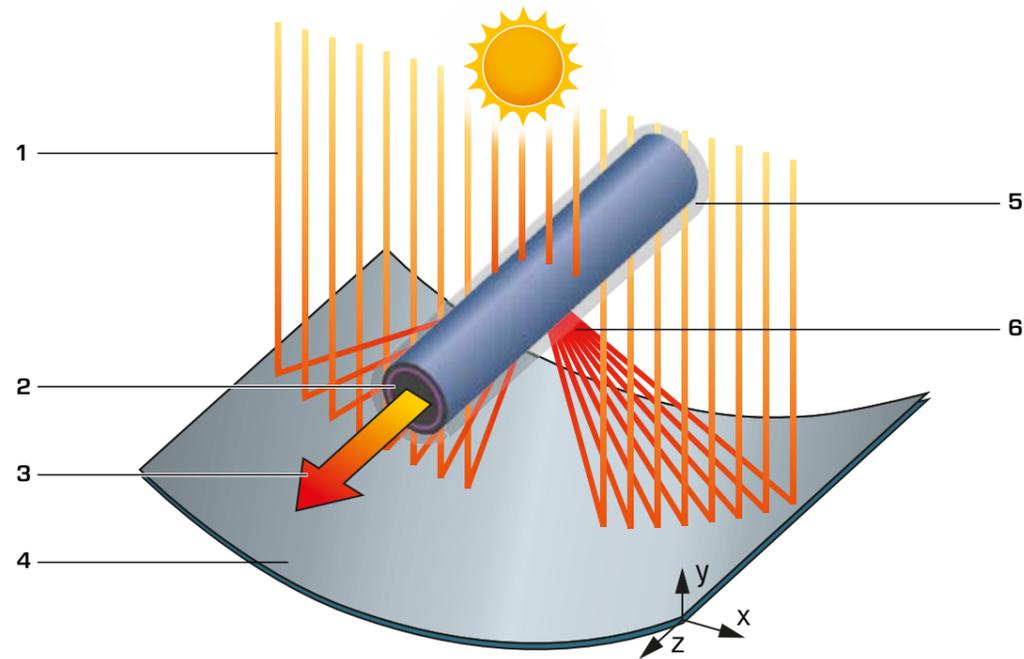
Basic knowledge Solar thermal energy

Parabolic trough collector

With concentrating collectors, the irradiation is multiplied optically by mirrors and lenses on the absorber. Since only the direct radiation portion can be concentrated, the use of such systems makes sense in regions with high direct irradiation.

The solar radiation is focused by a parabolic mirror onto an absorber tube. In the process, the radiant energy is absorbed

and converted into heat. To reduce heat loss, the absorber pipe is covered with a double-walled glass shell. With the help of a pipe in the absorber, the heat is transferred to a heat transfer fluid in the solar circuit and reaches the storage tank.



Design

1 incident solar radiatio, 2 absorber tube, 3 heat transfer fluid, 4 parabolic mirror with reflective surface, 5 glass tube, 6 concentrated solar radiation



