Technology, Ecology and Quality of Life in Harmony

Crailsheim's Solar Thermal System at a Glance

Stadtwerke Crailsheim

Contents

Welcome

Welcome from CEO Jürgen Breit

Dear readers,

The installation of the first solar panels on the roof of the sports hall Hirtenwiesen on December 6, 2002 represented the start of construction on the Stadtwerke's flagship project, the largest interconnected solar thermal heating system with long-term storage in Germany. About 10 years later, the plant was officially inaugurated, and has been successful ever since in everyday operation.

During the construction period, the Stadtwerke was already well aware of the huge importance of the use of renewable energy technology and the protection of our environmental resources. We are, therefore, especially pleased with all the awards the project has received, and the positive coverage it received during the construction period.

8,170 square metres of gross solar collection surface have been installed and provide the energy to supply the high school, the sports hall, and the inhabitants of Hirtenwiesen 2, the residential development, with hot water. A sophisticated storage system allows 50 % of the heating and hot water to be supplied by solar power.

We would like to thank the funding authorities, the academic supervisors, the city of Crailsheim, and of course, our employees, who implemented this project successfully and guaranteed a secure and steady supply of energy by putting the plant into operation.

We hope this brochure can provide you with insight into the functioning of the plant. On the following pages you will find a detailed description of the overall technical and ecological concept. Furthermore, you will also view information on the urban planning concept of the Hirtenwiesen 2 solar thermal system, as well as a graphic overview.

I hope you enjoy reading this brochure.

Jürgen Breit
Technical Director of the
Stadtwerke Crailsheim GmbH

Welcome from the Director-General and Head of Department (Energy Policy) Dr. Urban Rid

The energy transition in Germany is a huge task, a task which we aim to implement successfully. The nuclear accident in Fukushima clearly demonstrated that the decision to stop using nuclear energy by 2022 is the right one. This renunciation involves a long-term overall concept for a new way of energy supply to be implemented over four decades. The key elements of this kind of energy supply are well-directed development of renewable energy technology and the increase of energy efficiency.

Our country is trailblazing the way towards the energy supply of the future. We can be the first large industrialized nation to manage the change towards a highly efficient renewable energy system.

Projects like this pilot plant for solar district heating with seasonal storage in Crailsheim-Hirtenwiesen contribute to the achievement of these goals. That this solar thermal system with long-term storage is the largest one in Germany to date is outstanding, not only because of its size and the application of technical solutions, but also due to the societal example that it sets.

A cost-effective solution for heat storage was developed and put into practice here. Through the construction of this plant, the Stadtwerke Crailsheim and all partners in this project have impressively demonstrated the possibilities offered by solar thermal energy in connection with district heating grids and seasonal heat storage to provide entire residential areas with heat.

I hope this example is followed by many municipalities and public utilities, planners, and operators to achieve the ambitious goals of climate protection and saving of fossil fuels in the heating sector.

We have supported this project of the federal government's Energy Research Programme together with the Ministry of Environment of Baden-Württemberg and the city of Crailsheim. We would like to thank all the partners of this project for their excellent cooperation, and are proud of the result. The success of this project has a hand in our continued support of such pilot projects and their broad implementation, with funds also available in the future for research and development and the market incentive programme.

Dr. Urban Rid
Departmental Head of Energy Policy – Electricity and Grids - in the Federal Ministry for Economic Affairs and Energy

Welcome from Franz Untersteller, the Minister of the Environment of Baden-Württemberg

By putting Germany's largest solar thermal system with long-term storage into operation, the Stadtwerke Crailsheim set new standards with regard to the use of solar heat. It is not only the realized dimension of the solar plant that is new, but above all the basic idea behind the overall project. This is not just any solar plant, but rather an entire "solar city" that has been created.

An exemplary step into the future was made here without having any model to follow. However, in this case the intention is to use renewable energies on a large scale and the aim is quite clear: solar heat. The Stadtwerke Crailsheim succeeded in doing so in a very impressive way. Such an idea requires doers and implementers. Obviously there are such people in Crailsheim among those responsible both in the Stadtwerke and the city administration.

We need as many people as possible with creative ideas, great perseverance and even more power of persuasion who stand up for the realization of such projects in our federal state and its municipalities.

This is also particularly important because we will not be able to achieve our goals of the energy turnaround in the heat sector without a better and wider use of solar energy. In the case of solar thermal energy, we need above all larger plants and the associated operational experience in order to enter the market on a broader basis together with professional users. The Stadtwerke could become a trendsetter with this task, in particular. Crailsheim leads the way!

I hope that the inauguration of this plant will give further impetus to a better, more efficient and wider application of this technology throughout the country. Regarding the use of solar energy, the federal state of Baden-Württemberg represents in the truest sense of the word a hot-spot in Germany.

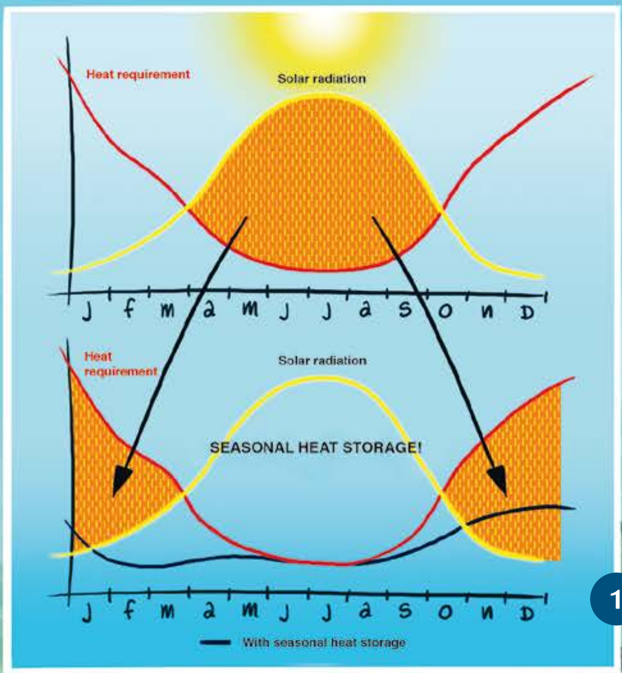
Only if we are on the right path in this regard, we will make real progress in the use of renewable heat. There are indeed more open potentials available along the learning curve of solar thermal energy.

I would like to thank the city of Crailsheim and the Stadtwerke for their courage and staying power during the implementation of the project.

