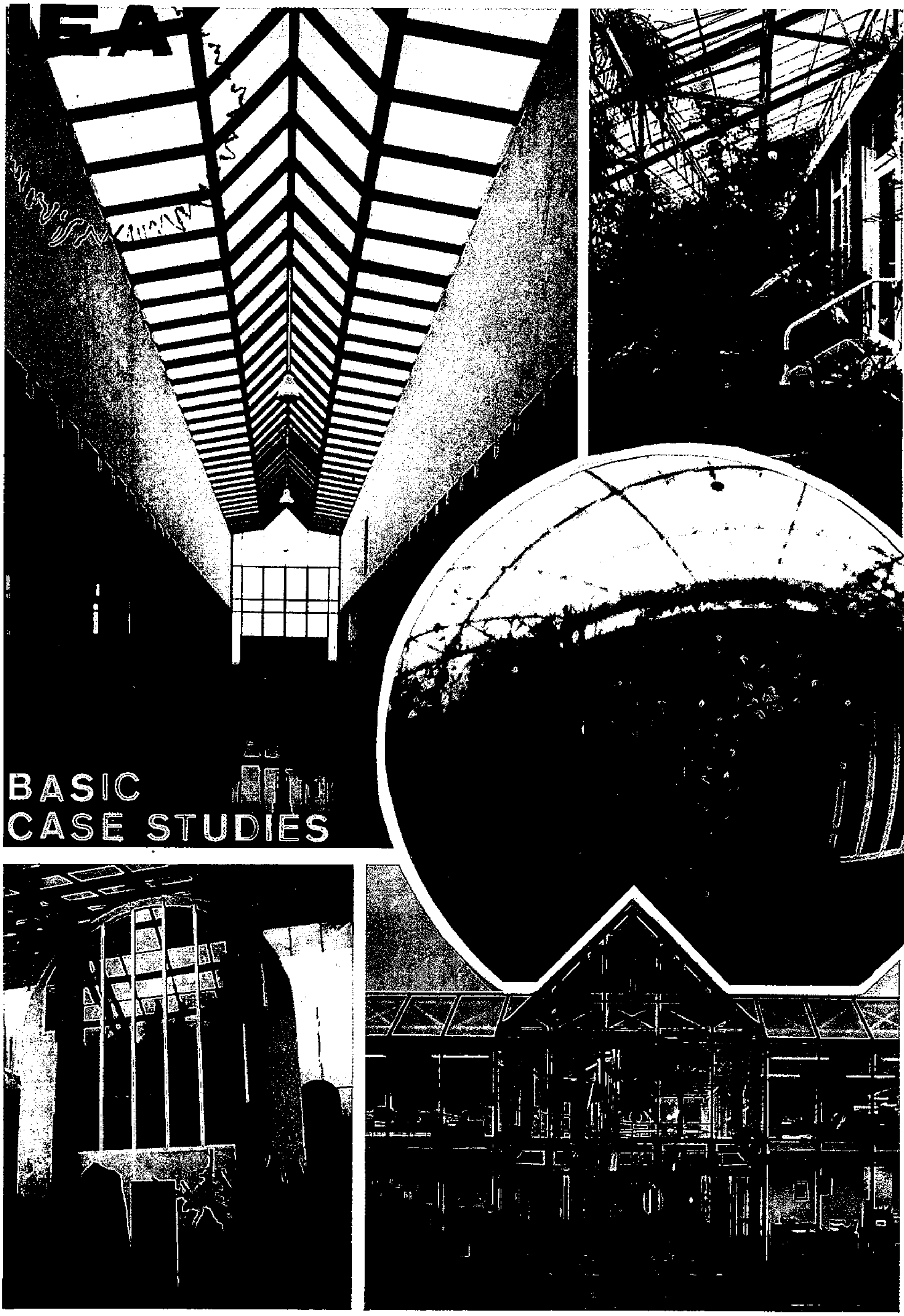
Passive and Hybrid Solar Commercial Buildings



INTERNATIONAL ENERGY AGENCY: SOLAR HEATING AND COOLING – TASK XI

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*The reader is also refered to additional case studies of passive solar non-residential buildings prepared under a research programme sponsored by the U.S. Department of Energy and published in the book; "**Commercial Building Design : Integrated Climate, Comfort and Cost.**" by, Burt Hill Kosar Rittelmann Associates and Min Kantrowitz and Associates (Van Nostrand Reinhold Company, New York, 1987), Library of Congress Catalogue Card Number 86-28997, ISBN 0-442-21156-2*

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PREFACE

INTRODUCTION TO THE INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA) was formed in November 1974 to establish cooperation among a number of industrialised countries in the vital area of energy policy. It is an autonomous body within the framework of the Organisation for Economic Cooperation and Development (OECD). Twenty one countries are presently members, with the Commission of the European Communities also participating in the work of the IEA under a special arrangement.

One element of the IEA's programme involves cooperation in the research and development of alternative energy resources in order to reduce excessive dependence on oil. A number of new and improved energy technologies which have the potential of making significant contribution to global energy needs were identified for collaborative efforts. The IEA Committee on Energy Research and Development (CRD), comprising representatives from each member country, supported by a small Secretariat staff, is the focus of IEA RD&D activities. Four Working Parties (in Conservation, Fossil Fuels, Renewable Energy, and Fusion) are charged with identifying new areas for cooperation and advising the CRD on policy matters in their respective technology areas.

IEA SOLAR HEATING AND COOLING PROGRAMME

Solar Heating and Cooling was one of the technologies selected for joint activities. During 1976-77, specific projects were identified in key areas of this field and a formal Implementing Agreement drawn up. The Agreement covers the obligations and rights of the Participants and outlines the scope of each project or "task" in annexes to the document. There are now eighteen signatories to the Agreement:

Australia	Japan
Austria	Netherlands
Belgium	New Zealand
Canada	Norway
Denmark	Spain
Commission of the European Communities	Sweden
Finland	Switzerland
Federal Republic of German	United Kingdom
Italy	United States

The overall programme is managed by an Executive Committee, while the management of the individual tasks is the responsibility of the Operating Agents. The tasks of the IEA Solar Heating and Cooling Programme, their respective Operating Agents, and current status (ongoing or completed) are as follows:-

Task I	Investigation of the Performance of Solar Heating and Cooling Systems - Technical University of Denmark (completed).
Task II	Coordination of Research and Development on Solar Heating and Cooling - Solar Research Laboratory - GIRIN, Japan (completed).
Task III	Performance Testing of Solar Collectors - University College, Cardiff, UK (completed)
Task IV	Development of an Insulation Handbook and Instrument Package - US Department of Energy (completed).
Task V	Use of Existing Meteorological Information for Solar Energy Application - Swedish Metorological and Hydrological Institute (completed).
Task VI	Performance of Solar Heating, Cooling and Hot Water Systems Using Evacuated Collectors - US Department of Energy (completed).
Task VII	Central Solar Heating Plants with Seasonal Storage - Swedish Council for Building Research (ongoing).
Task VIII	Passive and Hybrid Solar Low Energy Buildings - US Department of Energy (completed)
Task IX	Solar Radiation and Pyranometry Studies - KFA Julich, FRG (ongoing).
Task X	Solar Materials Research and Development - AIST, MITI, Japan (ongoing)
Task XI	Passive Solar Commercial Buildings - Swiss Federal Office of Energy (ongoing)
Task XII	Solar Building Analysis and Design Tools - US Department of Energy (ongoing)
Task XIII	Advanced Solar Low-Energy Buildings - Royal Ministry of Petroleum and Energy, Norway (ongoing).

TASK XI: PASSIVE AND HYBRID SOLAR COMMERCIAL BUILDINGS

Growing interest in the energy savings opportunities presented by the use of passive solar concepts in commercial buildings prompted members of the IEA Solar Heating and Cooling Programme to form a new task in 1985. At that time much of the national and international research into passive solar, energy efficient building design had concentrated on residential buildings. Task XI was an early recognition of the enormous potential for energy savings through the application of passive solar techniques to displace fuel used for heating, cooling and lighting in commercial buildings.

These buildings differ markedly from residences in much more than size. The variety of building forms, HVAC systems, controls, internal loads, occupancy profiles and schedules, and special user requirements is made more complex by their interactions. Furthermore, there is still relatively little experience of utilising passive solar techniques to save conventional energy in commercial buildings.

Task XI was structured to optimise the contributions, and national programmes, of the participating nations. It comprises three linked sub tasks:

A Case Studies:	led by the United Kingdom
B Simulation:	led by the United States of America
C Design Information:	led by Switzerland

This book is a product of Sub Task A and brings together, in a standardised format, basic information on 48 passive solar commercial buildings, (47 in Europe), spanning a wide variety of climates. Sub Task A also proposes to publish a collection of about 20 case studies from buildings researched (through measurement and simulation) in much greater detail, these are known within IEA as Advanced Case Studies (ACS).

In addition to this case study material, Task XI will publish the results of simulation studies (Sub Task B) which, together with the wide variety of case study material is being used to generate a comprehensive set of information for designers (Sub Task C). Thus the annex hopes to influence the next generation of low energy commercial buildings which will be designed to make effective use of the sun to reduce the conventional energy loads required for space heating (& cooling) and electric lighting.

One gratifying conclusion from these case studies is that not only is it possible to achieve energy savings through passive solar design, but also that the buildings can be exciting and stimulating additions to our built environment and be well liked by those who use them.

ACKNOWLEDGEMENT OF CONTRIBUTORS

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EXECUTIVE SUMMARY

A collection of 48 case studies of passive and hybrid solar commercial buildings from 12 countries and the CEC is presented, covering a wide variety of building types, climates and locations. Generalisations, concerning building performance, are difficult, and sometimes impossible, due to the diversity of buildings, systems and climates. It has also been difficult for authors to provide information about such complex buildings in a standard comparable format. However, the case studies presented confirm that it is possible to design passive solar, energy-efficient buildings within conventional constraints that are well liked by owners, operators and occupants.

It is apparent that the energy balance of commercial buildings, sometimes with high internal heat gains and low volumetric heat loss, presents designers with challenges if they seek to admit large amounts of solar heat and daylight to displace non-renewable forms of space heating and electric light. These case studies include many examples of ways intended to achieve this displacement of fuel use; these provide valuable practical feedback from both successes and failures.

Energy savings relative to conventional buildings range from about +90% to -35%, these savings (or losses) cannot be attributed entirely to passive solar features but are also dependant upon the energy management within the building. The average capital costs are about the same as those of conventional buildings, with most lying within a +/- 10%. There is no observed relationship between capital cost and energy performance and the case studies confirm that energy saving strategies are not a major cost in commercial buildings.

There is still much to learn, through both research and design, about the successful integration of passive and hybrid solar energy design into low energy commercial buildings. This applies particularly to how solar energy is integrated with heating, cooling, lighting and ventilation systems.

These case studies should encourage designers to adopt solar design principles and will provide some examples which includes both successes and failures. The case studies will also provide researchers with an insight into energy related issues of concern to the construction industry.

INTRODUCTION

It is tempting to think that a collection of 48 case studies prepared to a common format will yield a wealth of consistent, comparable and credible data which in turn provides great insight into the workings of passive solar buildings. However, reality does not conform to the controlled conditions of the laboratory; consequently each of the case studies was prepared in a national and cultural context. This makes comparison very difficult since not every case study provides the same data for all parameters. For example :

- Is floor area defined and measured as gross, net, heated, etc. and is it measured internally or externally?
- Is energy use expressed as primary energy, fuel delivered to site, heat supplied to building, measured or modelled or both, etc.?

These uncertainties are compounded by the complexity and diversity of non domestic buildings. For example :

- How can we compare a 100 m^2 earth sheltered office with a 10,000 m^2 atrium office?
- How do we compare fuel use in a building with a heat pump to one which uses waste in an incinerator, and to an all-electric building?

Naturally, the Basic Case Study project attempted to overcome these difficulties. For example :

- A standardised format was used.
- Degree days were defined in a standard fashion.
- Building costs were expressed in European Currency Units (ECU).
- Energy use was carefully defined.
- Reference or baseline cost and energy data were requested for each case study.

Whilst much effort has been expended in trying to make the data consistent there was little point in forcing this matter to extremes since consistency does not guarantee comparability due to the multiplicity and complexity of the wide range of buildings included.

THE SAMPLE

A total of 48 case studies were provided, 47 in Europe and 1 in Canada. Of these, 3 are not included in this overview analysis, since 2 are research experiments for model validation and the other is an illustration of an advanced hybrid technology (light pipe). The European sample cover the latitude range of 36° to 70° N. Their locations and descriptions together with the numbering used in this report are given in the map and table at the end of the introductory section. The distribution by country and building type is as follows :-

												not in overview			
	A	B	CH	D	DK	E	I	N	S	SF	UK	*CDN*	*CEC*	*D*	ALL
OFFICES			3	4	2		2	1	1	1	3	1	1	1	20
EDUCATION		1	3	3		3	1	3			2				16
ASSEMBLY		1	1												2
HOTEL				1							1				2
HEALTH											1				1
SPORTS	1					1									2
INDUSTRIAL			1												1
OTHER				1					2		1				4
ALL TYPES	1	2	8	9	2	4	3	4	3	1	8	1	1	1	48

Offices and educational buildings make up 75% of the sample, reflecting their importance.

Passive solar features were categorized according to the following typology :

- DaylightingDirect and Indirect
- Solar HeatingDirect and Indirect
- Solar ControlNatural Cooling and Shading & Insulation
- Atria

Daylighting features are intended to save energy and/or improve amenity through the displacement of electric lighting.

Solar heating features are intended to save energy and or improve amenity through the displacement of space heating by conventional fuels.

Solar control features are intended to save energy and/or improve amenity through the removal (natural cooling) or exclusion (shading & insulation) of unwanted solar heat.

Atria buildings were defined separately since they usually embody a mixture of passive solar strategies functioning in a unique interactive manner. Additionally, atria are still a controversial energy issue in many climates - do they save energy, improve environments, or are they only nice spaces ?

Individual buildings can incorporate many passive solar features and there can be some confusion stemming from the fact that all buildings incorporate direct solar heating and direct daylighting to some extent. Atria in particular proved difficult since they can be regarded as a subset or collection of other features. Most authors stressed that the passive solar features were an integral part of the whole design, not simple add-ons, and that this made the separation of their cost, performance etc. both difficult and meaningless.

Notwithstanding the strongly held view that passive features are inseparable from the overall design, the principal features ascribed to the buildings are as follows : (Note that many buildings have several passive solar features).

		OFFICES	EDUCATION	OTHERS	*ALL*
Daylighting	Direct	13	9	9	*31*
	Indirect	4	7	4	*15*
Solar Heating	Direct	11	10	6	*27*
	Indirect	6	9	7	*22*
Solar Control	Natural Cooling	5	3	3	*11*
	Shading & Insulation	8	7	3	*18*
Atria		7	6	3	*16*
Number of buildings		*20*	*16*	*12*	*48*

It is difficult to make reliable, precise, and quantitative inferences from the data, but the following may be worth noting :-

- Daylighting is very widely used to save energy, which reflects the great concern with the cost of electric lighting in commercial buildings.
- Simple direct systems are, as might be expected, the most widely used means of utilizing the sun's energy.

- Indirect systems are fairly common for utilising solar heat gain, often integrated with the space heating system through solar warmed air (redistribution, heat recovery, etc.)
- Atria are very popular although their energy performance is recognized as 'unclear'.
- Solar control, natural cooling and shading, is quite widely used even in northern latitudes. The benefit of displacing cooling costs (running and capital) is recognized.

CLIMATE

Figures 1 and 2 show the range of solar radiation and degree day characteristics for the case study buildings.

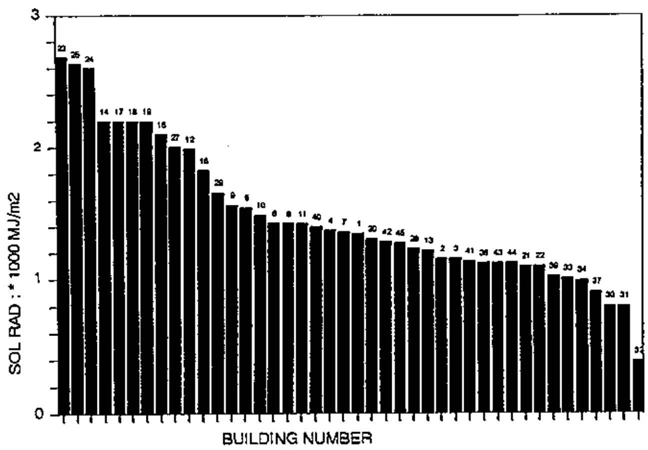


FIG 1 : Heating Season Solar Radiation

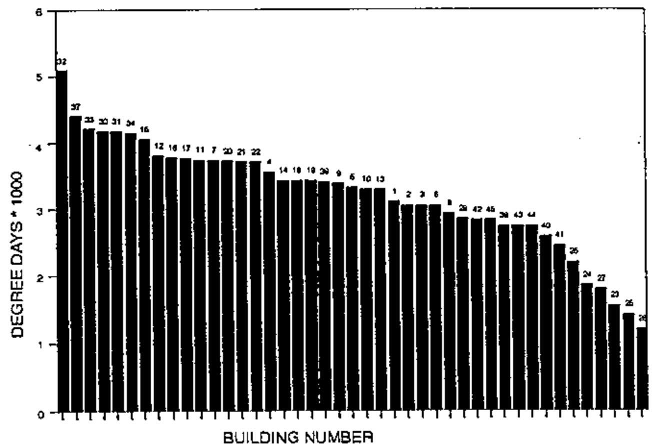


FIG 2 : Heating Season Degree Days (base 20)

BUILDING SIZE

Figure 3 shows the distribution of gross floor area. About three-quarters of the buildings are less than 5,000m^2 and are modest enough to be compatible with natural ventilation and daylighting. Therefore, these are buildings whose performance is likely to be determined by the envelope since they lack a large core separated from the effects of the climate by a perimeter zone. Consequently, they represent buildings with a significant potential for solar displaced fuel use.

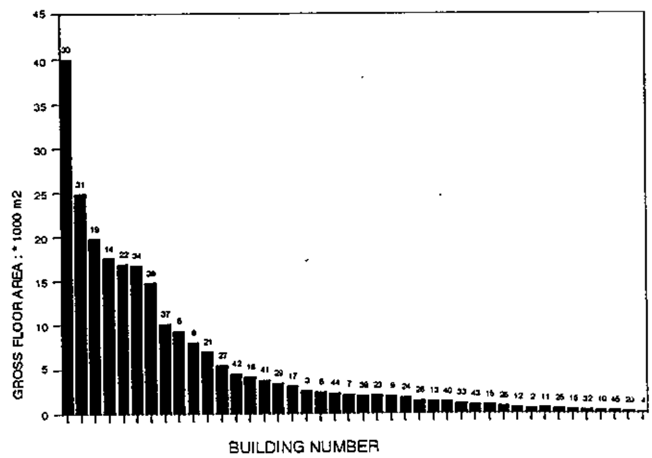


FIG 3 : Gross Floor Area

NOTE :

All graphs used in this introductory section are intended as diagrammatical aids to the text for showing general trends and as such should not be used for definitive values. Values used in producing the graphs are taken directly from the case studies and possible discrepencies may therefore occur due to assumptions made by individual authors. This is particularly the case with references, which are reliant upon individual assumptions.

BUILDING COST

Figure 4 gives cost data in ECU normalized for floor area. Understandably, comparisons are clouded by variations in exchange rates and by differing dates for the cost information. Nevertheless the range is very wide, almost 10:1.

CONVERSION TABLE : JULY 1989 (rates per ECU)

ECU	AS	FB	SFr	DM	Dkr	Pts	ItL	NOK	SEK	FIM	UK £	CDN $	US $
1.0	14.6	43.3	1.8	2.1	8.1	130	1508	7.6	7.1	4.6	0.7	1.3	1.1

It was considered important theat the case study buildings should be compared with conventional buildings. Many authors were able to give some indication of typical or reference costs for similar conventional buildings, these allow an estimate of the saving for the case study building (a negative saving means the building cost more than its references). The data are illustrated in figure 5. About 50% of the sample cost within +/-20% of their reference costs confirming the widely reported view that low energy commercial buildings can be built for about the same as conventional buildings. The few that cost substantially more or less than the norm are exceptional as explained in their reports.

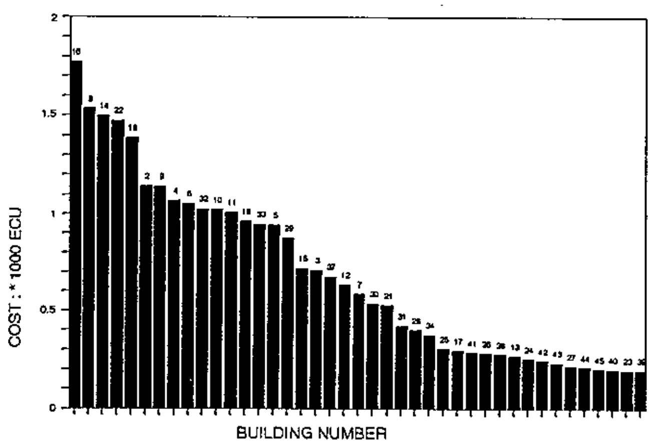


FIG 4 : Construction Cost

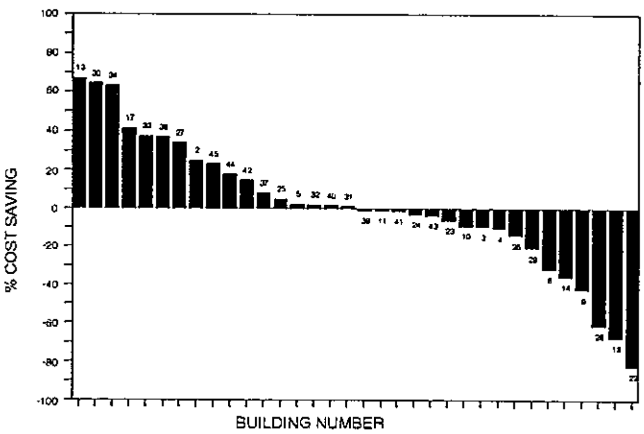


FIG 5 : % Cost Saving Relative to References

Authors reported that it was usually not possible to identify extra costs associated with the passive solar features since they were an integral part of the building design and could not be regarded as additive.

ENVELOPE THERMAL PERFORMANCE

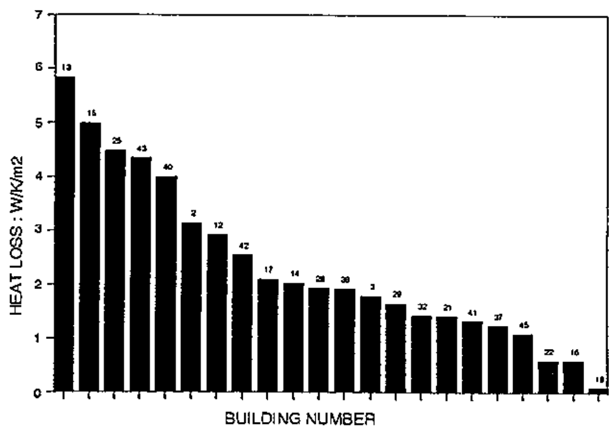


FIG 6 : Envelope Heat Loss / Floor Area

Many of the case studies provided an estimate of the building's envelope heat loss in Watts/K (fabric conduction together with infiltration & ventilation) per unit floor area. As might be expected from the wide range of degree days this parameter varies greatly, from 0.5 to 6.0, but with about one half of the sample with values between 1.0 and 2.0 (Figure 6).

ENERGY USE

Comparisons between buildings are very difficult when the sample has great variation in :

- building type and size,
- standard of envelope performance,
- HEVAC systems,
- hours and types of use,
- scale and nature of energy uses for use other than environmental conditioning. Etc.

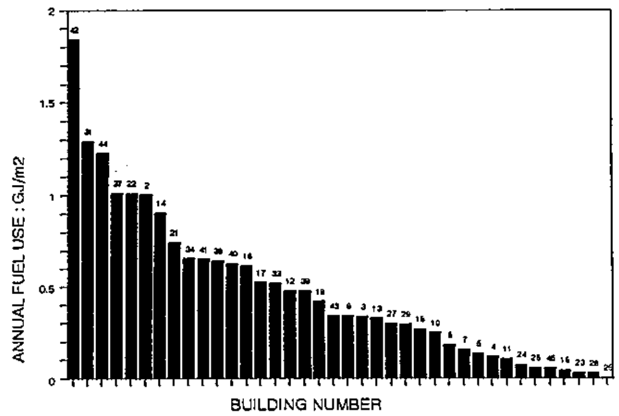


FIG 7 : Total Annual Fuel Use /Floor Area

The analysis of the data supplied has confirmed that this basic information can provide only limited insight into the quantitative aspects of energy performance. Nevertheless, it is instructive to look at the 'bottom line' namely the annual total of fuel entering the building. This has been normalised for gross floor area and the data are illustrated in Figure 7. Despite the numerous sources of perturbation in the data, the annual MJ/m^2 values span a limited range with most buildings using between 300 and 800 MJ/m^2 p.a.

No relationship was found between total building fuel use and apparently significant characteristics of the building or its location, e.g. degree days, building heat loss coefficients etc. This can be explained by closer inspection of individual case studies where it is found that the fuel used for environmental conditioning (e.g. space heating and lighting) has often been reduced to a small percentage of the building total.

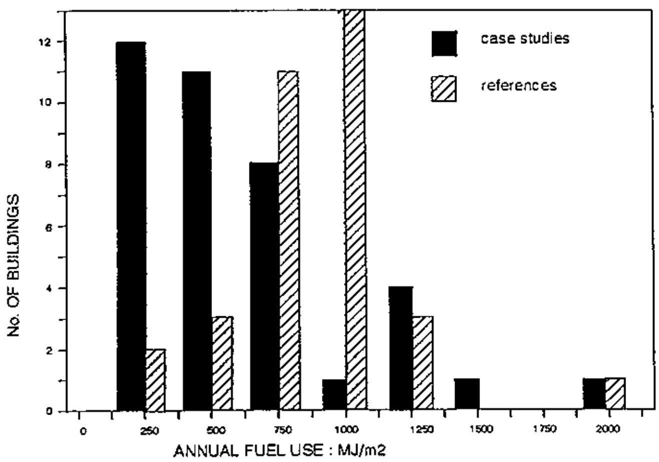


FIG 8 : Frequency of Annual Fuel Use

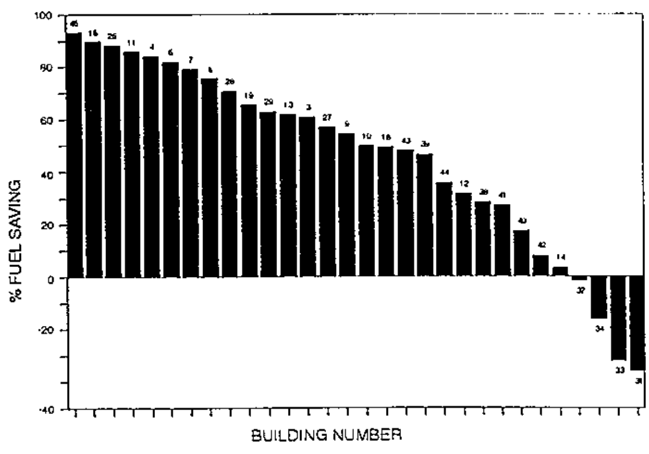


FIG 9 : % Fuel Saving Relative to References

More revealing is an analysis of the comparisons made by individual case study authors with fuel use for similar typical buildings in the same location. Figure 8 compares the two data sets (actual and reference fuel use), whilst figure 9 presents an analysis of the difference.

There are 6 cases where the saving is less than 10%. In 4 of these the buildings employ large heated atria where the energy penalty of this is regarded as acceptable relative to the additional amenity. Of course, the reference building would not have such an atrium. In another case the building has abnormally high energy use for functions not related to building performance. In the final example, the building has suffered from its complex hybrid system failing to function correctly.

There are 14 buildings with savings in excess of 50% . The individual case studies reveal that in these cases special circumstances apply e.g. two are earth sheltered buildings, others have limited hours of use. The remaining 10 in the sample show energy benefits relative to references of between about 15% and 90% (or 300 to 800 MJ/m^2).

We should be cautious in interpreting these bald statements of energy saving. For example, authors generally emphasised that the performance of passive solar features could not be easily identified separately, since the features were an integral part of the overall building performance. Therefore, not all of the energy benefit should be ascribed to passive solar features alone. Nevertheless, it does seem that these buildings constitute a variety of successful low energy designs.

There is no relationship between a building's cost (relative to cost norms) and its energy performance (relative to energy norms) strengthening the view that low energy design is not a significant factor in determining the capital cost of a commercial building.

AMENITY

The case studies widely report that the buildings are very well liked by users, and that the potential disadvantages of climatically responsive buildings occur less frequently than anticipated. If and when such disadvantages do occur they are usually outweighed by the positive response of occupants to the admission of large amounts of sunlight. Of course, these buildings usually benefited from a design team that took considerable care to avoid risks associated with solar gain.

Atria in particular elicit positive responses from users. This is so prominent that the energy saving potential of such spaces is often negated in the interests of enhanced amenity. For example, in one case covering a courtyard to form an atrium increased energy use due to extended use of the new space created. In another, the fact that the atrium (which functioned as a covered street) remained unheated was regarded as a severe restriction by the users who were not persuaded by the argument that the unheated space was superior to an uncovered street.

PRACTICAL ISSUES

Inevitably with a sample of innovative buildings there have been some difficulties and problems, but these then provide useful feedback to designers.

The most common problems were associated with the integration of the building services systems into the passive solar strategy. This difficulty usually related to manual and automatic controls, a selection of examples includes :

- Attempts to enhance the utilization of solar heating to displace space heating by the interconnection of the passive solar feature to the main heating system, were frustrated by malfunctioning of complex control equipment and strategies. (In one case three heating seasons were required to properly commission the system)
- An automatic control system intended to reduce the use of electric lighting in response to enhanced daylight penetration failed to achieve maximum energy savings .

- The potential energy savings from the buffering effect of an 'over-all' atrium were negated by an inefficient heating plant for the sheltered parent building.

Unfortunately, this practical experience cannot be satisfactorily generalised or summarised and the reader is advised to consult the individual case studies. However, the message seems to be that passive systems should be kept as simple and as passive as possible.

SOME RANDOM COMMENTS AND VIEWS

The following is a selection of comments form the authors of this overview based on their reading of the Basic Case Studies. Other readers will, inevitably, take something different from their own interpretation of the information and they are encouraged to do so.

- ☞The use of solar heat gain to displace space heating seems well understood in all its forms and because there are sufficient examples to show that it is viable in most commercial buildings. Because of the high internal heat gains in many commercial buildings it is not possible to transfer experience with heating of residential buildings to commercial buildings. In particular, it seems that the passive solar heating concept should be carefully integrated with the space heating system such that it functions reliably and without undue dependence on complex controls (manual or automatic).
- ☞It is interesting to note that in a few cases where the heating and cooling requirements are small and infrequent, then the passive solar/low energy design strategy has eliminated the need to install conventional heating or cooling plant. This provides a substantial cost saving.
- ☞A high quality, thermally insulated, envelope is one of the most important conditions required to minimize a buildings requirement for space heating. The impact of the internal gains will also reduce the demand for space heating. These 2 factors can limit the potential for solar displaced space heating and in summer can combine with the solar gains and lead to overheating. The full impact of the heat balance of commercial buildings in terms of the integrated design of solar heat gain, heating systems, and the prevention of overheating, is probably not yet widely exploited to optimum advantage. This topic would benefit from further research and more built examples.
- ☞The use of daylight to displace electric lighting is of widespread concern now that lighting costs probably exceed the costs for space heating. However, there is still a dearth of practical experience, especially in the integration of daylight provision with electric lighting systems and their controls. There is considerable scope for more work in these areas. However, as for heating strategies, the effective integration of the passive and active systems appears to be essential if energy savings are to be maximised. Complex strategies are often not the most effective.
- ☞Atria are everywhere ! This amazingly popular built form is not very well understood in energy and environmental terms by researchers or designers, yet its popularity with building owners and users is such that concern about small energy benefits or penalties is swept aside in favour of the huge amenity benefit. In this headlong rush for atria it is noted that some are energy wasteful and that, at the very least, research should inform designers of atria as to how they can maximise amenity benefits without compromising energy performance. For example, it does seem that we need an improved understanding of the coupling of the atrium with the adjacent 'parent' spaces, in terms of daylight, heat flows, and ventilation.