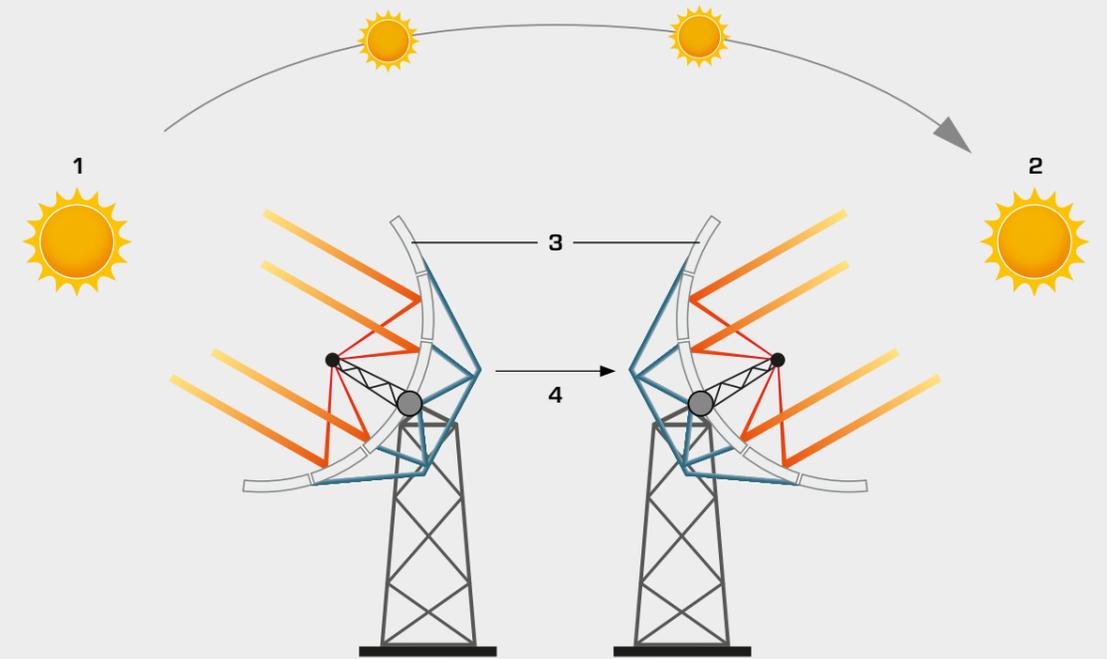
For a power plant, individual parabolic trough collectors can be connected in a collector field.

Sun tracking

Concentrating systems for solar energy use require tracking of the concentrating optical elements (lenses or mirrors). The orbital and rotational movement of the earth causes the sun's elevation and of the sun's altitude (elevation) and orientation (azimuth). The decisive factors for a single- or double-axis design are the technology used and the geographical location. Large parabolic trough power plants are preferably realised

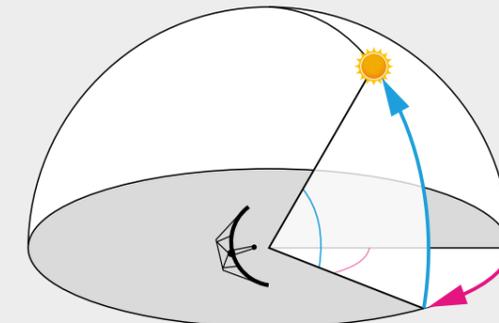
with single-axis tracking at locations with a small geographical latitude.

For so-called tower power plants with point absorbers, the mirrors must be continuously tracked in both directions during the day.



Functional principle of the sun tracking system

1 East, 2 West, 3 pivotable collector with two-axis tracking, 4 position during the day



Sun position and angle of incidence

■ azimuth: horizontal or horizontal angle when adjusting the mirror
■ elevation: vertical or perpendicular angle when the mirror is adjusted