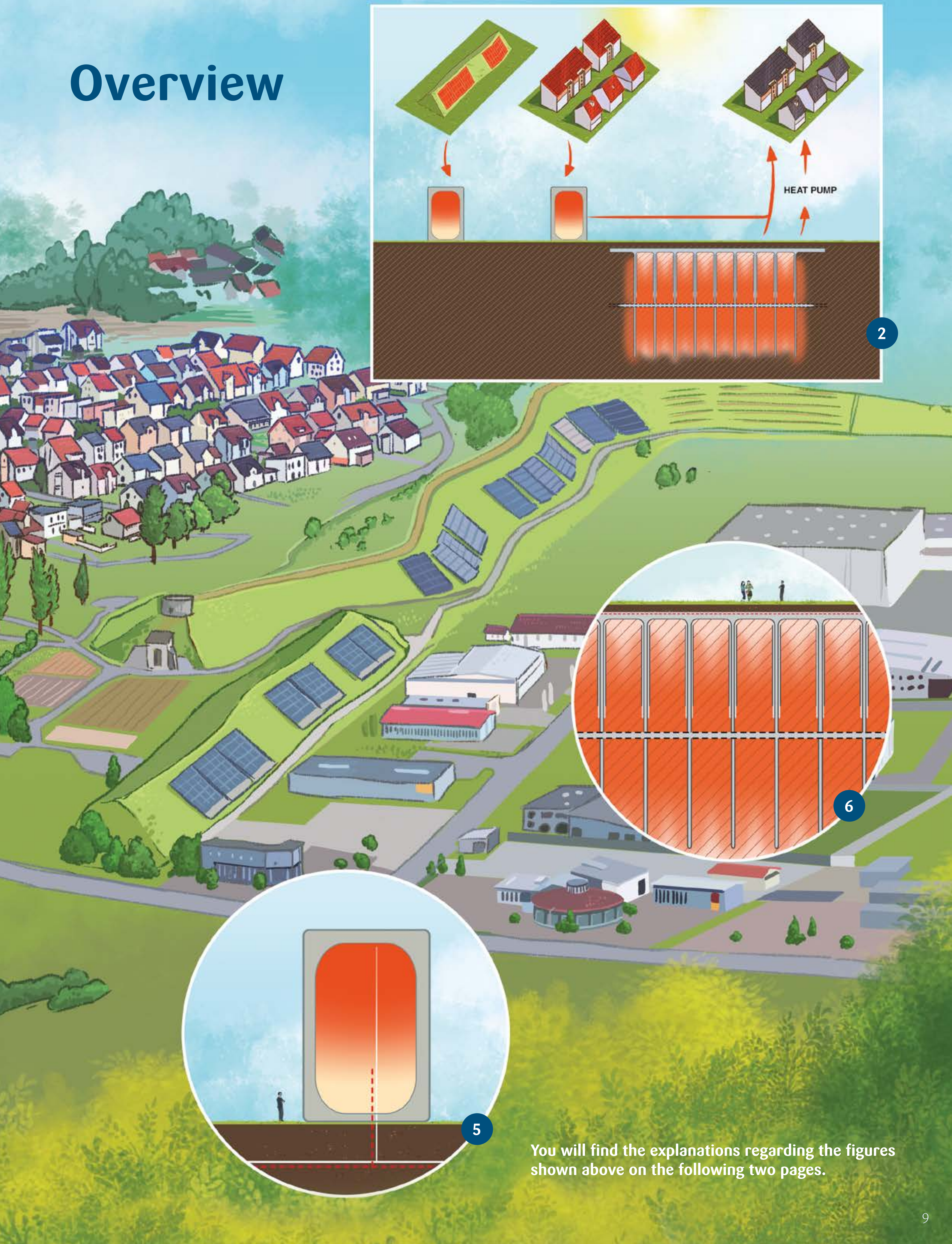
I hope the project's positive practical experiences provide new incentives for the creations of comparable projects.

Franz Untersteller, MdL (Member of the Parliament of Baden-Württemberg)
Minister of the Environment,
Climate Protection and the Energy Sector of Baden-Württemberg

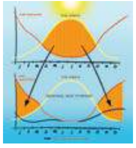
Hirtenwiesen 2



Overview

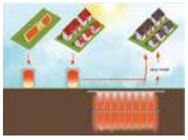


You will find the explanations regarding the figures shown above on the following two pages.



1. The challenge of seasonal heat storage of solar energy

The red line shows the heat requirement of the buildings in Hirtenwiesen 2: During the heating period from September until April, the demand for water heating increases due to space heating. Overall, about three quarters of the annual heat requirement is needed to ensure a warm home and hot water supply during the heating period.
Due to natural causes, however, in Crailsheim the sun delivers about three quarters of its annually incoming solar energy outside the heating season which is shown by the yellow curve.
When half of the total annual heat requirement is produced by solar energy, as it is the case in Hirtenwiesen 2, the heat must be generated during summer and stored until winter. This is referred to as seasonal heat storage!



2. The principle of solar district heating with seasonal heat storage

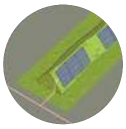
In Hirtenwiesen 2, it would also be technically possible to produce half of the total annual heat requirement by means of solar energy in each individual building. A common solution for all buildings together, however, is considerably cheaper. Furthermore, it is not necessary to meet extensive technical requirements for the construction of a building in Hirtenwiesen 2. Only the space heating system needs to be designed for a maximum flow temperature of 60 degrees Celsius. This is necessary as the solar collectors produce these temperatures with a higher efficiency and more economically than higher temperatures.
The solar panels on the noise reducing berm and on the buildings collect solar energy. This energy is stored in the buffer storage tank located between sports hall and high school and also in the buffer storage that is integrated in the noise reducing berm. These buffer storage tanks are filled with water which is heated to a maximum temperature of 108 degrees Celsius similar to the principle of a pressure cooker. All the buildings in Hirtenwiesen 2 are provided with the solar thermal energy stored in the buffer tanks. Whenever the summer sun delivers more solar heat than the buildings consume or the buffer storage tanks can store, the excess heat is stored in the seasonal heat reservoir – the borehole thermal energy storage shown in figure no. 2 on the previous page. If there is not enough solar heat available in the buffer tanks to provide the buildings with heat, thermal energy will be retrieved from the borehole thermal energy storage. If the temperature of the borehole thermal energy storage falls, it can be increased by means of a heat pump. This heat pump is located in the solar station, which is installed in the noise reducing berm.
The heat distribution to the buildings is achieved through a local heating network. The grid consists of pipes laid in the streets through which hot water flows to the buildings and back again after having cooled off. The water is then reheated in the solar control station located in the sports hall. When there is not enough solar heat available from the solar collectors, the buffer storage tanks or the seasonal heat storage, the required heat will be delivered by the existing district heating network, Hirtenwiesen 1.

3. Integration of solar panels in the buildings

Solar panels are used to produce heat from solar energy. The panels can be made of vacuum tubes or can be constructed as a rectangular box shape. These so-called flat-plate collectors are, in contrast to the vacuum tube collectors, completely waterproof. They can then be installed onto a roof instead of roof tiles.

Solar panels were installed extensively on the southern roofs of the new buildings such as the high school and sports hall, as well as the former barrack buildings. The roofs of the former barrack buildings are thus completely glazed "collector roofs". Besides a large solar collection surface, these roofs consist of skylights, gutters, sheet metal flashing to verge and dormers, snow guards, etc.

The panels contain a dark, selectively-coated copper sheet ("absorber") that converts about 95 % of the incidental solar energy into heat. This thermal energy is transferred to a water-glycol mixture that flows in small copper tubes on the back side of the absorber. The water-glycol mixture prevents the solar circuit from freezing during the winter. This heat carrier fluid transports the solar heat via a solar grid to the two heat control stations where the solar heat is transferred to a conventional water cycle. From there the thermal energy is directly delivered to the users through the district heating grid or stored in one of the two buffer storages.



4. Collection surfaces on the noise reducing berm

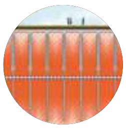
The majority of the solar panels are located on the noise reducing berm. Since many panels can be mounted and connected at once, the installation of collector surfaces on the berm is less expensive than on the roofs of the single family homes in the new residential area. Furthermore, the panels and the roofs would have to match each other, and it would not have been possible to have each type of skylight or dormer window in the roof.

As the material that comprises the noise reducing berm was dumped loosely, its surface could partly settle. In order to install the solar panels, a substructure had to be developed to protect the glass surface of the panels from the risk of soil settlement. On the eastern part of the berm, concrete beams were mounted and rest on four supports. These supports can be readjusted in case of soil settlement. On the western side of the berm an advanced construction method was implemented, which was less expensive in the end: underneath the solar collection fields, a full length concrete slab was poured directly onto the berm. The collectors are screwed onto this concrete slab. The areas between the collectors were designed according to an ecological concept that is described separately. This concept ensures that shadows of plants growing in front of or next to the collector fields don't fall on the solar panels.

5. State of the art seasonal heat storage

Based on extensive computer-aided calculations the complete system was analysed and developed prior to planning. By means of these so-called transient simulations, the plant has been designed in such a way that the goal of covering half of the heat requirement by solar heat at the least possible cost can be fully achieved.

These advance calculations revealed that a seasonal heat accumulator with a water volume of about 10,000 m^3 (cubic metres) would be necessary. Storage systems with such large volumes are normally found next to large power stations, are made of steel, and have a height of 15 to more than 70 metres. The height alone shows that such storage systems cannot be implemented in a residential area. Additionally, these accumulators are relatively expensive and therefore not cost-effective for a seasonal heat storage where the storage tank is only loaded and unloaded once a year. For this reason, a storage type had to be found for Hirtenwiesen 2, which was not yet state-of-the-art, but still on development and testing.