AND - IN CONCLUSION :-

The overall impression after reading these case studies is :

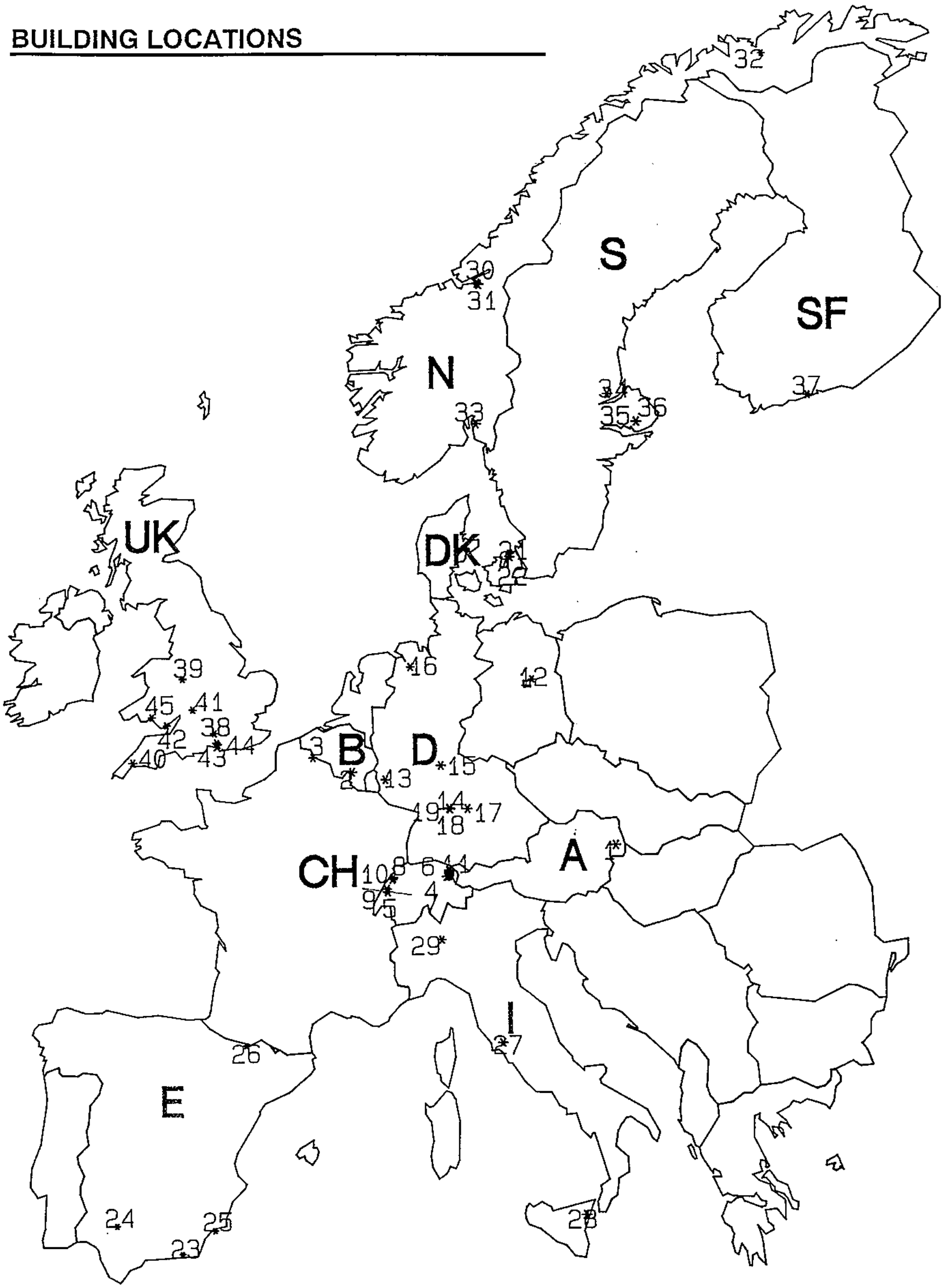
It is possible to design passive solar energy efficient buildings within conventional constraints that are well liked by owners, operators and occupants.

Finally, the contribution of the owners and designers of these innovative buildings should be recognized. Without their willingness to extend their knowledge and experience our research would be much poorer.

DATABUILD, 12/07/89
A. Hildon & A. Seager

BCS No.	TITLE	NATIONALITY	FUNCTION	PRINCIPAL PASSIVE SOLAR FEATURE(S)						
				Daylight		Atria	Thermal			
				Direct	Indirect		Direct	Indirect	Nat Cool	Other
1	Tropical Pyramid	A	sport	*			*			
2	Auditoires - Ful	B	assembly	*			*	*		*
3	School of Tournai		education	*	*		*	*		*
4	Haas & Partners	CH	office	*				*	*	
5	Canton Vaud		office	*			*			
6	Gumpweisen Sch		education	*			*			
7	Rutishauser		office	*						
8	Neuchatel Uni		education	*				*		
9	Penthaz School		education	*			*	*		
10	Reinach Youth Centre		assembly	*				*	*	
11	Meteolabor		industrial	*				*	*	
12	Day Care Centre	D	education	*			*	*		
13	ESA Building		hotel	*			*	*		
14	St. Monika		other		*	*				
15	Tegut Building		office	*	*		*	*		
16	Energielabor		education		*	*				
17	Ziehl-Abegg		office						*	
18	Technologie-Zentrum		office			*				
19	Züblin-Haus		office			*				
20	Schopfloch K'garten		education		*		*	*		
21	Time/System	DK	office				*			
22	BRF Headquarters		office	*		*				*
23	School in Almeria	E	education	*	*	*	*	*	*	*
24	School in Guillena		education	*	*	*	*	*	*	*
25	Los Molinos		education	*	*		*	*	*	*
26	Polysportive		sports	*	*		*			*
27	Montefiascone Sch	I	education				*			*
28	Sogeca Office		office	*				*		*
29	Enea Building		office	*				*		*
30	Technical Uni	N	education			*				
31	Dragvoll Uni		education			*				
32	Day Care Centre		education			*	*			
33	Solar Dairy		office				*	*		
34	Wasa City	S	other	*		*	*		*	*
35	Bodbetjänten		office			*				
36	Skärholmen		other			*				
37	PI - Group H'quarters	SF	office	*		*	*			
38	Gateway 2	UK	office		*	*	*		*	*
39	JEL		office	*		*	*	*	*	*
40	Looe School		education	*			*	*		*
41	SSWC		office	*	*		*		*	*
42	Ystradgynlais		health	*	*		*			
43	Netley Abbey Sch		education	*	*			*		*
44	John Darling Mall		other	*	*			*		
45	Caer Ilan		hotel					*		
46	Victoria Park	CDN	office		*					
47	Solar Laboratory	CEC	office	*			*			*
48	Ente	D	office	*			*			*

BUILDING LOCATIONS

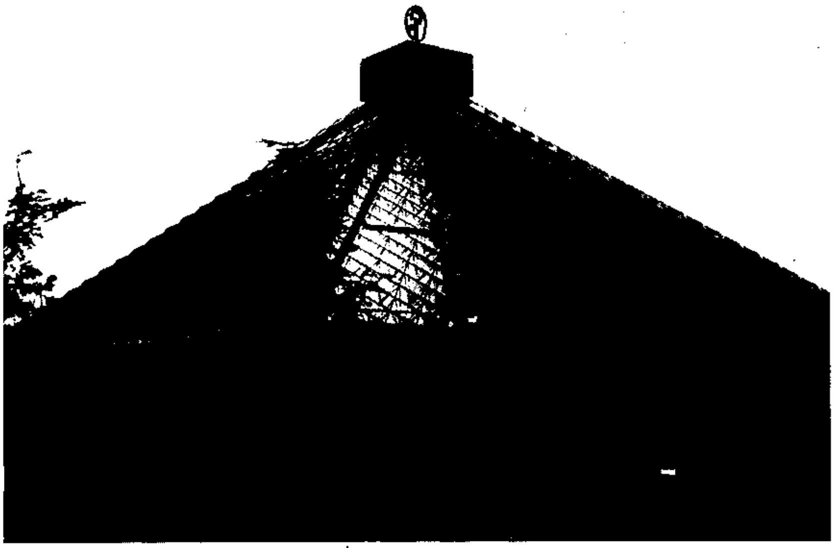


(A) AUSTRIA

BCS No.	Building Title
1	TROPICAL PYRAMID

TROPICAL PYRAMID

A TROPICAL PYRAMID



Building type:
Sport centre with indoor swimming pool and tropical garden

Passive features:
Solar Heating:
Direct
Daylighting:
Direct

Occupancy date:
1983

Floor area:
Gross -
Heated - 7 450m²

Volume:
Ventilated - 100 000 m³

Cost (1983):
AS - 1 200 000 000
ECU - 88 000 000

Annual delivered fuel:
Heat - 41 800 GJ
Elect. - 13 400 GJ

Heat and Elect
- 7 400 MJ/m² gross

Client:
Donau-Finanz, Wien (owner)
City Club Vienna (lessee)

Architect
Bruner/Wojnarovski

Energy consultant
Mannesmann Centi Wien

SUMMARY

The "tropical pyramid" is part of a sport centre and hotel complex with a 5-star-hotel (471 rooms) and a conference centre. The pyramid has a square base and four transparent sides, it covers a "tropical garden" with palm trees, an artificial lake, restaurants, small houses built in colonial style, etc.

The basic philosophy was to create a tropical landscape in the open air which should look as natural as possible. The well-known and popular pyramid is frequented by the hotel guests, club members and day guests from Vienna and its environs. It has become an attractive recreational centre for the demanding guest and an asset for the hotel and conference centre.

The space and pool water heating as well as the lighting combine manual and automatic control (energy management).

The Specific Energy Consumption of the Pyramid and the outdoor pool which is frequented throughout the year does of course exceed that of a large, conventional indoor swimming pool.

PROJECT DESCRIPTION

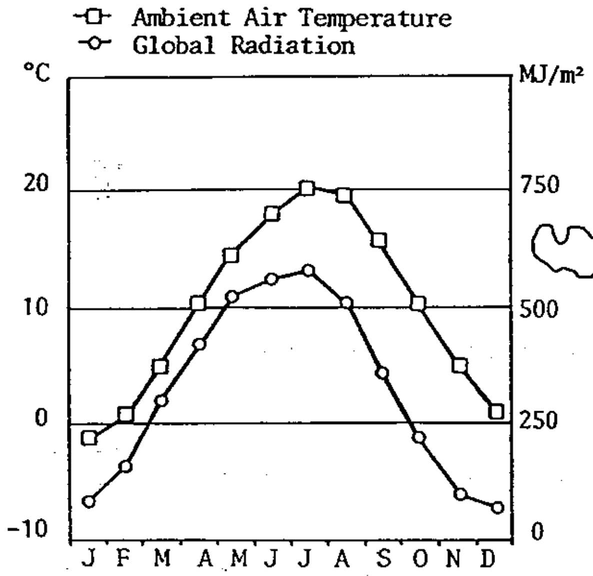
The whole complex was designed as a first class sport and hotel centre. The Pyramid with its transparent sides gives the quest the impression of being in the open air, making at the same time the best use of day-light.

There are almost no overheating problems in summer since air temperatures up to approximately 30°C can be tolerated.

The whole complex (pyramid + hotel + conference centre) is supplied with heat from a nearby central heating station.

SITE AND LOCATION

The complex is situated in Vosendorf, approximately 20 km south of Vienna, surrounded by large shopping centres and small and medium scale industrial companies, which are spread out over the area with most of the buildings having one to three floors.



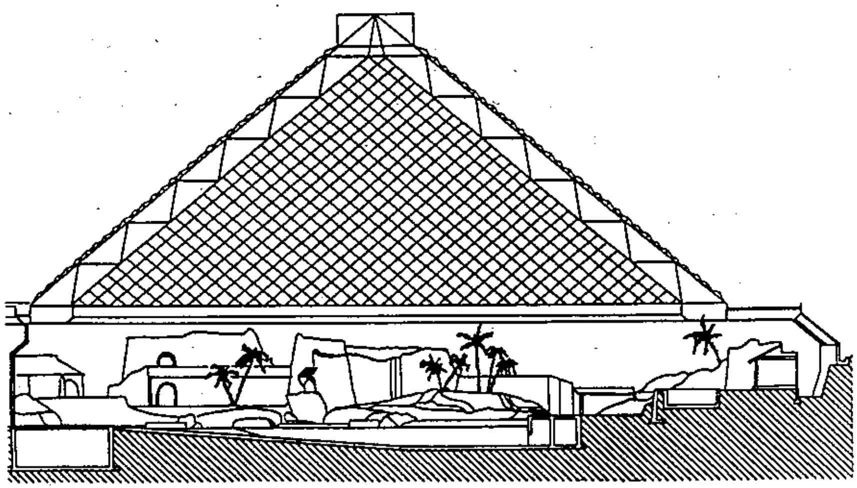
Site data:
Latitude - 48° 10
Altitude - 16° 25

Climate data
Oct. to Apr. incl.
Degree Days: 3 114 Kd
(base 20/12)
G_H 1 348 MJ/m^2

Annual
Degree Days 3 233 Kd
(base 20/12)
G_H 3 924 MJ/ m^2

BUILDING FORM

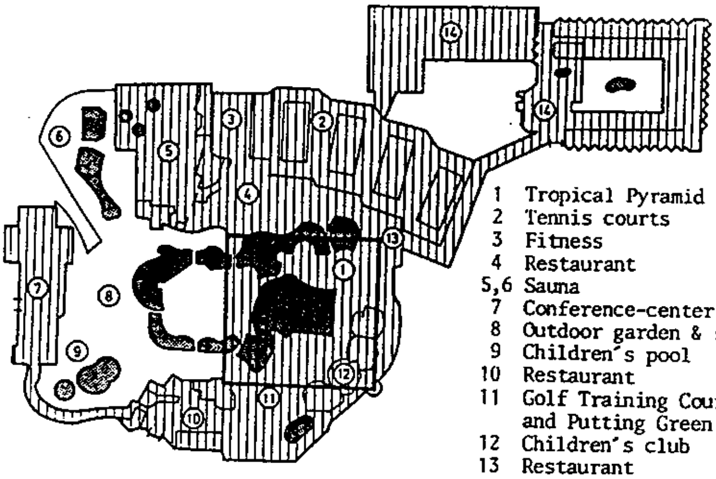
The pyramid has a square base and its four sides are transparent. It is built on a ground construction, consisting of vertical walls which are 10 m high. Parts of the vertical walls are glazed.



Volume: (m^3)
Pyramid
Gross: 100 000

Dimensions:
Floor to ceiling height in the centre of the Pyramid: 34 m

Surface areas (m^2)
Pyramid
Tropic Garden + Pool - 7 450
Tropic Pool - 1 400
Transparent Roof- 6 700
Sporting Club
total -18 000



1 Tropical Pyramid
2 Tennis courts
3 Fitness
4 Restaurant
5,6 Sauna
7 Conference-center
8 Outdoor garden & swimming pool
9 Children's pool
10 Restaurant
11 Golf Training Course and Putting Green
12 Children's club
13 Restaurant
14 Hotel
|||| Indoor

BUILDING CONSTRUCTION

U-Values: (W/m² K)
Floor 0.35
Wall (opaque) 0.35
Roof (transparent) - 2.5

The transparent cover consists of a space framework construction (system WACO) with a two-fold transparent mantle, made of 4-mm Acryl-elements. The distance between the outer and inner transparent cover is 2.5 m. The interspace is ventilated.

Envelope heat loss: (kW/K)
Pyramid
Transmission - 20
Ventilation - 60

BUILDING SERVICES

Installed capacity:
Heating + DHW
5000 kW_t^h
Heating (Sauna), Lighting, Pumps, Fans, etc. 1 500 kW_{el}

Design conditions:
Internal air temperature: 29°C
Tropic Pool (water) temperature 27°C
Relative Humidity: 65%

The whole complex is supplied with heat from a nearby central heating station (90/70°C), also supplying a large shopping centre. The heat is transported by two independent heating lines (2 x 165 m^3/h).

During the heating period both lines are used for heat transport; in summer one line is used for cooling purposes. The pyramid itself is heated by floor- and air heating. Other rooms of the sport centre have radiators.

A substantial part of the sensible and latent heat content of the humid air is recovered.

The installed capacity of the entire sport centre is:

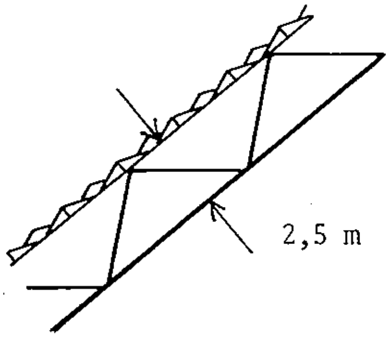
Ventilation	1690 kW
Hot Water	403 kW
Heating	1500 kW
Basin Water	1200 kW
Floor Heating	350 kW

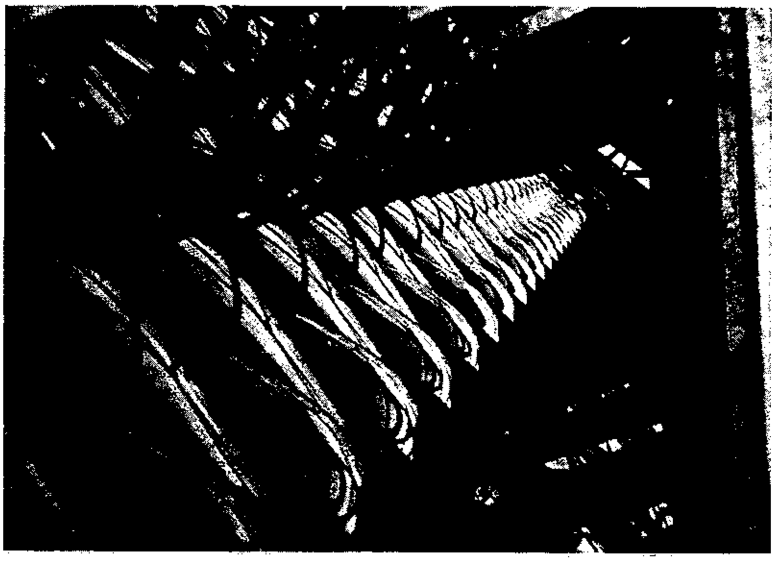
PASSIVE SYSTEMS

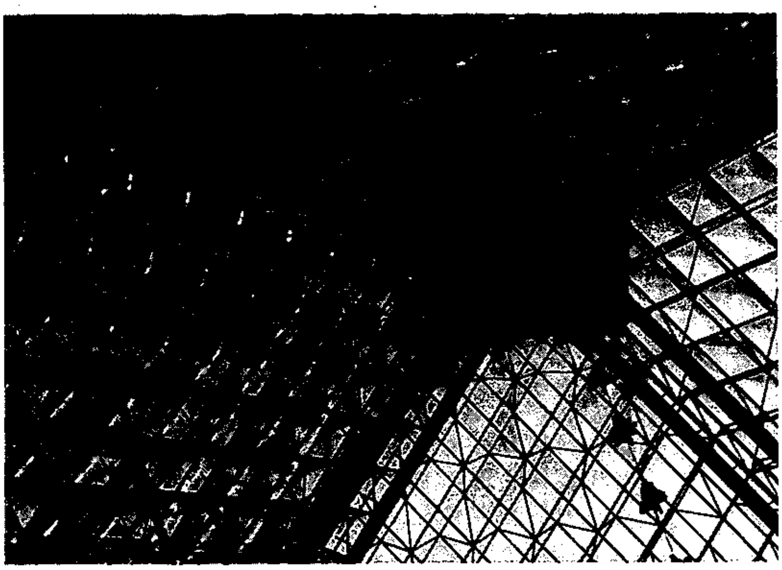
On the one hand, the transparent surfaces enable optimal use of daylight levels and the realisation of solar heat gains. On the other hand, they cause high transmission heat losses. Solar heat gains are registered by temperature sensors and lead to a lower heating capacity of the air heating.

There are hardly any overheating problems in the summer since air temperatures up to approximately 30°C can be tolerated.

Glazing properties:
Double glazed, intermediate space ventilated
u = 2.5 W/m² K
Solar transmission (Global Radiation): 65%







BUILDING COST

<u>Building cost (1983)</u>:
Pyramid:
AS - 161 000/m^2 gross
ECU - 11 800/m^2 gross

The pyramid is almost unique, it was planned at a time when - as compared with today - there was little experience with large passive buildings. Consequently, it is not significant to compare the pyramid's costs with typical costs of "similar" buildings such as sport centers or indoor swimming pools.

ENERGY PERFORMANCE

<u>Annual fuel use</u>
7.5 GJ/m^2 gross space
0.56 GJ/m^3 gross volume
Typical large indoor swimming pool:
Existing: 0.5 - 0.7 MJ/m^3
"Best" new: 0.29

District Heat	GJ/m† Gross
Space Heating	3.9
Domestic Hot Water	0.4
Pool Water	1.3
Cooling	0.01
Electricity	1.8

(Energy consumption of the entire sport centre: pyramid, outdoor pool, saunas, covered tennis courts, etc.)

HUMAN FACTORS

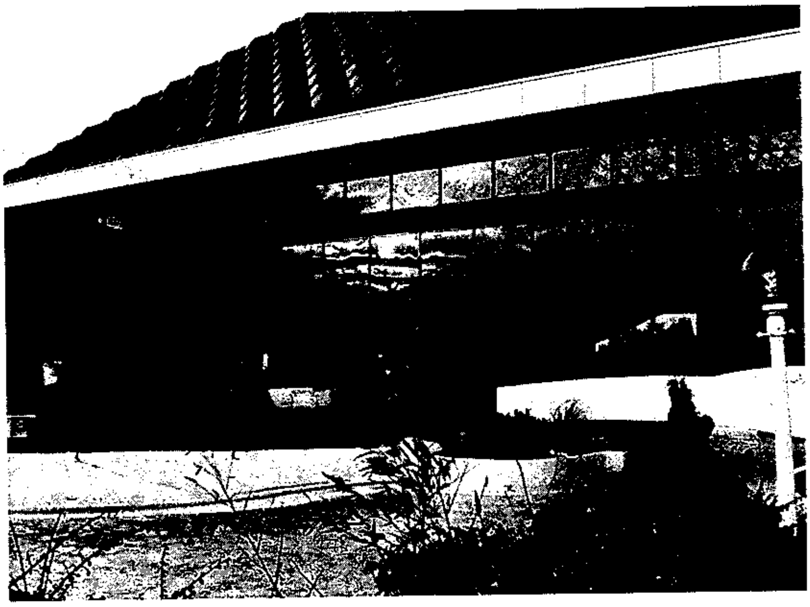
<u>Design occupancy</u>:
Pyramid 1 500

<u>Opening hours</u>:
Daily 9am to 12pm

The Tropical-Pyramid-Concept turned out to be a remarkable success. The pyramid and its extensions have become an attractive and highly accepted recreational centre.

CONCLUSIONS

The energy concept reflects the state-of-the-art of the early 80's. Although the transparent cover has a fairly high U-value, it was possible to keep the energy consumption relatively low thanks to an efficient energy-management system.



INFORMATION

For information and further details please write to:

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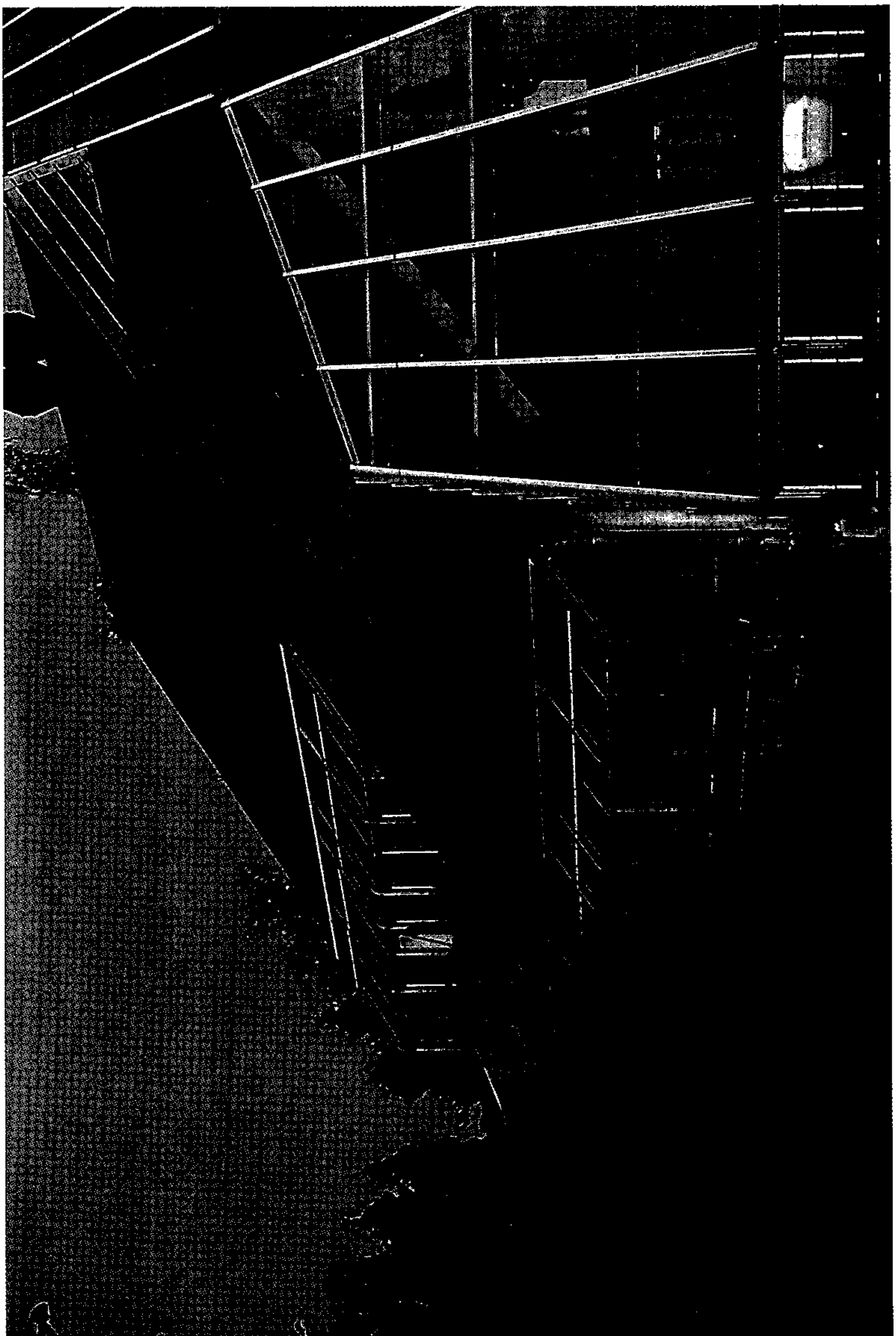
Technical Director of the City Club Vienna
Vosendorf
Parkallee 2
A-2334 Vienna
Telephone: 43222 69 35 35
Telex: 134 855

Report prepared by
Kanzlei Dr. Bruck in Cooperation with Andre Dossman, City Club Vienna

(B) BELGIUM

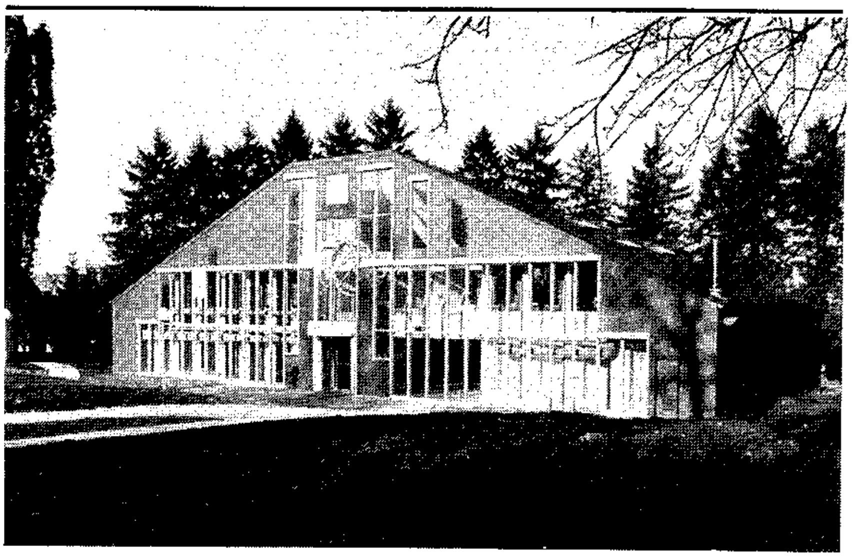
BCS No.	Building Title
2	AUDITOIRES-FUL-ARLON
3	SCHOOL OF TOURNAI



SCHOOL OF TOURNAI

B

AUDITOIRES - FUL - ARLON



Building type :
Education - Assembly

Passive features :
Solar heating :
Direct and Indirect
Daylighting :
Direct
Solar control :
Insulation

Occupancy date :
October 1986

Floor area :
Gross - 666 m^2
Heated - 570 m^2

Cost (1986) :
FB - 30 400 000
ECU - 760 000

Annual delivered fuel (1987) :
Gas - 388 000 MJ (measured)
Elect - 282 000 MJ (estimated)

Gas - 583 MJ/m^2 gross

Client :
Fondation Universitaire Luxembourgeoise

Architect :
Association momentanée:
A. Barbason,
C. Brevers,
Y. Jacques,
Architectes associés
+ J. Godart

Energy consultant :
Econotec, sprl

Monitoring :
Team " Energie "
Fondation Universitaire Luxembourgeoise

SUMMARY

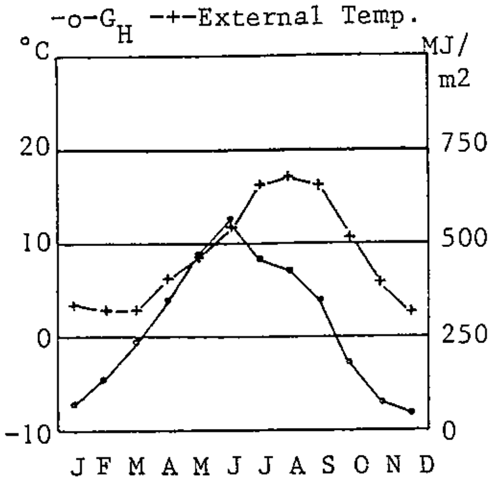
The " Academique " building of the " Fondation Universitaire Luxembourgeoise " is a passive solar building, of two storeys. A south-oriented glazing-area and a short-time storage concrete wall are the typical passive features. The building aims to filter climate variations, providing the occupants with constant thermal level by means of natural light and heat.

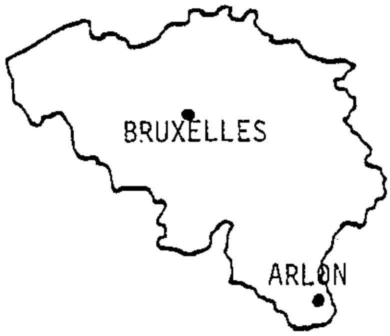
PROJECT DESCRIPTION

On the first level, the building includes two amphitheatres (120 and 80 places) and a central hall. University lessons and conferences are held in these rooms. The second level consists of two meeting-rooms and several offices. The design aims at a lowered energy consumption. The building is highly insulated and open to solar radiation (light and heat). The building is monitored : external temperature, solar radiation, rooms and walls temperature.

SITE AND LOCATION

The building is situated in the peripheral of a small town (15 000 inhabitants) on a horizontal surface, not far (200 m) from a highway. The south facing glazed area is very favourable to the sun light. There is no material obstruction to solar radiations.





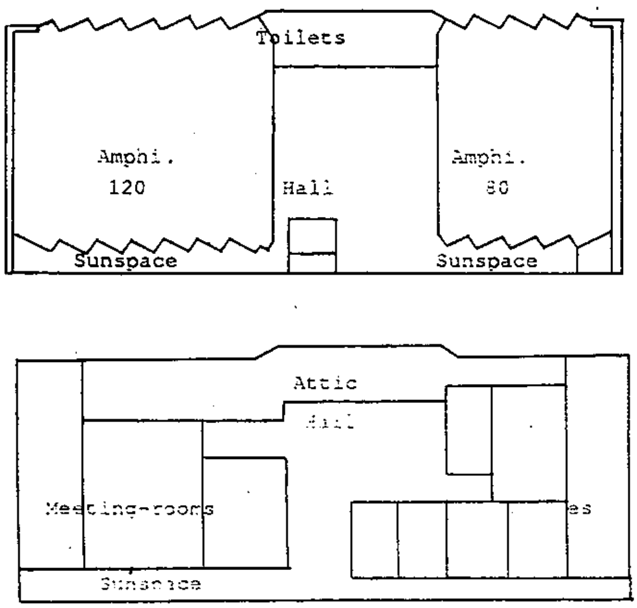
Site data :
Latitude : 49.8 N
Altitude : 408.8 M

Climate data :
Oct. to Apr. inclusive
Degree Days - 3 060
(base 20)
G_H - 1 154 MJ/m^2
Actual Sun Hours
634
Actual/Theoretical
0.29

Annual :
Degree Days - 3 754
(base 20)
G_H - 3450 MJ/m^2

BUILDING FORM

The building has a rectangular (30 x 14 m) shape. The south-oriented wall has a trapezoidal shape with a maximum height of 9.75 m. The first level consists of two amphitheatres enclosing a central hall. The second level includes two meeting rooms and some offices enclosing the same hall. The amphitheatres are separated from the glazed area by concrete walls and sunspace areas.