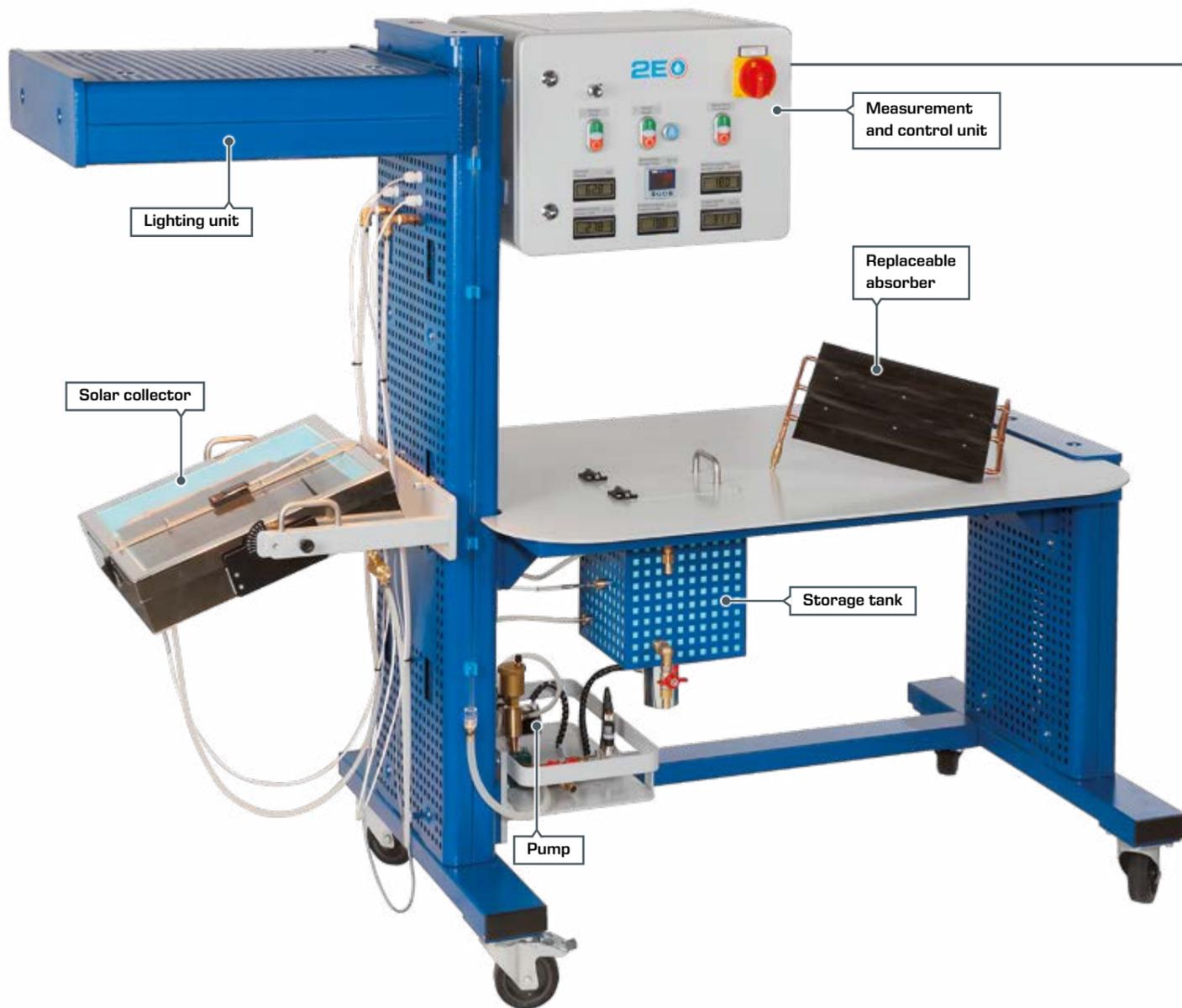
ET 202

Principles of solar thermal energy

The ET202 trainer allows you to undertake systematic measurements on a solar thermal system with flat collector. A lighting unit simulates the natural solar radiation. The light is converted into heat in an absorber and transferred to a heat transfer fluid. A pump conveys the heat transfer fluid through a storage tank. There the heat is released to the contents of the tank by an integrated heat exchanger. The pre-installed absorber with selec-

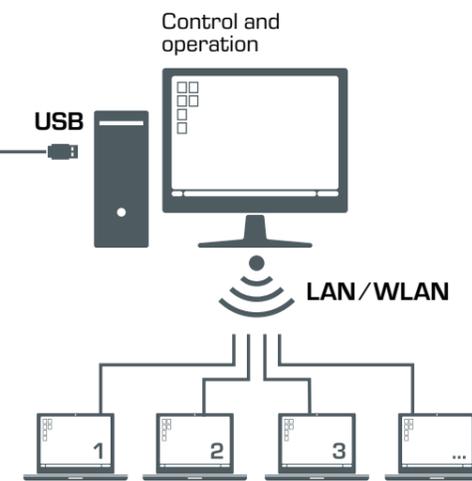
tive coating can be replaced for a simpler blackened absorber, to obtain comparative measurements of collector losses. The electric heater in the storage tank shortens the heating times for experiments at higher temperatures.

