Rolf Disch SolarArchitektur – Merzhauser Str. 177 - 79100 Freiburg - Tel 0761 459 44-0 Fax 0761 459 44-44

# Rotatable Solar House

# HELIOTROP®

## The experience of living rotating completely around the sun

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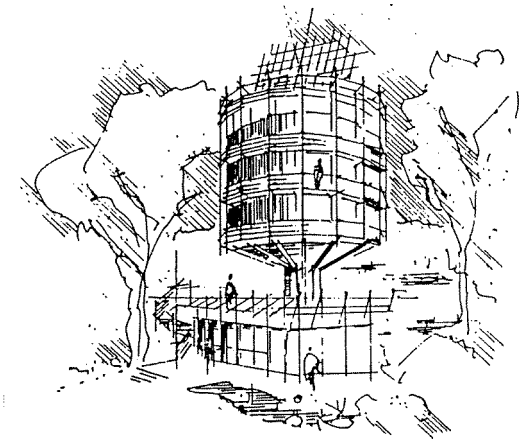
The rotatable solar house HELIOTROP® is not only a residential or studio building reflecting an exquisite taste, but also the demonstration how the most modern technologies which are available on the market can be used for energy saving and ecological purposes.

**HELIOTROP® - House of the Future**

Conception and architecture of the HELIOTROP® are the attempt of finding an answer to the challenges of our time. The most important aim is to bring together ecology, energy, economy and construction, technology and design - a contribution for high-quality living, for "house-keeping", for "lasting economical acting".

The HELIOTROP® is a solar power plant with floors in the top house of 180 m² A second living unit can be located in the basement. Dynamic simulations show a heating energy demand of only 21 kWh/m², whereby the active solar systems being able to reduce the heating energy demand to zero are actually not considered.
In addition the HELIOTROP® is an energy-producing house which in regard to its own electric power consumption produces a multiple amount of electric power and supplies the exceeding amount to the public power supply system.



*Construction*
*manufacturing*
All constructive, load-bearing parts of the "top house" are manufactured from the re-growing building material wood. All parts are industrially manufactured with CNC technologies. The largest pre-fabricated part is the central column with a height of 14 m and a diameter of 2,9 m. Meanwhile all rooms can be mounted in the factory, so that the house itself is built by connecting the segments to the central column. The effect of this manufacturing method is a low-cost serial production of HELIOTROPS: houses with exclusive living quality and depending on the lay-out with lowest, zero or even plus energy balance.

*Column*
The central load-bearing wood column containing the spiral stair has a diameter of 2,9 m and a height of 14 m. Since the HELIOTROP® is world-wide the first building hanging at a load-bearing wood column a new calculation method for statics has been developed together with the Swiss

Technical University Zurich. As the only possible wood material veneered crosswise laminated wood, Kerto-Q, which is produced in Finland was identified.
The column, as well as the building itself, is an eighteengonal construction. The 18 laminated wood sheets or boards have a semicircle shaped groove at the vertical longitudinal sides which are filled with epoxy resin in order to join the boards together. By means of ring-shaped steel ties which "surround the epoxy resin column" a very close join is obtained. The join strength in longitudinal direction of the edges is 90% of the wood strength, that is to say in the case of extreme stresses first of all steel and epoxy resin are deformed before the board itself is destroyed.

**The HELIOTROP®**
**as a Plus-Energy House**

*Passive Solar Heating Systems*
Glazing/Thermal Insulation
Glazing and thermal insulation make an essential contribution to the passive use of solar energy. The basement itself is a low-energy house. It is a conventional R.C. construction though with thermal insulation without heat bridges.
Modern windows with heat absorbing glass - threefold heat absorbing glass with an k-value of 0.5 - contribute on the front side to the energy balance. The walls with a thermal insulation layer of 30 cm are nearly heat-tight and the k-value is in the range of 0.1 - 0.13.
Although the wintry heat losses of the windows are relatively high in comparison with the insulated walls, their insulating effect in summer may be disadvantageous because they retain heat in the room which may lead to over-heating. For this reason the inspection balconies - also to be used as fire escape ladders - are sunshades for the glass fronts during May, June and July when the sun is high in the sky so that only a small amount of solar radiation falls into the building.

*Rotation Mechanism*
The HELIOTROP® is not the first rotatable building, but the first rotatable building using rotation in order to minimize the heating energy demand. Under normal conditions the building rotates for 15° per hour following the sun.