Level 1

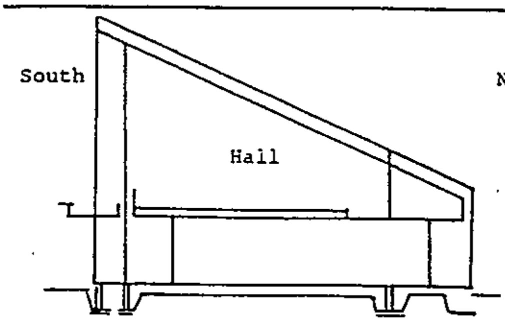
Floor plans

Volume : (m^3)
Gross - 2 260
Heated - 1 988

Dimensions :
Floor to ceiling height of 2.3 m

Surface areas : (m^2)
Ground floor - 425
Roof - 482
Wall
(excl. windows) - 450
Windows - 154

Window data :
Glass area is 66 % of south facade



Cross-section

U - values : (W/m^2K)
Floor - 0.41
Wall - 0.28
Window :
Glass & Frames - 3.02
Roof - 0.18

Envelope heat loss : (kW/K)
Transmission - 1.6
Infiltration and Ventilation - 0.54

Installed capacity :
Space heating :
Heated Areas - 190 W/m^2

Design conditions :
Internal temperature 20°C

Installed capacity :
Lighting (offices) :
Ceiling - 15 W/m^2

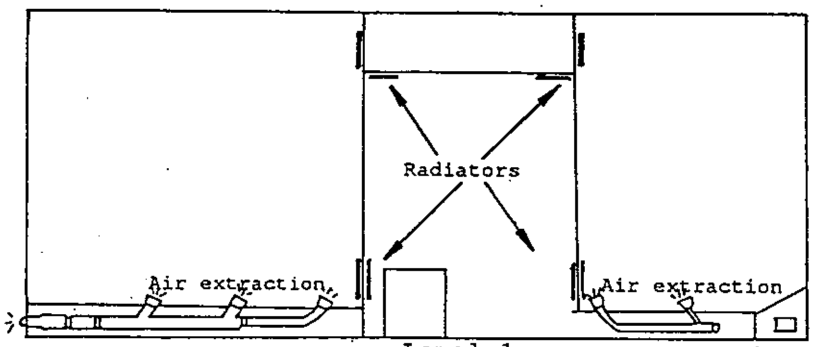
Design conditions :
Lighting (offices) :
not specified

BUILDING CONSTRUCTION

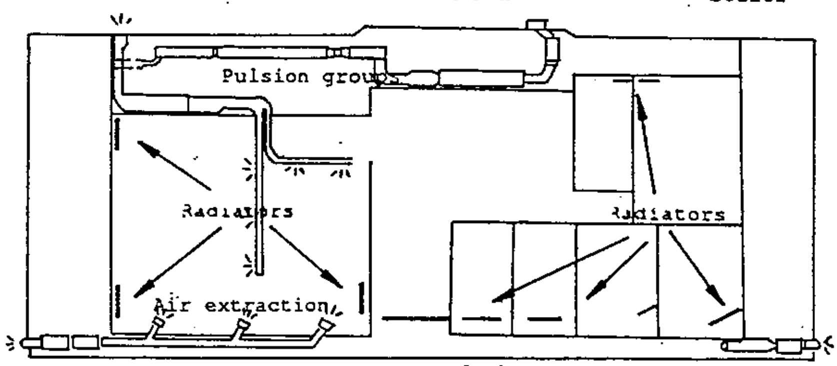
The structure of the building is composed by load-bearing masonry walls with an insulating material (thickness : 12 cms) and a covering material. The south-faced side is highly glazed. Concrete walls are situated behind the glazing and have a bearing function. The north-faced side is insulated and consists of load-bearing concrete walls. The windows are double glazing with aluminium frame. The insulating material of walls, roofs and floors is glass-wool.

BUILDING SERVICES

The rooms are heated by the solar radiation coming through the glazing. The concrete walls provide short-term heat storage for amphitheatres, meeting-rooms and offices. During cloudy days, heat is provided by an auxiliary gas-fired boiler. In case of overheating or pollution, ventilation is activated in amphitheatres and meeting-rooms.
No computer control is provided.



Level 1



Level 2

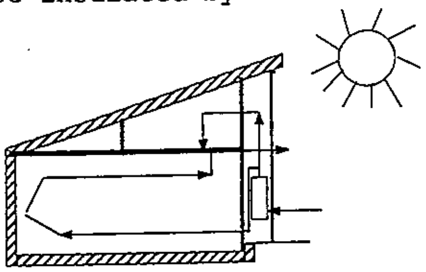
PASSIVE SYSTEMS

The sun is collected by the south-facing glazed area and accumulated in the narrow sunspaces. The heat is transmitted by natural convection to the walls, conducted within these walls and then distributed in the rooms by natural convection and radiation. The floor and wall building materials have a high thermal inertia. The high insulation level lowers heat losses. The south-faced area can be insulated by means of roller blinds.

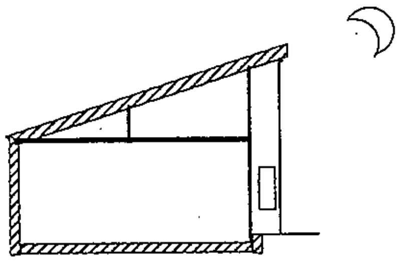
Glazing properties :
Double glazed, argon filled
(12 mm) U = 3.0 W/m^2K

Concrete storage walls:
Volume - 40 m^3
Thickness - 0,25 m

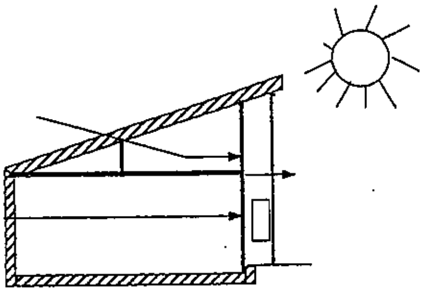
Roller blinds :
Set - 6 pm to 8 am
Removed - 8 am to 6 pm



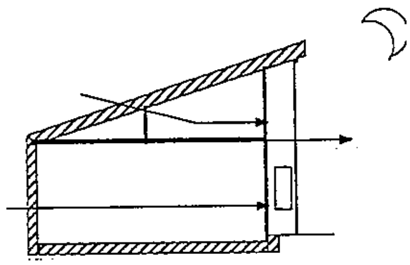
Winter day : ventilation for hygienic and energy distribution



'Winter night : insulation of the glazing and closing of ventilation



Summer day : ventilation and optional closing of shutters



Summer night : ventilation

COSTS

The building cost is
FB 30 400 000
The cost of passive systems is
FB 5 800 000
(sunspaces, storage walls)

It's very difficult to distinguish between passive systems and non-passive systems as the whole building design is depending on the passive solar architecture.

Building cost (1985) :
FB - 45 680/m^2 gross
ECU - 1.981 210/m^2 gross

Typical cost (1985) :
FB 30 000/m^2 - FB 40 000/m^2

ENERGY PERFORMANCE

Calculated energy consumption (heating) :
332 000 MJ

Measured energy consumption (heating) :
388 000 MJ

The measured energy figure covers the first year of occupation. During this period, an additional amount of energy has been used in order to dry the building structure.

Annual fuel use: (MJ/m^2)
583 (gross space)
681 (heated space)
380 (ref building)

Fuel costs (1987) :
Gas - FB 0.214/MJ
Elect. (average) - FB 1.009/MJ

FUEL TYPE	FUNCTION	DELIVERED TOTAL	FUEL / M2 HEATED FLOOR AREA
Gas	Space heating	388 417 MJ	681 MJ/m2
Gas	All	388 417 MJ	681 MJ/m2
Electricity	Lighting	not measured	-
Electricity	Water heating	not measured	-
Electricity	All	282.000 (est.)	495 MJ/m2 (est.)
Gas + Electricity	All	670.417 (est.)	1.176 MJ/m2 (est.)

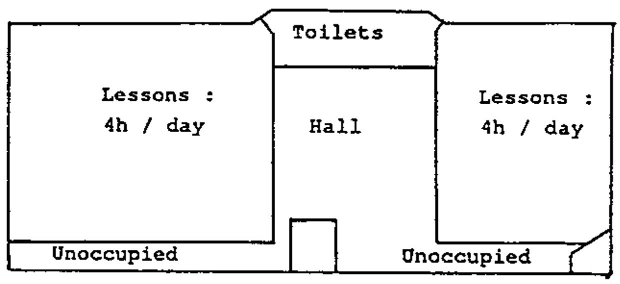
HUMAN FACTORS

Design occupancy :
Permanent - 5
Students - 100

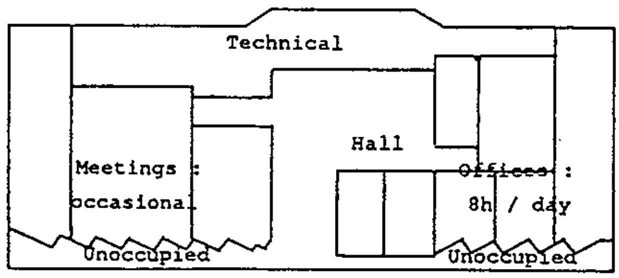
Functions :
Management
Administrative
Students
12.5 m^2 office space/person
1.5m^2 classroom space/student

Working hours :
08.00 to 18.00 hours

The designer's aim was to ensure occupants'comfort, using natural energy. In an ideal realisation, the people in the building would be insulated from the variations of the climate. The main problem occuring in this building is the overheating during warm days. The external protection does not please the inhabitants because of the suppression of natural daylighting. Some other possible actions may be necessary (ventilation for example) to provide better comfort to the occupants.



Level 1



Level 2

Rooms occupancy

CONCLUSIONS

The building's concept appears very successful as far as the amphitheatres are concerned. The thermal balance is reached despite climate variations and these rooms are very well day-lighted thanks to the openings in the storage walls. At the second level, the meeting-rooms and the offices are overheated during warm summer days. A mechanical ventilation system present in amphitheatres and meeting-rooms, but not in the offices is useful to insure comfort to the occupants.
It is difficult to make firm conclusions about energy consumption because the building has been occupied only for a short time.

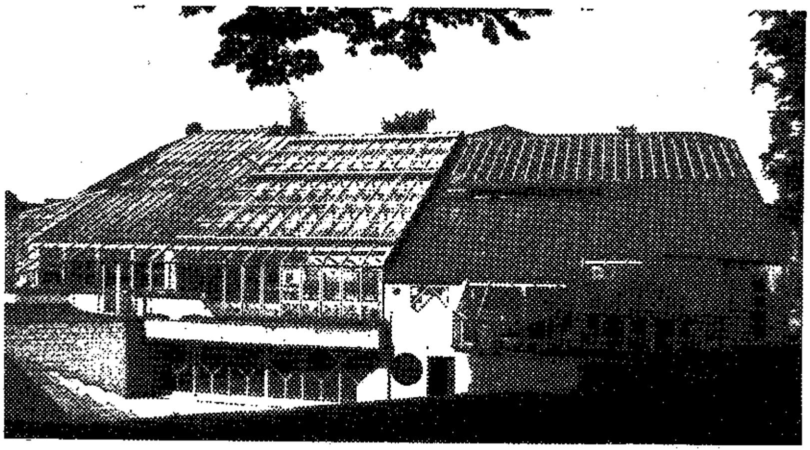
The indirect gain part of the building is efficient both at the heating and daylighting viewpoints.

The direct gain part is subject to overheating.

Report prepared by :
Fondation Universitaire Luxembourgeoise
Team " Energie "
rue des Déportés, 140
6700 ARLON
Belgium
Tél. : 063/22.03.80

B

THE SCHOOL OF TOURNAI



Building type :
Education

Passive features :
Daylighting :
- direct
- indirect

Solar heating :
- direct
- indirect

Solar control :
- shading

Date of occupation :
September '85

Gross floor area :
2635 m²

Heated floor area :
1720 m²

Capital cost (1985) :
approximately
75.000.000,-FB
(1.875.000 Ecus)

Measured Annual Fuel Use : (all functions)
890424 MJ/2635 m² gross floor = 338 MJ/m²

Client :
Ministère de l'Education Nationale, Fonds des Bâtiments Scolaires de l'Etat (FBSE).

Design team :
F.B.S.E. - Centre d'études et de recherches J. Wilfart et al.

Energy consultant :
Bluth, Clerdent and Alsteen.

Monitoring agents :
Centre de Recherches en Architecture de l'Université Catholique de Louvain.

SUMMARY

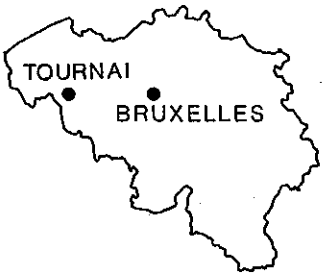
The design of the new primary school of Tournai is based on the use of solar energy without sophisticate equipment.
The climatic design is represented by the compact form of the three storey building, the buffer spaces at the North, a succession of greenhouses-buffers in front of the classrooms and a big central glass-roof.
The interior organisation invites the occupants to re-establish a seasonal nomadism. So the peripheral spaces will have a fluctuating occupancy according to the exterior temperature.
All these concepts aim to increase the sensitivity of the students to the climatic problem.

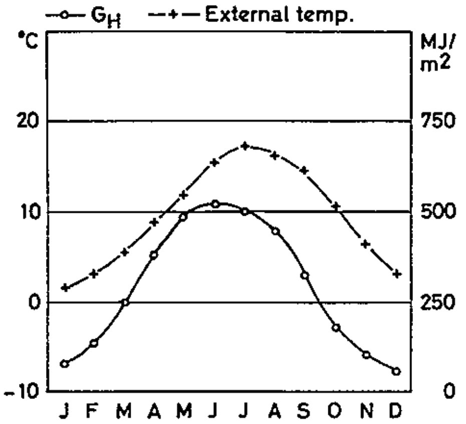
PROJECT DESCRIPTION

The project consisted of the construction of a school for children 5 - 12 years old. There are about 250 kids in groups of 25.
The school is composed of classrooms with differenciated spaces, workrooms, a library, a polyvalent hall, administrative and service rooms. (An important aspect is the behaviour of the children in relation with the pedagogy and the climatic aspects). The school has been monitored : internal and external climate, system, storage, occultation periods ... (about 150 measurement points).

SITE AND LOCATION

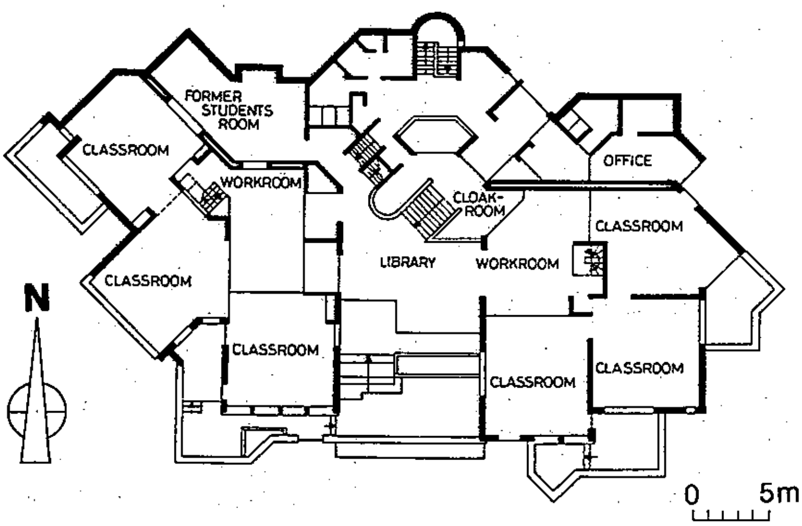
The isolated building is in the centre of a small town.
The school is in the middle of a small block of houses and is protected against noise from adjacent streets but it is connected with all of them. The building is protected from winds and is favourably arranged with respect to sunlight.





BUILDING FORM

The school is composed of two groups of classrooms (left part and right part).
These two wings enclose the library located in the great central sunspace. The two parts are protected from the exterior by buffer-spaces : greenhouses at south, service rooms at north.



Distribution of the walls and roof according to the orientations (the solar collectors are inclusived in the windows areas).

	N-E	N	N-W	W	S-W	S	S-E	E	m²	%
windows (glass+frame)	28.3	13.6	36.6	26.2	47	551.5	26.9	41.8	771.9	38.6
opaque walls	171.7	344.5	100.2	14.7	201.2	281.6	16.2	96.6	1226.7	61.4

Glazed area (without frame and solar collectors) is 549 m² or 27.5% of the roof and walls area.

Site data :
Latitude - 50°38'N
Altitude - 20m

Climate data :
(oct. to apr. inclusive)
- Heating degree days (20°C base) : 3060
- Global horizontal solar irradiation (unobstructed horizon) : 1154 MJ/m²
- Total actual sun hours 634h
- Ratio of actual to theoretical sun hours 0.285

Annual degree days (20°C base) : 3754
G_H - 3450 MJ/m²

Volume : (m³)
gross : 7885
heated : 5553
sunspaces : 774
north-buffer : 1558

Dimensions :
The mean floor to ceiling height : 3 m

Surface areas : (m²)
- opaque walls : 1227 m²
- glazed area : 772 m²
- ground area : 1095 m²

U-values :
walls = 0.36 W/(m^2K)
roofs = 0.19 W/(m^2K)
floors = 1.0 W/(m^2K)
windows = 1.6 W/(m^2K)

Envelope heat loss (kW/°K)
Transmission: 3.15 kW/°K
Infiltration: 1.5 kW/°K

Installed capacity :
Space heating
Heated Areas - 93 W/m^2

Design conditions :
Internal temperature : 20°C

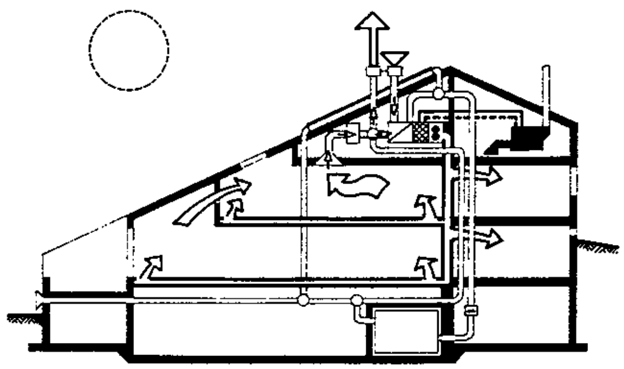
BUILDING CONSTRUCTION

The structure of the building is composed of load-bearing concrete blocks walls with a wooden frame. The floor is covered with black stone tiles in the greenhouses and with baked-clay tiles in the classrooms.
The openable windows are double "low emissivity" with wooden frames except the sunspaces wich are single glazing with steel frame. The exterior walls, the roofs and the floors are insulated with glass-wool.

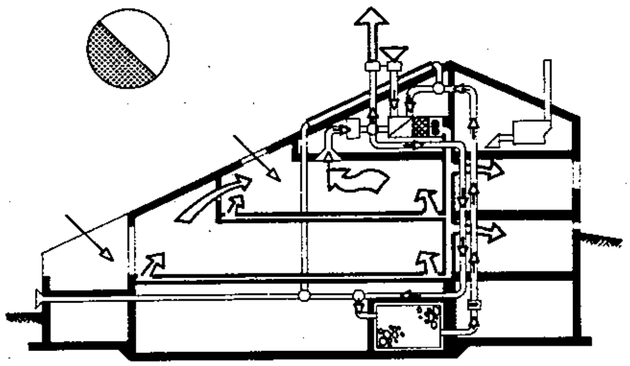
BUILDING SERVICES

Auxiliary heating is provided by a warm-air heating system. Air is heated in the 143 m^2 south facing solar collectors on the roof, and if necessary, further heated by the four gas-fired boilers.
On warm days, if the building requires no heating, the heat from the collectors is stored into a 49m^3 pebble store for the east wing and in a 4m^3 water storage for the west wing.
The warm air circulates through cavities in the internal central double wall and in the precast concrete slabs before reaching the outlets. Hence, heat is radiated from the walls and floors as well as being supplied as warm air. The whole heating system is micro-processor controlled.

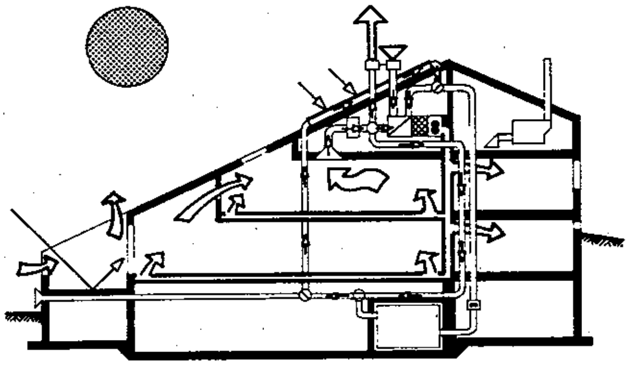
Some examples of functioning of the heating system, under various winter conditions.



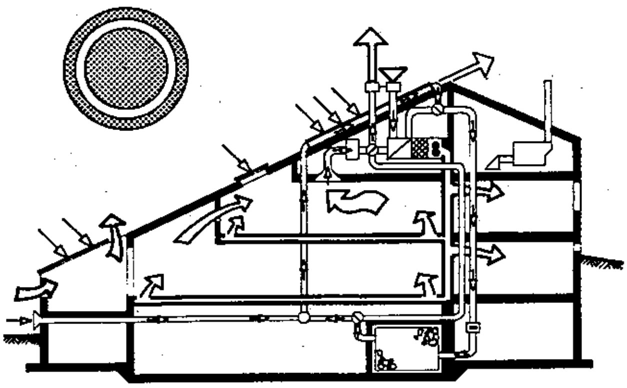
Heat is needed, the sun is not shining.



Heat is needed, the sun shines a bit, the rock bed temperature is high.



Heat is needed, the sun is shining, the solar collector air is sufficiently high for heating.



On warm days, if the building requires no heating, the heat from the collectors is stored into the rock bed.

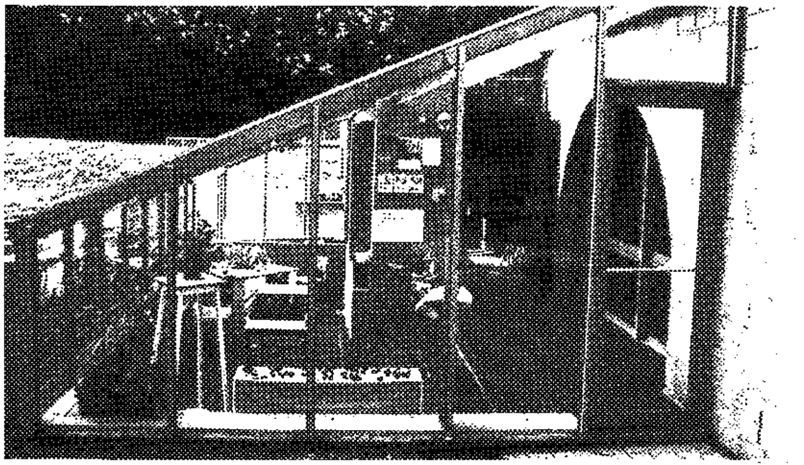
PASSIVE SYSTEMS

The sun is collected by the central and the small classroom sunspaces. The spaces have been organised in order to allow a good penetration of the sun rays.
The floor building-materials have been chosen in order to have a high thermal inertia.
The great central sunspace can be shaded by external roller blinds. The small sunspaces act also as buffer-spaces for the classrooms.
There are a rock bed storage and a water storage for the active system.

Volume of the sunspaces 774 m^3
Volume of the rock bed storage : 49 m^3 (78400 kg)
Volume of the water storage : 4 m^3

Glazing properties :
The windows of the sunspaces are single glazed,
U = 5.8 W/(m²K)
Daylight trans. = 90%
Solar trans. = 80%

The other windows are double glazed, low emissivity, argon filled,
U = 1.6 W/(m²K)
Daylight trans. = 69%
Solar trans. = 59%

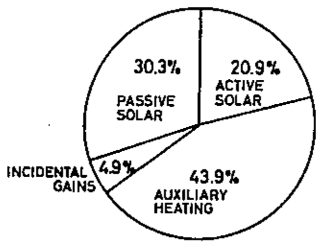


COSTS

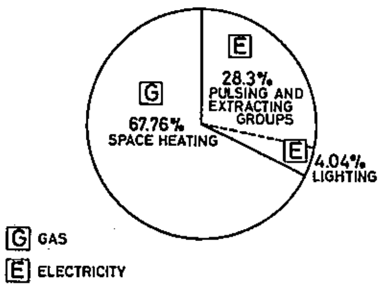
Building cost/m² gross floor area : 28460FB/m² (711 Ecus/m²).
Building cost/m² gross floor area for similar more conventional buildings : 26000FB/m² (650 Ecus/m²).

The building cost is approximately 75.000.000 FB (1875000 Ecus), it is about 15% higher than typical school building costs (sunspaces, solar collector, storages, black stone, cavities in the internal central double wall).

Space heating demand



Annual fuel use (all functions)



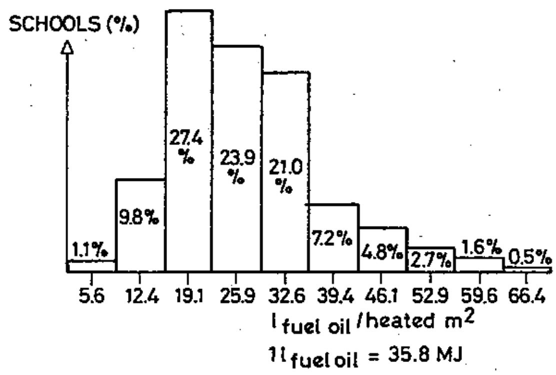
ENERGY PERFORMANCE

The space heating demand is 960300 MJ pa
- . incidental gains : 47173 MJ pa
- . passive solar gains : 290830 MJ pa
- . active solar system : 200710 MJ pa
- . auxiliary heating : 421587 MJ pa

The auxiliary fuel used for space heating is 603351 MJ pa (the efficiency = 0.7).

FUEL TYPE	FUNCTION	DELIVERED TOTAL MJ pa	FUEL / M2 heated floor area MJ/(m²)pa	gross floor area MJ/(m²)pa
gaz	space heating	603351	350.8	229.0
electr.	pulsing and extracting groups	251990	146.5	95.6
electr.	lighting	35973	20.9	13.65

For the school of Tournai, fuel use per m² heated floor area (for space heating and pulsing and extracting groups) : 497 MJ/(m²)pa.
For reference building fuel use per m² heated floor area: 862 MJ/(m²) pa



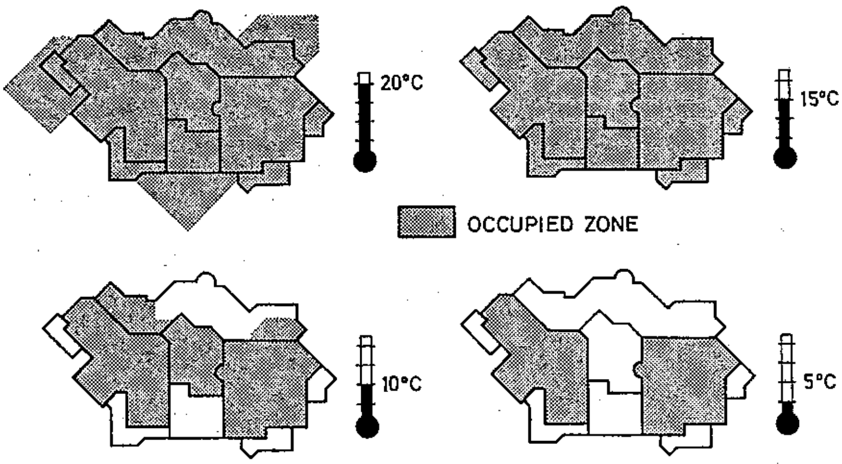
Statistics of space heating fuel use of Belgian schools.

The gas cost is :
0.3558FB/MJ (1986)

HUMAN FACTORS

The school offers the children and the teachers direct experience with energy problems. But 2-3 years will be necessary to induce an energy conscious behaviour because of the diversity of the possible actions (opening or closing of the door between the sunspace and the classroom, period of heat storage in water or rock bed, closing of the roller blinds of the central sunspace, ventilation of the greenhouse, seasonal nomadism ...).

Number of persons 250 children in groups of 25.
Area per child :
10,5 m^2/child
Normal working
hours : 8h30 —— 16h
Holidays : July - August
15 days at Christmas
15 days at Easter



Zones of occupancy according to the outside temperature.

CONCLUSIONS

The school's concepts are very interesting with regard to the internal organisation, the energy performance and the will to sensitize the kids to climatic problems.
It is difficult to make firm conclusions about the energy performances of the building since the school has been occupied only one year and the teachers and the children are not familiar with an energy conscious behaviour. Nevertheless, the space heating fuel consumption is low (497MJ/(m^2) pa compared with other Belgium schools (862 MJ/(m^2) pa.
On the basis of the results and analyses, a lot of recommendations will be established for the refurbishment and design of schools in Belgium.

Space heating consumption is much lower than ordinary schools.
The school will provide children with an energy conscious education.
There are some initial difficulties in learning the right operating mode.
The project is a good source of information.

INFORMATION

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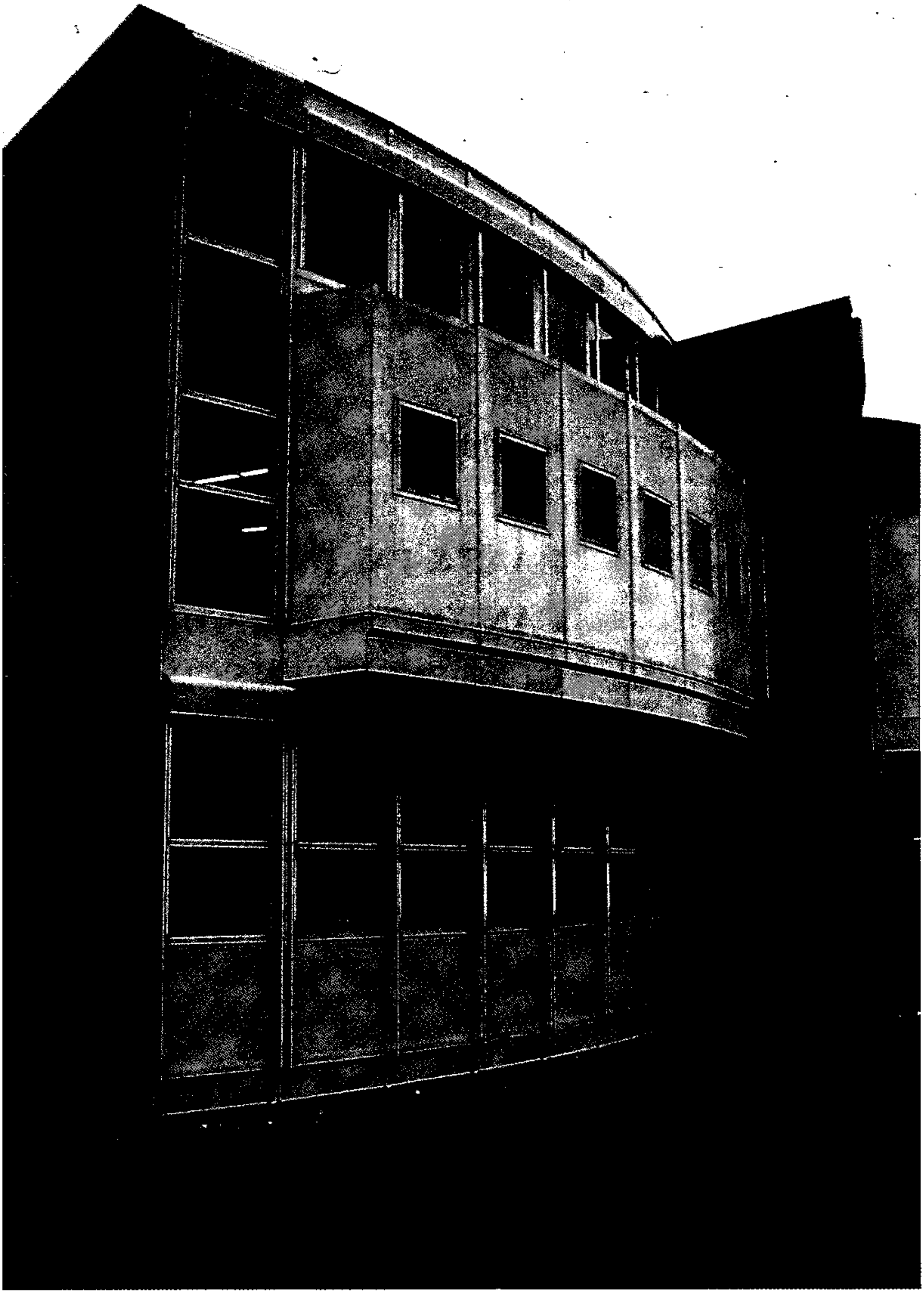
Tél. 010/47.21.39 - 47.22.23
Télex : UCL-B n° 59037
Fax : 010/45.03.45

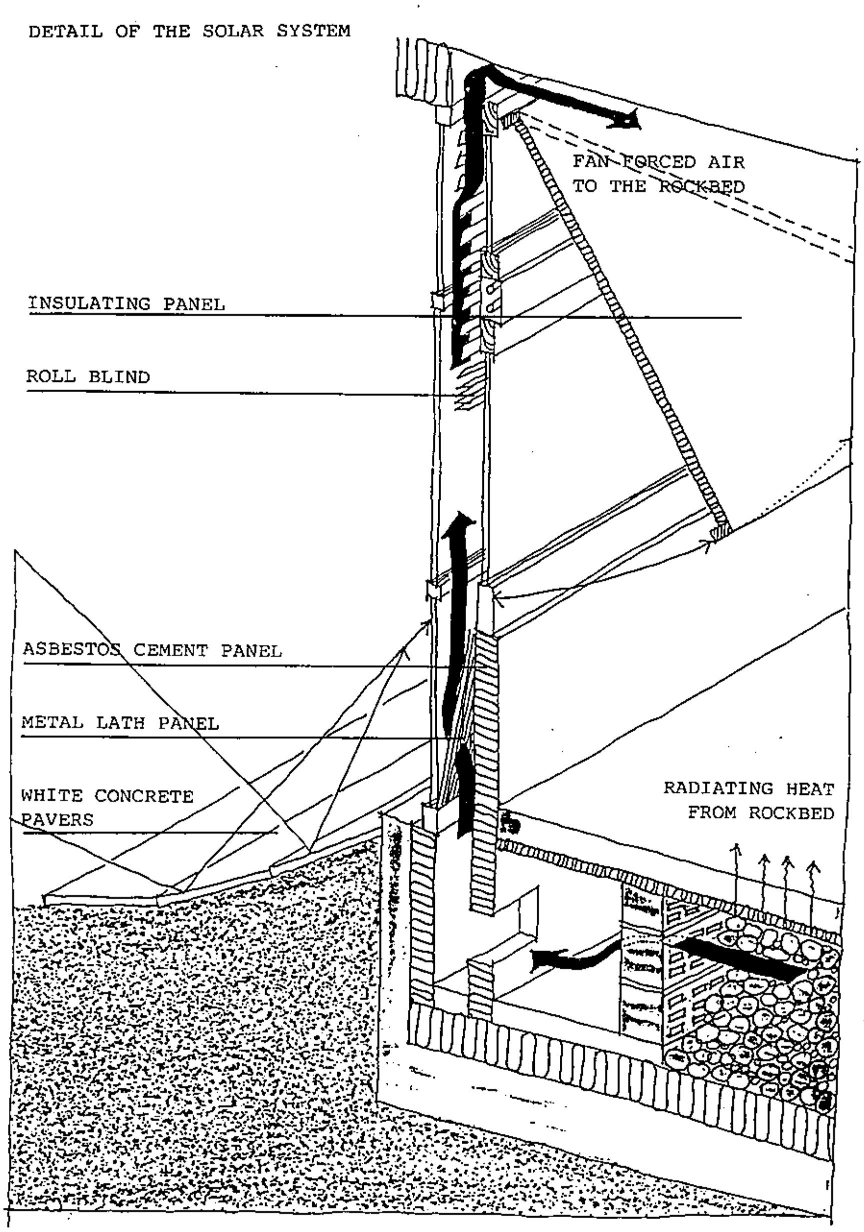
(CH) SWITZERLAND

BCS No.	Building Title
4	HAAS & PARTNERS OFFICES
5	CANTON VAUD ARCHIVES
6	GUMPENWIESEN SCHOOL
7	RUTISHAUSER DATA OFFICES
8	NEUCHATEL UNIVERSITY
9	PENTHAZ SCHOOL
10	REINACH YOUTH CENTRE
11	METEOLABOR LABORATORIES



CANTON VAUD ARCHIVES

DETAIL OF THE SOLAR SYSTEM



COSTS

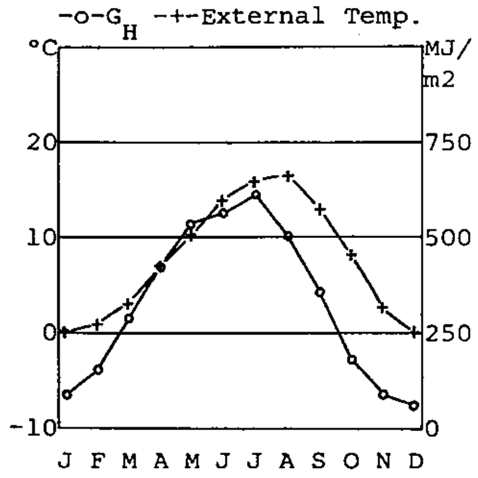
Relative to the building cost, the solar system seems expensive. However, when the structure is compared with conventionally heated offices, the combined capital cost and energy cost per m^3 are most reasonable.

