Portrait 5

Solar Energy Research Institute

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The new building site of Fraunhofer ISE is situated on federally owned property on the north-west edge of Freiburg´s city centre. The urban surroundings of this area are very heterogeneous, and therefore the new building provides a central town planning function. The building site is narrow and stretches in the north/south direction. A major emphasis in the planning was to create a high-quality working environment with low energy consumption and a high architectural quality.

Two-thirds of the main usable floor space are designated for laboratories and workshops. The remaining one third is used for office space. The building can accommodate approximately 300 employees.

The building complex has a comb-like structure. Three separate parallel wings are connected by a central access tract which runs in the north/south direction. An entrance block at the southern end of the access tract houses the administrative and central services. To the west of the central access tract are the technical prototype laboratory, workshops and a clean room with an area of 270m² for the development of solar cells. The entire building has a flat roof, parts of which function as outdoor test areas for experiments. The building wings are three storeys high. The offices are situated on the south side and laboratories are on the north side of the building wings. The main air ventilation shafts of the laboratories are organized in the vertical direction.

The building design was selected from three finalists, based on an evaluation procedure with regard to indoor climate and daylighting in the workspace as well as energy demand. The chosen building design was then further developed and optimised by extensive simulation calculations.

The combined heating, power and cooling system on the basis of a gas fuelled co-generation unit is the logical solution for meeting the large demand for electrical process energy and cooling. Solar energy systems on the building shell are used in conjunction with this system to supply electricity and heat.

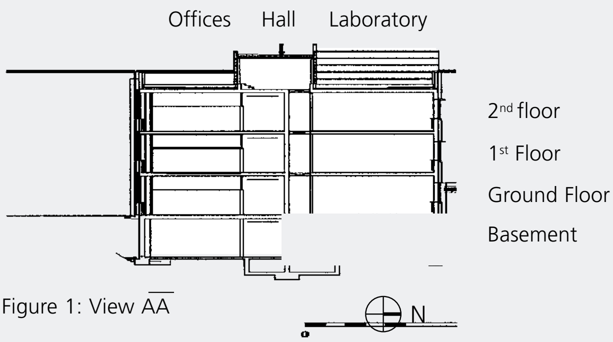


Figure 1: View AA

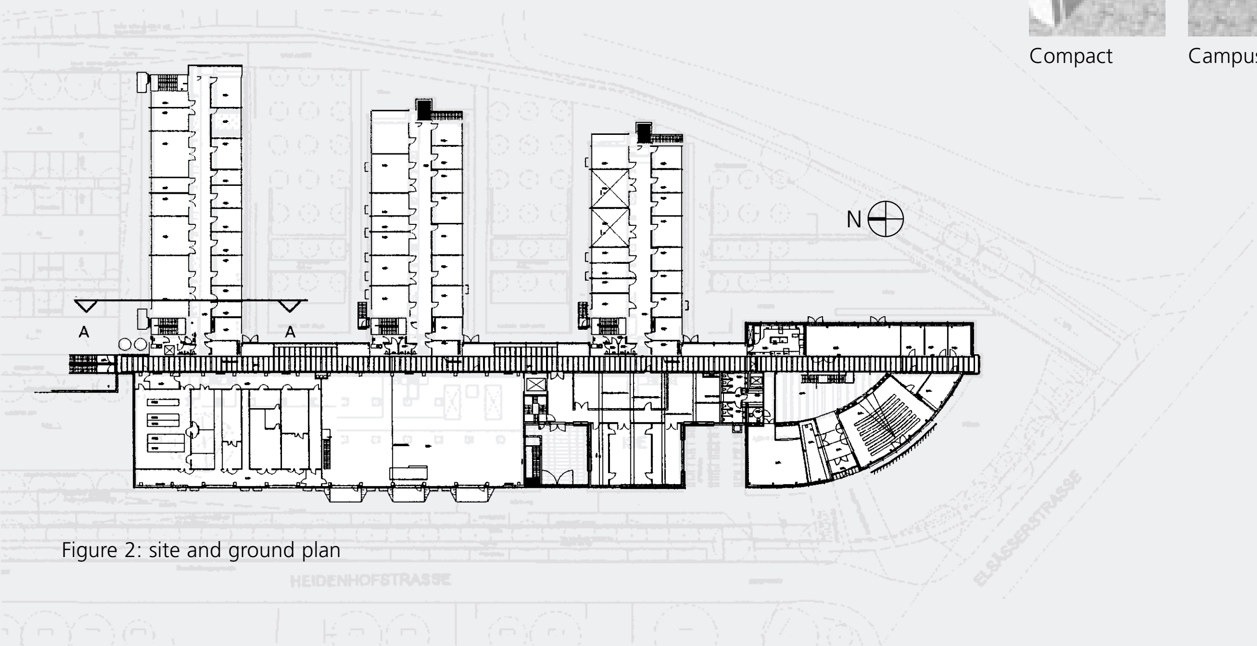
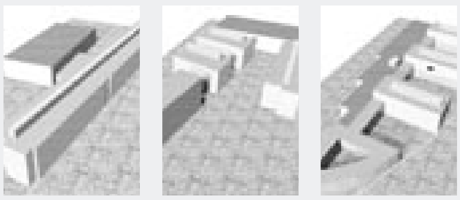


