



## Solarsiedlung am Schlierberg, Freiburg (Breisgau), Germany

Freiburg is located in the area between the Upper Rhine and the Black Forest. It is said to be Germany's ecological capital, situated in the sun belt of the country, the 'German Tuscany'. It is the home of one of the most modern housing estates in Europe, the so called "Solarsiedlung am Schlierberg" (in English: "Schlierberg Solar Estate").

This solar settlement is part of a larger urban redevelopment area in the Vauban district, a former barracks ground of the French army. Over a period of approximately ten years 60 "Energy-Surplus-Houses®" and a 125 m service block, called "Sonnenschiff", have been built along the main road. The "Sonnenschiff" provides retail, office and living spaces. The terraced houses are two and in some cases three storeys high while the "Sonnenschiff" is four to five storeys high and thus screens the community from the traffic on Merzhauser Straße.



Birds eye view of "Solarsiedlung am Schlierberg" with the "Sonnenschiff" in the front (copyright ©2007: Solarsiedlungs GmbH)

All roofs are covered with standard large area Photovoltaic (PV) modules which are smartly integrated in a plane above the south facing roofs of the different buildings. The total system size is 445 kWp. This large scale PV-application was fostered by the German National Renewable Energy Act (Erneuerbare-Energien-Gesetz, EEG) which was implemented on 1st April 2000.



West elevation of the “Sonnenschiff” with terrace houses on top, facing the “Merzhauser Strasse” (copyright ©2007: Solarsiedlungs GmbH)

The project is the result of the “ecologically sound atmosphere” of Freiburg and the personality and persistency of architect Rolf Disch, who wanted to provide evidence that his idea of an Energy-Surplus-House<sup>®</sup> can work well for terraced houses and commercial buildings. Finally he operated as the architect and as the entrepreneur of the Solarsiedlung am Schlierberg. This double function allowed him to ensure that his idea of an Energy-Surplus-House<sup>®</sup> could be put into practice.

At the same time he took a lot of personal risk to make this privately funded project happen and to provide the proof that today’s homes are able to generate more energy than they need.

This paper describes in detail the background and development of this solar settlement as well as the strategies used to overcome problems and barriers.

## Background

Freiburg is located on the western edge of the southern Black Forest. It is one of the warmest and sunniest regions of Germany with approximately 1800 hours of sunshine per year. The city, with 204 000 citizens, is the economic and cultural centre of the region and is the only major city in Baden-Württemberg with a constantly rising number of inhabitants.

Freiburg is well known for its’ many efforts to protect and preserve natural resources and the environment. The city received several environmental prizes, such as “Ecological Capital of Germany” in 1992 and “Sustainable City” in 2004. Several times it also won the “National Solar League”.

The roots for this environmental success in Freiburg can be traced back to the 1970’s. In this decade plans for a French chemical factory not far from Freiburg, as well as three nuclear plants in German, French and Swiss cities close by galvanised the population into widespread protest. This raised the environmental awareness of many of Freiburg’s citizens, and regional networks of environmentalists came into existence. For years critical and dedicated people have generated political pressure to achieve ecological progress.

After the Chernobyl disaster in 1986 Freiburg was one of the first German cities to adopt a local concept of energy supply in order to protect the climate. The programme included the reduction of consumption of energy, water and resources. Further issues were the use of renewable energy sources and the application of new energy technologies [1] [2].



During the 1990s, Freiburg undertook a study to investigate the economic significance of its' commitment to environmental policies. For the region as a whole, the study showed that solar energy and environmental policies have been important economic development assets for Freiburg, which has never had any major industry. It also fits with Freiburg's position in a major tourist area and as the home of a wide network of environmental organizations, businesses and research institutes. Among them are the Freiburger Oeko-Institute (Institute of Ecology), the BUND (Friends of the Earth), the ISES World Headquarters, the Fraunhofer ISE, the Solarfabrik etc.

In addition to the economic and environmental benefits, Freiburg's citizens enjoy a pride in their city for showing this kind of leadership. A significant percentage of the population votes Green and many of the residents are happy to pay an extra percentage on building cost, for a payback in lower energy bills as well as social and health benefits.

On a federal level Germany followed Freiburg's footsteps in trying to save energy, encouraged by the environmentally friendly Green Party that was in former Chancellor Gerhard Schroeder's governing coalition. In 2000, the German government decided to phase out nuclear plants by 2020, and has adopted legislation promoting the development and use of renewable energy sources.