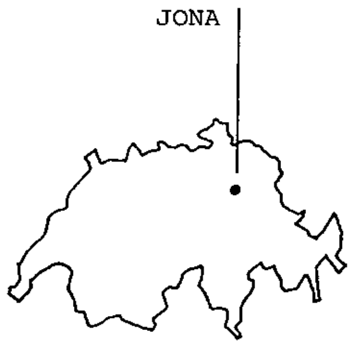
Building cost (1981):
SFr 410 000
ECU 240 000

SFr 1 822/m2
ECU 1 069/m2

Typical cost
SFr 1 500 - 1 800/m2

Cost of Solar System:
SFr 86 000
ECU 50 500





Site data:
Latitude 47°15' N
Altitude 500 m

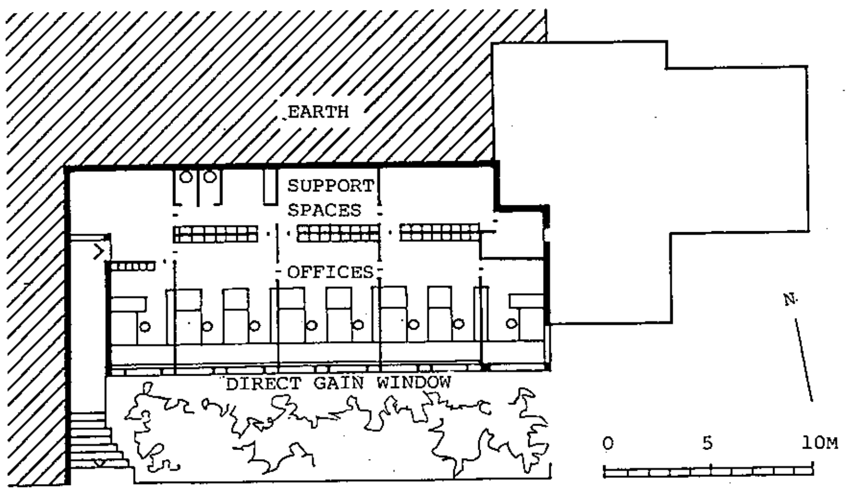
Climate data:
Oct. to April inclusive
Degree Days (base 20°C) 3 560
G_H 1 375 MJ/m2
Actual Sun Hours 643
Actual/Theoretical 0.29
Annual
Degree Days (base 20°C) 4 480

SITE AND LOCATION

The building is situated in the residential area of a small town on a south slope. There is no solar obstruction. Due to morning fog in the winter the solar facade was oriented 10° west from south.

BUILDING FORM

The one story building, with 213 m² of usuable floor area has an elongated axis running east/west. A row of offices occurs along the windows. A screen of cabinets separates a rear zone of supporting spaces (a meeting room, archives, kitchenette and toilets). This simple and functional spatial zoning leads to a natural thermal zoning: offices 20 °C, supporting spaces 18 °C, earth 4-10 °C. The 2.4 m ceiling height of the rear spaces rises to 3.0 m at the facade accomodating tall windows.

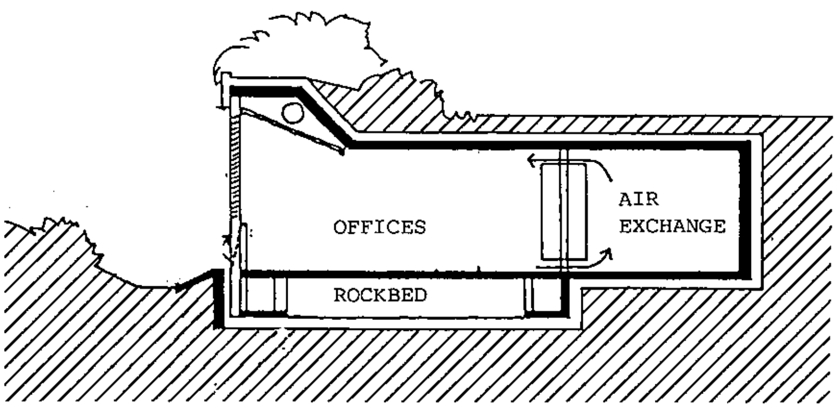


Volume:
Gross 1 180 m3
Heated 771 m3

Floor area:
Gross 225 m2
Heated 213 m2

Number of levels:
1

Window area:
South 41 m2



BUILDING CONSTRUCTION

U-values: (W/m2K)	
Roof	0.21
Walls	0.23
Floor	0.17
Windows day	1.60
night	0.35

All the structural elements of the building are reinforced concrete with 12 cm insultation outside the walls and roof and 20 cm enclosing the rockbed.

BUILDING SERVICES

The building is heated by radiation from a floor slab above a rockbed. The thermal mass of the building dampens fluctuctions in temperatures. During December, January, and February auxiliary heat is distributed via radiators. Undesirable solar gain is cut off from work places by slatted roll blinds within the windows. Two casement windows per office permit ventilation and cooling. For the rear supporting spaces without outside access, ventilation is provided through slits above and below the partition cabinets. Minimal fan-forced ventilation is also available. A high glazing band at the top of the partitions allows a sense of natural lighting in the rear zone.

PASSIVE SYSTEM

The hybrid solar system consists of 41 m² of direct gain widows with movable insulating panels and an underfloor rockbed of 60 m³. The air is warmed to 54 °C by the collector, then fan-forced to and through the rockbed in a closed loop. The collector performance is enhanced by several features. White asbestos cement panels and concrete pavers reflect sunlight onto the collector to increase gain. The absorbers are black metal lath panels, inserted from September until April. A slatted roll blind serves as a movable absorber in the upper part of the facade. It has a bright side for reflection and a dark side for solar absorption, according to need.

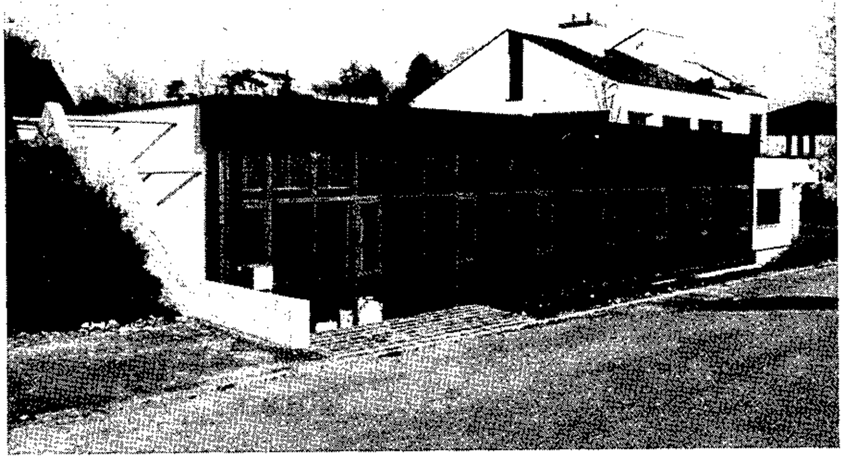
Collector window:	
Glazing area	41 m2

Storage:	
Volume Rockbed	60 m3
Thermal mass	80 kWh/K

CH HAAS & PARTNERS OFFICES

Building type:
Offices

Passive solar features:
Direct daylighting
Indirect thermal gain
Natural cooling



Occupancy date:
1981

Floor area:
Gross 225 m2
Heated 213 m2

Cost (1981):
SFr 410 000
ECU 240 000

Annual delivered fuel:
(1982/83)

Electrical	70 MJ/m2
Oil	52 MJ/m2
Site energy	122 MJ/m2

Client, Project Planer and Monitoring:
Kurt Haas

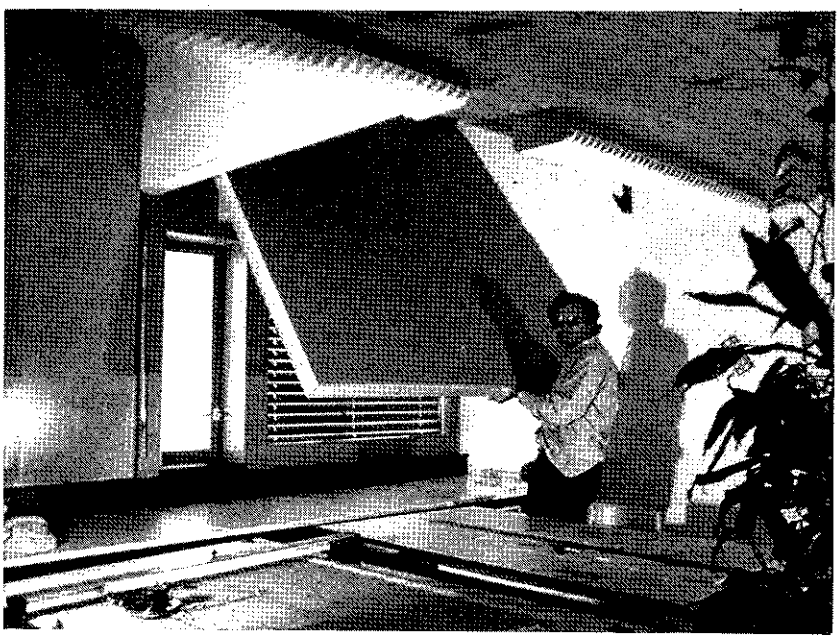
Architectural design:
Beat Ernst

SUMMARY

The office building of Haas + Partners, Engineers in Jona (SG) is earth-sheltered and solar heated. The roof and facades to the north and west are earth-sheltered. The spatial layout permits natural thermal zoning. The south facade has fixed and movable absorber and insultation panels to adapt to different climatic conditions. The office building is claimed to have the lowest auxiliary heating requirement in Switzerland.

PROJECT DESCRIPTION

The client aimed for a scheme which integrated functional and low energy requirements and which could be adjusted to adapt to changing climatic conditions. An IEA Solar Task XI monitoring project with ca. 40 measurement stations will provide data on the building performance as a passive system in 1987/88 and as a hybrid system 1988/89. The benefit of the earth sheltering is also a main theme of investigation.



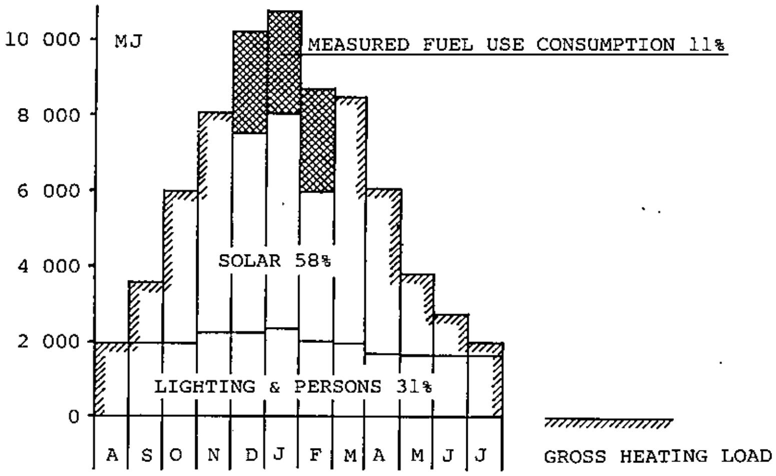
Annual fuel use 1982/83:
(MJ/m2)

Heating	52
Lighting	58
Ventilator	7
Hot water	5
Site energy	122
Typical existing Office building	750

ENERGY PERFORMANCE

The Haas + Partner office building has a very favourable energy balance. The earth covering as well as moveable insulation at the windows minimize heat loss. As result of the solar and conservation features, the building requires only 10 percent of the heating energy of a conventional building. The heating load is covered as follows:

- 58 percent by solar energy
- 31 percent by lighting and persons
- 11 percent by an oil-fired furnace (231 Kg of oil and 322 KWh ventilator)



HUMAN FACTORS

The building with its integrated control elements is very user-friendly. Natural light and natural ventilation can be adjusted individually in each office. The enclosing earth creates a perceptible and agreeable feeling of shelter and protection. The design requires occupants to participate in the seasonal and daily adjustment of the building to the ambient conditions.

Number of occupants:
8

Space per person:
26.63 m2

Time of occupancy:
Working hours
(about 43 hours/week)

CONCLUSIONS

According to the client, the building has the lowest auxiliary energy requirement in Switzerland. The solar system, with only one ventilator, runs without any problems. Better solar protection is needed. The insulation (3 cm) above the rockbed should have been thicker to slow the rate of heat release and increase the effectiveness of the thermal storage.

Lowest heating requirement in Switzerland

Solar protection needs improvement

INFORMATION

Haas & Partners AG, CH-8645 Jona, provided this information.

Publications:

Haas K., 1984: "Erdbedecktes Bürohaus mit Chamäleon-Fassade und Geröllspeicher", Sonnenenergie No. 3, Postfach, CH-8050 Zürich.

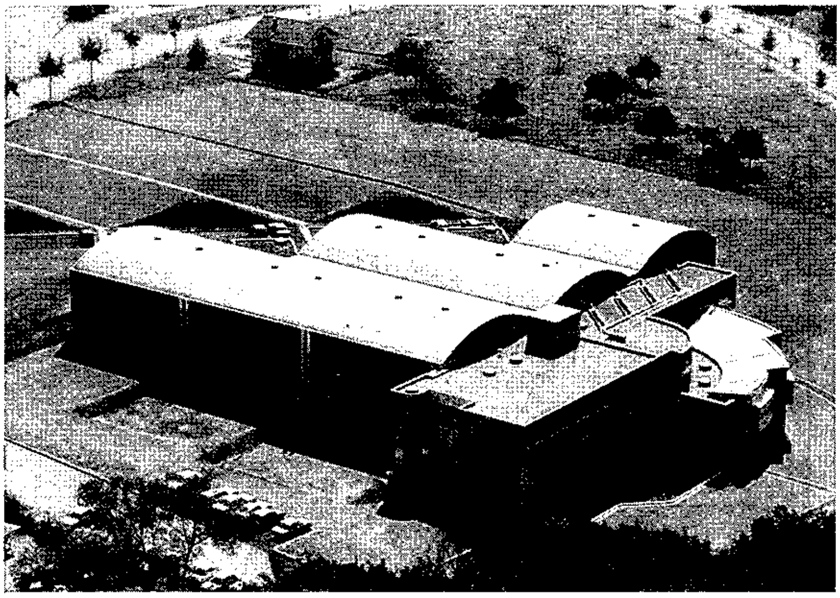
Schäfer U. and S., 1983: "Passive und hybride Sonnenenergie-Nutzung in der Schweiz", Infosolar, CH-5200 Brugg.

Hastings S.R., 1986: "IEA Task VIII - Passive Solar Buildings in Switzerland", EMPA, CH-8600 Dübendorf.

Report prepared by:
Pinna/Schwarzenbach/
Süsstrunk Architekten
Schifflände 22
CH-8703 Erlenbach-Zürich
Tel. 01/910.55.45

CH

CANTON VAUD ARCHIVES



Building type:
Offices

Passive solar features:
Direct daylighting
Direct thermal gain

Occupancy date:
1985

Floor area:
Useable 9 377 m2

Cost (1985):
SFr 15 071 000
ECU 8 839 000

Annual delivered fuel:
(1985/86)

Electrical	6 MJ/m2
Gas	130 MJ/m2
Site energy	136 MJ/m2

Client:
Canton de Vaud

Architects:
Atelier Cube

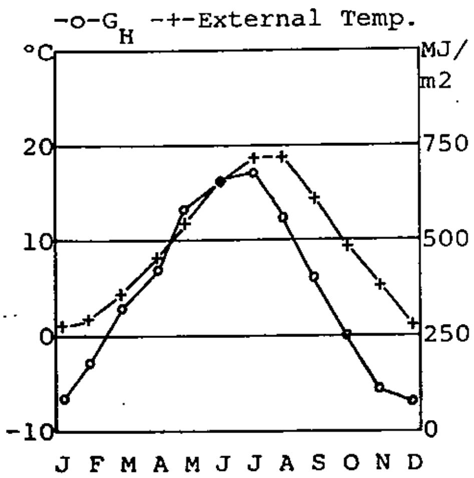
Energy consultant and
Service engineer:
Lucien Keller

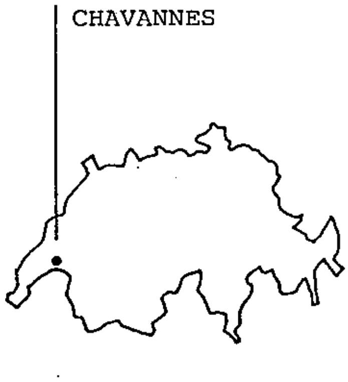
SUMMARY

The public records complex of the Canton Vaud in Chavannes is comprised of two building parts with quite different uses and thermal requirements. The public and administration spaces are orientated towards southwest while the archives are situated to the northeast because a constant room climate (temperature and humidity) is extremely important for the preservation of documents. Minimized energy use was obtained by optimum thermal insulation, well suited passive solar features, and good energetic and exergetic efficiency of the building services. These services include four heat and power generators, one heat pump, a water heat storage tank and 16.5 m^2 of solar collectors. The comprehensive energy concept evolved out of an economic analysis of several variations.

PROJECT DESCRIPTION

The design and energy concept were selected by a competition. Decisive were the quality of architecture and the simple solar features. The economics of energy saving measures were continuously checked relative to the value of fuel savings. The hvac system is regulated by a computer which also provides energy balances.





Site data:

Latitude	46°32' N
Altitude	398 m

Climate data:

Oct. to April inclusive

Degree Days (base 20°C)	3 330
G_H	1 548 MJ/m2
Actual Sun Hours	687
Actual/Theoretical	0.33

Annual

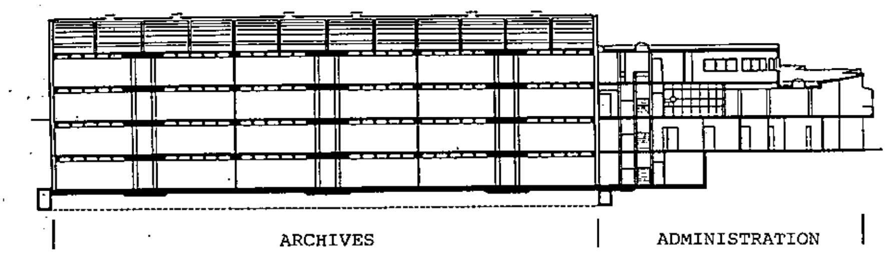
Degree Days (base 20°C)	4 000

SITE AND LOCATION

The building is situated on the outskirts of Lausanne in an area of dispersed buildings of mixed uses. The large unobstructed land parcel permitted a wide choice of designs. Due to morning fog the offices are orientated towards southwest.

BUILDING FORM

The two distinct functional areas of the building complex are evident in the architectural design. 1. To the south are the "occupied" spaces: distribution and classification of documents on the ground level, reading-rooms on the middle level, and administrative offices on the upper level. 2. The archives, placed to the north, consist of three shifted volumes containing a total of 23 square compart-ments on four levels. This spatial arrangement allows easy future expansion.

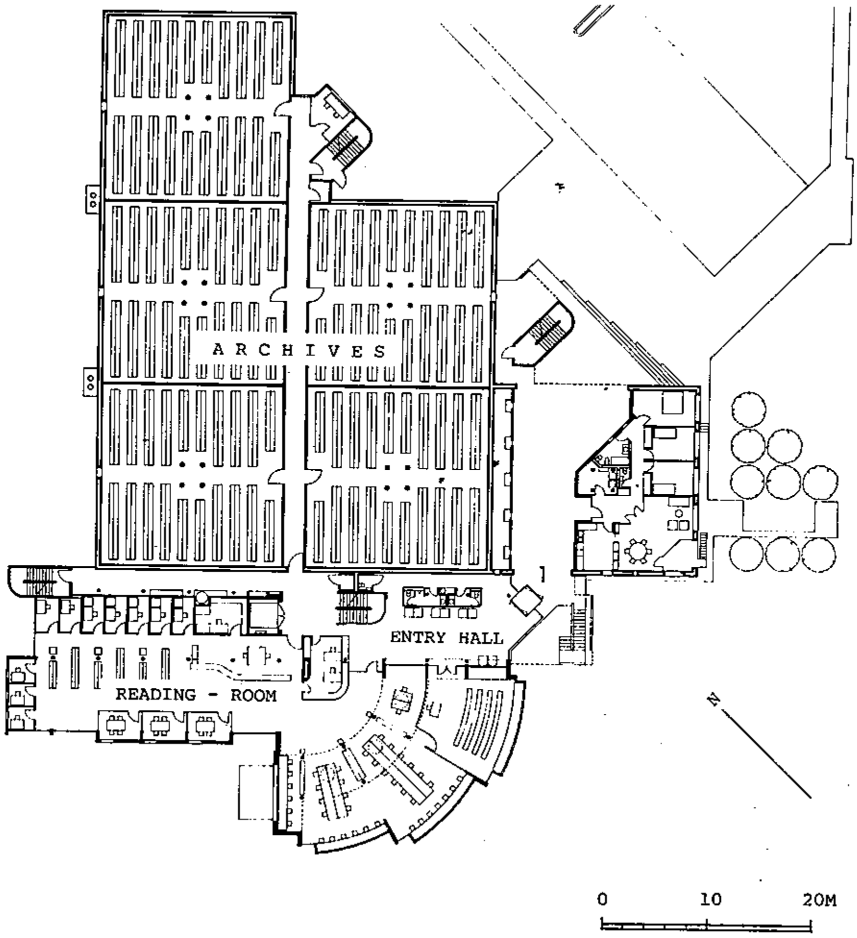


Volume:
Gross 38 020 m3

Floor area:
Gross 9 377 m2

Number of levels:
3 + basement

Window area:
South/Southwest 295 m2
31% of facade



BUILDING CONSTRUCTION

U-values:
(W/m2K)

Roof	0.44
Walls Offices	0.46
Archives	0.26
Windows South	2.80
N,E,W	1.80

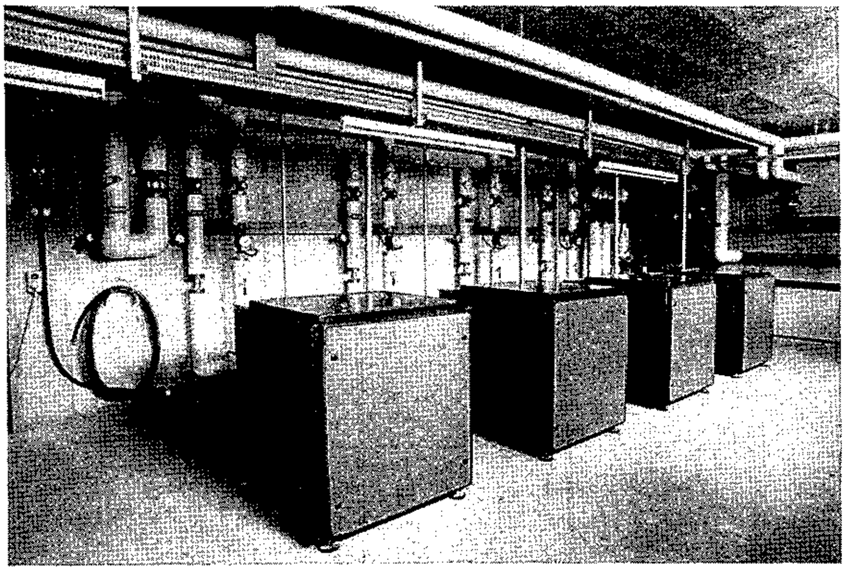
All structural elements, including the modular ceilings of the archives, are reinforced concrete. The curtain wall of the offices is lacquered aluminium. The external skin of the archives is coloured concrete block. All windows have double glazing. Continuous polyurethane insulates the archives which are kept at 15°. The offices (kept at 20°) are insulated with 8 cm of polystyrene in the curtain walls and 14 cm on the roof.

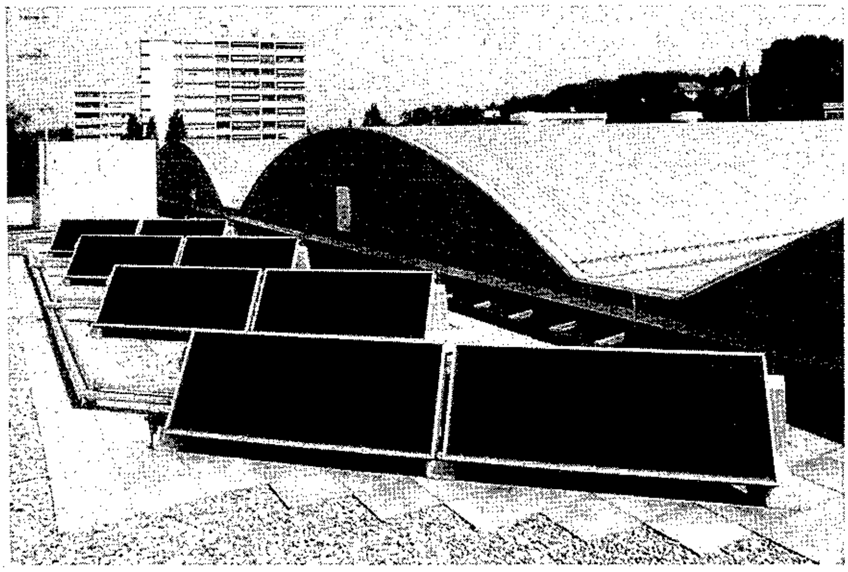
BUILDING SERVICES

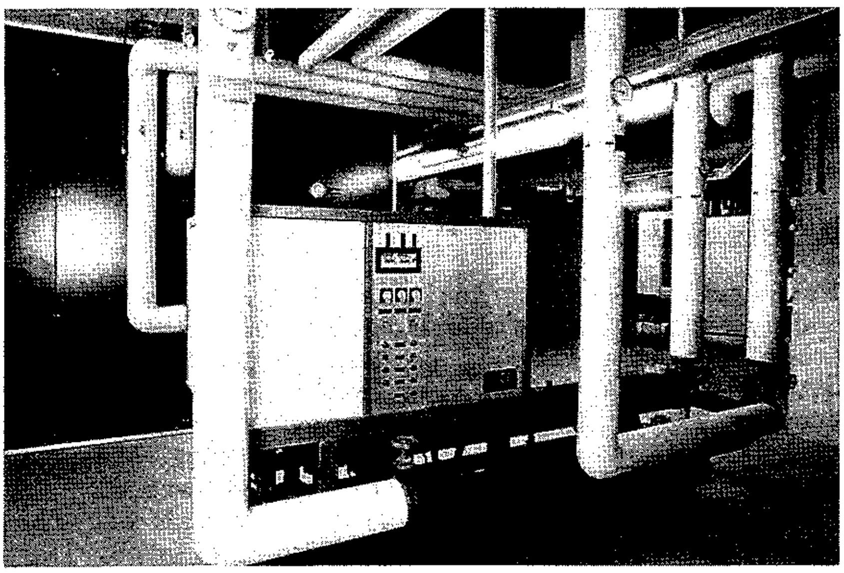
Installed capacities:

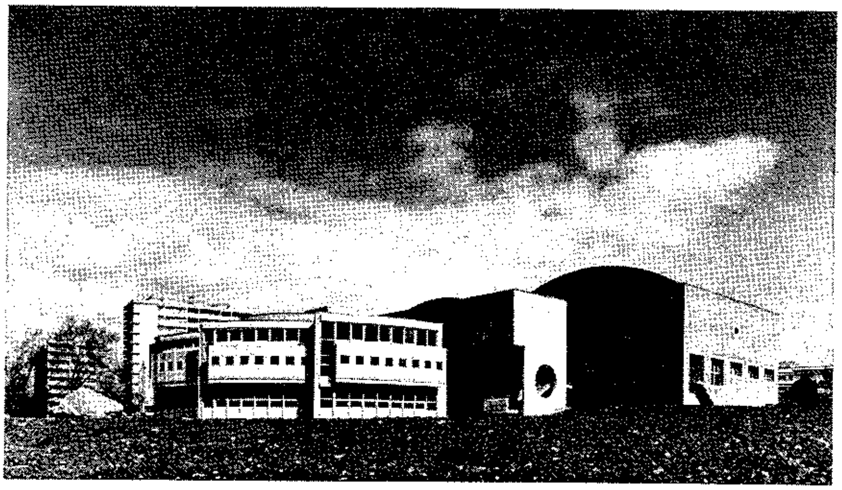
Heat/Power Modules	
thermal	4 x 41 kW
electrical	4 x 15 kW
Water storage	10 m3
Collector area	16.5 m2

The heating system includes four Totem (total energy module) heat/power generators and a two stage heat pump. Solar collectors provide service hot water. A boiler provides heat storage for surplus energy from the solar system and permits the heat/power generators to run during off-peak hours. Room heating occurs by radiators. A mimimal ventilation system provides fresh air for the archives, offices are naturally ventilated.









PASSIVE SYSTEM

The solar concept is comprised of a few fundamental passive solar features with minimally heated rooms requiring only intermittent lighting. Rooms for human activities are on the south side, the archives are situated to the north. Massive walls and floors help reduce temperature swings. Exterior insulation and glazing areas, carefully sized to heating needs, reduce the risk of overheating. In the summer undesirable solar penetration is cut off by the precisely calculated projections on the south side of the building.