6. Borehole thermal energy storage in Hirtenwiesen 2

An initial examination of the Hirtenwiesen 2 construction site showed, after the consultation with professional geologists, that the underground could be suitable for seasonal heat storage. However, it had to be made sure that this thermal energy did not affect ground water or would not be carried away and subsequently lost due to possible ground water or stratum water currents. A comprehensive geological pre-site survey with three test drillings at the potential storage site revealed that the existing layers of Keuper and limestone in the subsurface were suitable for heat storage. Ground water was found at a depth of about 63 metres, so approximately 55 meters can be used for heat storage.

80 drillings with a depth of 55 metres each, at a distance of 3 metres from each other, were made in Hirtenwiesen 2. Geothermal probes were installed in these vertical holes. The probes consist of two plastic pipes made of PEX (cross-linked polyethylene). They were placed into the borehole and backfilled with a special cement-based material. The pipes were connected at the earth's surface so that the water can circulate within the pipes. During summer this water is heated by the solar cycle of the collector fields, and then flows through the storage and transfers its heat to the layers of Keuper and limestone. During winter this thermal energy is extracted from the storage by pumping colder water through the pipes. The water heats up and thus unloads the heat storage. About 37,000 m^3 of the underground are used to store thermal energy in this fashion.

In order to minimize the heat loss of the storage towards the earth's surface, the surface is thermally insulated and sealed up with Goretex foil underneath the topsoil to prevent rainwater from flowing through the storage and cooling it off.

Seasonal heat storage systems of this type are called borehole thermal energy storages and are still being developed and tested. In comparison to above-ground heat accumulators made of steel, the construction cost of the borehole thermal energy storage in Crailsheim only amounted to about one third of the above-ground cost!

Urban Planning Concept

Urban planning concept and background

The preamble of the urban development concept for the building area Hirtenwiesen 2 from January 31, 2002 states:

“A sustainable building area shall be created on the Hirtenwiesen 2 building site. Due to its clear basic structure with regard to urban design combined with the development and the public spaces, Hirtenwiesen 2 offers a tremendous scope for individual house building according to future user requirements. The design of public and semi-public areas is of particular importance for the new building area. A high degree of identity for future inhabitants as well as excellent locations for businesses and services shall be provided this way.”

At the end of the project it can be noted that the previous goals were implemented completely and even supplemented by its ecological character.

Initial situation

The city of Crailsheim defined a complete conversion area as a redevelopment area. The development into a new residential neighbourhood and more was supported by funds from the state of Baden-Württemberg. The conversion area, with the former “McKee Barracks” (a US military base), comprised at that time a total of 150 ha. Hirtenwiesen 2 makes up about 42 ha of this area. Hirtenwiesen 2 was planned to be developed as a residential and mixed-use area with public facilities.

Goals and purposes

The development conception for Hirtenwiesen 2 was an attractive residential and mixed-use area that also functioned as a new entrance between the city district Roßfeld and the west section of the city of Crailsheim.

This included the development of a district centre and the integration of infrastructural facilities such as high school and sports hall with open spaces for sports. Besides the high quality of living, the strengthening of environmentally friendly means of transport through bus connection and integrating the development into the existing bicycling routes network were of primary importance.

Limiting energy consumption and the release of air pollutants through low energy buildings and efficient energy supply was also an essential part of the development of district Hirtenwiesen 2.

The energy supply concept was implemented in the entire district.


Hirtenwiesen 2 area with solar berm in 2012

Concept

Hirtenwiesen 2's urban development concept is characterized by its unique layout.

The new development area's most distinctive features are its wide residential avenues and an impressive middle zone. The residential area's new commercial centre includes public and private service companies, shops, cafés, and a variety of housing types. The central area was designated as a traffic-free zone, with public paths and open spaces offering a wide range of possible uses. Green, well-landscaped areas give the development a park-like character. Hirtenwiesen 2 has become a great location for a diverse array of service providers due to its excellent transport links.

Two-storey semi-detached houses, tract houses or detached houses comprise the majority of the residential development. Most of the roofs are low-sloped saddle and shed roofs, which allows passive and active use of solar energy or roof greening. The Lise-Meitner-Gymnasium (high school) makes up a major part of the concept and the public use of the building area. The high school is a connecting element between Hirtenwiesen 1 and the Realschule (intermediate school) and is integrated into the growing western part of the city as a living urban element. This connection enables young people to satisfy their need for integration and communication.

The sports hall with areas for sports and leisure time activities was positioned in the west part of this new education area in order to allow a variety of activities without disturbing any residents.

These public institutions are located a short distance away from Hirtenwiesen 2. They are equipped with generously sized parking facilities and bus stops for public transport.

Another central emphasis of the urban plan was to integrate the building area into its surroundings through foot and bicycle paths. This meant that existing path connections had to be incorporated, or new ones created. This integration made an internal and external interconnectedness of the district possible.

Green and open space planning

The former dominant species of trees in the district Hirtenwiesen 2 consisted exclusively of long rows of planted poplars and birches. The value of these tree species held was mainly the way they shaped and formed the landscape. Due to their short life expectancy and the lower resistance to storm-related hazards, this tree population had to be reduced. The existing trees were only preserved as individual trees or in groups in suitable places. From the beginning, this urban quarter has exhibited a particularly scenic impression and integration into its surroundings. The rows of trees on both sides lend the streets an avenue-like character.

The widely spaced trees and woody plants, as well as the change between mown lawns and expansive meadows lend the green areas along the berm and within the residential area the character of a landscape park. Spatially distributed common areas, playing fields and lawns for sunbathing, as well as playgrounds for different age and user groups all contribute to the high quality of open spaces in the green areas.

Generously curved and wide foot and cycle paths open up the green areas and connect Hirtenwiesen 2 to the surrounding sections of the city.

Environmental protection/Ecology

In 1999, the Stadtwerke Crailsheim GmbH and the Steinbeis-Transferzentrum Energie-, Gebäude und Solartechnik (STZ-EGS) had already developed a concept for heat supply. This concept was made more concrete during the implementation phase. At that time the existing noise reducing berm was already an inherent part of the energy strategy and concept.

The 10-15 meter noise reducing berm protects the residential and mixed-use area Hirtenwiesen 2 from any noise produced in the adjacent industrial area. The berm allowed the simple and cost-effective installation of solar panels as well as the integration of the whole solar collection plant.

By recommending low energy construction techniques as a minimum standard, and building a district heating network as low temperature network with a long-term solar storage, a higher reduction of CO_2 emissions can be achieved when compared to a conventional energy supply.

The long-term effect of the implemented concept and the significant reduction in CO_2 emissions especially highlight the sustainable and ecological importance of this project.

Technical Overall Concept

Basic concept of „solar district heating“

The basic idea of the Stadtwerke Crailsheim's project is the combination of modern, family-friendly living with environmentally responsible behaviour through the use of solar energy.

To this end, the Stadtwerke constructed a solar district heating system with seasonal heat storage in Hirten-wiesen 2, which is Germany's largest interconnected solar thermal system with long-term storage. The site has been worked on and redeveloped on a former conversion area in the western part of Crailsheim since 2003. It offers space for 2,000 citizens and features all the conveniences of a modern and family-friendly life. These conveniences include short distances to all the public facilities, comprehensive infrastructure with kinder-garten, schools, sports facilities and shopping possibilities in the immediate vicinity, as well as an appealing landscape with recreational value and species-rich flora and fauna.

In solar district heating systems the heat generated by one or more solar collection areas is transported to the solar station by means of a solar network. From there the thermal energy is distributed to the connected households through the district heating network. Integrating solar thermal heat in district heating systems enables the construction of large, interconnected collection areas, which are considerably cheaper, compared to small solar plants. The solar station is connected with a short-term or – as it is done in Crailsheim, with a seasonal heat storage system. Figure 1 shows a diagram of the plant.