About the product:



Features

- operation independent of weather conditions
- inclinable flat collector with replaceable absorbers
- network capability: observe, acquire, analyse experiments via customer's own network

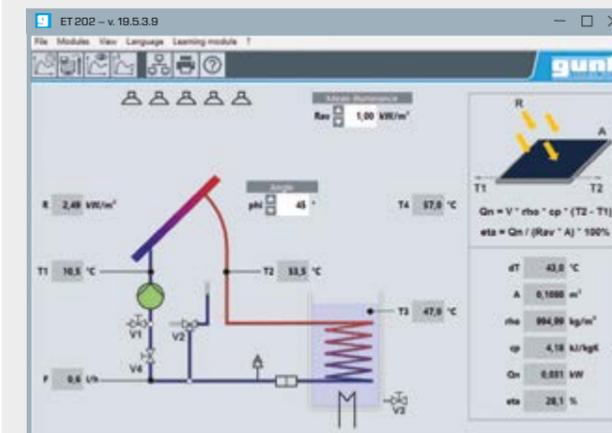


Learning objectives

- design and operation of a simple solar thermal system
- determining the net power
- energy balance on the solar collector
- influence of illuminance, angle of incidence and flow rate
- determining efficiency curves
- influence of various absorbing surfaces

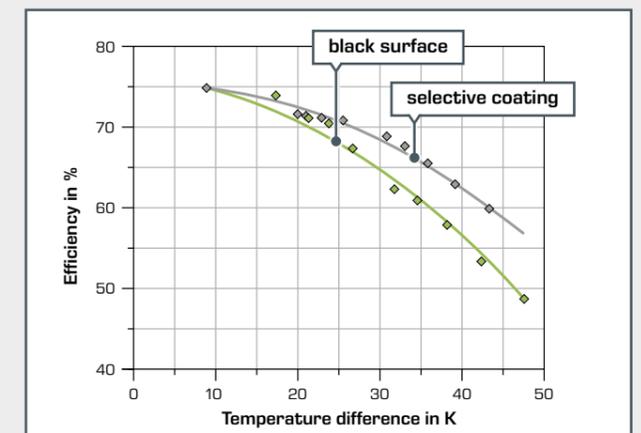
Software

The software displays the measured values in a system diagram and enables the recording of individual measuring points or a time function. Stored measurement data can



GUNT software for measurement data acquisition via PC

be imported into a spreadsheet programme (e.g. Microsoft Excel) and processed there.



Efficiency depending on the collector temperature. A special coating of the absorber allows higher efficiencies.