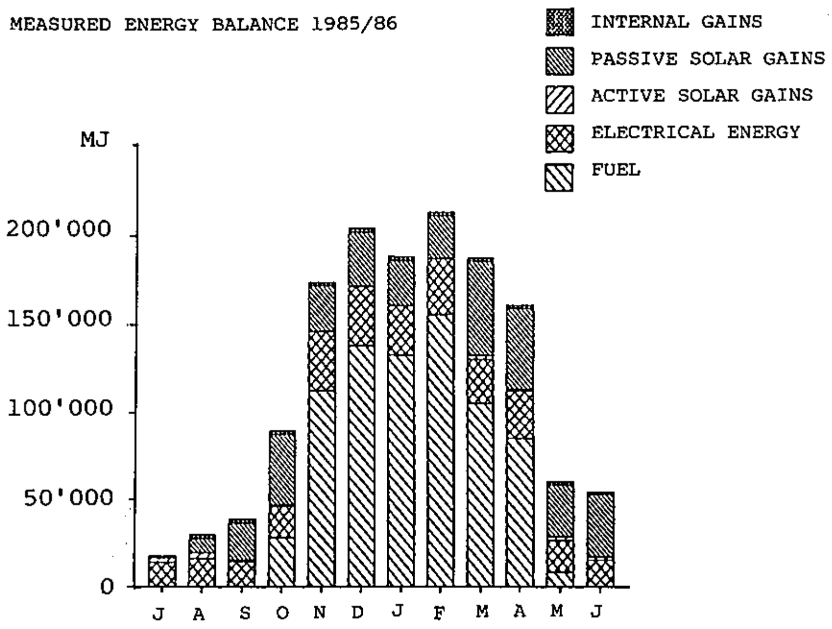
Building cost (1985):
SFr 15 071 000
ECU 8 839 000

SFr 1 607/m2
ECU 943/m2

Typical cost
SFr 1 500 - 1 800/m2

COSTS

In spite of the bold architectural design and building service systems, capital costs were not unreasonable. Continuous economy checks during planning have been rewarded by the low running costs of the systems. The added expense of the thermal insulation will be amortized in 20 years.



Annual fuel use 1985/86: (MJ/m2)	
Heating	111
Lighting/Electrical	30
Hot water	1
Site energy	142
Typical existing office building	750

ENERGY PERFORMANCE

During the reported period imperfections of the control system appeared and numerous adjustments were made. Although the building is only partly solar, the energy balances show the importance of the passive gains.

CONCLUSIONS

According to the design team, the objective of minimal primary energy use was achieved and the building performs as expected. The COP of the heat pump is circa 3.5. Problems, however, occur regarding the extraction of heat from the exhaust from the motors for the electric generators. This is being further studied. The client has provided funds to monitor the building and systems. Detailed measuring is presently underway.

The building layout is logical for energy conservation and the lighting and mechanical systems are well integrated into the overall concept

INFORMATION

L. Keller, Bureau d'études, CH-1171 Lavigny, and the architects provided the information and data for this report (photos by J.-F. Luy).

Publications:

Keller L., Vogel P., Collomb M., Collomb G., 1986, "Archives Cantonales Vaudoises", Schweizer Ingenieur und Architekt No. 43, CH-8021 Zürich.

Report prepared by:
Pinna/Schwarzenbach/
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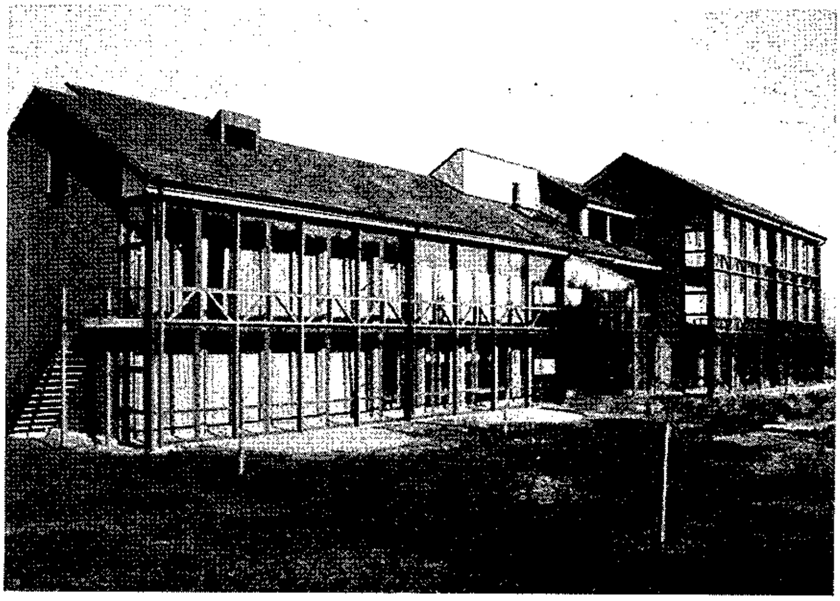
CH-8703 Erlenbach-Zürich
Tel. 01/910.55.45

CH

GUMPENWIESEN SCHOOL



Building type:
Education

Passive solar features:
Direct daylighting
Indirect thermal gain

Occupancy date:
April 1984

Floor area:
Heated 2 470 m2

Cost (1984):
SFr 4 436 000
ECU 2 602 000

Annual delivered fuel:
(1986/87)

Electrical	105 MJ/m2
Oil	78 MJ/m2
Site energy	183 MJ/m2

Client:
Municipality of Dielsdorf

Architect:
Rolf Lüthi

Energy consultant:
Bruno Wick

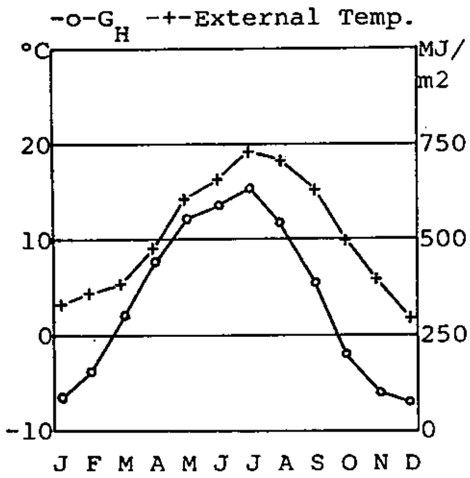
Monitoring:
EMPA-Bauphysik

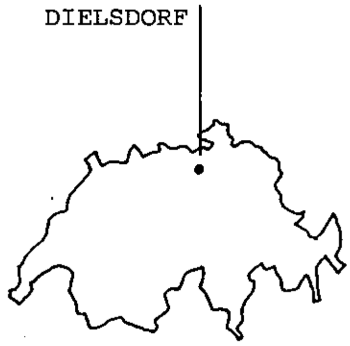
SUMMARY

The school building Gumpenwiesen in Dielsdorf (ZH) has an annual heating energy consumption of 115 MJ/m², less than a fourth of that of a comparable conventional school. Orientation, inner spatial zoning and the envelope of the building are adapted to passive solar principles. The building shape and the attached gymnasium are elongated on an east/west axis. There are hardly any openings towards north and the large roof gives optimal protection against north an east winds. The south facade is covered by a veranda which can be closed by 22 movable glass doors. Passive solar gains and heat recovery from exhaust air meet 55 percent of the heating load. The mechanical ventilation is regulated by the teachers. Through 1988 the building was monitored in detail as part of a national research programme. Detailed results are available in the final report.

PROJECT DESCRIPTION

The scheme for the building was chosen by an architectural competition. The client demanded an environmentally friendly energy concept. In addition all of the usual requirements for school buildings had to be fulfilled (functional, saftey, hygiene, and comfort aspects). During the first measuring period particular attention was given to the fresh air quality.





Site data:

Latitude	47°28' N
Altitude	439 m

Climate data:

Oct. to April inclusive

Degree Days (base 20°C)	3 060
G_H	1 429 MJ/m2
Actual Sun Hours	643
Actual/Theoretical	0.25

Annual

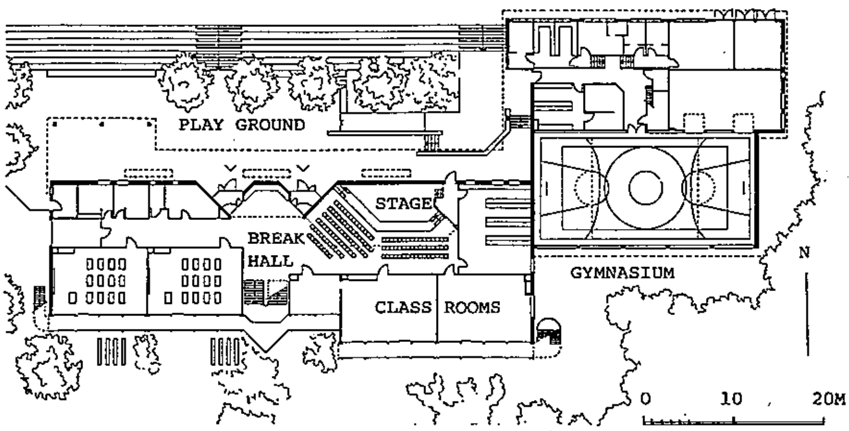
Degree Days (base 20°C)	3 610

SITE AND LOCATION

The building is situated on the border of a village. A small forest bounds the school grounds westward, otherwise the building is exposed. A nearby international airport necessitates the windows being closed to shut out the noise.

BUILDING FORM

The two blocks of classrooms and gymnasium are distributed over two and three storeys and are orientated to the south, overlooking a biotope (biological garden). The supporting spaces and the large, open break hall occur on the north side, permitting thermal zoning. Outside on the north side are the noisy playgrounds.



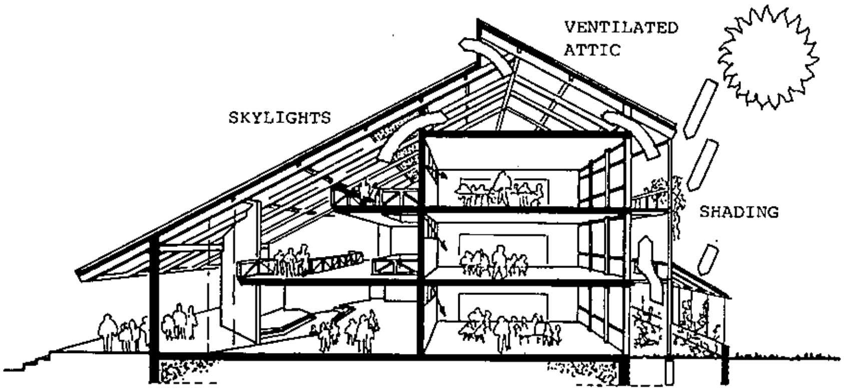
Volume:
Gross 13 890 m3

Floor Area:
Heated 2 479 m2

Number of levels:
2 and 3

Window area:
South 450 m2

PASSIVE COOLING IN SUMMER



BUILDING CONSTRUCTION

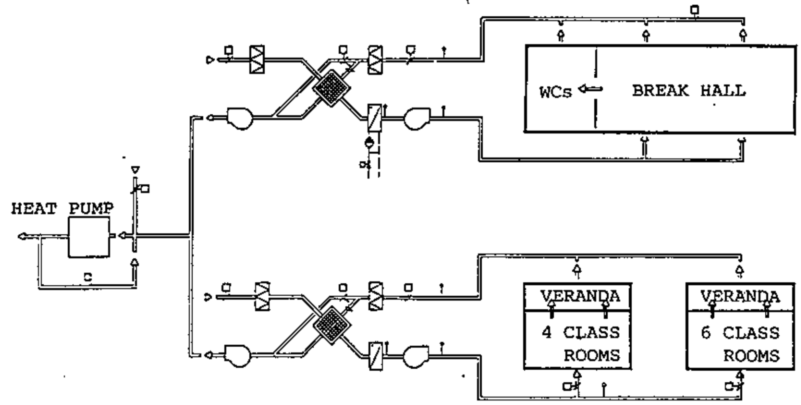
The massive building construction reduces temperature swings. By request of the client, natural materials were chosen when possible (facebrick walls and lamenated wooden beam roof construction). The external walls are cavity wall construction with 10 cm of thermal insulation. The ceilings are reinforced concrete. The veranda facade is metal frame, floors here are also reinforced concrete.

BUILDING SERVICES

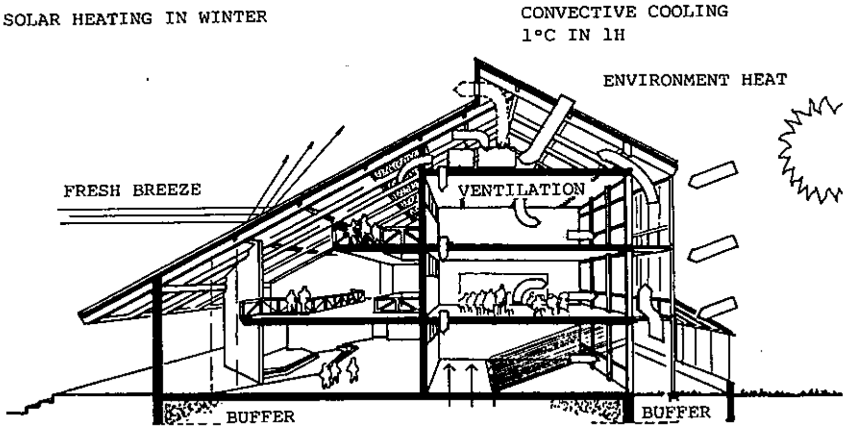
Installed capacities:

Oil Heat	2 x 35 kW
Heat Pump	7 and 21 kW

Bivalent heating is provided by two air/water heatpumps and two oil-fired furaces. The low powered heatpump extracts heat from the exhaust air of ventilation system, the other heatpump is coupled to outdoor air. The rooms are heated by a floor heating system. Service hot water is preheated by the space heating system. Fresh air is distributed by mechanical ventilation. Exhaust air and internal waste heat are vented through adjustable slits to the veranda and then to the heat-exchanger/heatpump in the attic.



AIR SYSTEM WITH HEAT RECOVERY SYSTEM
(PLATE HEAT EXCHANGE-EXHAUST AIR HEAT PUMP)



PASSIVE SYSTEM

The main elements of the solar system are the glazed verandas which act as collectors and thermal buffers for principal spaces. Operable windows on the side façades as well openable skylights in the roof reduce overheating during spring and fall. Massive ceilings provide thermal inertia.

Veranda:
Glazing area 450 m2

COSTS

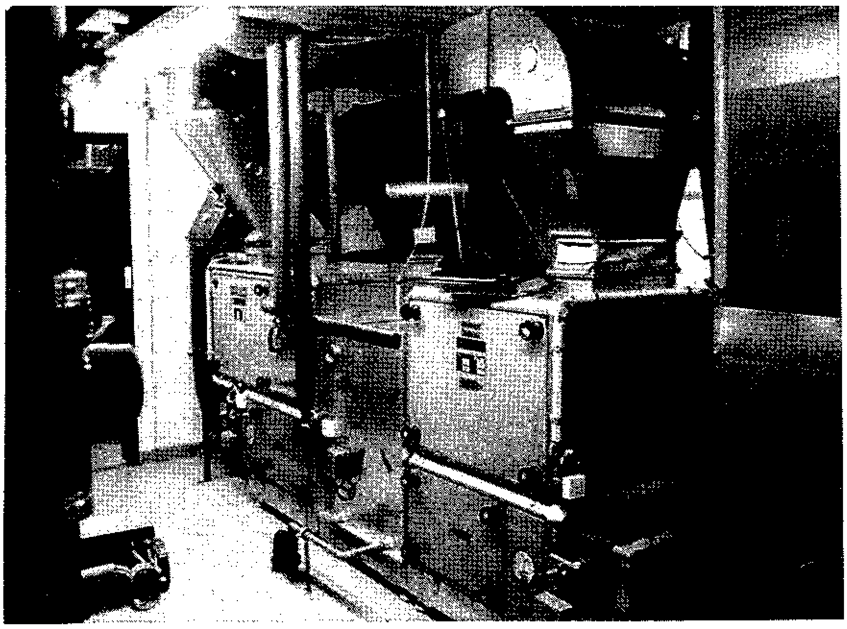
The planning costs were high, but overall expenditures have been most favourable. The additional costs for the solar system are partially offset by annual fuel savings of SFr. 6,000. Provided that energy prices remain stable, the additional capital costs should be amortized within 15 years.

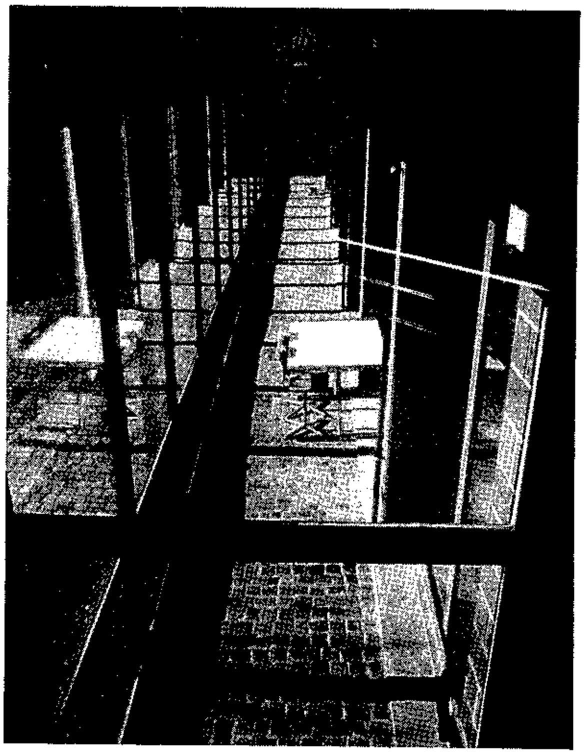
Building cost (1984):
SFr 4 436 000
ECU 2 602 000

SFr 1 700/m2
ECU 1 000/m2

Typical cost
SFr 1 200 - 1 500/m2

Cost of Passive System:
SFr 55 000
ECU 32 300





ENERGY PERFORMANCE

Annual fuel use 1986/87: (MJ/m2)	
Heating	115
Lighting/Electrical	57
Hot water	11
Site energy	183
Typical existing Education building	750

The monitored annual energy use of 183 MJ/m^2 in 1986/87 was far below the calculated 207 MJ/m^2. The main reason was that hot water consumption was overestimated. The predicted maximum consumption of 5000 l of fuel oil was realistic as were also the predicted energy flows divided as follows:

- 29 percent environmental energy
- 21 percent heat recovery
- 20 percent electrical energy
- 30 percent fuel oil

The energy requirement for artificial lighting is modest because classrooms face to the south.

HUMAN FACTORS

Number of occupants:
Variable

Time of occupancy:
8 a.m. to 6 p.m.
on school days

The air quality and the controlled ventilation system of the school building were given particalur attention during the first measuring period. The observed level of CO_2 concentration occasionally exceeded allowable levels because not enough fresh air could be supplied. The classroom air quality has been improved by carefully adjusting the system to the room usage.

CONCLUSIONS

This example demonstates that such a solar system can effectively fulfill the functional and psychological requirements of school buildings. The experience to date has been very positive. The energy saving goals were surpassed. Even at outdoor temperatures of 0 °C there is no need to run the floor heating system. Internal and passive gains extracted by the 7 kW heatpump are adequate to heat all rooms including the gymnasium. Better glare protection is needed. The inner textile curtains create very diffuse lighting conditions not well suited for teaching.

No room heating at 0°C outdoor temperature

Sun blinding protection needs improvement

INFORMATION

T. Baumgartner, EMPA-Bauphysik, CH-8600 Dübendorf, and R. Lüthi, CH-8198 Regensdorf, provided the information for this report.

Publications:

Lüthi R.,1987: "Laubengang vor dem Schulzimmer", Sonnenenergie/Energie solaire No. 6, Postfach, CH-8050 Zürich.

Baumgartner T. et al., 1989: Schlussbericht Messprojekt Gumpenwiesen, SIA Dokumentation Reihe: Planungsunterlagen zu Energie und Gebäude, SIA Verein, Postfach CH-8039 Zürich.

Report prepared by:
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CH RUTISHAUSER DATA OFFICES

Building type:
Offices

Passive solar features:
Direct daylighting
"Super glazing" system

Occupancy date:
1986

Floor area:
Useable 2 200 m2

Cost of HIT facade and Building services (1986):
SFr 2 200 000
ECU 1 290 000

Annual delivered fuel: (1987/88)
Ventilation system 157 MJ/m2

Client:
Rutishauser Data AG

Construction plans:
AIP Plan AG Hoppe

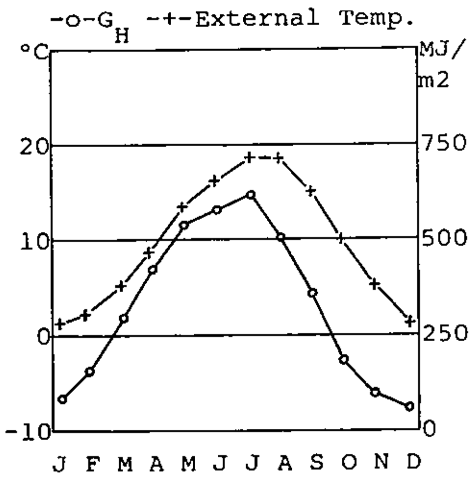
Energy consultant and Service engineer:
Geilinger AG

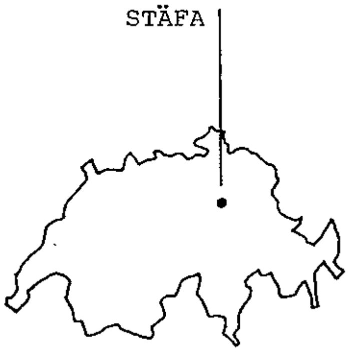
SUMMARY

The retrofit of the 20 year old office building in Stäfa (ZH) is a good example of the use of the new high insulation technology (HIT), a super glazing system. The low rate of heat loss results in warmer interior surface temperatures and elimination of cold drafts adjacent to windows. This allows greater flexibility in the furnishing of the offices, a desk can be placed directly beside a window for example. The high insulation value of the glass makes it possible for the facades in all directions to be fully glazed. In fact transmission heat losses of the building envelope are so low that almost no auxiliary heating is needed. The heating requirements to warm ventilation air is also minimized by heat recovery via a heat exchanger.

PROJECT DESCRIPTION

Renovation of this 20 year old building was necessary to solve condensation problems with the associated corrosion of the windows and air conditioning system as well as to improve comfort while reducing the high energy consumption. An energy consultant was employed to develop a concept to solve these problems. He recommended the high insulation technology system. With this system direct heating could be largely eliminated except in the first floor. The office floors could be heated via the HIT facade air heating system. This required, however, the construction of partition walls with integral air channels.





Site data:
Latitude 47°15' N
Altitude 420 m

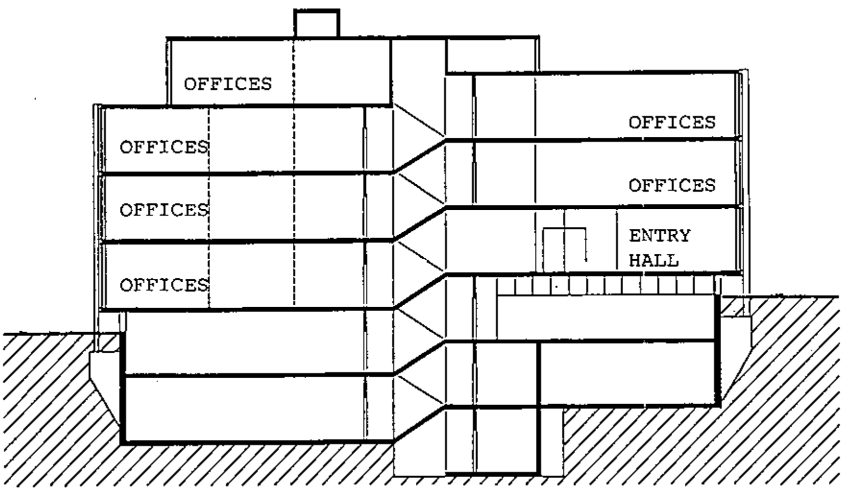
Climate data:
Oct. to April inclusive
Degree Days (base 20°C) 3 740
G_H 1 360 MJ/m2
Actual Sun Hours 643
Actual/Theoretical 0.29
Annual
Degree Days (base 20°C) 3 850

SITE AND LOCATION

The freestanding office building is located at the foot of a south slope in a town on the shores of Lake Zürich. To the north and west are parking areas, to the south is an open field. Mature trees and shrubs provide a park atmosphere.

BUILDING FORM

The offices are located in two building blocks offset in plan, joined by a central stair and elevator core. The complex is three stories above grade and two stories below grade. The entrance with its large roofed terrace approach occurs to the north. The building structure is comprised of exterior perimeter columns. The service core of (stairs, lift and toilets) provides lateral stiffness to the structure.

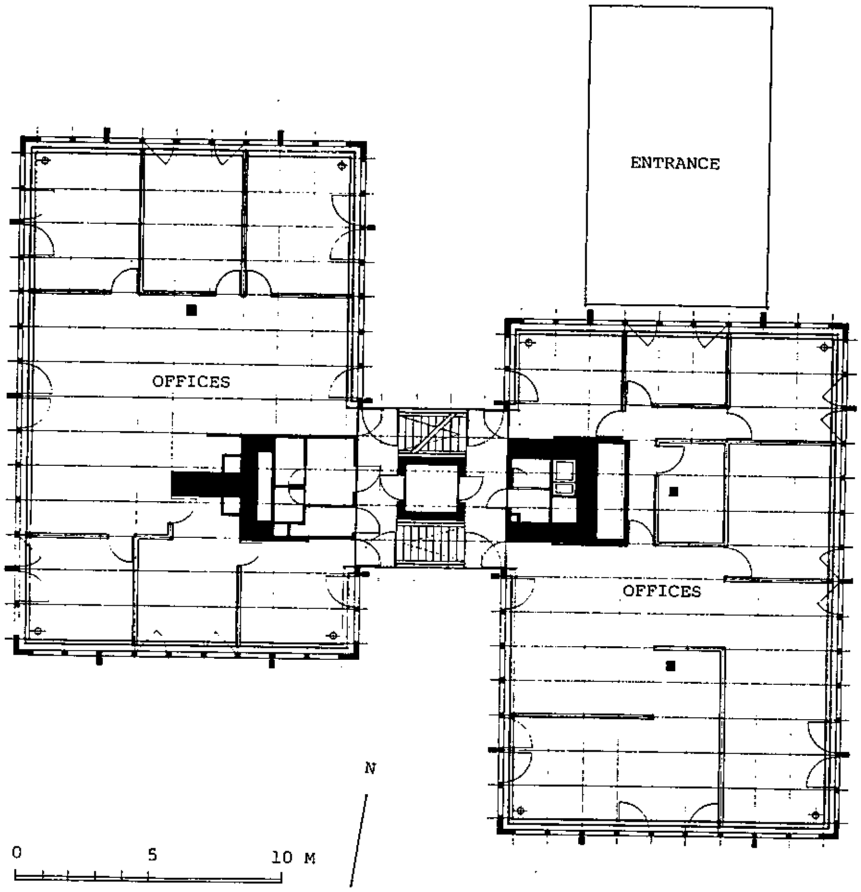


Volume:
Gross 8 226 m3

Floor area:
Useable 2 200 m2
Offices 1 300 m2

Number of levels:
3 + 2 below grade

Window area:
61% of all facades



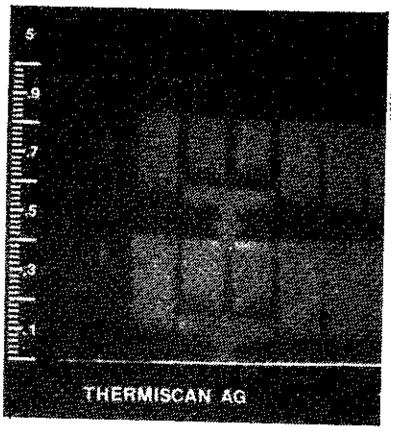
BUILDING CONSTRUCTON

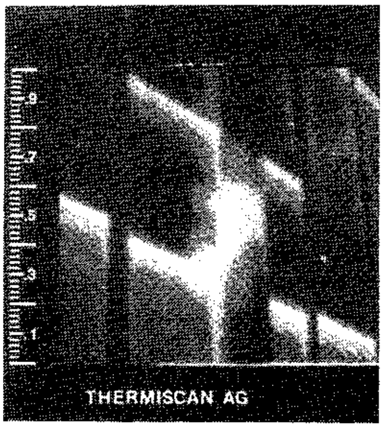
The main purpose of this renovation was to replace the building facade. The connection of the horizontal support structure to the exterior columns required a total of 40 penetrations of the facade. The anchoring of the facade to the structure therefore required special attention during detailing and construction.

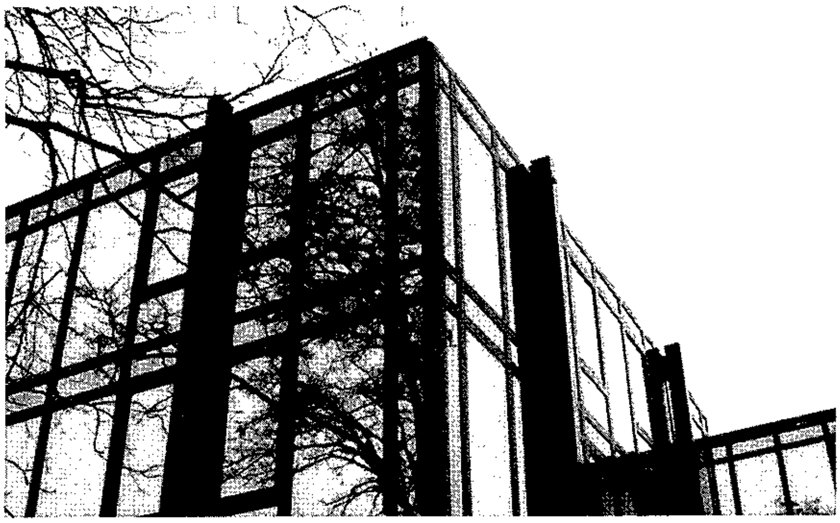
The HIT facade provides a very good and uniform level of insulation. The basis of this system is a glazing unit with a 90 mm air space subdivided by two IR selectively coated films. These reduce heat loss by air circulation within and radiation across the cavity. The framing of the glazing unit is also highly insulative.

U-values:
(W/m2K)

Glazings	0.60
Frames	1.00
Curtain walls	0.38





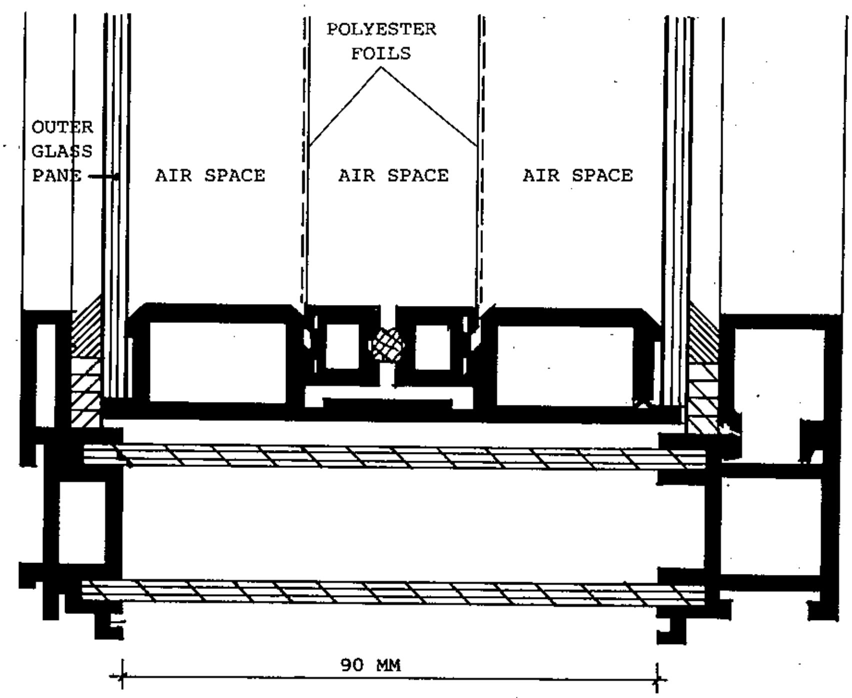


BUILDING SERVICES

The 1,300 m² of offices are heated by an air system with two central electric resistance heaters. Cooling in summer is provided by a compressor. The ventilation system is based on a displacement concept. Fresh air heated or cooled to a comfort range is delivered to an office by large cross section ducts with almost continuous openings at baseboard level. The air enters the room at a very low velocity, less than 15 cm/s. Stale air is displaced towards the ceiling where it is withdrawn. Due to the effective separation of fresh and stale air, the amount of fresh air which must be supplied can be reduced compared to a conventional system. The low air velocity which is thereby possible reduces undesirable drafts. Natural downdrafts at the windows are also practically eliminated. The very good insulation value of the glass results in surface temperatures not less than three degrees from the average room air temperature.

Installed capacities:

Air heaters	2 x 22 kW
Fans	9 kW
Direct heating in basement and staircase	22 kW



PASSIVE SYSTEMS

The facade of the two main building blocks was completely replaced with high insulation windows. The frames (thickness 145mm) have a U-value of 1.0 W/m²K. The glazing consists of two float glass panes with an airspace further divided by two stretched polyester-foils thus creating three air spaces. The overall glazing U-value is 0.6 W/m²K. The massiveness of the building results in it cooling down very slowly. The combined effect of all these factors is a building which is practically heated by internal and solar gains alone. This advantage occurs largely independent from building orientation.

COSTS

Cost of HIT facade and Building services (1986):
SFr 2 200 000
ECU 1 290 000

Cost of HIT facade:
SFr 1 000/m2
ECU 590/m2

The costs of this renovation were high, in part due to the higher than ususal energy consulting fees, but mostly due to this being a new facade technology. Finally, the renovation involved an almost complete replacement of the facade, the interior partitions (new partitions with air channels were installed), and the mechanical systems. On the positive side, this energy conserving system allowed substantial savings on the heating and cooling system costs.

ENERGY PERFORMANCE

Prior to the renovation, the building had an oil heating system with a capacity of 727 kW and two compressor motors with 350 kW cooling capacity. Heating required 50 - 80,000 l of heating oil per year (1050 MJ/m²a).