Figure 2: site and ground plan

Figure 3: Evaluation of the three competitive designs

Criteria	Compact	Campus	Wings
Summer comfort	–	o	+
Daylighting	–	o	+
Energy use	+	–	o



Compact Campus Wings

Building Information

The supporting structure is made out of reinforced concrete. Depending on the orientation and the function, three types of facades are used: On the southern side of the three wings and at the entrance building, wooden prefabricated curtain facade elements with a height of one storey were installed. The facade cladding is zinc-coated, white lacquered steel. The double-glazed windows have heat insulating glazing and a wooden-aluminium compound frame.

For the northern side of the wings, the laboratory and the workshops, a facade with a compound insulating and finish system and wooden/aluminium windows was chosen. For the access tract a glass facade with a wooden/aluminium frame structure was used.

Use

times of use	Mo-Fri 8 -20 h
number of users	300
completion	2001

Building

storeys	3 storeys, some with basements
mean room height	3,4 m
surface to volume ratio	0,31 m^{-1}

Area and Volume, DIN 277

Volume	
	Gross room volume BRI 64.322 m^3
Area	
	Net floor area NGF 14.001 m^2 (13.150 m^2)*
	main usable floor area HNF 6.474 m^2
Concentration	
	HNF/NGF* 49%

* = net heated floor area

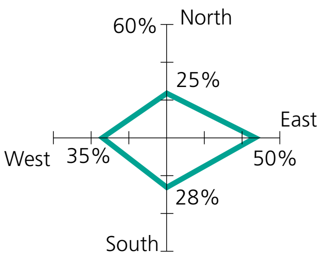
Heating Code Calculation

building part	U-value (W/m^2K)
wall with compound insulation and finish system	0,20
wall with steel facade	0,23
glass facade of access tract	1,60
windows	1,40
main roof	0,34
floor: storage, technical prototype laboratory	0,42
floor: laboratories	0,23
mean U-value	0,43

Annual heating demand according to German Heating Code `95

maximum allowable per volume		19,2 kWh/m^3a
existing	per volume	13,8 kWh/m^3a
existing	per area	41,2 kWh/m^2a
Below the max. allowable by 28%		

Window Area



Fraction of window area to the facade area for each orientation. In total 0.21m^2 window area per m^2 net floor area.

Costs

Gross Construction Costs, Cost Calculations

Item	Building Construction DIN 276: KG 300	Technical Equipment DIN 276: KG 400	Construction Costs KG 300+KG 400
Gross room volume DIN 277	210 Euro/m^3	161 Euro/m^3	377 Euro/m^3
Net floor area DIN 277	985 Euro/m^2	738 Euro/m^2	1.720 Euro/m^2

First Experiences

The energy consumption of institutional buildings performing high-tech research is, in general, very high. A reduction in the energy consumption is less affected by the architecture and building envelope properties, but rather by the efficient and prudent operation of the installed equipment and the energy consumption for each additional piece of equipment acquired. Through its careful use of energy, the building concept chosen stimulates such behaviour.