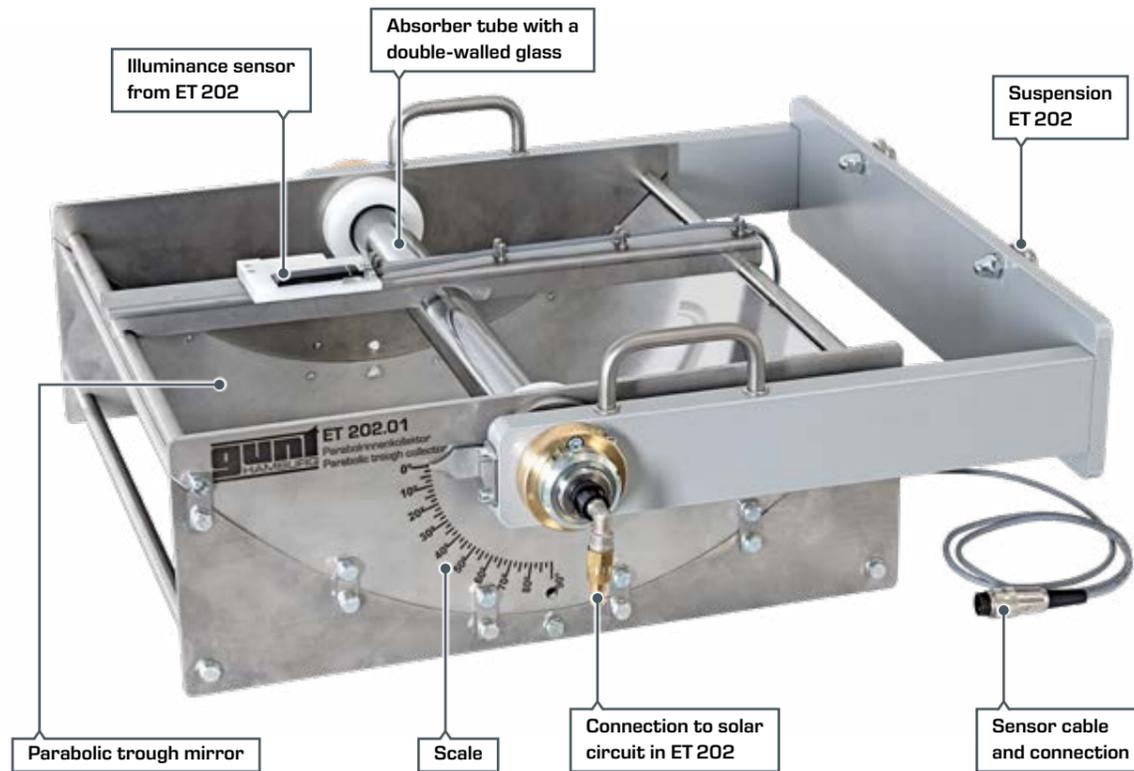
ET 202.01

Parabolic trough collector

ET 202.01, together with the ET 202 trainer allows you to investigate fundamental aspects of concentrating solar thermal energy use. The light from the lighting unit in ET 202 is focused onto the absorber tube by means of the parabolic mirror. The absorber tube is fitted with a double-walled glass casing to reduce heat losses. The heat is transferred through a pipe in the absorber to a heat transfer fluid in the solar circuit of the ET 202 trainer, where it enters the storage tank.

In experiments, the efficiency of a concentrating parabolic trough collector is directly compared with a classic flat collector.

About the product:



ET 202.01 illuminated with the light source of ET 202



pivoting parabolic trough collector

Learning objectives	
■	focusing solar radiation with a parabolic trough mirror
■	optical concentration factor
■	conversion of radiant energy into heat
■	losses in thermal solar collectors
■	efficiency characteristics

Features

- pivoting parabolic trough collector with highly reflective mirror
- absorber tube with selective coating
- evacuated double-walled glass tube to reduce heat losses



ET 202 together with ET 202.01



ET 203

Parabolic trough collector with solar tracking

With the parabolic trough collector, main aspects of solar thermal energy use are being investigated. The solar radiation is focused onto an absorber tube with the help of the parabolic mirror. The radiation energy is absorbed and converted into heat. The heat reaches the solar circuit via a heat transfer fluid and from there the hot water circuit.

The parabolic trough collector can be adjusted to the position of the sun via two geared motors. Both control according to calculated astronomical data and sensor-based control are possible. The collector can be pivoted and aligned vertically for experiments with the artificial light source HL 313.01. Rollers and movable supports allow positioning at a suitable outdoor location.

About the product:



Features

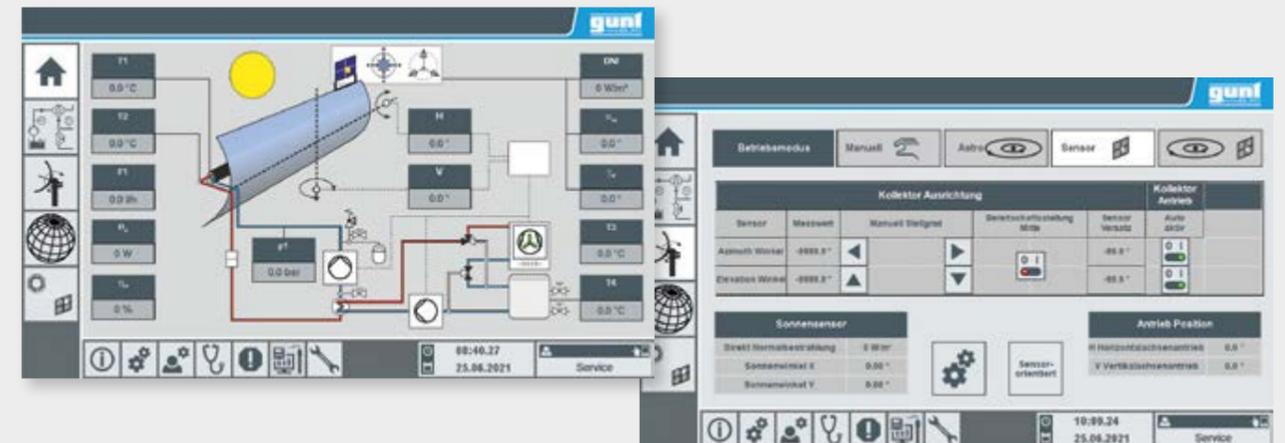
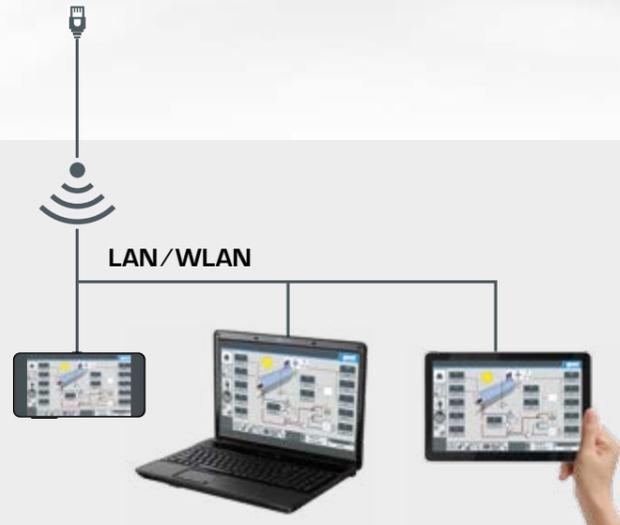
- mobile parabolic trough collector with motorized two-axis tracking
- astronomical and sensor-based tracking
- integrated router for operation and control via an end device and for screen mirroring on additional end devices: PC, tablet, smartphone