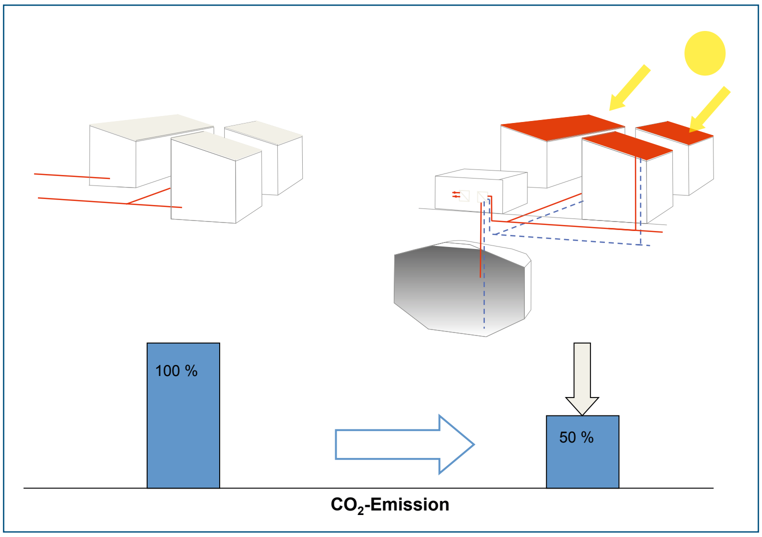


Figure 1: Diagram of a solar district heating system with seasonal heat storage

The larger the heat accumulator, the more solar heat can be used in the district heating network. When 50 % of the annual heat requirement is covered by solar heat as is done in Crailsheim, the thermal energy must be collected in summer and stored until winter in order to meet the high heat demand for space heating. Figure 2 explains that the annual course of solar radiation is the opposite of the course of heat requirement. So, if large amounts of the annual heat requirement are to be covered by solar heat, a seasonal heat accumulator is necessary.

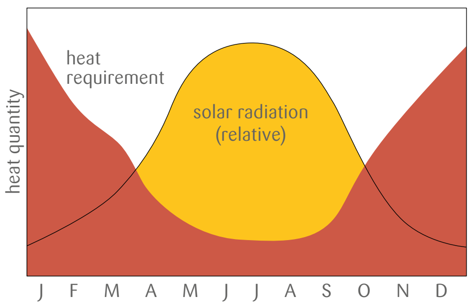


Figure 2: Use of a seasonal heat accumulator to balance the differences between solar radiation in summer and heat requirement during the heating period

Energy supply

The Stadtwerke Crailsheim supplies the residential area Hirtenwiesen with water, electricity and heat. Half of the thermal energy required for hot water and space heating is generated by the solar thermal system. Due to the innovative heat storage technology with two hot water storage tanks and the seasonal borehole thermal energy storage, it is possible to use the heat generated during summer during the winter. If additional heat is required, it is provided by the Stadtwerke's thermal power station. This is achieved by two boilers fired with environmentally friendly natural gas as well as a block-type CHP (combined heat and power unit) with an efficiency of 90 %.

District heating system

The entire residential area of Hirtenwiesen 2 including the Lise-Meitner-Gymnasium (high school) and the Hirtenwiesenhalle (sports hall), as well as the three multi-family buildings, are provided with solar energy through the district heating system.

The district heating system Hirtenwiesen 2 in Crailsheim consists of three basic components (see also Figure 1 on page 17):

1. **Solar control station** with heat provision: It is installed in the basement of the sports hall, gets the heat from the solar system or the Stadtwerke's thermal power station and heats the water in the district heating network (Figure 3). There is a second solar station within in Hirtenwiesen 2's district heating system, which is integrated into the noise reducing berm. This solar station distributes and controls solar heat levels, and also the charging and discharging of the heat storages.

Figure 3: Solar control station in the basement of the sports hall

2. **District heating network** consists of two thermally insulated steel pipes laid in such a way underneath the streets that each house can be reached. In one of the pipes the water heated up by the solar control station flows to each individual house. Each house has its own heat transfer station. A heat exchanger within the transfer station absorbs the heat from the district heating network and transfers it to the pipes for hot water and heating within the house. This way the water of the district heating network cools off and flows back to the solar control station in the second pipe where it will be reheated. The result is a closed circuit with little loss of heat.

   In addition to the high share of solar heat, special attention was given to efficient heat distribution in Hirtenwiesen 2's district heating system. In one part of the district heating network it was tested to what extent innovative, better insulated double pipes, where both pipes are placed within the same outer casing with heat insulation, can improve the efficiency of district heating networks (Figure 4).

Figure 4: Installation of a new type of double pipes in Hirtenwiesen 2's ground storage system

3. **The heat transfer station** (Figure 5) located in each individual house replaces a regular heating system. The heat delivered by the district heating network is transferred to the building through this transfer station in the most efficient way. The more the hot water supplied by the district heating network can be cooled off, the more efficient is the heat transfer station.

   The efficiency of the already existing excellent technology of Crailsheim's heat transfer stations has been further increased for the Hirtenwiesen 2 district heating system.

Figure 5: Typical heat transfer station in the district heating network Hirtenwiesen 2

Building technology

The lower the operating temperature of solar collectors, the more efficient they are. Therefore, the temperature level of the heat being supplied to the buildings via the district heating network is just as important as the temperature to which the building can cool down the supplied heat. Water and space heating in each of the buildings connected to the solar district heating system must work at the lowest possible temperatures. In order to avoid high additional costs for homeowners in Hirtenwiesen 2, the Stadtwerke Crailsheim chose a moderate temperature limit: water for space heating may only be heated to a maximum temperature of 60° C, and is supposed to reach a return temperature of 30 ° C. In order to still guarantee a high overall efficiency of the solar district heating system, the Stadtwerke developed a quality assurance procedure:

1. In the sales contract for the building plot, the city of Crailsheim states that the connecting conditions of the Stadtwerke Crailsheim have to be observed by each building supplied with heat and water by the solar district heating system.

2. The Stadtwerke Crailsheim holds informational events for buyers of building plots as well as their planners and tradespeople. These events provide information on how the building technology can be adjusted to the requirements of the solar district heating system in the best and most cost-efficient way.

3. If needed, the Stadtwerke Crailsheim is available for any technical issues or information during the planning and construction phase of each house.

4. The heat transfer station in each house will be delivered and installed by the Stadtwerke Crailsheim. By doing this, the Stadtwerke can ensure uniform technological standards for all of the heat transfer stations in the district heating system. A precondition for the installation of the heat transfer station is a calculation of the heating system of the building. This ensures that the individual heating surfaces and their pipelines are calculated in accordance with the technical regulations. If required, the heat transfer station can be provisionally put into operation during the construction phase, for the drying process of the house, for example.

5. Once the building is completed, the heat transfer station can be put into operation. At that time, it will also be verified whether the building complies with the connecting conditions. The most important point in this context is to keep the return temperature below the maximum allowable value. Should this upper limit be exceeded, the heat transfer stations will not be put into operation and the house owner will have to solve the problem before being provided with heat.

6. By limiting the return temperature in the heat transfer station, a permanent efficiency of the heat transfer is secured: In case the temperature returned from the building is too high, the heat transfer station will limit the volume flow. If any problems regarding the heat supply of the building should then occur, the Stadtwerke's 24-hour emergency services will always be available.

Solar thermal energy and heat storage systems

The following chapters describe all the components of Hirtenwiesen 2's district heating system that are required to use renewable solar heat.

The solar panel

The solar panels (Figure 6) convert sunlight into usable energy: The sun's radiation passes through the glass cover that protects the panel's sensitive interior. There, the radiation strikes the absorber plate which consists of a black coated sheet. Little pipes are welded or soldered onto the back of the absorber plate. The black coating is so highly physically developed that more than 95 % of the irradiated solar energy are converted into heat, but only about 5 % of this solar heat is emitted again as thermal radiation. This coating is also called a "selective absorber coating". For further reduction of heat loss, the back side of the solar panel is thermally insulated.
A heat carrier fluid consisting of water with additives for corrosion and frost protection is flowing through the absorber pipes. This liquid heats up during solar radiation and can then transport the solar heat to the solar control station. For this purpose the collectors are connected with each other and each collector field is connected with a solar grid. This grid is similar to the district heating network and also consists of a flow and return pipe. However, the solar grid is specially designed for the high operating temperatures of the collector fields. In case of strong sunlight and missing volume flow, for instance in the event of pump failure, these temperatures can reach up to 180 ° C.