Research institutes are also an example of public buildings, in which the investment costs are considered independently from the operating costs of the building at a later date. Costs saved by reduced energy use can not be used for financing the higher investment costs incurred during the building construction phase.

Assuming a normal budget, the planning team of the new building aimed to achieve the energy standards ordered by the building users and to integrate solar components without causing additional building costs. As a result, the co-ordination between the architecture and the building technical service required a much greater amount of communication. In many situations decisions had to be made with respect to the design and the technical aspects as well as with respect to the financial considerations to achieve the energy saving goal. For example, the choice of material for the curtain facade was weighed with the investment costs of the combined heating, power and cooling system.

In the planning process the unusually high amount of participation from the future building users (employees of Fraunhofer ISE) contributed to the fact that the quality and functionality of the planned workspaces remained in the forefront. Since completion in 2001, the building is being tested in this respect.

Figure 7: 5 kW$_p$ PV-System for the roof of the central atrium

The energy concept of the building is based on energy savings and an efficient energy supply system. An increased thermal insulation and a heat recovery system for the laboratories as well as for a large number of the offices reduces the heating consumption in winter. The high electrical energy demand in the clean room, the laboratories and workshops centres are met with a gas-fuelled heat/electricity co-generating unit, which also serves as a back-up in the case of a grid breakdown. This unit is coupled to a combined heating, power and cooling system by means of an absorption chiller. In winter the waste heat from the co-generating unit is used for heating the building, in summer it provides air-conditioning for the laboratories and other special rooms. A boiler and a compression chiller are additionally installed to meet the heating and cooling energy demand during peak use.

The waste heat of the co-generating unit is also used for the dehumidification of the incoming air for the clean room. Thus, cooling loads are transferred into heating loads.

Table 2: Evaluation of variations in the roof glazing for the atrium with different tilt angles

north ←		glass / PV	
daylight	–	o	+
indoor climate	+	o	–
electricity	+	o	–

A 200m^2 photovoltaic array serves both to demonstrate various approaches to building integration on the facade and roofs as well as to contribute to the electrical energy supply of the building. On the roof of the entrance building, 20m^2 of solar collectors contribute to the central hot water system of the cafeteria.

The building design and planning as well as sizing of the energy supply system were investigated in detail by computer simulations.

Figure 4: The energy demand in comparison: Above all, the combined heating, power and cooling system contributes to a reduced primary energy demand and therefore a decrease in the CO^2 emissions in comparison to a conventional design. The increased end energy demand is due to the combined heating/cooling. The heat used for cooling is the waste heat from the co-generating unit.

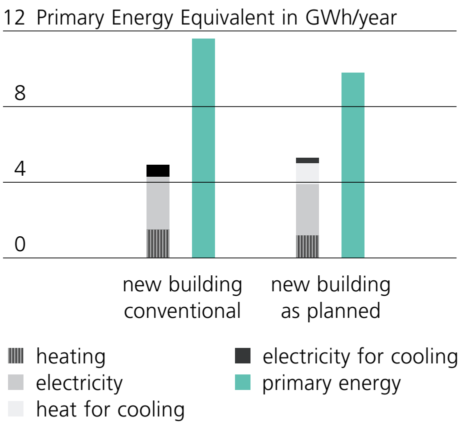


Table 1: Characteristic values for the earth-to-air heat exchanger

material	PE-pipe
number of channels	7
length of channels	100 m
width	DN 250 mm
depth	6 m
rated volume flux	9.000 m^3/h