*Active Solar Heating Systems*
Photovoltaic Power Supply System
Size and Power output: On the roof of the HELIOTROP® 54 m²of high-efficient monocrystalline silicon solar cells are installed allowing higher efficiency than most of the polycrystalline silicon solar cells. The solar panel has a two-axis solar tracking system turning around the horizontal and the vertical axis. The tracking system allows a 30 - 40 % higher energy gain than that of conventional, fixed plants. This is system is one of the largest, may be the largest photovoltaic power supply with two-axis solar tracking system in Germany.

Public network and input: Surplus of the photovoltaic power supply system is supplied to fixed prices to the public network of Freiburg which is on the other hand the electric power supplier as soon as solar insolation is not sufficient to operate the whole plant. In that way the network is used as a store. This is from the ecological point of view a reasonable solution because available electric

batteries use heavy metals which have to be disposed in a proper way. Further network supply guarantees higher system efficiency.
Some investigations show that a supply amount to the public network of 20% by renewable energy sources for electric power generation is possible without problems. An amount which is actually far away to be reached.
The yearly power output of the plant will be in the range of 9.000 kWh. This is approx. five times the amount of the building's electric power consumption.
Hot-Water Evacuated Tube Collectors
At the inspection balconies evacuated tube collectors are installed as railing elements. They produce hot water for the building. For hot water heating for domestic use 6 m² collector surface would have been sufficient for a 100 % solar fraction during the summer months. For the HELIOTROP® 31,5 m²have been installed in order to use solar heat for space heating. The heated water is supplied to the storage tanks in the service rooms.

*Installations/Heating Systems*
Dynamic simulations show a heating energy demand of 47 kWh/m² for the basement and of 21 W/m² for the top house.
(Earth) Heat Exchanger
One of the heat exchangers is located in the service room of the basement. It supplies the active ventilation system of the basement. The principle is very simple: energy of the outgoing air is transferred to the cool supply air which leads to a reduction of energy losses by the ventilation system. The ventilation of the top house is the same principle whereby the heat exchanger is located in the service room of this building part. This kind of controlled ventilation with heat recovery bases on the principle of air heating. In addition air can be led through the earth heat exchanger which is located in the slope behind the basement. In summer the supply air is pre-cooled, in winter if the earth temperature, similar to the summer, is in the range of 8°C, the air is pre-heated. The air is then led through the heat exchangers and is finally heated up in the solar store to comfortable room temperatures.

*Floor Heating System*
The 65 mm thick screed layer as well as the water in the floor heating system are used for heat storage of solar energy falling through the windows into the room and being absorbed by the floor. Low-temperature heating systems have the advantage that they can easily be used in winter together with thermal solar plants. In winter such collectors do not reach the summery peak temperatures which may exceed 100°C. For low-temperature heating systems temperatures of about 30°C are sufficient. A value which can easily be reached with collectors plants in winter. A floor heating system is a thermally inert system, because the energy amount required for heating is relatively high. They are not suitable for quick space heating but mainly as a stand-by system for space pre-heating. The floor heating system of the HELIOTROP® allows independent control of all rooms which makes it possible to pump solar heat from the side facing the sun to the opposite side of the building.

*Low-Temperature Ceiling Radiation System*
The low-temperature ceiling radiation system is a quick-acting heating system. As soon as hot water is pumped into the system the heating surfaces - a strip system - are heated up quickly and

give off heat in form of radiation heat by means of 37 m²surfaces in the building. Since the radiators are mounted at the ceiling they give off only a little amount of heat to the **air**. This also not intended because comfortable conditions shall be effected by **radiation heat**.
This quick-acting system allows lower stand-by temperatures in the rooms than for conventional residential buildings. Comfortable room temperature (only when the room is used) can be ensured by radiation heat which reduces the energy demand for space heating.
Similar to the floor heating system the flow temperature is 45°C max. which is suitable for a combination with solar collector plants.

**Waste Concept / Conserving Resources**

*Waste Water*

A dry compost toilet ensures that waste water of the house is kept without faecal matters which allows pre-cleaning without disturbances by smell outside the building. In two seepage basins located one above the other mechanical and chemical purification is carried out. By means of a cascade the water is enriched with oxygen and flows then into a small pond where the water quality is good enough for gold-fishes to live there. Pumping the water into a grey-water well where rainwater is also collected it can re-used (for example in the washing-machine).