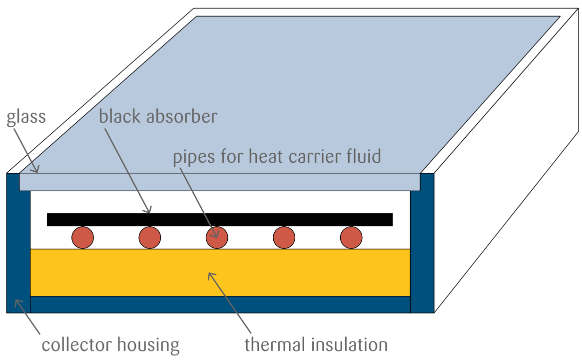


Figure 6: Cross-sectional view of a solar collector

In the solar control station this generated heat will be transferred from the heat carrier fluid to the water circuit of the overall system via a heat exchanger. Hot water that is not required immediately, will be delivered to the corresponding buffer storage tank.

Solar roofs

On selected buildings, the solar panels replace the conventional roofing, such as roof tiles, and form the watertight layer itself. Through this roof integration, an architecturally sophisticated design with low installation cost (Figure 7) has been made possible. The collectors were mounted on the southern roofs of the existing multi-family homes (1750 m², 875 kWth) as well as the Hirtenwiesenhalle (sports hall: 200 m², 100 kWth) and the high school (550 m², 275 kWth).

Due to integral planning of the collector areas - in accordance with the renovation measures of the property developer - architecturally high-quality collector roofs could be developed and implemented on the first three apartment buildings. By doing this, it was possible to create a large, south-facing collector surface and high-quality attic flats with skylights and roof terraces. Figure 8 shows a detailed view of one of these roofs.

Figure 7: High school, sports hall and in the background the roof areas of the five former U.S. barracks

Figure 8: Architecturally sophisticated roof integration of solar collectors on the refurbished U.S. barracks

Solar panels on the noise reducing berm

The majority of the solar panels (5,000 m^2; 2,500 kWth) are installed on the southern flank of a 13 to 15 m high noise reducing berm separating the residential area from the adjacent industrial park. By integrating the large solar collection surfaces on the southern flank into an overall ecological concept, this area has become a place with recreational value, and offers suitable habitat for many native plants and animals.

The conceptual simplicity of installing the solar panels on the noise reducing berm became a challenge during further planning: As the berm was constructed loosely, its surface could partly settle by up to 50 cm. This requires a substructure underneath the individual collector surfaces that can compensate for these possible future settlements. Otherwise, individual pipe connections and glass covers of the collector field could break.

The substructure for the eastern part of the berm, which was the first to be realized, consists of two horizontal concrete beams. The upper beam rests only partially on supporting concrete slabs. Due to the anchoring with bored piles, the lower beam keeps the solar panels from slipping off. The version chosen by the solar panel supplier uses steel girders that are fixed onto the upper and the lower concrete beam. This steel structure then holds the individual panels.

The individual collection fields are connected with the solar network whereby the transfer point is located at the upper end of the collector field.

Figure 9 shows the installation of the substructure and Figure 10 the completed solar collection fields on the eastern part of the berm.

Figure 9: Installation of the substructure for the solar collection fields on the eastern berm

Figure 10: Panels on the eastern noise reducing berm shortly after the completion

The substructure for the western part of the berm was developed further. Through the combination of several collector surfaces into larger field units and the straightening of the berm's surface, it was possible to place the in-situ concrete slabs directly onto the berm. The collectors were secured on these slabs through a frame system consisting of metal rails. For convenient maintenance the transfer point of each collector field to the solar grid is located at the bottom of the collector fields in a lowered shaft. Figure 11 shows the implementation of the substructure on the western part of the berm, while Figure 12 shows the completed solar installation.

Figure 11: Construction of the substructure on the western part of the berm

Figure 12: Completed solar installation on the western part of the berm

Hot water storage tank

Both parts of the system, “solar roof collectors” and “berm collectors”, have their own technical control centre with its own hot water storage tank. The size of the hot water storage tank is adjusted according to the size of the corresponding solar panel surface based on dynamic system simulations. The two control stations are connected with each other through district heating pipes. The solar heat generated by the roof collectors is stored in the 100 m^3 hot water storage tank located in the schoolyard. The panels on the noise reducing berm deliver their solar heat to the hot water storage tank with a capacity of 480 m^3, which is partly integrated into the berm. Only the upper 3 metres of the large tank are visible. On top of this storage tank there is a publically accessible platform that serves as an observation point on the berm.
Both storage tanks are round, made of concrete and lined with stainless steel in order to ensure watertightness. Both concrete structures are also insulated with foamed glass granulate, which is 50 cm thick. The hot water storage tank located on the schoolyard consists of five concrete rings (Figure 13), while the tank in the noise reducing berm was concreted on-site (Figure 14).

Figure 13: Hot water storage tank in the schoolyard during construction


Figure 14: Construction of the hot water storage tank in the berm


Figure 15: Charging unit in the interior of the tank. Here, the first section of the unit connects with the inlet pipes.

Since both backup storage units are operated with a pressure of three bar, cover and base plates are secured to withstand the pressure. These pressure conditions make it possible to store the water up to a maximum temperature of 108 degrees Celsius without starting to boil. By raising the peak temperature to 108 degrees Celsius, the usable heat content of the buffer storages is 15 % higher compared to conventional heat storage systems, which can only be operated at a temperature of up to 95 degrees Celsius. A mechanism in the tank directs the water heated by the solar panels into the proper temperature layer in the buffer storage tank (Figure 15).

Seasonal borehole thermal energy storage (BTES)

The Hirtenwiesen 2 district heating system in Crailsheim covers 50 % of the annual heat requirement of the residential area with hot water and heat produced from solar energy. As mentioned at the beginning, solar heat has to be collected during summer and stored until the winter heating period. In Hirtenwiesen 2, this is achieved through one of the largest heat accumulators in Germany – the borehole thermal energy storage. It uses the underground rock layers (here "upper shell limestone," or Muschelkalk) as the storage medium.

The heat generated by the collectors is first transferred to the 480 m^3 hot water storage tank. This tank absorbs the high heat yields of the collector fields in order to deliver them to the directly connected borehole thermal energy storage over a period of 24 hours. The heat is transferred to the rock/soil through a plastic pipe with a "U" bend at the bottom. These U-pipes are inserted down the 55 metres deep vertical boreholes. Each of these 80 boreholes is equipped with such a "double-U-pipe-probe." Because water can flow within the upper 4 to 5 metres of the BTES field, the upper metres of each borehole are thermally insulated. The individual geothermal probes are connected with each other. When solar heated water is available to be stored, it is pumped through the U-pipe series of the BTES field where the heat will then be transferred to the surrounding soil and rock. As soon as the cooled return water of the district heating network flows through these pipes, it absorbs the heat stored in the ground and heats up again.

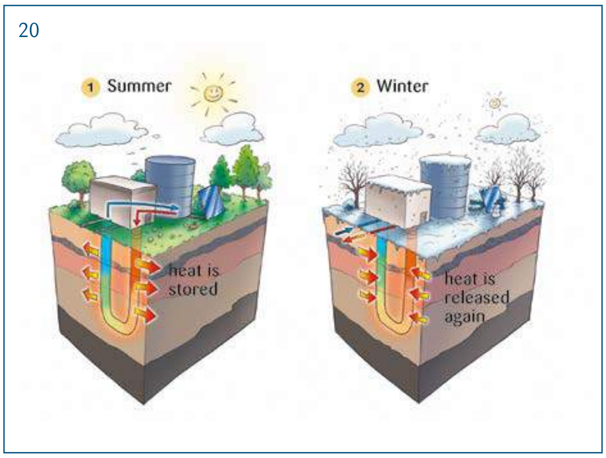
The heat storage unit's 80 geothermal probes use about 37,500 m^3 of rock to store the heat. In order to keep the heat loss as low as possible, the borehole thermal energy storage is thermally insulated near the surface and sealed up with a watertight foil. This foil prevents rainwater from flowing through the storage and cooling it off by directing the water around the storage. The storage's surface is green and full of vegetation, and is not easily or explicitly recognizable as the top of a storage unit.