The building after renovation requires 157 MJ/m² (electric) of which 75 percent is used for space heating (two air heaters at 22 kW). Not included is direct electric heating of the stairs and basements 22 kW by -10° outside temperature. 25 percent is used for controls and ventilation (Fans: 9 kW). In addition there is 26.6 kW of lighting power and 11 kw cooling capacity.

Annual fuel use 1987/88: (MJ/m2)

Ventilation system	157
Typical existing Office building	750

HUMAN FACTORS

The occupants appreciate the generous view afforded by the floor to ceiling glass. No particular problems have occured concerning air quality with the displacement ventilation concept, although noise in certain rooms has still to be reduced. No special ventilation system was included for the conference rooms, this requires the occupants sometimes opening the windows to freshen the room. The problem of tobacco smoke does not exist, smoking is prohibited throughout the building.

Number of occupants:
Variable

Time of occupancy:
Working hours

CONCLUSIONS

This high-tech facade system eliminates common thermal problems (thermal bridges, large heat loss through glazing and drafts). The minimal heat loss results in a highly uniform temperature within the offices and a very slow drop in temperature (2°) over the weekends when the system is shut down. The energy and environmental goals set during the design have been achieved by the renovation.

HIT facade provides a very good and uniform level of insulation

INFORMATION

Dr. B. Keller, Geilinger AG, Metal Construction Department, CH-8401 Winterthur and AIP Plan AG Hoppe, CH-8610 Uster provided the information for this report.

Publications:

Keller B. (Geilinger), and Francelet P.A. and Roulet C.A. (GRES), NEFF-Project 225: "Der Einfluss von hochisolierenden Fenster- und Fassadensystemen auf Raumklima und Energiebedarf", Geilinger AG, CH-8401 Winterthur.

Report prepared by:
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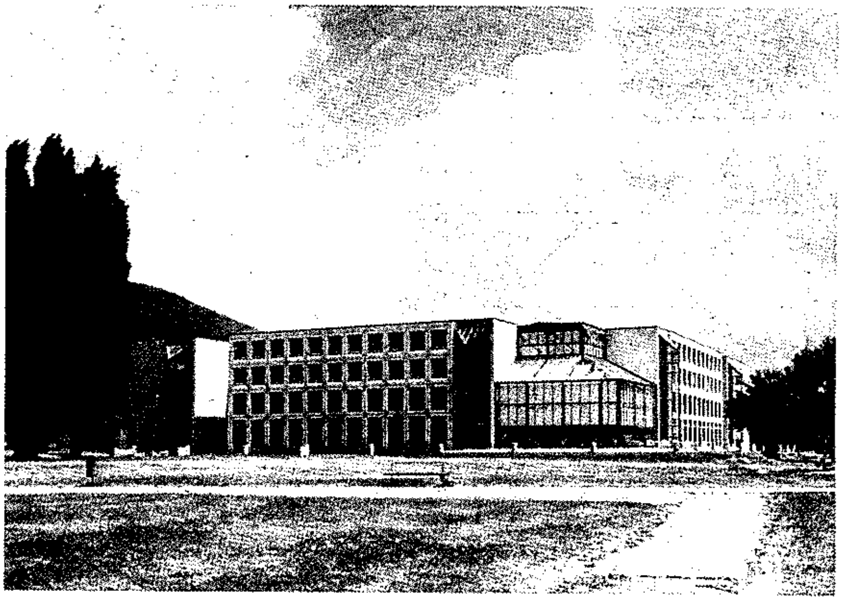
CH-8703 Erlenbach-Zürich
Tel. 01/910.55.45

CH

NEUCHATEL UNIVERSITY



Building type:
Education

Passive solar features:
Direct daylighting
Sunspace

Occupancy date:
October 1986

Floor area:
Gross 8 100 m2

Annual delivered fuel:
(estimated)
Heating energy 215 MJ/m2

Client:
Canton de Neuchâtel

Architects:
NCL Architecture-Urbanisme

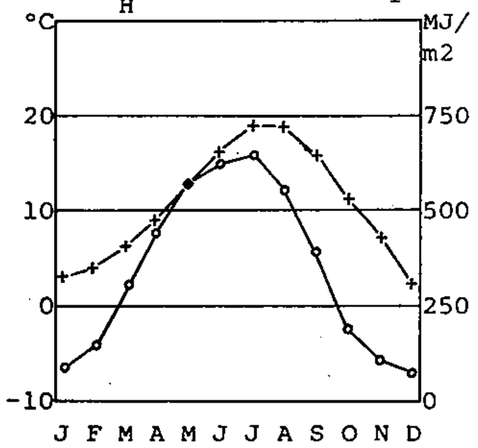
Energy consultant:
Sorane SA

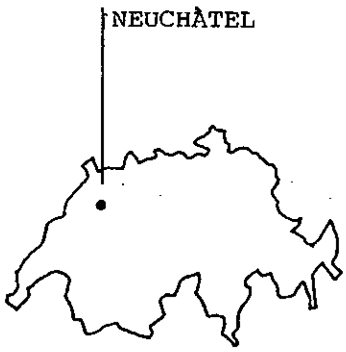
SUMMARY

The new building of the faculty of literature of the University of Neuchâtel has a heating energy demand of only 215 MJ/m²a. The symetrical building has a central courtyard and attached sunspace. It is heated by a heatpump with backup on extremely cold days from district heating. The prominent large sunspace was conceived as a passive solar heated space. The building is deliberately not air conditioned and only special rooms have mechanical ventilation. The glazed space is tempered in summer through natural ventilation and evaporative cooling from pools of water.

PROJECT DESCRIPTION

This building design was chosen from a design competition. The energy consultant, who was engaged in the project since its conception, gave particular attention to the sunspace. During 1989 it will be monitored in detail as part of the Swiss partication in IEA Solar Task XI. The goal of this monitoring is to assess comfort in the sunspace under different climatic conditions, winter through spring. Temperature stratification and air movement will also be studied. Through computer simulation the parameters of glazing, size of the ventilation openings, placement of sunshading and orientation will be analysed.





Site data:

Latitude	47°00' N
Altitude	438 m

Climate data:

Oct. to April inclusive

Degree Days (base 20°C) 2 940

G_H 1 425 MJ/m2

Actual Sun Hours 665

Actual/Theoretical 0.26

Annual

Degree Days (base 20°C) 3 450

SITE AND LOCATION

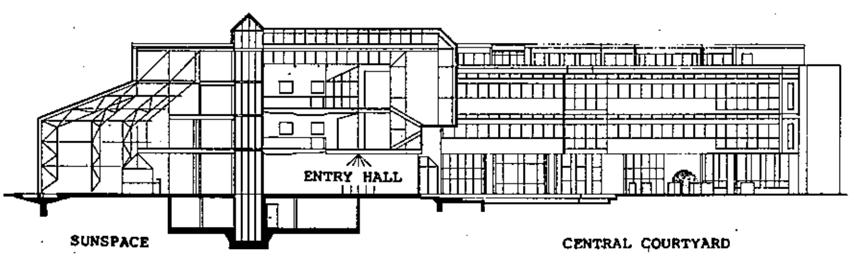
The project is located on landfill on the Lake Neuenburger. To the west is a large open park area.

BUILDING FORM

The 3-4 story building complex, organized around a central court, is comprised of six blocks:

- four nearly identical blocks housing a library, class rooms and offices
- a 12 x 12 x 12 m sunspace with 160 m² of vertical glass and 130 m² of sloping glass.
- a central block with the entry hall, cafeteria and commons area.

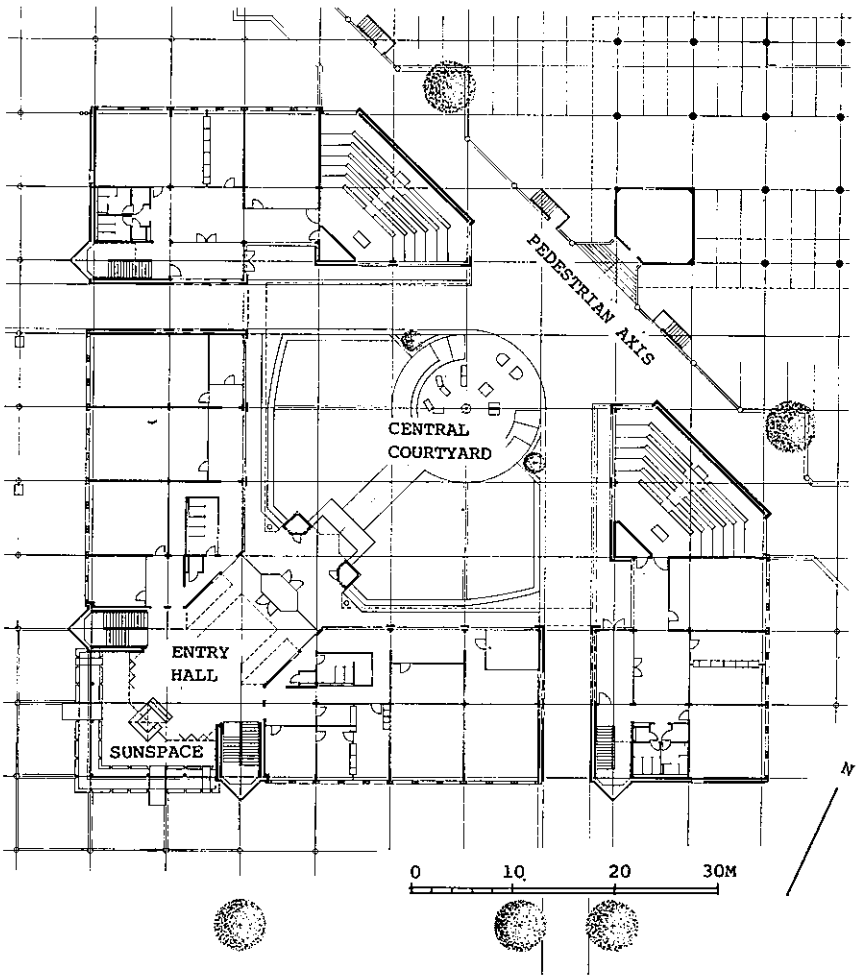
A pedestrian axis passing diagonally through the building connects the town to the open park land forseen for festivals. This axis passes through the commons area which can be used independently from the normal operations of the building.



Volume:
Gross 24 600 m3

Floor area:
Gross 8 100 m2

Number of levels:
4 + basement



U-values:
(W/m2K)

Windows	3.10 and 1.60
Walls	0.35
Building	0.70

BUILDING CONSTRUCTION

The concrete framing, ductwork and other services are all exposed rather than hidden with a suspended ceiling. The construction is based on a 7.2 m grid. The sunspace is single glazed to the outside and to the building proper.

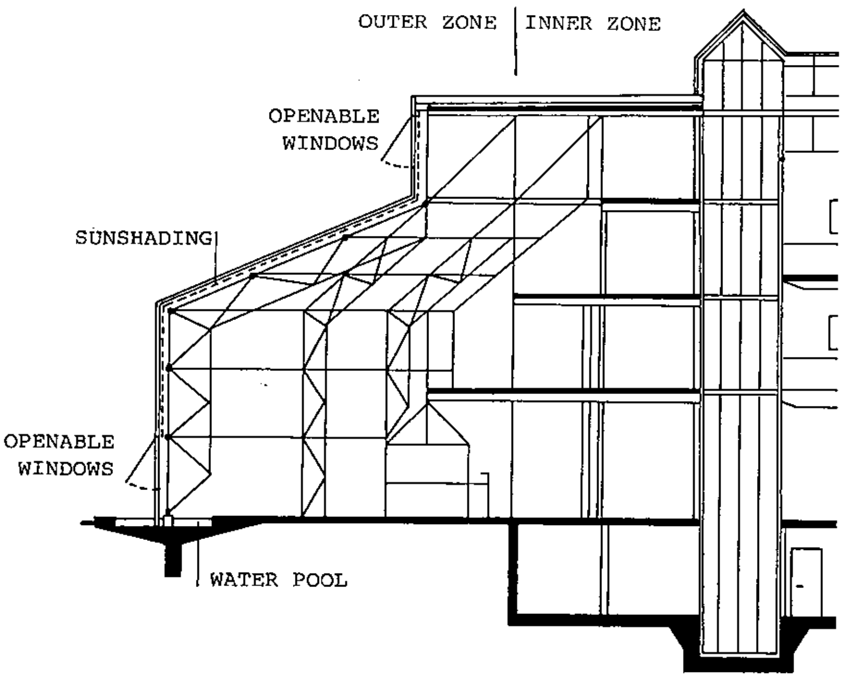
BUILDING SERVICES

80 percent of the heating requirement of the building is covered by the two heat pumps each with 500 kW capacity. One uses a nearby sewage treatment facility as a heat source, the other uses heat rejected from an artificially cooled ice skating rink. The heatpumps are adequate to heat the building when outdoor temparatures are above -15°C. Below this temperature the district heating is also used. Excess heat produced by the heatpumps during mild weather is put into this district heating. Heat is delivered to the rooms via radiant floor heating. The principle spaces are heated to 20°C, the circulation and connecting spaces are heated to 16°C. A ventilation system is provided for the commons, the auditorium and the library stacks .

Installed capacities:

Heat Pumps	2 x 500 kW

CROSS SECTION THROUGH SUNSPACE



PASSIVE SYSTEM

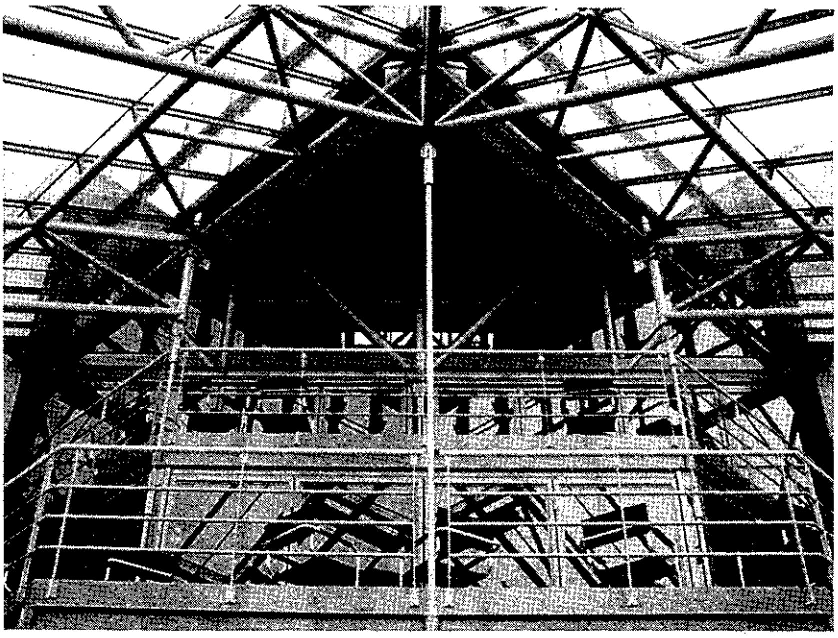
The sunspace is divided in two zones, an outer zone which is unheated and serves as a sun tempered buffer, and an inner zone which is heated. In the summer large glass areas can be opened at the base and top of the sunspace to induce natural convection within the sunspace volume. Pools of water at the perimeter further enhance natural cooling by evaporation. Interior sunshading provides glare and overheat protection.

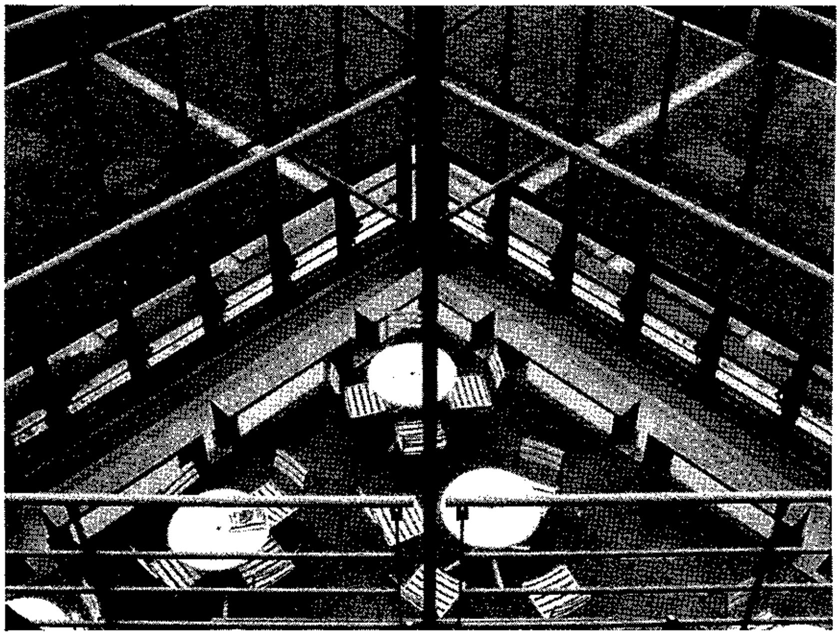
Sunspace:

Volume	660 m3
Floor area	100 m2
Glazing area	325 m2

COSTS

The entire building complex was estimated to cost SFr. 17,500,000. Actual costs were 20 percent higher. Part of this overcost included additonal insulation, decided upon during the course of construction.





ENERGY PERFORMANCE

Annual fuel use:
(MJ/m2)
Heating (estimated) 215

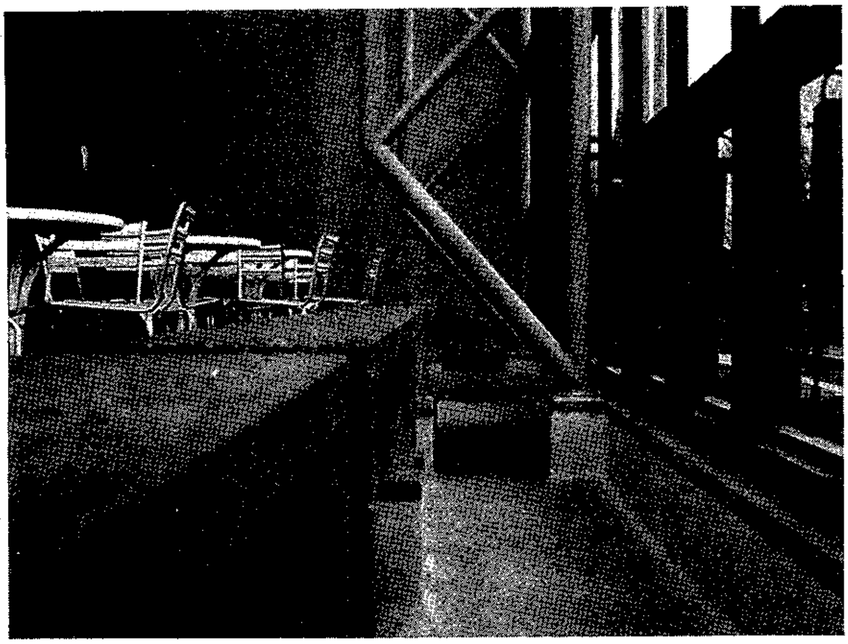
The estimated annual energy consumption for heating is 215 MJ/m^2a.

HUMAN FACTORS

Number of occupants:
Variable

Time of occupancy:
Lecture hours

The frequent and full occupancy of the sunspace proves its success as a gathering space. Students are apparently willing to accept cooler temperatures of the space in the winter in order to enjoy the amenity of the "outdoor" character of the space.



INFORMATION

The information for this report is from J.-M. Triponez, NCL Architecture Urbanisme, CH-2300 La Chaux-de-Fonds and from D. Chuard, Sorane SA, Route du Châtelard 52, CH-1018 Lausanne.

Publications:

"Université de Neuchâtel, Aula et Faculté des Lettres, Plaquette éditée à l'ocasion de l'inauguration", 31.Oct.1986: Université de Neuchâtel, Secrétariat général, Avenue du ler Mars 26, CH-2000 Neuchâtel.

Report prepared by:
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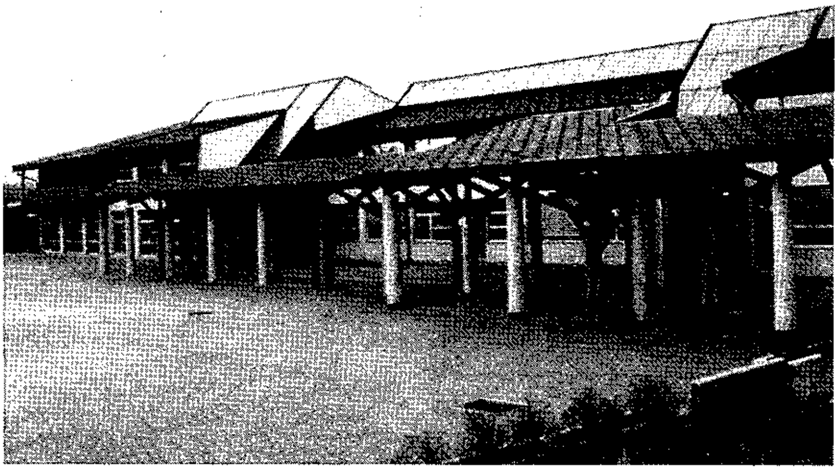
CH

PENTHAZ SCHOOL



Building type:
Education

Passive solar features:
Direct daylighting
Direct/indirect thermal gain

Occupancy date:
1984

Floor area:
Heated 2 000 m2

Annual delivered fuel:
(1984/85)

Electrical	72 MJ/m2
Oil	270 MJ/m2
Site energy	342 MJ/m2

Client:
Municipality of Penthaz

Architects:
F. and A. Dolci

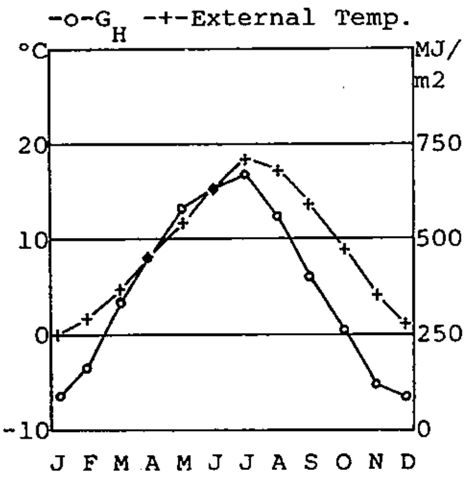
Energy consulting and Monitoring:
Energies Rationelles

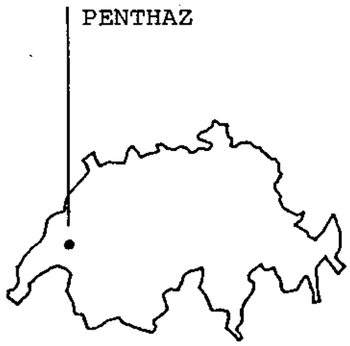
SUMMARY

The designers of this school in Penthaz (VD) aimed for an energy concept combining conservation, passive, and active solar elements. The resulting solution includes exterior insulation to allow the masonry walls to provide thermal mass for the building interior, large window areas with highly insulative glazing and a control system for the active solar and back-up heating which responds to passive solar gains. A wheel heat exchanger recovers heat from exhaust air. These energy features provide low running costs and comfort in winter as well as in summer. Monitoring is currently underway.

PROJECT DESCRIPTION

The project planning required close co-operation between the municipality, architects and energy specialists. The basic aims were to minimize heat losses and maximize the combination of passive and active solar gains. Moreover, the fresh air standards for school buildings had to be met. Cost/benefit checks of the energy features were made throughout the planning.





Site data:
Latitude 46°40' N
Altitude 487 m

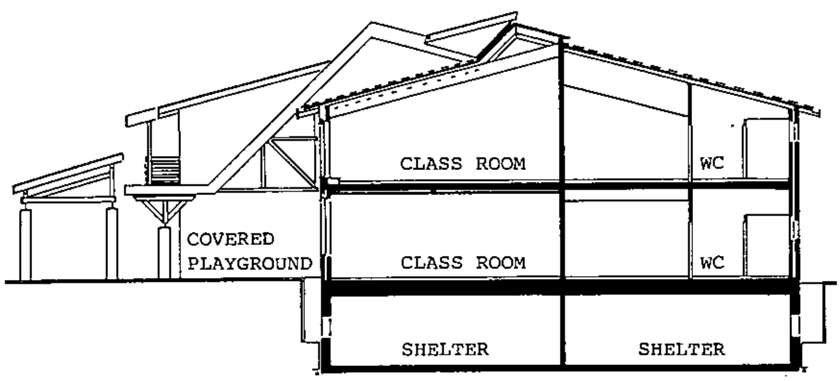
Climate data:
Oct. to April inclusive
Degree Days (base 20°C) 3 390
G_H 1 566 MJ/m2
Actual Sun Hours 687
Actual/Theoretical 0.33
Annual
Degree Days (base 20°C) 4 120

SITE AND LOCATION

The school grounds are located in the outskirts of a small rural village. A slight hill to the north of the isolated building protects it against the strong winds. An older multi-purpose hall is close-by and was also included in the energy scheme and is provided with solar heated hot water for showers, washing etc.

BUILDING FORM

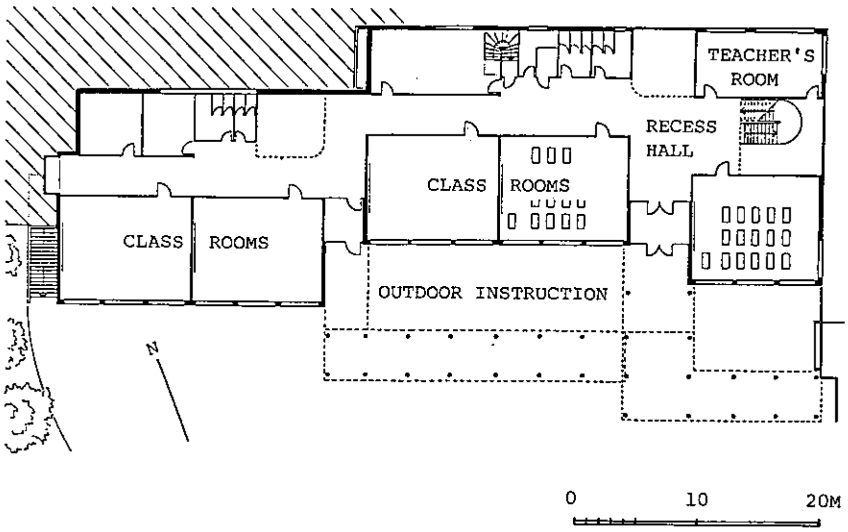
The principal spaces of the elongated two-story building are nine classrooms, a room for special lessons, a teachers' room and a caretaker's flat. The classrooms are all orientated to the south with indentical glazing areas. Supporting rooms are situated to the north as buffer zones. The 45° projection of the collector's permitted a band of skylights enhancing the daylighting of the upper classrooms.



Floor area:
Heated 2 000 m2
Gross circa 3 300 m2

Number of levels:
2 + underground floor

Window area:
South 170 m2
46% of facade

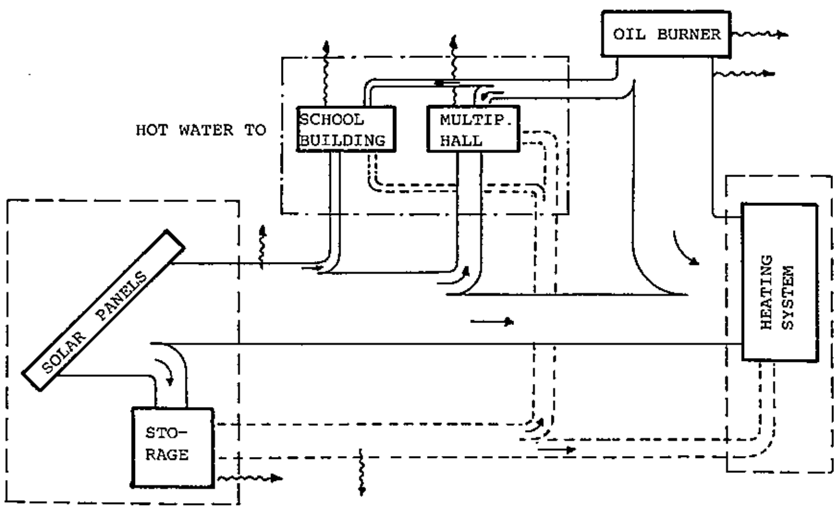


BUILDING SERVICES

Installed capacities:

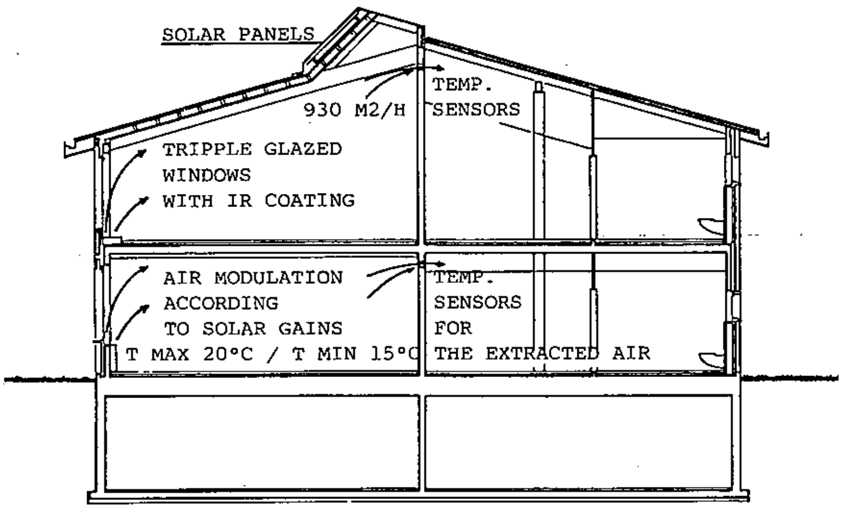
Oil Burner	140 kW
Water Storage	26 m3
Collectors	200 m2

80 percent of the auxiliary heating is provided by a floor heating system, the remaining 20 percent is delivered by the ventilation system. Heat from the 200 m^2 of collectors is injected directly into the heating distribution system. Surplus energy is delivered to the storage tanks. The mechanical ventilation system is equipped with an air to air heat exchanger (a rotating wheel) which recovers 85 percent of the heat from the exhaust air. A microprocessor provides an accurate and comprehensive control, with day, week, and holiday programmes.



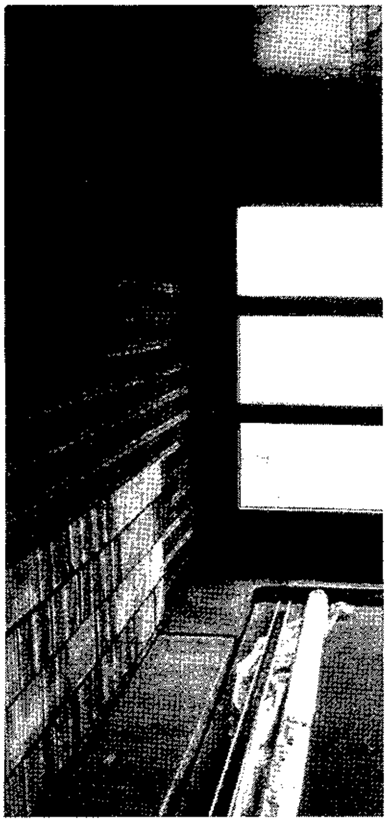
ENERGY TRANSFER WITHIN THE SYSTEM

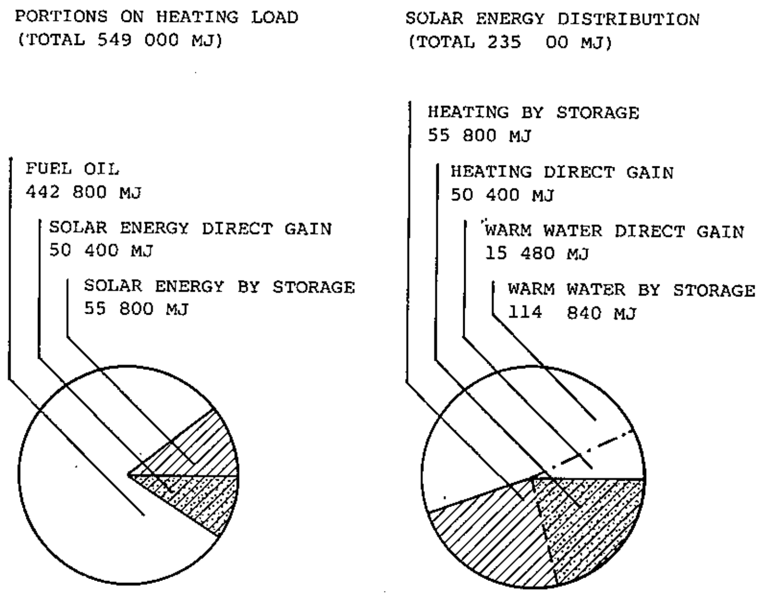
HEATING OF THE CLASS ROOMS /
RESPONSE TO SOLAR GAINS THROUGH THE WINDOWS



PASSIVE SYSTEM

The envelope insulation is located outside of the structural elements. The windows have triple glazing with a selective infra-red coating (U = 1.1 W/m²K, solar energy transmission = 63 percent). Temperature sensors placed in each classroom shut off the floor heating system before overheating can occur. Solar heat is then rerouted to the storage.