Learning objectives

- optical concentration factor
- DNI: Direct Normal Irradiance
- sensor-based or astronomical sun tracking
- conversion of radiant energy into heat
- efficiency curves

External operation

Operation and control are carried out via the integrated PLC and the touch screen. By means of an integrated router, the trainer can alternatively be operated and controlled via an external end device. The user interface can also be displayed on additional end devices (screen mirroring). Access to stored measured values in the PLC is possible from end devices via WLAN with integrated router / LAN connection to the customer's own network.





HL 313 / 314 HL 313.01

Domestic water heating with flat collector or vacuum tube collector Artificial light source

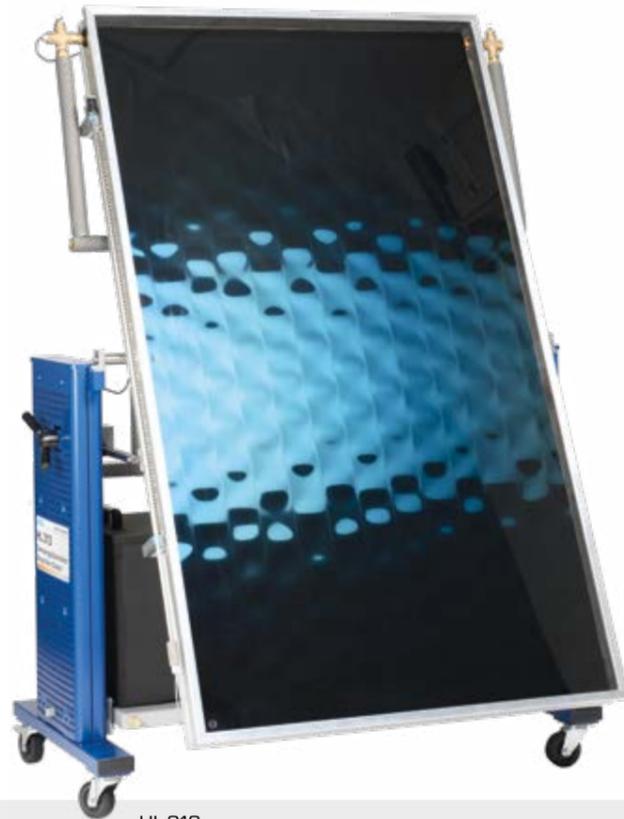
The trainer contains typical components from the practice of solar thermal heat generation systems. The absorbed heat is transferred in the flat collector to a common heat transfer fluid in the solar circuit. The heat reaches the hot water circuit via a plate heat exchanger. The solar controller controls the pumps in the hot water and solar circuit.