Figures 16 to 19 show the implementation sequence of the borehole thermal energy storage in Crailsheim.

The borehole thermal energy storage is charged from April to September. The highest temperatures of 70 °C averaged through the storage volume were reached in September. The lowest average temperatures of 15°C were achieved in March. Figure 20 shows the seasonal functioning of the geothermal energy storage.

In autumn the storage is discharged directly if sufficiently high storage temperatures are available. The stored heat is extracted from the borehole thermal energy storage. When the storage has cooled down accordingly, a heat pump increases the temperature to the level required by the end user and transports it to the residential buildings via the district heating network.

In order to properly use and install the heat pump, uncharted territory also had to be entered. The heat pump installed in the solar station in the berm has a nominal heat output of 480 kWth. With heat source temperatures between 15 and 45°C, the heat pump can extract solar heat from the borehole thermal energy storage and permanently deliver 75°C for the district heating network. Figure 21 shows the heat pump.



On the circular storage area there is a gravel drainage layer; the connection shaft can be seen in the middle (16). Geothermal probes are installed and uncoiled from the drilling device (17). Installation of the thermal insulation, which consists of foam glass gravel in big packs (18). Completely insulated storage, start of waterproofing measures on the heat insulation, and soil covering (19). Seasonal heat storage through borehole thermal energy storage (20). Heat pump of solar station in the noise reducing berm (21).

Environmental benefits

The solar thermal system produces more than 2 million kWh of thermal energy per year – without generating any kind of pollutants. This corresponds to half of the energy demand in the residential area Hirtenwiesen 2. In order to generate the same heat quantity with heating oil, 200,000 litres of oil would have to be burned. The use of conventional fuels is reduced by half and the remaining heat is generated by the Stadtwerke's combined heat and power plant, which is highly efficient and equipped with the latest technology. This keeps more than 900 tons of carbon dioxide emissions per year from entering the environment.

Beyond from the production of renewable heat particular attention was also paid to the environment during the installation of the short-term heat accumulator and the manufacturing of the components. As the hot water storage tank is made of concrete, CO_2 emissions were already reduced during construction compared to conventional accumulators made of steel.

Investments and partners

The large scale solar system, with a total investment volume of about 8 million € , was financed by the Stadtwerke Crailsheim GmbH. The plant was subsidized by the Federal Ministry for Environment, Nature Conservation and Nuclear Safety with about 2.4 million €, with about 1.4 million € by the Baden-Württemberg Ministry for Economic Affairs and with about 1.4 million € by the city of Crailsheim.

Besides the Stadtwerke Crailsheim GmbH as owner and operator, the University of Stuttgart's Institute for Thermodynamics and Thermal Engineering (ITW) is in charge of the scientific measurements of the pilot project. The Steinbeis Research Institute for Solar and Sustainable Thermal Energy Systems (Solites) with experience gained from 9 previous pilot plants is involved in the implementation of the district heating system Hirtenwiesen 2 as scientific support. After a nationwide invitation to tender, the Hamburg Gas Consult GmbH (HGC) has taken over the overall planning.

Public interest

The construction of Germany's largest solar thermal system with long-term storage has aroused considerable national and international interest.
Crailsheim also has a leading position in the Solarbundesliga. Thanks to the wide dispersal of solar energy among Crailsheim's population and the solar district heating network Hirtenwiesen 2, Crailsheim was able to win the competition in the category "medium-sized cities" in the 2008 season. In 2009 and 2010 Crailsheim took second place and in 2011 third place. Crailsheim was even able to take first place in the European RES-Champions League (RES: Renewable Energy Solutions) in 2011.

STADTWERKE AWARD

In 2015 the Stadtwerke Crailsheim succeeded in winning the STADTWERKE AWARD in Gold for the solar thermal system. With the slogan "Energy Turnaround: Innovative Solutions for the Energy World of Tomorrow" the project convinced the jury at that time.

With this solar project, Crailsheim makes a significant contribution to climate protection by exploiting energy saving potentials, energy efficiency, the use of renewable energy and by creating environmental awareness in all sectors of the city.

ptJ Projektträger Jülich Forschungszentrum Jülich

Baden-Württemberg
WIRTSCHAFTSMINISTERIUM
MINISTERIUM FÜR UMWELT, KLIMA UND ENERGIEWIRTSCHAFT

Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit

Project Management Jülich
Jülich Research Centre

Federal Ministry for the Environment,
Nature Conservation and Nuclear Safety

Ministry of Economics
Ministry of the Environment, Climate Protection and the Energy Sector

Overall Ecological Concept

Habitat, vegetation and flora

The design of open spaces around the solar panel installations has particular ecological objectives. The individual elements are:

- Design of **solar habitats** such as dry and semi-dry grasslands, vineyard with Mediterranean, light-loving and thermophile plants
- Vegetation units and plant species from the area around Crailsheim served as a **model**
- Design of **open land and areas with low amounts of vegetation** with local rock and soil in order to avoid shading on solar panels
- **Wild herbs** used in deliberate contrast to the technical solar plant due to their diversity in structure and colour

Vegetation in contrast to the technical solar plant

The wilderness-like character of the vegetation around the panels displays features that contrast sharply with the technical design of the solar panels: the spiny flower heads of the wild teasel are reflected in the glass cover plates. Between the panels, the vegetation is irregular, diverse and seasonally changing: from fresh green in spring, blossoms in summer, to grey-brown of dry stems and fruits in winter. Throughout the year, the blossoms and fruits attract a variety of animal species, such as insects, butterflies, bugs, spiders, and birds. A lot of insects spend the winter in the hollow stems. Diversity with a wilderness character is the planning concept and objective of the landscape design.

Jagsttal and Gipskeuper in the Kocher-Jagst-Plain serve as models

The vegetation on the southern part of the solar noise reducing berm was modeled after the flora of the area around Crailsheim. On steep and dry Muschelkalk (shell limestone) slopes of the Jagst valley there are rock falls, clearance cairns, scree hillsides with semi-dry grasslands, shallow nutrient-poor grasslands and thermophile herbaceous fringe and vegetation of perennial herbs. On the high plateau, in the area of the Gipskeuper (Gypsum Keuper), the landforms are softer. On the gently rolling Gipskeuper hills and plains there are grasslands, and here and there some hedgerows and grass strips in between. Sheep pastures on nutrient-poor grass hills are typical for this area. They also serve as a model for the northern part of the berm which is less steep.

Soil preparation for specific vegetation

The subsoil was prepared according to the specific vegetation that was planted above it. Regional rocks and raw soil were spread over the heterogeneous ground of the berm consisting of construction waste and different soil deposits. The upper layers are 15 to 30 cm thick and consist of shell limestone material from local quarries:

- **Rock debris**: Unsorted crushed rock from blasting in quarries, with an edge length from 0 – 300 mm in the lower third of the berm. The largest quarry stones were placed at the toe of the slope in order to avoid downward movement.
- **Pre-screen**: Unsorted fine rubble with a thickness from 0 to 50 mm used in the upper two thirds of the berm above the panels and on the debris as thin top layer.

The **raw soil** between the solar collection fields originates from the Keuper top layers of the quarries

Seeds of nutrient-poor grassland with sedum sprouts were applied on the pre-screen areas via hydroseeding. The regional seeds come from a company from the area around Crailsheim. Even on the areas with raw soil, the seeds were only sown sparsely and in the upper parts, regional shrubs and woody plants were also planted.

Example: Steep slopes of the Jagst Valley (1), starting material: pre-screen (2), starting material: rock debris (3).

Figure 4: Dry and semi-dry grassland on pre-screen areas

Figure 5: Nutrient-poor grasslands and thermophile vegetation of perennial herbs and raw soil areas

Figure 6: Vegetation of tall perennial herbs with viper’s bugloss along the fences

Maintenance through employees of the Umweltzentrum Schwäbisch Hall

Targeted vegetation and plants on the southern sides: xerophilous, thermophile and heliophile

The sides of the berm feature the ideal conditions for plant communities that thrive in dry soil and locations, high temperatures, and sun and light.