*Faecal Matters, Organic Wastes*

The ecotoilet of the top building is used for composting faecal matters and organic kitchen wastes. In the composter located in the service room the wastes to be decomposed are dehydrated biologically. The result is an odourless, mass-reduced dry matter. Only once per year 40 litres of dry compost have to be taken from the composter.
The toilet itself works without water flushing and consists mainly of a stainless steel downpipe. Also the kitchen wastes are led directly from the kitchen into the composter over a downpipe.

*Site, Sealed Ground*

At first the ground on which the house is located was planned not to be built-up, because it was a part remaining at a slope. The kind of the house built on this ground makes it to a top ground. A specific advantage of the building is, that remaining parts on slopes which could not be used otherwise or small sites - the HELIOTROP® ground is 512 m²- are enhanced to the status of excellent sites.
Due to the thin trunk of the building the terrace place can be used twice. On the site it self and in form of the roof garden with 60 m².

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# HELIOTROP® - Flat Floor Space and Floors

**Flat Floor Space and Floors m²**

| | | |
|---|---|---|
| **Top house** | | |
| Flat floor space | 90.83 | |
| Seminar and working rooms | | |
| incl. 60 m²2 roof garden | | 117.83 |
| Overall | | 208.66 |
| **Basement** | | |
| Exhibition, seminar and office room | | 77.21 |
| Overall top house and basement | | 285.87 |
| **In this space not contained** | | |
| Service and store rooms | | 40 |
| and | | |
| Stair floors, Entrance of top house, Balconies | | |
| **Auxiliary spaces** | | |
| Ground of the HELIOTROP | | |
| prototype | | 512 |
| Covered by the top house, planted and usable space | | |
| (Projection space) | | 90 |
| Ground covered and "sealed" by the trunk | | 9 |

## Construction / Technical Layout

The HELIOTROP® Freiburg consists of the basement as the foundation, the rotatable tower and a "solar sail".

*Tower*

| | |
|---|---|
| rotatable about | 400° |
| electric motor | 120 W |
| yearly power consumption only | 20 kWh |
| external diameter | 10,5 m |
| heated space tower | 180 m² |

*Column*

| | |
|---|---|
| internal diameter | 2.6 m |
| height | 14.5 m |
| mass incl. technical appliances and stair | 15 t |
| wall thickness | 111 mm |

from 18 Kerto Q-boards (produced in Finland) The joints of the longitudinal edges are carried out with steel ties filled up with epoxy resin.

*Modules*

Room cells connected in spiral form to the column. To be entered from the trunk or the neighbour elements.

Solar panels with two-axis tracking system

| | |
|---|---|
| aperture space | 54 m² |
| peak load | 6.6 $kW_p$ |

***Safety engineering / Strength***

In order to take into account all possible load scenarios the following maximum stresses have been considered in the column footing:

*Normal stresses*

| | |
|---|---|
| Own weight, imposed load,snow load | 1700 kN |

*Bending moments*

| | |
|---|---|
| Wind load on the building and solar platform and un-equal load distribution | 1850 kNm |

*Torsion moments*

| | |
|---|---|
| Asymmetric wind loads on the building and the solar platform | 55 kN |

*Swing*

Maximum swing at the top of the column25 mm

For the maximum bending moment of 18050 kNm two pictorial examples can be found:

≅ At the HELIOTROP® a free cantilever bar of 2,7 km length is fixed; on the free end a person of 70 kg weight is sitting.
400 people are standing at the same side of the tower and look out of the window.

**Ecology**

The HELIOTROP® fulfils ecological requirements.

*Building materials*

Wood, Kerto Q-Boards from Finland, wood framework in BSB technique, steel

*Thermal insulation*

| | | |
|---|---|---|
| Wall, roof and floor insulation | k-value | 0.10 - 0.13 |
| Windows with three-fold heat protection glass (average value incl. frame) | k-value | 0.6 |
| Glass with Krypton filling | k-value | 0.5 |

| | | |
|---|---|---|
| Glass with Xenon filling | k-value | 0.4 |

*Heat*

Rotatable tower - heating or cooling with sun and shade. Evacuated tube collectors at the railing for hot water heating for space heating and domestic use, water store and latent heat store, earth heat exchanger for supply air

*Wastes/faecal matters*

decomposed

*Water/rainwater*

collected on the roof

*Waste water*

Water purification in two plant clarifying basins and a pond as collecting pond in the garden in order to use the water for clothes washing and rinsing.

*Covered area*

is compensated by planting of the roof surfaces of the basement and the tower.