The trainer has been designed so that it is possible to carry out a complete preheating as part of a practical experiment. Use in the laboratory with artificial light source HL 313.01 or outdoors if sunlight is sufficient.

About the product:



Learning objectives	
■	determining the net power
■	relationship between flow and net power
■	determining the collector efficiency
■	relationship between temperature difference (collector/environment) and collector efficiency



HL 313
Flat collector



HL 314
Tube collector

In a vacuum tube collector, thermal collector losses are significantly reduced by evacuated glass envelopes. Heat pipes in the absorbers transfer the heat to a transfer fluid in the solar circuit. Here, too, the heat then reaches the hot water circuit and the storage tank via a plate heat exchanger. The same solar controller is used as in HL 313.

In the experiments with the artificial light source HL 313.01 or with real solar radiation, for example, it can be directly observed that the lower losses have an advantageous effect especially at higher operating temperatures.

About the product:



Features

- system with heat exchanger and two separate circuits
- solar controller with data logger and integrated router for operation via web browser using an end device and for tracking experiments on numerous end devices: PC, tablet, smartphone



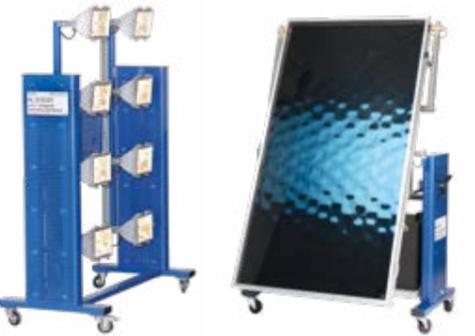
HL 313.01
Artificial light source

**HL 313.01
Artificial light source**

The artificial light source HL 313.01 enables solar energy experiments independently of natural sunlight. As a result, trainers for the use of solar energy such as HL 313 and HL 314 can be operated in closed laboratory rooms. With this light source, it is possible to ensure reproducible test conditions at any time.

About the product:





HL 313 together with artificial light source HL 313.01



LAN/WLAN

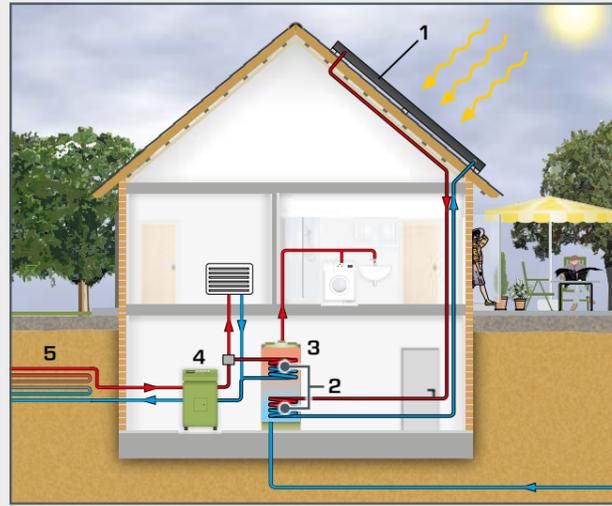
External operation

The solar controller for both collectors is operated by means of an integrated router. The user interface can be displayed on any number of end devices via a web browser. Access to recorded measured values is possible on Windows-based end devices via WLAN with integrated router or LAN connection to the customer's own network. An additional producer software of the solar controller is supplied for this purpose.



HL 320.03 HL 320.04

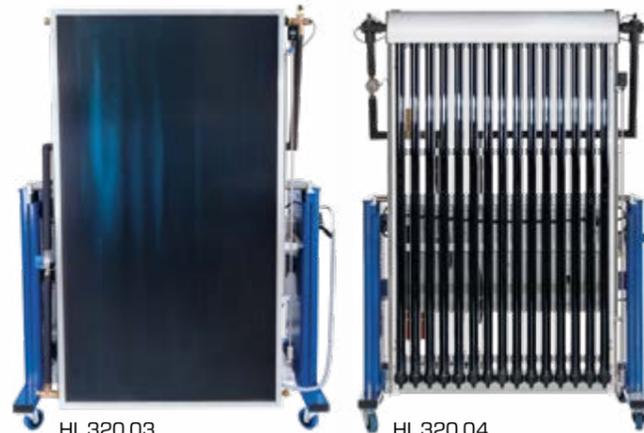
Modular concept with flat collector or evacuated tube collector



Doing away with a conventional heating system represents a genuine alternative for modern residential buildings with good thermal insulation in many cases. The combination of solar thermal collectors with a heat pump very often guarantees significant savings with reliable year-round supply.