The most important piece of legislation is the Renewable Energy Sources Act (EEG) which was approved in spring 2000. According to this law, grid operators have to pay fees for electricity from renewable energy sources. The difference between fees and the market price for electricity from traditional sources is apportioned to consumers via their electricity bills as EEG apportionment. The different types of renewable energy sources receive different fees based on the cost of electricity generation. This way of promoting electricity generation from renewable energy sources has proved to be extremely successful, in particular for wind power and PV.

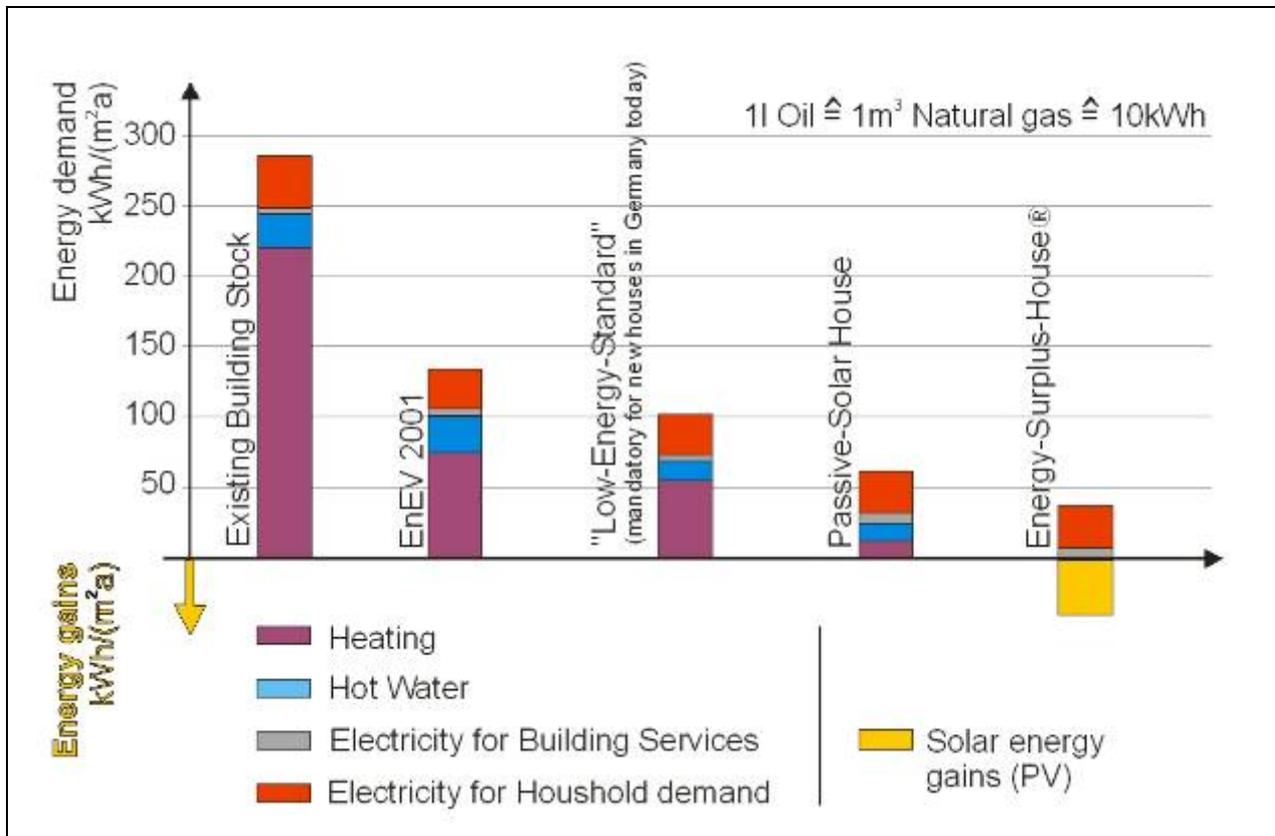
### **Project development**

The Solarsiedlung am Schlierberg is the result of these national and local framework conditions and in particular of the courage, patience and spirit of innovation of the locally rooted architect and entrepreneur Rolf Disch and his team.

Rolf Disch is one of the most renowned solar architects in Europe. With his work he intends to provide living spaces that have a future in both ecological and economic terms. "Surplus energy houses are a good example for that", he says. On a calculative base such buildings need less energy than they produce during their life-time, see Fig. 1. They utilize, in a smart way, active and passive solar design strategies, such as super insulation of the building shell, triple glazing for windows and door openings, the use of heat pumps, heat recovery systems, solar hot water collectors and PV.