COSTS

Building cost (1984):
SFr 6 500 000
ECU 3 812 000

SFr 1 950/m2
ECU 1 140/m2

Typical cost
SFr 1 200 - 1 500/m2

Cost of total energy system:
SFr 800 000
ECU 469 000

SFr 400/m2
ECU 235/m2

This school building required increased planning expense. The additional costs for the conservation features should be amortized in less than ten years. An economic analysis of the active system requires supplementary input from the measurements.

ENERGY PERFORMANCE

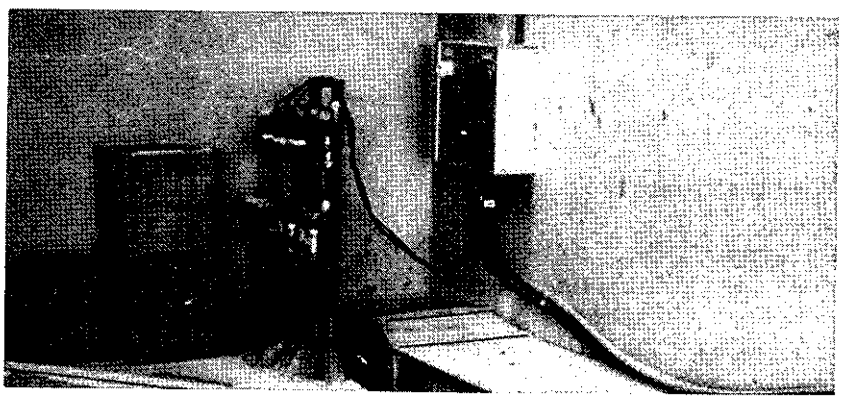
The mix of active and passive elements permits the two systems to compliment each other making possible a well controlled storage of heat. 20 percent of the gross heating load is covered by active solar gains as follows:

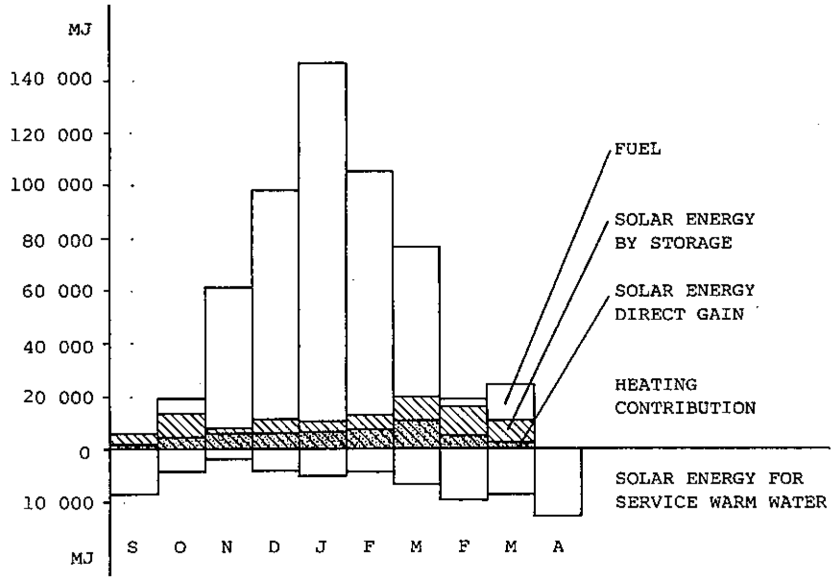
- 09.5 percent direct heating from the collectors
- 10.5 percent from the heat storage tanks of the solar system

The passive solar heat gains have not yet been evaluated.

Annual fuel use 1984/85:
(MJ/m2)

Heating	270
Lighting/Ventilation	72
Site energy	342
Typical existing Education building	750





HUMAN FACTORS

The teachers at first were very skeptical of the effectiveness of mechanical ventilation, claiming that they much prefered to simply open windows. The system, however, easily provides 30 m^3/h of fresh air per person and the teachers have individual control of the classroom temperature.

CONCLUSIONS

The solar system has proved highly efficient. The quick system response to solar gains is achieved by adjusting the heating of ventilation air according to the output of room air temperature sensors. A micro-processor and 31 sensors facilitated the start-up adjustments of the system. Automatic calculation of ten heat balances permits optimum system regulation. Improved efficiency of the oil-fired furnace has been, however, difficult to achieve. Extensive measurements were conducted through 1985.

Solar use is maximized by the alternatives of direct room heating or storage as determined by sensors and a control program

INFORMATION

M-O.Nilsson and C.Calatayud, Energies Rationelles, CH-1110 Morges, provided this material.

Publications:

Calatayud C., Nilsson M.-O., 1985: "Présentation des installations solaire au complexe scolaire de Penthaz", Proceedings of the 5. Solar Symposium, EPFL-GRES, CH-1015 Lausanne.

Report prepared by:
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CH

REINACH YOUTH CENTER

Building type:
Assembly

Passive solar features:
Direct daylighting
Indirect thermal gain
Natural cooling

Occupancy date:
1984

Floor area:
Gross 390 m2

Cost (1984):
SFr 680 000
ECU 399 000

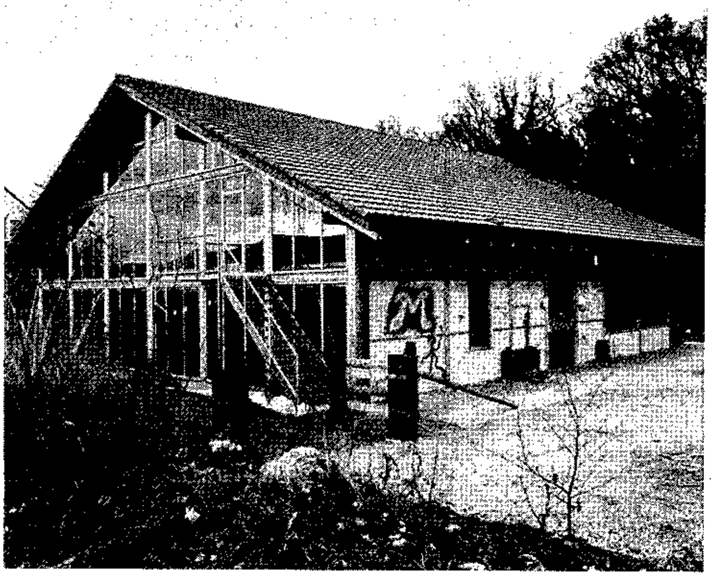
Annual delivered fuel:
(1986/87)

Electrical	151 MJ/m2
Firewood	100 MJ/m2
Site energy	251 MJ/m2

Client:
Municipality of Reinach

Architects:
Felix Meier and
Rainer Senn

Energy consultant:
Ruedi Kriesi

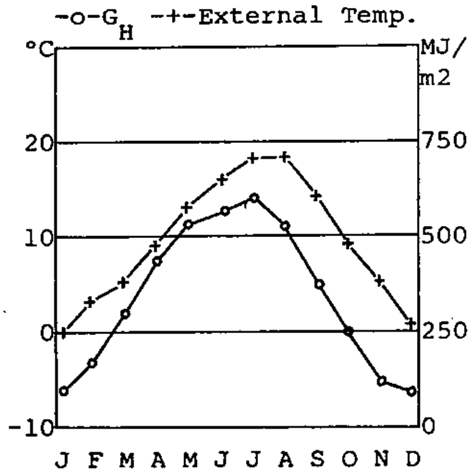


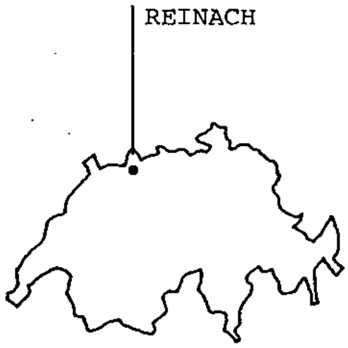
SUMMARY

A youth center in Reinach (BL) is equipped with a hybrid solar system which together with direct gains covers about 50 percent of the heating load of the relatively open-plan building. The simple closed-loop air system is comprised of a southern collector window, an underfloor rockbed and a 380 W ventilator. In summer the collector front provides solar driven ventilation as well. Auxiliary heating is provided by a wood burning cooking stove. This heat is distributed via water to radiators.

PROJECT DESCRIPTION

The design began as a spatial concept for gatherings. Thus, the scheme proposed by the architects is reminiscent of an ecclesiastical assembly room from Reformation times. The solar consultant was not brought into the project until the design was already well along.





Site data:
Latitude 47°29' N
Altitude 300 m

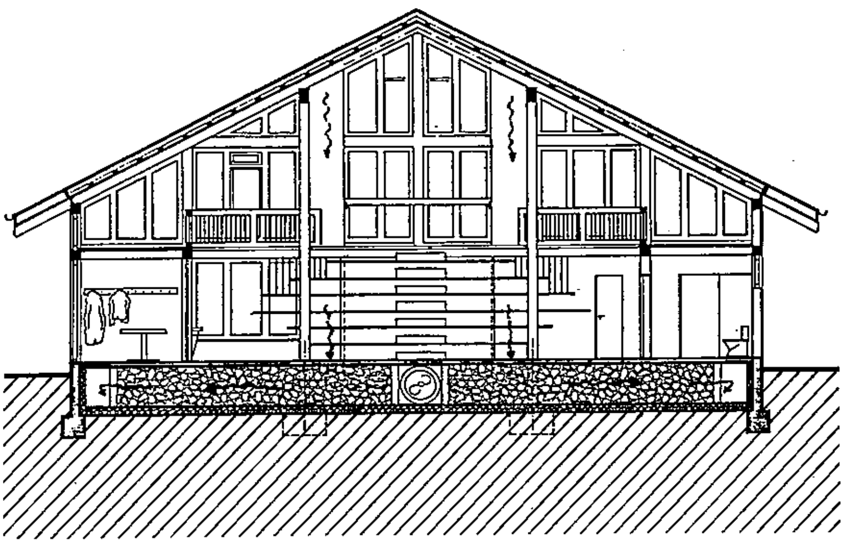
Climate data:
Oct. to April inclusive
Degree Days (base 20°C) 3 300
G_H 1 490 MJ/m2
Actual Sun Hours 743
Actual/Theoretical 0.31
Annual
Degree Days (base 20°C) 3 940

SITE AND LOCATION

The isolated building is on the boundary of a small town. Only 10m in front of the south facade there is a feeder road to the motorway with intense traffic noise. The north is bounded by a forest.

BUILDING FORM

This nearly archetypical building has a square shape 16.4 m to a side. Four middle pillars support the roof. At ground level an octogonal main space is bounded by supporting rooms: two group rooms, a workshop, an office, a kitchen, toilets and a porch. A surrounding gallery occurs above these supporting spaces. The entirely glazed south front provides excellent daylighting.

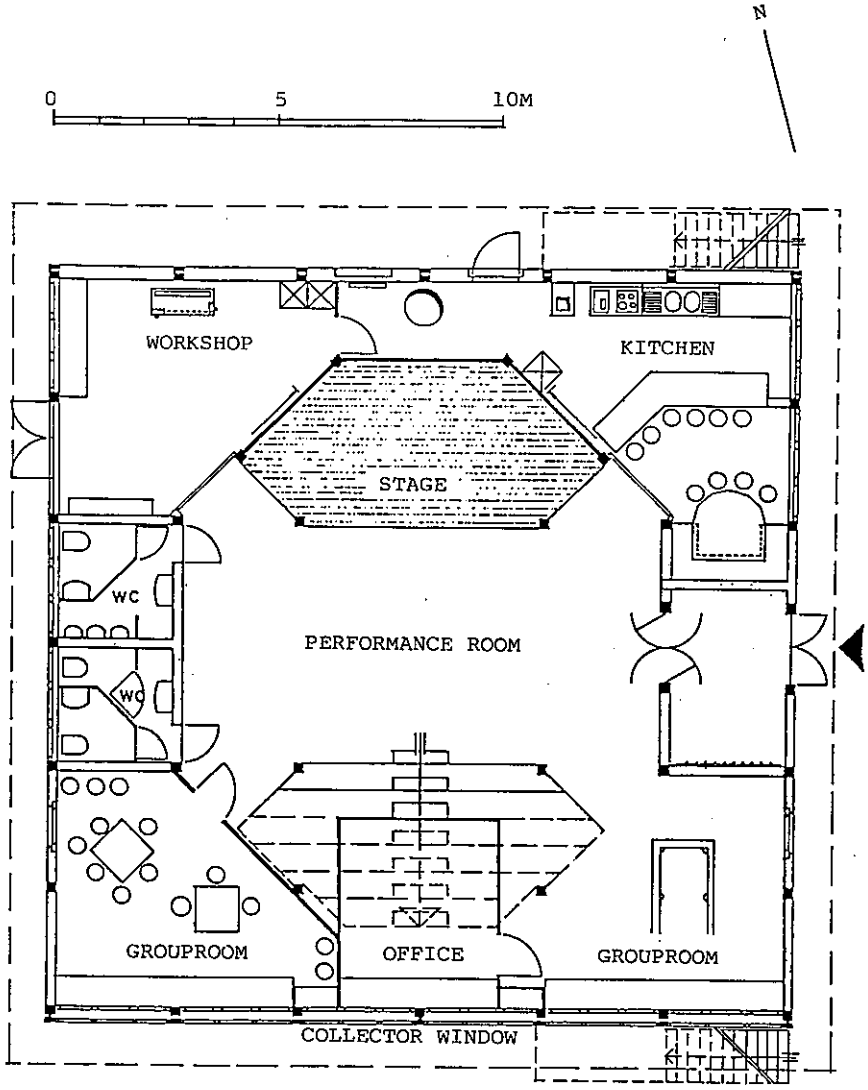


Volume:
Gross 2 200 m3

Floor area:
Gross 390 m2

Number of levels:
1 + gallery level

Window area:
South 90 m2



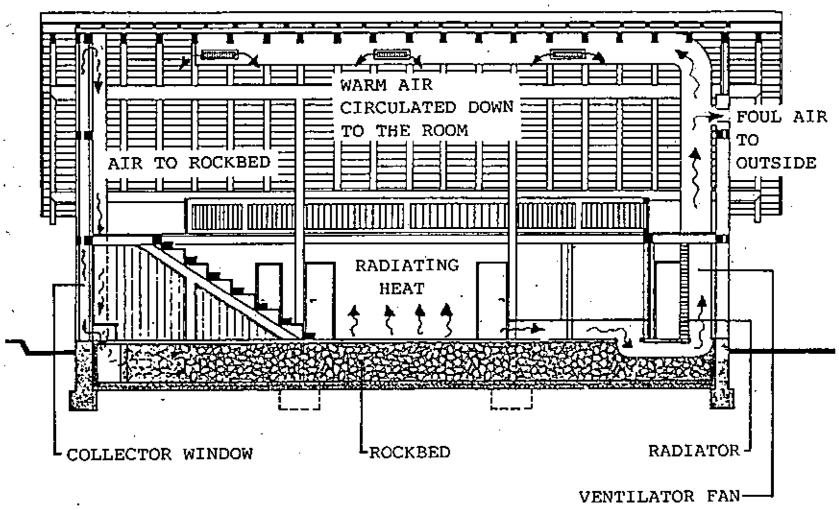
BUILDING CONSTRUCTION

All structural elements of the walls and roof are biologically treated fir. Exterior walls are constructed from insulating bricks. For the interior natural building materials such as wood and clay products were favored. The collector windows consist of two double glazed façades: the exterior façade is steel framed, the interior façade is wooden framed. This quadruple glazing provides optimal noise isolation as well as very good insulation.

BUILDING SERVICES

Installed capacities:
Ventilator Power 380 W

Auxiliary heating is provides by the wood-burning heating stove which also serves for cooking. Heat distribution is by radiators including one located in the ventilation loop to warm intake fresh air.



PASSIVE SYSTEM

The south front is an air collector with an intermediate space of 25 cm between the two double glazings. Black roll blinds serve as absorbers. Warmed air is fan-forced in a closed loop to a rockbed under the floor slab which then warms the room. The rockbed contains stones 8-12 cm in diameter. It is insulated from the earth with 20 cm of foam glass. 2 cm of mineral fiber insulation in the floor above the rockbed slow the rate of heat release to the room.

The collector window can be opened at the top to the outside and below to the room. In summer the collector warmed air is exhausted at the top. This draws cool air from the forest through the rooms to the bottom of the collector. The roof overhang and roll blinds provide solar protection.

Collector window:	
Glazing area	90 m2

Rockbed storage:	
Volume	210 m3
Depth	1 m

COSTS

Building cost (1984):
SFr 680 000
ECU 399 000

SFr 1 743/m2
ECU 1 022/m2

Typical cost
SFr 1 400 - 1 800/m2

The costs of the solar system are comparable to those of a conventional heating system. Operation is necessarily economical because rooms are heated only when users are present.

ENERGY PERFORMANCE

Annual fuel use 1986/87:
(MJ/m2)

Heating	123
Lighting	38
Electrical	38
Hot water	52
Site energy	251
Typical existing Assembly building	750

A detailled energy balance is difficult to establish, nor has energy consumption been measur-ed. The heating requirements are about 8-10 m^3 of hard wood and 9,000 MJ of electrical energy. The estimated 50 percent heating contribution of the solar system exceeds predictions.

HUMAN FACTORS

Number of occupants:
30 - 60
(100 - 400 by events)

Time of occupancy:
Mainly evenings,
Sometimes afternoons

The spatial layout turns out to be ideal for the users' needs. They report that the solar system positively influences the building's character, particularly the room comfort. Moreover it offers the young people direct experience with primary energy resources. Since the system is controlled by the users, occasional incorrect operation can occur.

CONCLUSIONS

The architects consider the air system successful, due much to its simplicity and transparent technology. It was erected partly by the young people within a work programme. Heating control presents no problems. Better thermal insulation of the external walls would have been advisable.

Successfull air system

Better thermal insulation advisable

INFORMATION

F. Meier and R. Senn provided this information.

Publications:

Meier F., Senn R., 1984: "Beispielhaftes Jugendhaus", Sonnenenergie/Energie solaire Nr. 5, Postfach, CH-8050 Zürich.
and
1988: Schweizer Architektur Nr. 81, Editions Anthony Kraft, 13 av. du Tirage, CH-1009 Pully.

Report prepared by:
Pinna/Schwarzenbach/
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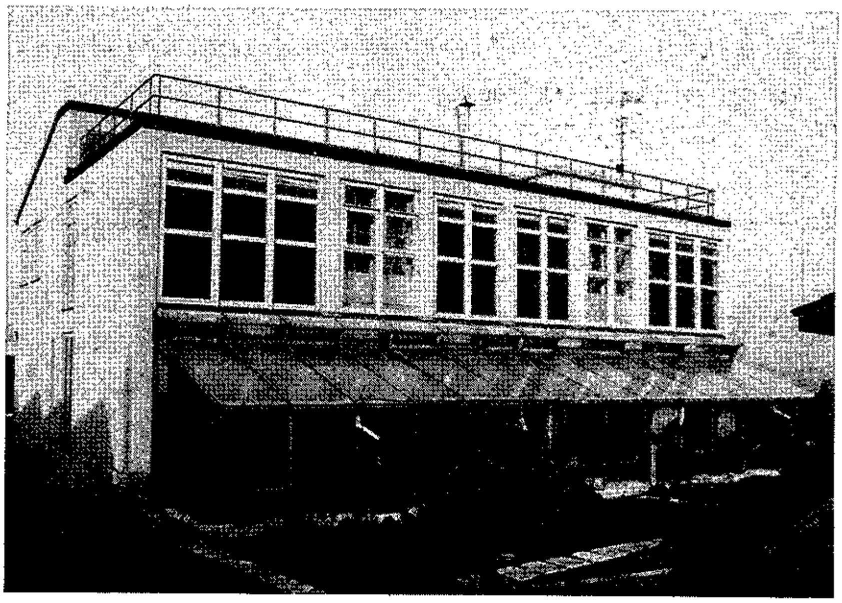
Tel. 01/910.55.45

CH

METEOLABOR LABORATORIES



Building type:
Industrial

Passive solar features:
Direct daylighting
Indirect thermal gain
Natural cooling

Occupancy date:
1985

Floor area:
Gross 640 m2
Heated 420 m2

Cost (1985):
SFr 1 100 000
ECU 645 000

Annual delivered fuel:
(1985/86)

Electrical	105 MJ/m2
Oil	2 MJ/m2
Site energy	107 MJ/m2

Client:
Meteolabor AG

Architect:
Peter Gutersohn

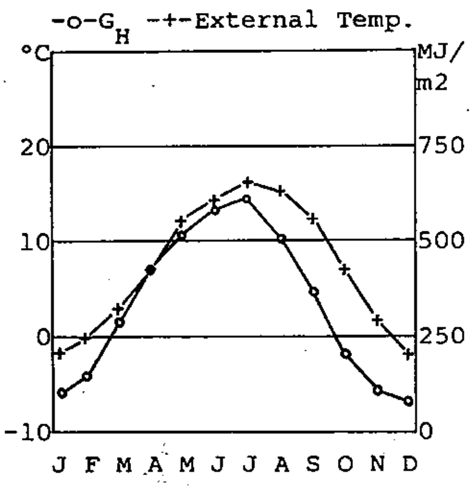
Energy concept:
Meteolabor AG

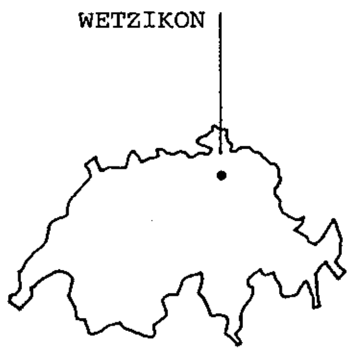
SUMMARY

Meteolabor AG, an electronics firm in Wetzikon (ZH), wanted to apply energy conserving concepts in its new multi-function building addition. The concept chosen consists of using the building structure to store heat from a greenhouse and solar air collectors. A nearly constant storage temperature of about 20 °C is achieved from October through April, thanks to the immense inertia of the building. The resulting thermal lag does, however, require occupants to adapt to the seasons. In general the calculated values have been confirmed by measurements to date.

PROJECT DESCRIPTION

The buidling's energy concept originated from the client's intention to apply his experiences in the production of precise meteorological measuring instruments to his own building. Simple energy features were however a prerequisite. The client wanted to limit the construction to conventional technologies and tradional craftsmanship. The current monitoring is being done by the client. The results are registrated together with output from the building's weather station.





Site data:

Latitude	47°20' N
Altitude	548 m

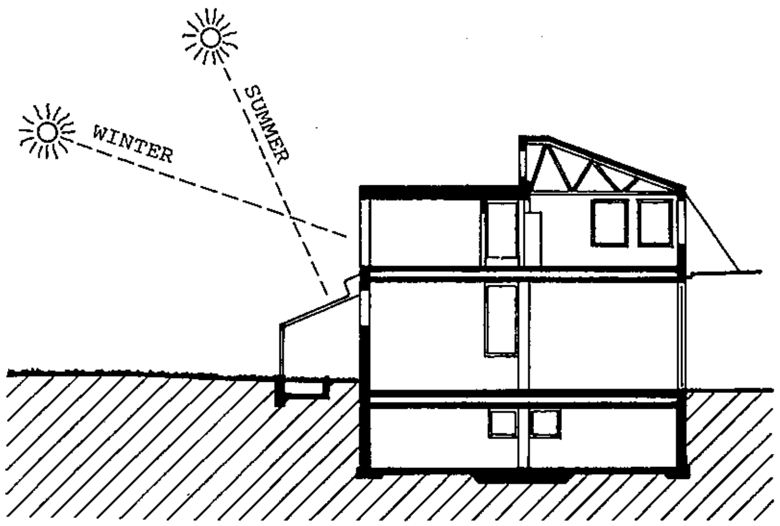
Climate data:
Oct. to April inclusive
Degree days (base 20°C) 3 750
G_H 1 425 MJ/m2
Actual Sun Hours 643
Actual/Theoretical 0.25
Annual
Degree Days (base 20°C) 4 730

SITE AND LOCATION

The building, situated in the industrial zone of a small town, has other buildings on three sides. To the northeast it is exposed to the open landscape. From this direction come heavy and cold winds.

BUILDING FORM

The two storey building forms a relatively compact volume. The current usage of the building results in intermittent occupancy, namely: storage in the cellar; workshops and a delivery department on the ground floor; and a meeting room, exposition hall, photo laboratory, reproduction room, and measuring room on the upper floor. A terrace is located on the roof on the south part of the building, to the north is a lean-to roof.



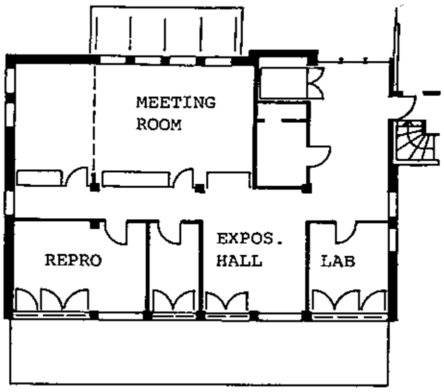
Volume:
Heated 1 670 m3

Floor area:
Gross 640 m2
Heated 420 m2

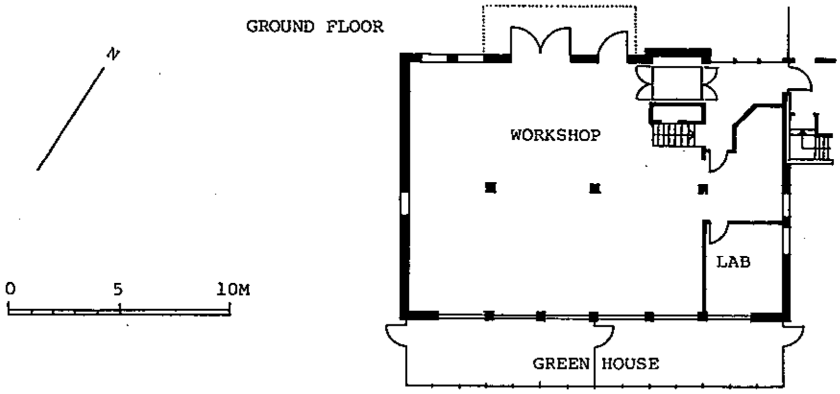
Number of levels:
2 + basement

Window area:
South 110 m2
90% of facade

FIRST FLOOR

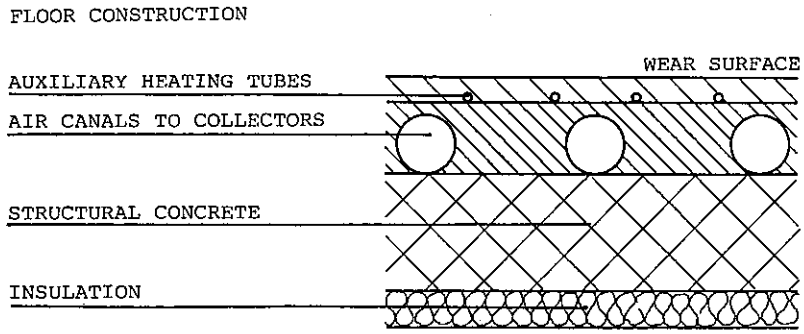


GROUND FLOOR



BUILDING CONSTRUCTION

The solar concept uses the massive construction of the building, 25 cm masonry perimeter walls and reinforced concrete floors. The roof structure is wooden trusses and planks. The service and personnel doors are of insulated sheet-steel. The greenhouse construction is a laminated wood framing construction with triple glazing of plexiglas.

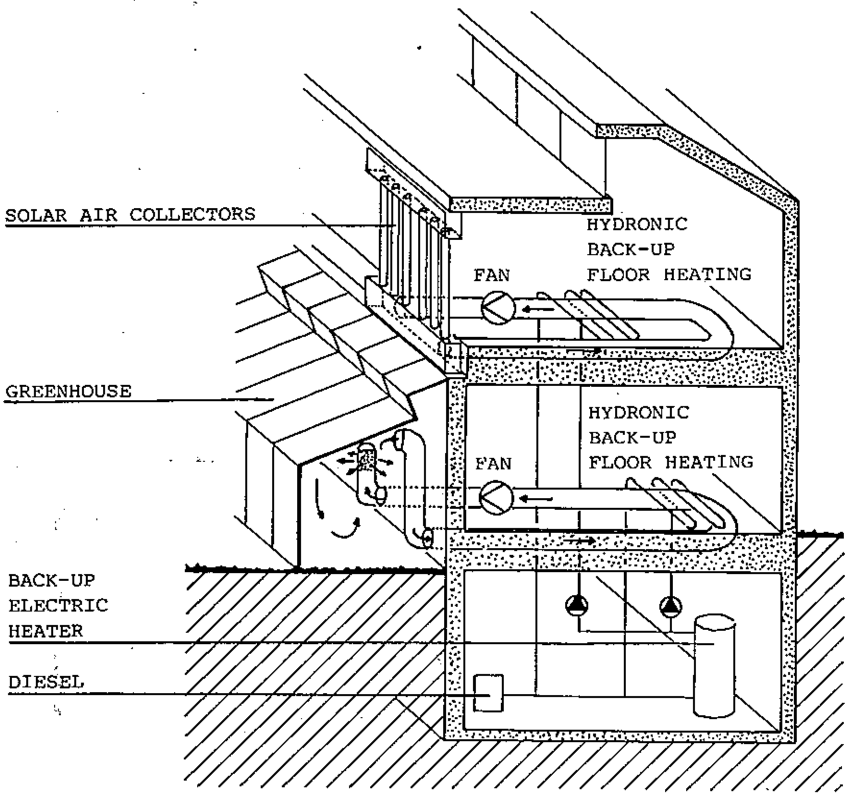


U-values:
(W/m2K)

Walls	0.28
Lean-to-roof	0.21
Windows	1.98
Building	0.36

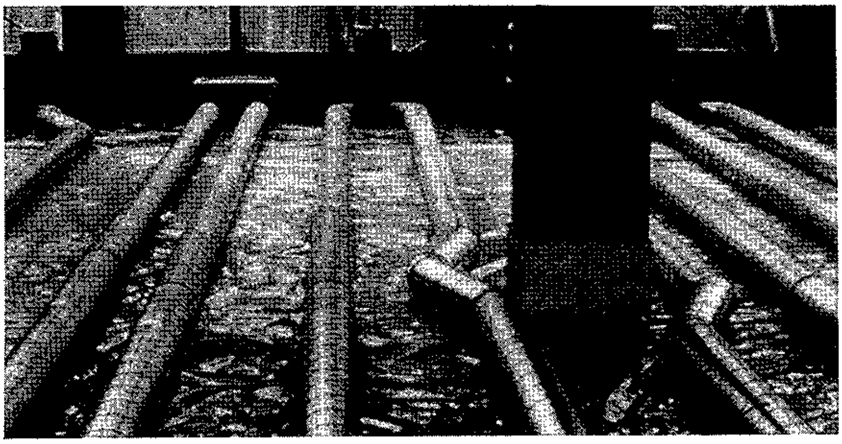
Building heat loss:
320 W/K

CROSS SECTION SHOWING THE ENERGY SYSTEM



BUILDING SERVICES

The rooms are heated by a hollow radiant floor through which solar heated air is fan-forced from the greenhouse and the collectors. The air is circulated through sheet metal tubes 15 cm Ø embedded in the concrete. The system incorporates nine fans on ground level and six fans on the upper level. Auxiliary heating occurs by a copper tube grid imbeded in the floor. Auxiliary heat from a resistance electric heater and waste heat from diesel generator is needed only occasionally, mostly in the night.



Installed Capacities:

Fans	15 x 80 W
Flow-through Water Heater	15 kW
Diesel Generator	22 kW

Greenhouse:

Volume	126 m3
Floor area	50 m2
Glazing area	110 m2

Collector windows:

Absorber volume	1.5 m3
Glazing area	27 m2

Storage:

Volume	317 m3
Thermal mass	752.4 MJ/K

PASSIVE SYSTEM

Solar heated air is provided from the greenhouse on the ground level and by black metal tubes behind wooden-framed, double-glazed panels on the upper floor. In summer undesirable irradiatation is kept away from the collectors by reflecting roll-blinds. 16, windows openable manually or mechanically, reduce overheating in the greenhouse which has no sun protection. The rooms are also cooled by natural ventilation. Though the amount of glazing is minimal, the rooms receive sufficient daylight, particulary the upper rooms, thanks to clerestory windows underneath the lean-to roof.

Annual fuel use 1985/86:
(MJ/m2)

Heating	97
Lighting	6
Fans	4
Site energy	107
Typical existing Industrial building	750

ENERGY PERFORMANCE

In the winter 1985/86 solar gains covered 68 percent of the gross heating load. This computes to a use of 31 percent of the 285,000 MJ of available solar radiation. If the rooms were used continuously, auxiliary heating would have been still further reduced by the internal gains of people, lighting and equipment.

HUMAN FACTORS

This simple and understandable energy system requires the users to behave according to the seasons. Provided he/she dresses accordingly, the existing room temperatures between 18 °C and 24 °C do not create any problems. In any case differences of temperature from one day to the other, and from one room to the other do not exceed 1 °C.

Number of occupants:
Variable, smal

Time of occupancy:
Working hours

Building cost (1985):
SFr 1 100 000
ECU 645 000

SFr 1 730/m2
ECU 1 015/m2

Typical cost
SFr 1 500 - 1 900/m2

Cost of Passive System:
SFr 140 000
ECU 82 110

SFr 197/m2
ECU 115/m2

CONCLUSIONS

According to the client, the low storage and absorber temperatures result in good effiency of the solar system. The small temperature gradient between the concrete floor and absorbers had to be taken into account in dimensioning the canal configuration and ventilator capacity. The performance of the greenhouse has been most satisfactory. The wood-frame construction and excellent glazing permit a solar contribution to the building even in mid-winter. The effectiveness of the fan regulation strategy will be quantified after completion of the test period. This will help in determining the optimum temperature difference between supply and return air in the floor canals and collectors. At present the system is being monitored and controlled by a personal computer which permits fine tuning of its operation.