Figure 6: Energy Supply

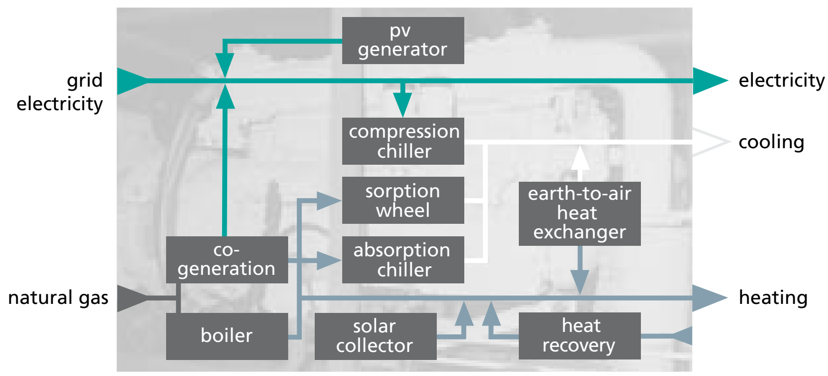


Figure 5: Not considering the energy demand for the clean room, equipment and laboratory technique, the energy savings become evident. The energy consumption is reduced by 40%, 30% of the consumption is met by the PV system. This is approximately equivalent to the consumption of the artificial lighting.

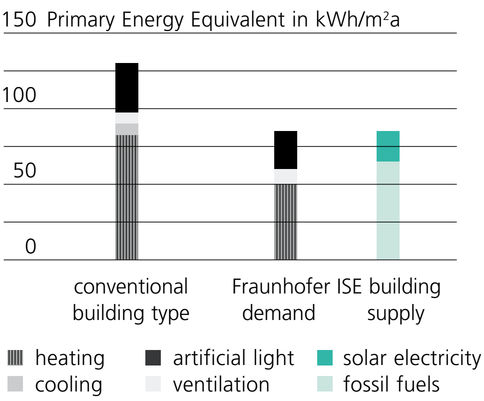


Table 3: Characteristic values for the energy supply

	electricity kW	heat kW	cooling kW	area m^2
co-generation unit	230	370		
boiler		690		
absorption chiller			350	
compression chiller	215		780	
photovoltaic	20			200
solar collector				20
specific power in W/m^2		81	86	

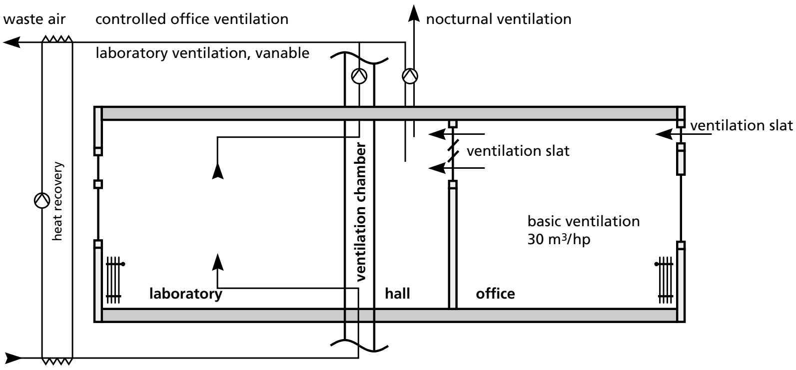
Fig. 11: Light redirected by special glazing in the upper windows of the library

Ventilation, Heating and Air-conditoning

In the laboratories constant indoor conditions are required while at the same time large heating loads exist, thus making an air-conditioning system a necessity. To reduce the ventilation losses, all systems are demand dependent and have a variable air flow with heat recovery. In the air-conditioning system for the 270m² clean room, a system for the sorptive dehumidification of the large input air volume up to 60,000m³/h is installed for the first time.

Due to the high density of people in the office spaces, a mechanical ventilation system is applied to provide improved air quality. In winter, a mechanical waste air system provides the offices with the necessary air change rate of 30m³ per hour and person. The outdoor air ventilates the offices through gaps in the window frames, using the principle similar to ventilation for low energy houses. Driven by the subpressure, the air passes into the hall through the ventilation slats above the doors. From there the waste air is centrally channelled and transfered to the waste heat recovery of the laboratories. In summer a passive cooling strategy is applied. In addition to reducing the internal and external cooling loads, an active nocturnal ventilation 'cools' down the building mass. For low pressure drop, the upper windows are opened manually. For the rooms with larger heating and ventilating requirements in the main entrance block (cafeteria, conference room), a 100m long earth-to-air heat exchanger is installed. The atrium functions as a central space to supply fresh air to the offices.