With the Solarsiedlung am Schlierberg project Rolf Disch demonstrated that a high energy standard, previously tested at his experimental house "Heliotop", built in 1994 with a 40m<sup>2</sup> PV-tracking system on top, can also work technically and economically for ordinary terraced houses and commercial buildings.

The opportunity arose in 1990 when, after the fall of the Berlin Wall, French troops vacated a vast area south of the centre. The city of Freiburg bought the plot from the federal authorities and in 1993 started a challenging urban renewable process for the area, which is located next to one of the arterial roads of the town, the Merzhauser Strasse.



**Fig. 1:** Energy demand of different building standards in Germany (copyright©2007: Ingo B. Hagemann)

The local city-planners remained responsible for the planning and development of the plot, located west of the Merzhauser Strasse, focussing on a sustainable development. However the target set for these buildings was not as ambitious as the plans for the Solarsiedlung am Schlierberg from Rolf Disch. The so called Vauban district became a showcase for extended citizen participation that went far beyond the legal requirements and enabled citizens to participate in the planning process.

On the grounds of the former sports facilities of the Vauban barracks, located on the east side of the Merzhauser Strasse, zoning regulations required a due south orientation for new buildings. This, together with the local infrastructure under development for the new Vauban district to the west of the road, seemed to provide ideal conditions to realize Rolf Disch's vision of an Energy-Surplus-House® standard on a district level.

Rolf Disch succeeded in getting the property developer Rolf Deyhle and his firm Instag AG as a partner for the project. This partnership was very promising since Rolf Deyhle was a well known property developer and successful businessman, operating on a large scale. He considered the Solarsiedlung am Schlierberg project a starting point for the widespread marketing of such settlements. He also registered the Energy Surplus House® as a trademark.

Instag AG concluded an option contract for the plot with the city of Freiburg. This was followed by the submission of plans for the Solarsiedlung am Schlierberg by the Architects Office Rolf Disch.



The local planning authority adopted the existing building regulations according to these plans and provided the building permit. Unfortunately Instag AG then got into financial difficulties with other projects. By the end of the 1990's it was impossible to continue the project with this team.

In this situation financial help was urgently needed to rescue the ambitious project. Finally Rolf Disch, with the help of the chocolate manufacturers Alfred Ritter and Marli Hoppe-Ritter, founded Solarsiedlungs GmbH. The new company aimed at to take over all existing rights and liabilities of the Instag AG for the plot of the Solarsiedlung am Schlierberg.

However the city of Freiburg rejected this idea and invited new tenders for the plot east of the Merzhauser Strasse. Solarsiedlungs GmbH won this new competition but received only 40% of the original plot to continue the project. The other 60% of the plot was allocated to different investors to build conventional houses. The original ecological water concept for the whole plot, making use of the rain and streamlets from the nearby Loretto Mountain, remained therefore uncompleted.

Consequently the plans for the Solarsiedlung am Schlierberg needed to be revised. The number of houses shrank from 219 to 60 and the length of the service centre, shielding the houses from the Merzhauser Strasse, was cut down from 300m to 125 m. Since Rolf Disch was acting as the general manager of the Solarsiedlungs GmbH as well as the architect of the Solarsiedlung am Schlierberg, the targets with regard to the ambitious energy concepts remained untouched.

The construction of the terraced houses has been carried out gradually as they were sold. This turned out to be a tough job for Rolf Disch and his team, since several jobs needed to be done in parallel, such as the supervision of the ongoing construction site, the selling and marketing of the houses, the consulting with building owners and the adoption of plans according to special requests.

## Financing

Teething troubles occurred with the sales of the houses. Rumours of astronomically high house prices circulated. Creditors set a precondition for giving loans to prospective house buyers that the Solarsiedlungs GmbH should prove that at least 60% of all houses in Solarsiedlung am Schlierberg were sold. Therefore it was initially difficult to sell houses.

However this changed after the project was awarded as an external project of the World's Fair EXPO 2000 and the Deutsche Bundesstiftung Umwelt (DBU) provided some subsidies for communication and monitoring of the project.

Both measures helped in creating greater public awareness for the project. As a result public interest emerged in financial participation in the project. The financial difficulties were solved in 2001 by starting a fund, called "1. Solar Fond Freiburg", with an invitation for subscription to shared certificates of €5000 each. The total investment was €1,5 Million. This new financing model was the key to success. The first one was followed by three other investment funds with a total investment of €3 Million each.