- **Dry and semi-dry grassland** with sedum, thyme, golden thistle, hawkweed on the areas with fine debris above and between the panels
- **Thermophile** vegetation of perennial herbs and poor grasslands with upright brome, tor grass and numerous herbs such as wild majoram, cypress spurge, rest-harrow, wild basil, wall germander, carthusian pink on areas consisting of raw soil beyond the panels.
- **Blackthorn-rose-bushes** border the upper edge of the berm in some places

On the plain areas at the foot of the slope and on the edges of the depressions, lawns consisting of clover and herbs and dry or fresh tall perennial herbs amongst others with wild carrot, viper's bugloss, tansy, common mallow, toadflax and musk thistle are sown.

In addition to the seeding many wild herbs are growing spontaneously. The large number of open spaces offers ideal conditions for the germination of ephemeral or perennial ruderal species of the cotton thistle, sweet clover, wild carrot and hawkweed oxtongue. One of the most conspicuous species of these thermophile weeds is the wild teasel. In the past the flower heads were used for carding – the combing of raw wool prior to spinning.

In the drainage channels and ditches tall perennial herbs and typical hydrophytes such as blue rush and hairy willow-herb are growing spontaneously.

Habitat control and maintenance plan

In order to avoid the extensive spreading of common invasive weeds such as the creeping thistle, broad-leaved dock and wild rye, blackberry, and dewberry within the first few years, their spread needs to be controlled. These weeds were brought in with the landfill soil and the construction waste, and carried in by the wind from the adjacent areas.

The maintenance plan, which depends on the desired vegetation in each area, determines the type and extent of maintenance, which could include mowing, selective removal of unwanted herbs and spontaneously growing woody plants.

The maintenance is carried out by the Stadtwerke. Employees of the Umweltzentrum Schwäbisch Hall (environmental centre), who are experienced plant experts, help to remove these unwanted herbs and woody plants manually.

Types of dry grasslands: stonecrop (7), white stonecrop (8), golden thistle (9). Species of thermophile perennial herbs and poor grasslands: rest-harrow (10), wild majoram (11). Species of short-lived thermophile ruderal communities: dyer's woad (12), wild teasel (13). Typical species of thermophile shrubs: dyer's greenweed (14), French rose (15).

Vineyard

On the southwest side of the berm, which is sheltered from strong winds there is a small vineyard. The vines are grown on six terraces: one half consisting of table grapes, the other half consisting of wine grapes

Revival of a local tradition

The Stadtwerke's vineyard helped to revive an old local tradition. Like many other neighbouring municipalities, the city of Crailsheim owned vineyards in the Jagst valley, around the year 1600. In Crailsheim the vineyards were located on the southern slopes of the Karlsberg, the Kreckelberg (large hills near the city) and in the vineyard in the northeast of the city.
The cool climate of the natural region of the Kocher-Jagst-plain, the permanent risk of frosts in the deep valleys, and the losses due the vine pest (phylloxera) in the 19th century brought about the final end of viticulture.

Figure 1: 2006 terrace profile before planting

Figure 2: 2007 installation of the wire construction and planting

Vineyards are solar habitats

The fact that vines are growing again forms part of Hirtenwiesen 2's overall ecological concept. After all, the topic "solar energy" applies to all the components of the plant: the supply of hot water as well as the design of open spaces.
On the southern part of the berm solar habitats were created and shaped. On the one hand, there are naturally occurring biotic communities and on the other hand, there are specific cultures, like grapevines, that benefit from the sun and only thrive in particularly warm and sheltered areas.

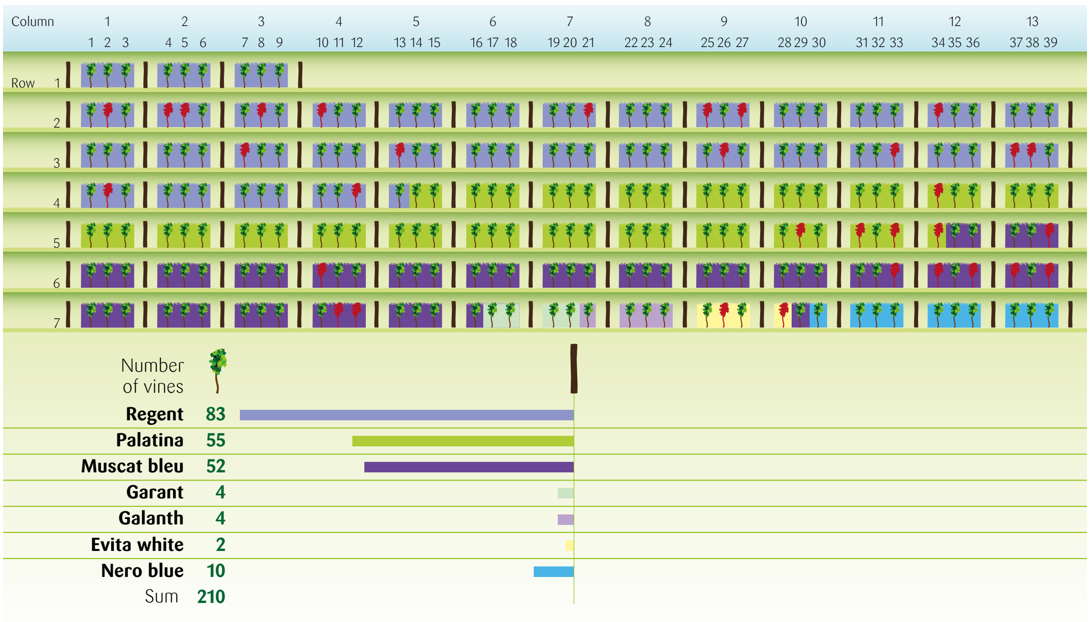


Figure 3: Planting plan

Organic production

The Stadtwerke's vineyard areas are cultivated organically. Due to this, experiments are being conducted with eight different grape varieties. These vines need to be robust and to a large extent they have to get along without the use of chemical antifungals, mainly against Peronospora, which causes the downy mildew disease.
The major part of the vines that were planted here are various fungus-resistant grape cultures from the State Institute of Viticulture and Enology (WBI) in Freiburg.

Red varieties:

Regent	Popular, widely spread fungus-resistant wine grape
Muscat Bleu	Table grape
Galanth	Table grape, breeding from Muscat Bleu x Solaris
Nero blue	Table grape from Hungary

White varieties:

Palatina	Table grape from Hungary, a culture from "Königin der Weingärten" x Villard Blanc
Garant	Table grape
Evita	Table grape
Talismann	Table grape

Figure 4: Vineyard in the 3rd year

Figure 5: In 2011 the first grapes were harvested from the Hirtenwiesen berm.

No harvest without plant care

Just like any other kind of fruit, vines require intensive care.

A wine year is divided into following steps:

January/February	Pruning grape vines
March	Installing the wire system, tying vine shoots
April	Replanting damaged plants, watering young plants, grapevine shelter, fertilizing
May	Tying up grapevines, traditionally with willows, alignment, hoeing
June/July	Foliage work, mowing
August	Foliage work, thinning, mowing
September/October	Grape harvest
November	Grape processing
December	Straw mulch for soil care and weed control

Many working hours are necessary until grape juice or wine from the Hirtenwiesen berm can be tasted.

Cheers!

Good things come to those who wait:
After four years the first grapes were harvested in 2011. In 2013 the trainees of the Stadtwerke used the harvest to make grape juice and wine jelly or jam, which was then distributed to the employees. This is a good example of how the sun nourishes plants on the solar berm to create wonderful products, which are also pure, regional and unique.