Figure 8: Ventilation of the Offices and Laboratories



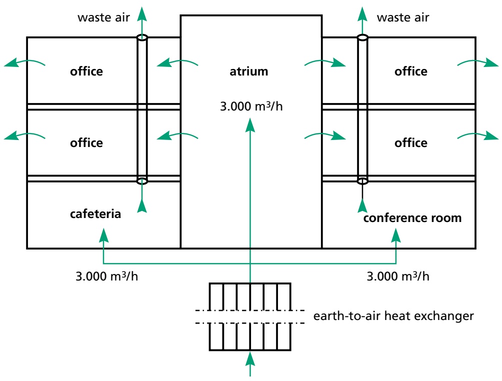
Daylighting and Artificial Lighting

The choice of the building design and its further development as well as the lighting strategy were assisted by lighting simulations. The daylighting concept of the offices is made up of the following:

- Ideal room dimensions for daylighting
- Upper windows in the facade, flush with the ceiling
- Upper windows in the inner wall between the office and the central corridor
- Solar control by a dual-partitioned external venetian blind
- Glare protection in the office space

In a south-oriented office at a central point 3m into the room as measured from the window, it is necessary to turn on the artificial lighting for only 15% of the daylight hours. The central corridor profits as well from the large amount of daylighting.

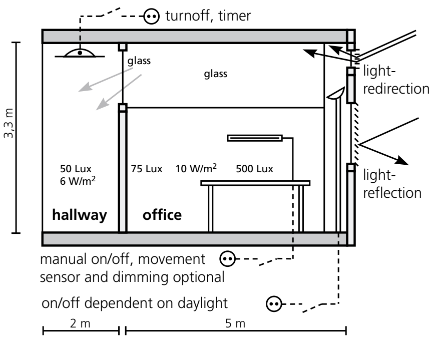
Figure 9: Ventilation of the entrance building (daytime mode)



The external venetian blinds are automatically controlled by the central building services. Of course, the user can alter the setting manually at any time.

The artificial lighting for the offices is made up of a two-component lighting system that was developed individually within the framework of this building project. The background lighting (75lux) ensures indirect lighting, and the lighting for the workplace (direct lighting) is provided by table lamps. In offices with low daylighting levels, lamps are decentrally controlled by movement sensors and automatically ensure a constant illuminance on the work area. The background lamps are centrally turned off in the case of sufficient daylight. A dimming strategy has no advantages here. A simple automatic timer turns off the ceiling lights in the central corridor after a certain period of time. All lights are flourescent with electronic ballasts.

Figure 10: Lighting concept for the offices



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SolarBau:MONITOR

This document was prepared within the framework of the research project ´SolarBau: MONITOR. The accompanying research documents, analyzes and communicates the results of the demonstration projects of SolarBau of the German Ministry of Economics and Technology BMWi.
The responsibility for the information in this brochure lies with Fraunhofer ISE.

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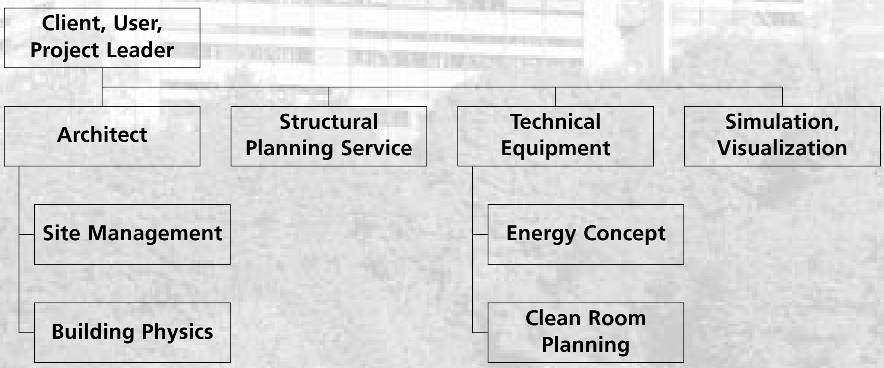

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