**PV UPSCALE**

Urban Scale Photovoltaic Systems



Site plan  
(copyright ©2007: Solarsiedlungs GmbH)



Large south facing roof overhangs  
(copyright ©2007: Solarsiedlungs GmbH)



Sonnenschiff view from south-west /  
Merzhauser Strasse  
(copyright ©2007: Ingo B. Hagemann)



View from south  
(copyright ©2007: Ingo B. Hagemann)



View of terraced houses from west  
(copyright ©2007: Solarsiedlungs GmbH)



South facing patio of terrace building  
(copyright ©2007: Ingo B. Hagemann)



The purchase price for the terraced houses, including property and developers costs, ranged between €2.700 /m<sup>2</sup> and €3300 /m<sup>2</sup>, depending on the individual fittings. In total 15 houses belong to these four solar funds. The houses are rented out for an average rent of €11 /m<sup>2</sup>. This corresponds to the upper price level in Freiburg. However one needs to bear in mind that surcharges for heating costs would normally need to be added. In this case they are negligible, since heating bills for each house are between €50 and €100 per year.

The roof integrated PV-systems are marketed separately. Either the homeowners or other investors purchased them. A return on investment is granted by the 20 years payment of the feed-in-tariff of the German National Renewable Energy Act.

The results proved that in spite of higher construction costs, the terraced houses allow for higher nominal yields. The reasons for that are the very low operational cost of the buildings (heating costs are negligible) and the revenues from the PV-installations. Therefore the Energy-Surplus-House® concept is an attractive investment!

The funds are traditional closed-end real estate funds. Their average interest yield is 5%- 6% which is about an average interest yield for this type of investment. The shareholders are primarily private persons who are interested in the project and wish to make a sustainable and sound long-term investment. Recently the 5th fund, called 1. Sonnenschiff Fond, started successfully with a total investment of €5,56 Million. It owns part of the service centre with total construction costs of €20 Million.

One could say that the major challenge of this project was the validation of financing. The funds described, provided a successful alternative financing model, when conservative creditors had difficulty investing in the innovative concept.

### **PV-System**

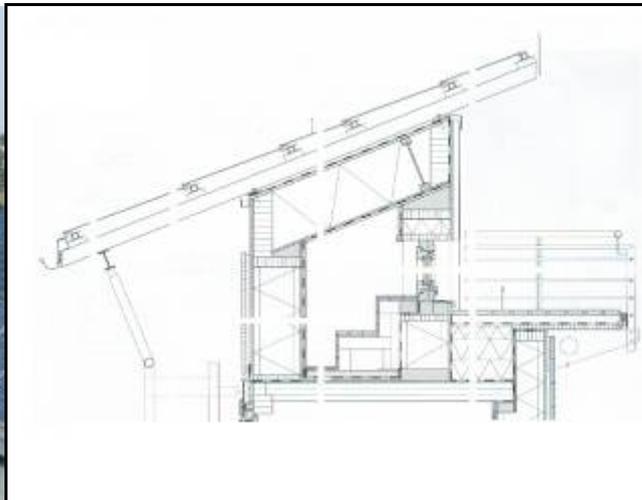
In contrast to the severe funding difficulties, which resulted in an innovative funding concept, the technical design of the PV-system and its architectural integration into the overall design concept was not a problem. For both the architect and the installers PV was not a new topic. For this reason a professional collaboration between the different parties involved could be established, resulting in a simple but elegant solution for the mounting of the PV-Modules.

Standard, semitransparent PV-laminates are integrated into a plane with an air-gap of 16 cm above the south facing roofs of the terrace-buildings. The PV-modules are mounted point-wise on 30 mm RHS (rectangular hollow section) stainless steel profiles which themselves rest on hot-dip galvanised 100 mm I-beams. The roofs water barrier consists of a plastic-sheet sealing layer. Structurally, and therefore also legally, the PV-Array and roofing are two separate units. However, from the design point of view both parts belong together and are one prominent, pleasant looking design feature of the Solarsiedlung am Schlierberg.

The PV-System is an essential part of the overall energy and design concept of the Surplus Energy Houses®. Due to the cost of PV in the 1990's early plans of the Solarsiedlung am Schlierberg did not include as much PV as it is seen today. However, the German National Renewable Energy Act (Erneuerbare-Energien-Gesetz, EEG), coming into force in spring 2000, made it financially attractive to use PV. "This new law fits right in with our plans", said the architect.



View from south-east showing the PV-roofs  
(copyright ©2007: Solarsiedlungs GmbH)



Vertical section: PV-modules support structure out of stainless steel profiles which themselves rest on hot-dip galvanised 100 mm I-beams "copyright ©2007: DETAIL 12/2006 Review of Architecture and Construction Details, p. 1416"



Underneath view of support structure for PV-Modules  
(copyright ©2007: Solarsiedlungs GmbH)



Row of inverters  
(copyright ©2007: Ingo B. Hagemann)

To increase the roof area and allow additional roof space for PV the flat roofs initially designed were converted into asymmetrical gable roofs. For the service centre and the terraced houses on top of it, shed roof constructions are used. Both roof styles have large overhangs on the south face and therefore provide shading on these facades in summer.