Figures 6+7: Winter work in the vineyard – pruning and straw mulch application

Fauna

A new home for rare Mediterranean-climate animal species

The open areas of the southern side of the berm have some special features that are attractive to animals:
- Dry and warm steep slopes, rock piles, clearance cairns, next to cool, damp recesses and hollows
- Quarry stones, coarse gravel with clefts and niches, as well as fine rubble and open soil
- Vegetation-free and thinly vegetated areas with very varied vegetation, including regional herbs
- Tall perennial herbs and individual shrub groups and thorn-bushes

The open landscape areas and the thinly vegetated pioneer habitats, especially, magically attract rare species that depend on this warm, dry habitat to live. Amongst them are specialists such as certain grasshopper species that lay eggs in open soil, as well as species of wild bees and bumblebees that build their nests in the loose soil.

An important target species for the open, warm-dry rubble areas is the xerophilous blue-winged grasshopper (Oedipoda caerulescens), an eye-catching flying grasshopper species. The most striking characteristic is the bright blue and black coloration of the transparent hind wings, which are only visible when the insect is flying. According to the Bundesartenschutzverordnung (Protection of Species Order) this species is especially protected and is considered to be endangered in Baden-Württemberg (red list BW3). They live mainly in Mediterranean regions, but also in warmer regions north of the Alps such as the Upper Rhine Valley and the Main-Tauber area.
The blue-winged grasshopper found a new habitat in an adjacent area which has been built-up in the meantime.

It is still possible for animals to migrate from other regions, and is easily observed, as some of the areas in the immediate vicinity have physical features that are similar to fallow land. However, once Hirtenwiesen 2 is completely built up, the open areas around the panels will be a natural oasis amidst well-kept flower gardens and neatly trimmed lawns. The significance of this island of nature will only continue to increase in the future.

Figure 1: Blue-winged grasshopper – target species for stone rubble areas

Figure 2: Field grasshopper, the best flyer among all the grasshopper species in Baden-Württemberg

Botanical and structural diversity creates faunistic diversity

Due to the variety of subsoil and flora, the open areas around the collectors are full of life. Hundreds of mice live in the berm, and hares like to hop around in the area. When disturbed, they disappear in the tall perennial herbs or look for shelter underneath the solar panels. Numerous insects such as butterflies, burnet moths (Zygaenidae), hoverflies and bees buzz around the blossoms of dry grasslands and perennial herbs.
Thorn-bushes and fence posts serve as perches and are favorite places for hunting birds. Partridges stroll through the tall perennials while searching for food and in autumn and winter, one can watch flocks of buntings and finches on the dry fruit shrubs and plants.

As the thinly vegetated rubble areas have developed into dry grasslands, annual and perennial herbs, and nutrient-poor meadows, the number of flower-visiting insects has increased, and this large number of insects in turn attracts insectivorous birds. In the meantime, some species that are specially protected at European level, such as the marsh warbler, the whitethroat, the yellowhammer and even the red-backed shrike have been breeding in the open areas of the eastern berm. At present all of the four species mentioned above are classified as near-threatened on the red list BW.

The noise reducing berm, a vivid example of biological connections and food chains:

- **-Flowers and leaves** provide food for insects (butterflies, wild bees, hoverflies, grasshoppers) and for the different stages in their life cycles (caterpillar). Hollow stems, gaps between stones, holes in the ground, abandoned nests of mice and ground vegetation provide nesting places for insects
- -The rich **insect world** is a precondition for insectivorous birds to take up residence (red-backed shrike, whitethroat, marsh warbler, black redstart). Sand lizards and numerous spiders with their cobwebs between the stems of the tall perennials hunt for the insects
- **Seeds** are food for granivores such as mice, and birds like finches, sparrows, goldfinches, yellowhammers, as well as partridges.
- -A large **mouse population** provides food for hunters such as kestrels and buzzards. Both birds of prey are regularly observed in the berm area.

Figure 3: Great green bush-cricket

Figure 4: Burnet moth

Animal descriptions

Species name	Scientific name	Living space, edible plants, observations
Field grasshopper	Chorthippus brunneus	Flying grasshopper, lives in warm, dry open areas around the solar station in the berm and on rubble areas between and below the panels
Great green bush cricket	Tettionia viridissima	Teasels and blossoms of tall perennial herbs
Wasp spider	Argiope bruennichi	Between stems of perennials
Swallowtail	Papilio Machaon	Often on wild carrot, teasel and oxtongue
Clouded yellow	Colia crocea	Rare migratory butterfly from the South, red clover, lotus
Brimstone butterfly	Gonepteryx rhamni	Carthusian pink, buckthorn
Small tortoiseshell	Aglais urticae	Teasel
Marbled white	Melanargia galathea	Knapweed, thistles
Gossamer-winged butterflies	Lycaenidae	Restharrow, lotus
Burnet moth	Zygaenidae	Teasel, wild majoram
Wild bees, bumblebees, brown-banded carder bee	Bombus humilis	Viper's bugloss, lotus
Red-backed shrike (red list BW 3)	Lanius collurio	Breed in thorn bushes above the collectors I and XIII
Whitethroat (classified as near-threatened on the red list BW)	Sylvia communis	Breed in thorn bushes at eastern berm
Marsh warbler	Acrocephalus palustris	Breed in tall perennials at eastern berm
Yellowhammer (classified as near-threatened on the red list BW)	Emberiza citrinella	Breed in bushes at eastern berm
Partridge (red list BW 2)	Perdix perdix	Ground-nesting bird, lives in fallow land between eastern berm and industrial park
Black restart	Phoenicurus ochruros	Breed in half-open nests under panels
Sand lizard (classified as near-threatened on the red list BW) strictly protected according to BNATSCHG (Federal Nature Conservation Act)	Lacerta agilis	Rock piles and clearance cairns
European hare	Lepus europaeus	

The advantage of protection and cover

By tolerating uncontrolled growth around the collectors on open areas, the Stadtwerke deliberately protects and supports the animal world. Red-backed shrike, whitethroat and yellowhammer have been breeding close to the ground in thorn bushes. The undergrowth of green and dead blades and stems offers protection for many animals, even during the winter.

An electric fence contributes considerably to the habitat quality of the open areas, as there is a quiet area behind the fence, far away and protected from dogs and people walking by. The fence is hardly perceptible or disturbing to the eye. Migratory species of wild animals can pass through the fence. It protects an ideal natural reserve for delicate ground dwelling animals such as partridges and European hares.

Stadtwerke and local conservationists are working together for the protection of species

Conservation and targeted support of animals needs to be coordinated. The Stadtwerke is supported by the Umweltzentrum Kreis Schwäbisch Hall (Schwäbisch Hall environmental centre). Several times per year, especially in spring and late summer, dedicated helpers remove undesirable herbs and woody plants from the particularly valuable open rubble areas, which are the habitat for flying grasshoppers. Faunistic and botanical excursions have been offered each year since 2012.

Brimstone butterfly on Carthusians' pink (5); quite similar, but rarer: the migratory butterfly 'clouded yellow' coming from the South (6); Swallowtail (7), Wasp spider building its web between high stalks (8), Red-backed shrike (9), Finches (10) and goldfinch foraging in autumn (11), European hare looking for shelter underneath the collectors (12), Sand lizard colonizing the stone heaps (13)

Company Information
Stadtwerke Crailsheim GmbH
Friedrich-Bergius-Straße 10 – 14, 74564 Crailsheim
Germany
Phone: + (49) 7951 305-0, Fax: +(49) 7951 305-118
info@stw-crailsheim.de, www.stw-crailsheim.de
CEOs: Uwe Macharzenski, Jürgen Breit

Picture/Figure credits
Hirtenwiesen 2 Overview (page 8 – 11):
Solites (templates for graphs 1 – 6)
Urban Planning Concept (page 12 – 15):
Stadtwerke Crailsheim
Technical Concept (page 16 – 29):
Solites (figures 1+2, 6, 8+9, 11+12, 14, 16 – 19)
Stadtwerke Crailsheim (figures 3, 4, 5, 7, 10, 13, 15, 20+21)
Ecological Concept (page 30 – 43):
Inge Maass (figures: Habitats, vegetation and flora/
Vineyard/Fauna)

Ecological Concept (page 30 – 43)
Co-author: Co-authoress Dipl. Ing. Inge Maass, Landscape
planning, Open space planning and Landscape ecology