1 flat collector, 2 heat exchanger, 3 hot water storage tank, 4 heat pump, 5 geothermal energy absorber
■ hot heat transfer fluid
■ cold heat transfer fluid



HL 320.03 Flat collector

HL 320.04 Evacuated tube collector

HL 320.03 and HL 320.04 are modules of the HL 320 system and enable experiments on the integration of thermal solar collectors into a contemporary heating system with regenerative energy sources.

Both collectors can optionally be connected to the HL 320.05 storage module and additional consumer modules via insulated heating lines. It is possible to use them to produce heated domestic hot water as well as for the combined production of domestic hot water and heating.

About the product:

HL 320.03

HL 320.04



Learning objectives

- determining the net power
- how temperature, illuminance and angle of incidence affect the collector efficiency
- integration of a collector in a modern heating system
- hydraulic and control engineering operating conditions
- energy balances
- optimisation of operating conditions for different types of use

Features

- pivotable collectors for converting solar energy into heat
- heat source with connections for the HL 320 modular system
- suitable for sunlight and artificial light

HL 320.05

Central storage module with controller

The storage module has a buffer tank and a bivalent storage tank. In addition, the storage module is equipped with a freely programmable universal controller. The vacuum tube collector HL 320.04 can be used as an alternative to the flat collector HL 320.03.

Particularly efficient system concepts can be determined through comparative measurement series on different test setups.

About the product:

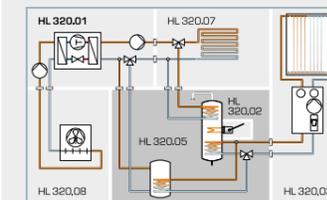


HL 320.05 Central storage module with controller

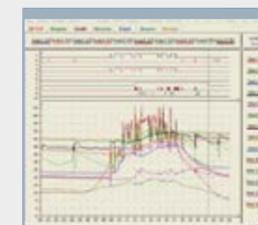
Controller

The heating controller is operated by means of an integrated WLAN router. The user interface can be displayed on any number of end devices via a web browser. A LAN/WLAN connection to the local network allows the recorded measured

values to be evaluated on a PC. Additional manufacturer software for the heating controller is supplied for this purpose.



Inclusion of HL 320.05 in one possible configuration of the HL 320 modular system



Software for data evaluation

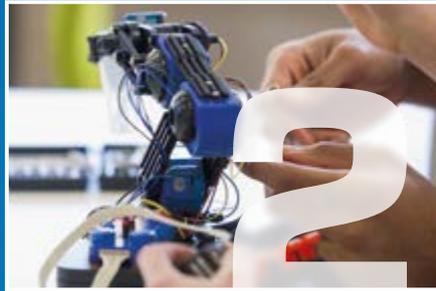


The complete GUNT programme



Engineering mechanics and engineering design

- statics
- strength of materials
- dynamics
- machine dynamics
- engineering design
- materials testing



Mechatronics

- engineering drawing
- cutaway models
- dimensional metrology
- fasteners and machine parts
- manufacturing engineering
- assembly projects
- maintenance
- machinery diagnosis
- automation and process control engineering



Thermal engineering

- fundamentals of thermodynamics
- heat exchangers
- thermal fluid energy machines
- internal combustion engines
- refrigeration
- HVAC



Fluid mechanics

- steady flow
- transient flow
- flow around bodies
- components in piping systems and plant design
- turbomachines
- positive displacement machines
- hydraulic engineering



Process engineering

- mechanical process engineering
- thermal process engineering
- chemical process engineering
- biological process engineering
- water treatment



2E Energy & Environment

- | Energy | Environment |
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| ■ wind power | ■ soil |
| ■ biomass | ■ waste |
| ■ geothermal energy | |
| ■ energy systems | |
| ■ energy efficiency in buildings | |

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