In total 445 kWp of grid-connected PV is installed. The string inverters are mounted right under the roof deck on the building exterior walls. The total annual solar electricity production is 420 000 kWh. This, together with the energy efficient building design, allows for 2 million kWh primary energy savings per year. This is the equivalent of 200 000 l of oil per year.

### Occupant's Feedback

Occupants report that they enjoy living in the Solarsiedlung am Schlierberg. They experience a variety of benefits compared to occupants of conventional settlements. For example:

- enjoying living in a solar home and contributing to a resource efficient life style
- benefits from the good inner-city location
- easy and short access to public transport facilities nearby
- an infrastructure appropriate for children (no cars etc.)
- less illness due to a healthy indoor climate/air quality
- finding the social environment they are looking for [3]

#### **Solarsiedlung am Schlierberg, Freiburg (Breisgau), Germany**

- Name: Solarsiedlung am Schlierberg (in English: Schlierberg Solar Estate)
- Location: Am Schlierberg, Freiburg (Breisgau), Germany
- Latitude/Longitude: 47° 59' 43" north, 7° 51' 11" east
- Time period from project idea to realisation: approx. 10 years

#### **Technical Data**

##### PV-Generator:

- PV-System size: 445 kWp
- Orientation: south
- Inclination (Terrace houses): 22°
- Grid connected
- Inverter company: <http://www.SMA.de>
- PV-Modules: 10 mm laminated safety glass
- PV-Installation: <http://www.SonnenStromAG.de>

##### Standard of construction: Terrace Houses:

- "Energy-Surplus-House<sup>®</sup>" (in German: "Plusenergiehaus<sup>®</sup>")
- Exterior walls: ca. 0,12 W/m<sup>2</sup>K
- Windows: Triple glazing units, U-Value: 0,70 W/m<sup>2</sup>K
- Heat-recovery-system
- Heating requirement: 1 l/m<sup>2</sup>a
- Use of rainwater

##### Standard of construction: Service Centre Sonnenschiff

- Exterior walls: 0,1 W/m<sup>2</sup>K
- Glass façade: Triple glazing units, 0,7W/m<sup>2</sup>K
- Heat recovery system



### Sources of further information

Architect Rolf Disch: [www.rolfdisch.de](http://www.rolfdisch.de)  
The “Energy-Surplus-House®” concept: [www.plusenergiehaus.de](http://www.plusenergiehaus.de)  
Solarsiedlung GmbH: [www.solarsiedlung.de](http://www.solarsiedlung.de)  
[www.sonnenschiff.de](http://www.sonnenschiff.de)  
Solar Funds: [www.freiburgersolarfonds.de](http://www.freiburgersolarfonds.de)  
[www.sonnenschiff-fonds.de](http://www.sonnenschiff-fonds.de)  
The City of Freiburg: [www.solarcity-freiburg.de](http://www.solarcity-freiburg.de)

### References:

- [1] “Umweltgeschichte - Regionalgeschichte - Geschichte: Oberrhein, Baden, Elsass und Nordschweiz” in “<http://vorort.bund.net/suedlicher-oberrhein/umweltgeschichte-regionalgeschichte-oberrhein.html>”
- [2] “Freiburg und Umwelt: Alles Öko in der Umweltstadt? in “<http://www.frsw.de/oekohauptstadt.htm>”
- [3] “Die Bewohner machen die Solarsiedlung zu dem, was sie ist: ein liebenswertes Wohnviertel für groß und klein” in “Die Solarregion 3- 2002 vom 25.10.2002., p. 9 (Interviews with several inhabitants of the “Solarsiedlung am Schlierberg”)

### Case Study prepared by

Dr. Ingo B. Hagemann of ARCHITEKTURBÜRO HAGEMANN  
e-mail: [info@architekturbuero-hagemann.de](mailto:info@architekturbuero-hagemann.de)

on behalf of

Fraunhofer-Institut für Solare Energiesysteme ISE  
contact person: Hermann Laukamp  
e-mail: [hermann.laukamp@ise.fraunhofer.de](mailto:hermann.laukamp@ise.fraunhofer.de)

ARCHITEKTURBÜRO  
**HAGEMANN**

  
**Fraunhofer** Institut  
Solare Energiesysteme