The building is very massive and well insulated and hence has very stable temperatures

The greenhouse and air collectors meet most of the heating demand

INFORMATION

P. Ruppert of Meteolabor, CH-8620 Wetzikon, provided this information.

Publications:

Schweizer Energiefachbuch 1988: "Ein Gewächshaus - wie es sein sollte", M&T Verlag AG, CH-9001 St. Gallen.

Büchler W., Gutersohn P., Ruppert P., Schlegel M., 1986: "Fabrikgebäude als Speicher", Sonnenenergie/Energie solaire No. 6, Postfach, CH-8050 Zürich.

Report prepared by:
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Süsstrunk Architekten
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CH-8703 Erlenbach-Zürich
Tel. 01/910.55.45

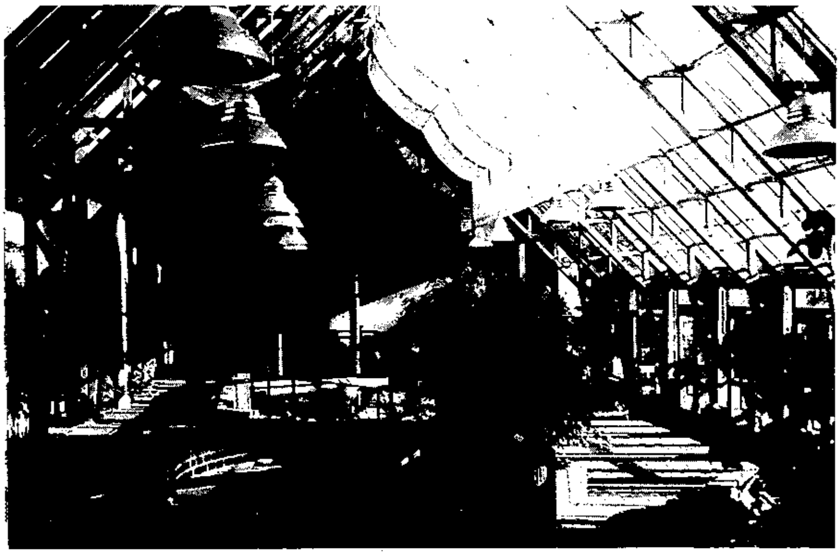
(D) GERMANY

BCS No.	Building Title
12	DAY CARE CENTRE
13	ESA BUILDING
14	St. MONIKA PALM COURT
15	TEGUT BUILDING
16	ENERGIELABOR
17	ZIEHL-ABEGG
18	TECHNOLOGIE-ZENTRUM
19	ZÜBLIN HOUSE
20	SCHOPFLOCH KINDERGARTEN

TECHNOLOGIE-ZENTRUM

D

DAY CARE CENTER



Interior View

<u>Building Type</u>:
Education

<u>Passive Features</u>:
Solar heating:
direct, indirect
Daylighting:
direct

<u>Occupant Date</u>:
End of 1988

<u>Floor Area</u>:	m^2
Old building:	
- heated:	481
- unheated:	13
Sunspace:	
- unheated	225
Gross:	719

<u>Building Costs</u>:
Retrofit and extension

ca.	DM 500 000
	ECU 240 581

Sunspace

ca.	DM 450 000
	ECU 216 523

<u>Annual Delivered Fuel</u>:	MJ
Before retrofit:	405 800
After retrofit:	347 200

<u>Client</u>:
District Council Berlin
Dep. of Youth and Sports

<u>Architect</u>:
Dipl.-Ing. Ch. Hartmann
Dipl.-Ing. I. Lütkemeyer
TU Berlin Department of
Bioclimatic Design
Prof. Hasso Schreck

<u>SUMMARY</u>

As a result of a students' competition at the faculty of "Klimagerechtes Bauen" at the TU Berlin, the day care centre at Olbersstraße in Berlin Charlottenburg is being altered and extended.

Various measures took place, which made an extension of the present building possible without additional need for energy. The main feature is the addition of a sunspace approximately 200m^2. The sunspace is thermally self regulating and is used as a childrens' play area. It is fitted with the simplest features of passive climatisation for buildings.

The elements of the solar sunspace are:

- massive building components for energy storage (floor, walls, spandrel walls)
- air vents at the top and the eaves
- roller blinds for shading, behind the south oriented glass front
- ventilated hollow mass construction in floor and spandrel walls

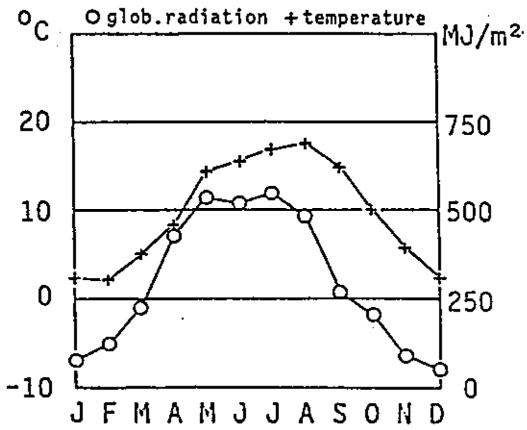
<u>PROJECT DESCRIPTION</u>

At present a youth recreation centre and a special day nursery are located in the single-storey building (ca. 500m^2). In the long term an alternative location has to be found for the youth centre.

On behalf of the local authorities in Charlottenburg a package of measures was designed so as to improve the functional conditions, and on to reduce the energy demand of the U-shaped building.

SITE AND LOCATION

The building is located in an urban area of Charlottenburg with free exposure to the south.



Site Data:

Latitude:	52.3° N
Altitude:	50 m

Climate Data:

Degree Days:	
September to May:	3 809
Annual:	3 964
Global Radiation:	MJ/m²
September to May:	1 996
Annual:	2 678
Sun hours:	
Actual:	1 706
Actual/theoretical:	0.39
Average temperatures:	°C
Winter:	7.0
Summer:	16.6
Annual:	9.5

BUILDING FORM

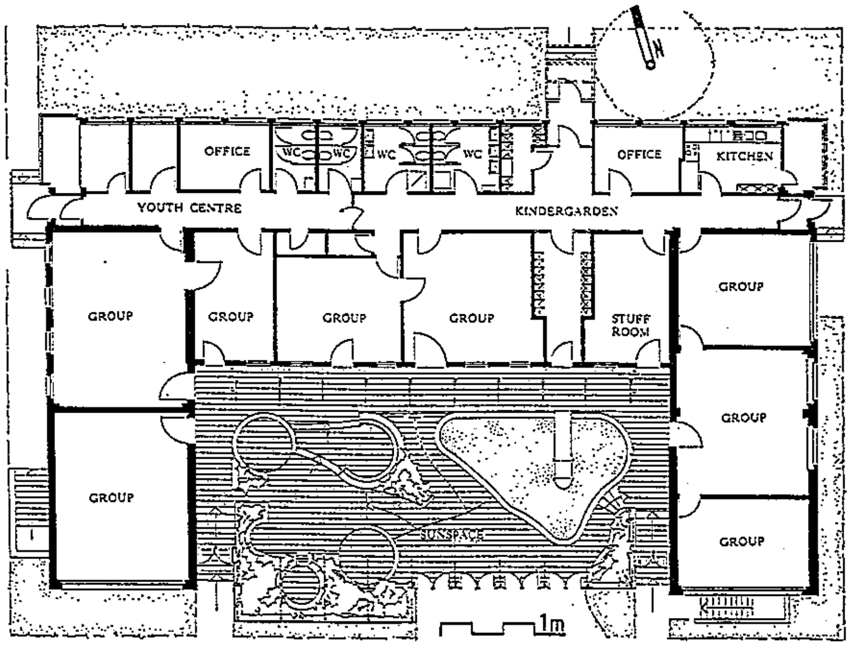
The leading idea is to roof over the south patio of the present building with a sunspace, which is a weather protected room outdoors, a green playing area under a glass sky. During spring, autumn and winter it offers various possibilities for games and creative activities.The sunspace is a transition area between inside and outside as well as a playing area.

According to these two functions two different spheres were created, one of which is a small, sheltered area and is introverted, whereas the other one is orientated to the free space and suitable for activities and games. Most of the groups'rooms are orientated towards the sunspace and have direct access to it. The reorganisation of the old building is closely connected with the measures for the new building. A cross-shaped hallway is planned; its east-west corridor is the link outdoors, the new north-south corridor connects the garden area and sunspace with the roadside and the new entrance.

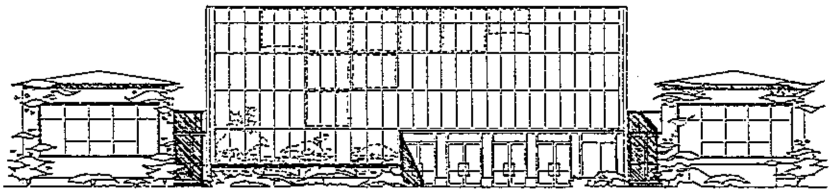
In addition to the existing buffer zones two sunspaces and a new entrance in the north have been installed. The south facing sunspace acts as a bufferzone and energy gain system.

Insulation of exterior walls and roof has been improved. Climbing plants at the facades will improve the microclimate.

Volume:	m³
Heated:	1 655
Unheated:	1 267
Surface Areas:	m²
Ground floor:	
Old building:	560
Sunspace:	230
Envelope:	
Old building:	1 107
Sunspace:	468
Glazing Area:	m²
Old building:	105
Sunspace:	253



Floor plan


South elevation

BUILDING CONSTRUCTION

U-values:	W/m²K
Old building:	
- walls	1.4
- windows	2.9
- roof	0.9
Sunspace:	
- glazing	3.0
- opaque components	0.5
- floor	1.3

Envelope Heat Loss:	W/K
Transmission:	
Old building:	1 110
Sunspace:	1 020

The present single-storey building is a double shell masonry construction with walls of 30 cm altogether (year of construction ca. 1930). The floor and the roof are wooden constructions; the ventilated roof is slightly tilted. The windows are mainly plastic frames with double glazing.

The extensions (sunspaces, porches) are wooden constructions and also equipped with double glazing.

The sunspace is a wooden framework construction with steel bars, and purlins which hold the puttyless double glazing. The floor consists of a reinforced concrete slap with bricks laid in mortar.

BUILDING SERVICES

<u>Installed Capacity</u>:
Sunspace unheated
Electric: 20kW
(lighting and minor consumption after retrofit)

<u>Design Conditions</u>:
Room temperature: 18.3°C
Sunspace: floating

The heating system of the day nursery is connected to the heating of a neighbouring school. The heat performance of the convectors which are situated in the underwindow spandrels, is controlled by thermostatic valves. The warm water is supplied by electrical appliances.

The sunspace is not heated; it is ventilated via ventilation flaps at the ridge and eaves.

PASSIVE SYSTEMS

South facing roof lights are to be installed above the east-west corridor so that the south sun can be used for daylighting and energy gain. The sheds have moveable night insulation (internal).

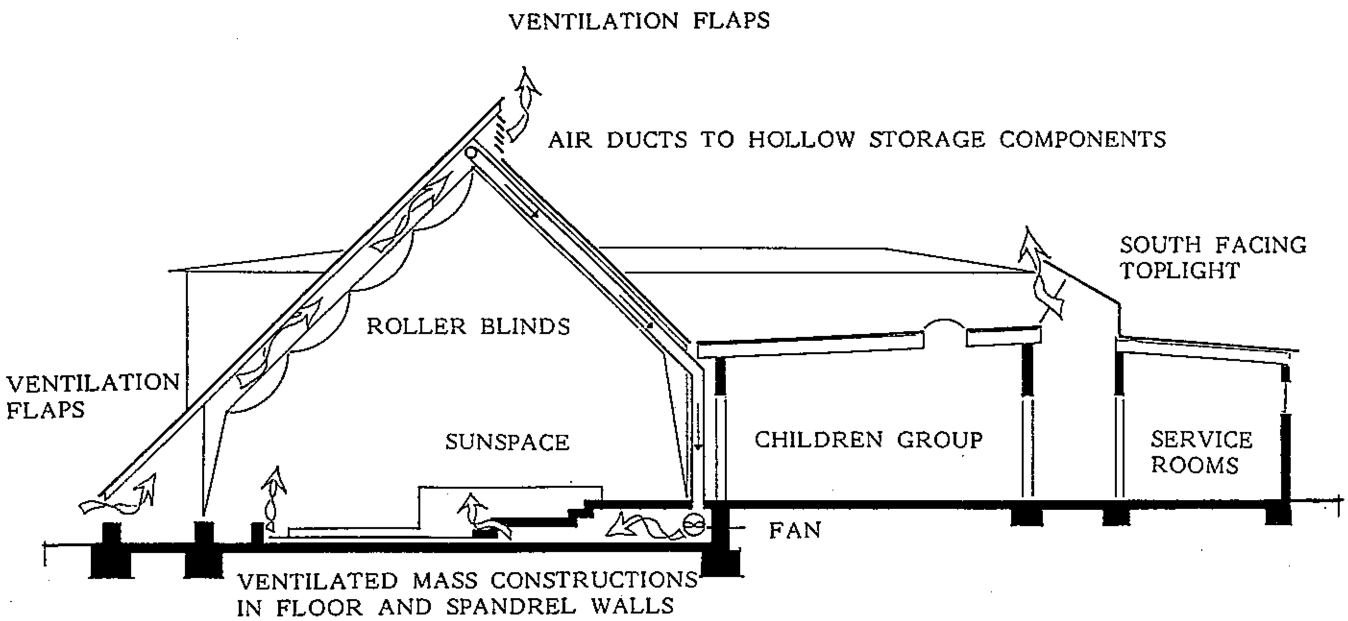
The south faced sunspace (200 m²) is unheated area of intermediate temperatures and is a buffer zone which works as a sun energy collector.

The radiation of the sun and the heat losses of the old building only, are used as heat sources. Although the sun radiation is primarily used for the conditioning of the sunspace, surplus energy can be directed into the inside rooms by opening the doors to the groups' rooms.

Main elements of the sunspace solar system:
- Internal thermal masses: bricks on the floor, walls of the old building, spandrels
- ventilation flaps at ridge and eaves
- inside shading blinds of the south glazing area
- tube system controlled by fans which suck out the warm air from the ridge of the sunspace and store the heat in the ventilated building areas within the floor of the sunspace.

CONTROL SYSTEM

Conditions in the sunspace can be controlled automatically or manually. The automatic control is necessary for a moderate room climate and the growth of plants, especially during weekends and holidays. The manual control allows the individual conditioning according to the users' requirements.



Building Costs: /m²

Retrofit:	DM	1 000
	ECU	481
Sunspace:	DM	1 950
	ECU	938
per child:	DM	20 000
	ECU	9 623

BUILDING COSTS

The building costs for the alterations and various minor extensions amount to DM 500 000 approximately; this equals a price of c. DM 1 000 / m² floor area.

The costs for the sunspace construction are estimated at DM 450 000, all solar devices included, which makes it DM 1 950 per square metre.

Annual Fuel Use: MJ/m²

District Heat:	
Gross	482
Heated	721
Reference building:	
new building	943
Hot Water:	
Gas:	6 750m³
Electricity	28 384kWh

Energy Costs:

Gas:	
Consumption	0.40 DM/m³
	0.19 ECU/m³
Total	0.51 DM/m³
	0.24 ECU/m³
Electricity	0.29 DM/kWh
	0.14 ECU/kWh

ANNUAL ENERGY PREDICTION

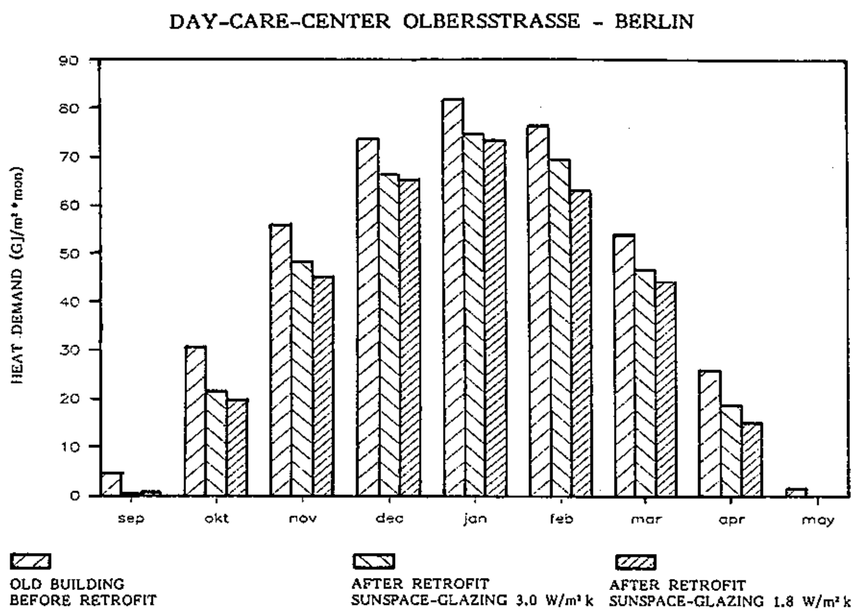
The Council of Charlottenburg asked for design strategies to reduce the energy consumption of the building by means of low expense. The aim was to increase the effective floor area without additional energy demand.

The attached sunspace expands the usable floor area of the building by nearly 50%. The sunspace is unheated as temperature swings are quite acceptable in the play and activity areas. This way the heating demand is reduced by 2/3 related to comparable demand per square metre of usable floor. The reduction of heat demand of adjacent heated space is about 17% (see graph).

The energy and temperature predictions have been provided by computer simulation of thermal analysis programmme SPIEL (Solar Passive Integrated Energy Language, by C. Green, Sheffield). The calculations show, that the big volume of the sunspace allows only a few usable energy support for the parent spaces. Therefore the sunspace was decided to act as a buffer space.

The target is to provide conditions of thermal comfort for the sunspace all year round.During the heating and transition period the air temperature should not exceed 25°C. On sunny days, when overheating tendency will occur, the interior shading device acts as an absorber. The heat accumulation of the air space between glazing and shading area will be used by sucking warm air from the top into the ventilated mass construction of the floor and the spandrel walls of the sunspace to be stored. Discharging of the storage occurs by time lag emission of heat.

By this way surplus energy can be stored to increase the usable solar gain without overheating the sunspace and to extend the temporal space use. Overheating in summer is avoided by ventilation flaps at the ridge and the eave. Ventilation and interior shading devices provide thermal conditions within comfortable ranges.



HUMAN FACTORS

As for the users'attitude only general statements about the nearly finished alterations can be made and assumptions about the expectations referring to the addition of the sunspace. Especially the improvement of the daylighting in the north parts of the building (kitchen, hall) is welcomed by the users. The functional reorganisation is backed up with a new pedagogical programme by the educators. Results are not available yet.

CONCLUSION

To what extend the project can be judged as successful, remains open until the definite inauguration. The users'willingness to be confronted with the problem "sunspace" in a day nursery has to be emphasized on the one side, but on the other side the difficulty to realize new, "not usual" but innovative ideas with a planning department and building control office.

The building is now not far from completion and it is hopefully expected that a monitoring programme could find an adequate funding. At least a low cost investigation of the actual energy performance is intended to be installed.

INFORMATION

A further report will be produced when building construction is completed (end 1988).
Contact:
Ingo Lütkemeyer, Technische Universität Berlin, Sekr. A 44, Straße des 17. Juni 135
D - 1000 Berlin 12, Tel.: 030 / 314 36 68

Design Occupancy:
Frequently 50 children
5 adults

Function:
Working
Playing
Education

Time of Occupancy:
15 hours per day
6-7 days per week

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on behalf of
Fraunhofer-Institut für Bauphysik
Nobelstraße 12
D - 7000 Stuttgart 80

D ESA BUILDING

Building Type:
Student home

Passive Features:
Solar heating:
direct and indirect
Daylighting:
direct

Occupant Date: Oct. 1986

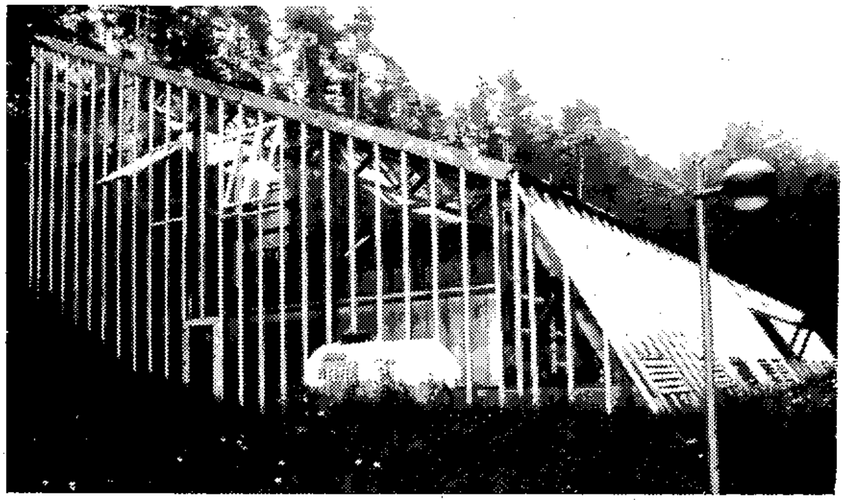
Floor Arae:	m^2
Gross:	1 403
Heated:	493
Unheated	910

Building Costs:	
DM	803 000
ECU	377 316

Annual Delivered Fuel:	MJ
total	386 663
$/m^2$gross	275
$/m^2$heated	784

Patronage:
Faculty of Architecture/ Department for Environmental Design/ Building Engineering, University of Kaiserslautern

Client
Student Association Kaiserslautern



West view

SUMMARY

The students'home in the grounds of Kaiserslautern University is a self build project which - apart from providing necessary accommodation - combines the aspect of living in a community with ecological questions. Furthermore the building has an experimental character with regard to its innovative architecture and its energy conscious design. It also gives students of architecture experience in practical work through design construction research.

The energy-saving aspect of the building consists of a 'house-in house' concept; the actual solid building is entirely wrapped into a thermal envelope (glass-house). Accommodation units are arranged in terraces ths allowing for varied structual and energy innovations (solar heat strategies). It also gives experience of living in a glass-house with intensive vegetation.

As expected the reaction of the participants (architects, workers, users) was heterogenous and varied - the mainly positive reaction of the inhabitants but also the somewhat imperfect experimental character of the building confirm the necessity of such innovative projects.

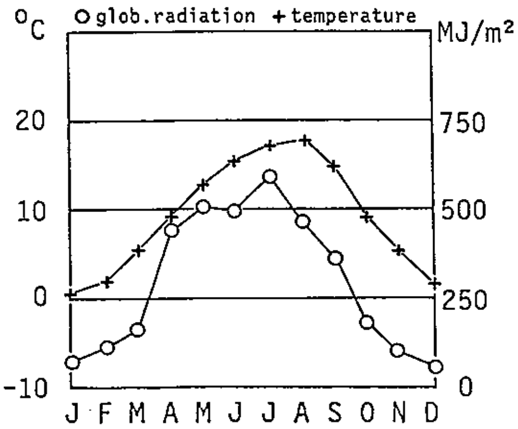
PROJECT DESCRIPTION

The building is situated on a slope and orientated south-south/west; its concept is a thermal envelope according to the house-in-house concept (size of plot 1080 m^2) In this particular self build experiment different types of energy saving concepts are being used and tested. The main aim was the achievement of an 'interim climate' by means of an artificial thermal layer, and observing the consequent conditioning of people and plants. The glass-house itself represents a buffer zone.

During the transition period heat is mainly supplied by solar radiation and the storage in the massive parts of the building. Further investigations concern the vented hollow block structures for the storage and transfer of solar gains, the use of mass walls (Trombe walls) which are fluid containers, air and water collectors as well as low temperature storage walls. In summer overheating of the thermal envelope is prevented by interior shading and adequate ventilation. Various types of irrigation systems are to be used on the cultivated terraces.

SITE AND LOCATION

The building is situated in a clearing on the edge of a wood of Kaiserslautern University area.



BUILDING FORM

The house-in-house concept presents a thermally massive centre with dwelling units and a thermal envelope covering the entire structure. 16 units in solid brickwork and 4 units in timber construction are spread over three floors of terraces. Apartments on the ground floor and first floor are reached via passages facing north. On the ground floor the entrance leads into an extensive hall from where adjoining staircases lead to the upper floor with a communal kitchen and dining hall for 20 students.

Bathrooms and toilets are centrally located on the ground-floor, apartments facing south have small patios; differentiated private and semi-public zones between the dwelling units are created by the staggered arrangement in the layout and the section. An oblique glass wall orientated south forms the thermal envelope for the entire building, which represents a temporary extension of the living area.

The thermal envelope itself is not heated and represents a climate zone independant of the exterior where luscious subtropical vegetation will help to improve living quality in the community.

Executive Design:
Bauen-Forschen-Partner
Eissler + Hoffmann
Co-op. A. Weber, H. Krämer, R. Heidemann et.al.

Construction Supervision:
Bauen-Forschen-Partner
Dipl.-Ing, W. Hoffmann

Site Data:	
Latitude:	49.5 N
Altitude:	275 m

Climate Data:	
Degree Days:	
October to April:	3 297
Annual:	4 208
Global Radiation:	MJ/m²
October to April:	1 218
Annual:	2 787
Sun hours:	
Actual:	1 528
Actual/theoretical:	0.35
Average temperatures:	°C
Winter:	6.6
Summer:	16.6
Annual:	9.1

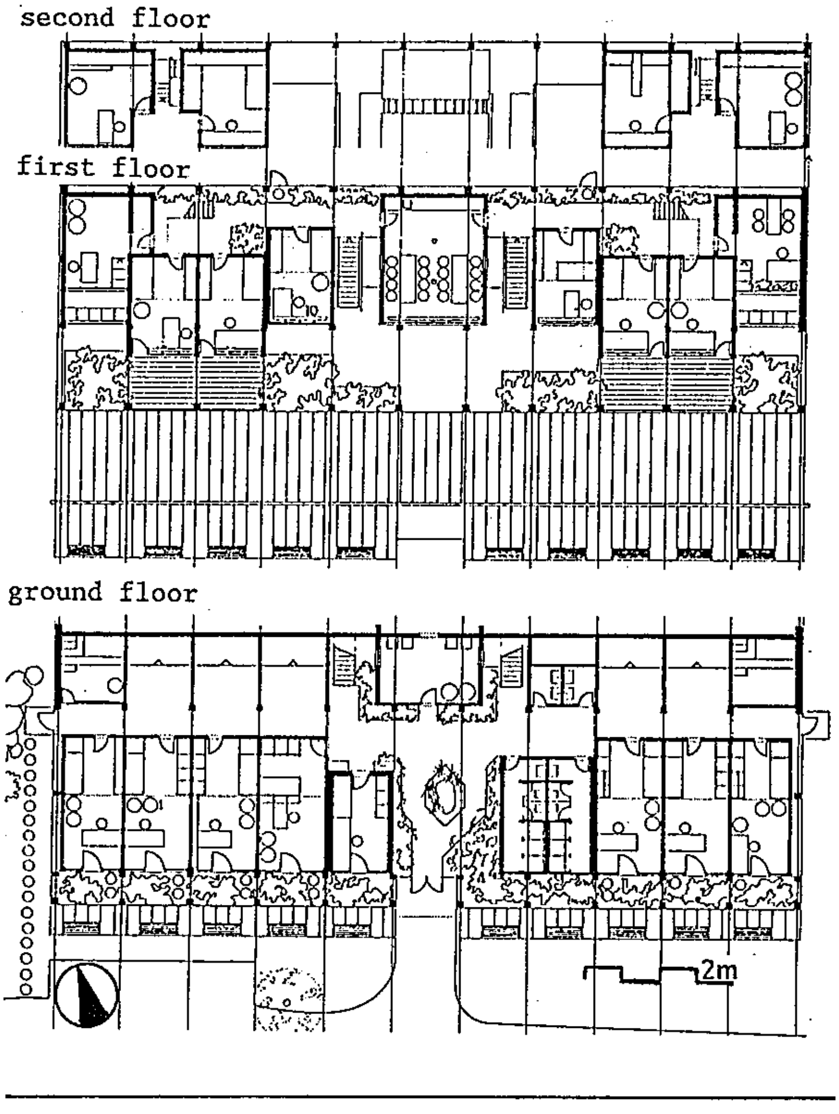
Volume:	m³
Gross:	4 503
Heated:	1 945

Surface Areas:	m²
Ground floor:	702
Envelope:	1 512

Glazing Area:	m²
exterior:	1 200
interior:	180

The main objectives of the experiment are:

- use of prefabricated brick elements such as low-temperature heat absorbing walls
- study of the effect of the thermal envelope and of plant behaviour under given conditions
- effect of massive brick on the interior climate
- feasability of a do-it-yourself project under given conditions (structure of course studies, student involvement, risks, co-operation on behalf of the University authorities)
- saving of heat-energy
- floor covering of U-shaped brick tiles partly enabling heat transfer
- use of mass walls by water containers
- cover of the thermal envelope with a U.V. transmittant plastic membrane
- use of plastic profiles for large glazed areas (side walls of the thermal envelope) as a do-it yourself task
- installing vacuum heatpipe collectors for domestic hot water supply
- construction of moveable shading units



BUILDING CONSTRUCTION

The terraced building located on a slope contains 16 units with ceilings and walls constructed of massive brick walls; 4 units are made of timber.

The thermal envelope is a timber-framed structure with a slope angle of 24° in the roof.

The roof consists of plastic clamps made of 0,15 mm strong Teflon-foil with a radiation transmission similar to window panes. The 59° vertical wall oriented due south and the flanks are made of glass and are equipped with vents.

Apart from the ventilation slats and the fire escape doors the northern wall is completely closed off. The exterior consists of galvanized corrugated iron; its interior surface is made from aluminium coated plastic foil and acts as a reflector.

U-values:	W/m^2K
Floor/ceiling:	0.31
Partition walls to Sunspace:	
Light-weight brick:	0.51
Northern wall:	0.33
Glazing:	
Living units:	2.80
Sunspace:	6.00

Envelope Heat Loss:	W/K
Transmission:	7 560
Ventilation:	no data

BUILDING SERVICES

Heating: The entire building is fitted with low-temperature radiator heating and a boiler with latent heat recovery supplied by a 2.7 m^3 tank of liquified gas by the side of the building. Thus initia costs for 300 m gas pipe could be avoided.

Ventilation: The dwelling units are ventilated via the thermal envelope (temperature hierachy by means of pre-heated fresh air). Ventilation is possible through aeration flaps at the base of the southern oriented, oblique glass wall and the roof ridge on the northern vertical wall ($30m^2$ aeration cross section). External thermostats help to regulate the system automatically.

Domestic water: Hot water is prepared by gas heaters, additional vaccuum collectors are being installed.

Irrigation: Irrigation of the extensive green house vegetation takes place automatically.

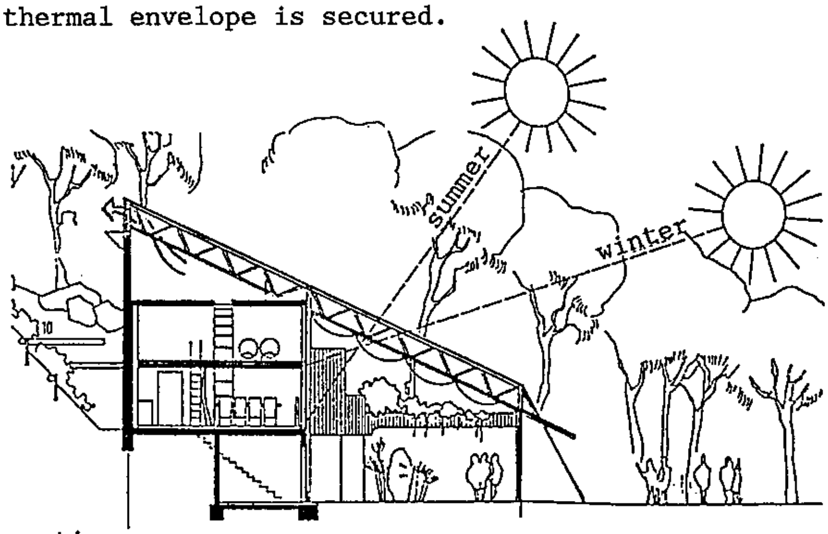
Installed Capacity:	W/m^2
Room heating:	40

Design Conditions:	
Room temperatures:	°C
Living units:	20
Greenhouse T_{min}:	5

PASSIVE SYSTEMS

The entire building acts as a collector with the internal units representing a sun storage system, e.g. they are planned as radiation and heat traps.The interior surfaces of the northern wall are reflective and increase the radiation (thermal) during winter and also increase daylighting.

The exterior glass house not only acts as a collector cover but also increases the enclosed living area during eight months of the year. In addition the glass house represents a thermal layer which reduces the effect of the wind speed to zero At the same time the ventilation heat loss of individual apartments drops to a minimum; and an exchange of fresh air from the preheated air of the thermal envelope is secured.



section

BUILDING COSTS

Building Costs (1987)/m²

DM	1 084
ECU	509
Reference costs:	
	DM 1 500 - 2 000

The building costs are around DM 800.000,-, which is approximately DM 1626,- per m² effective area. In relation to the inhabitable area under glass of which half can be taken into account, a price of DM 1084,- per m² for the effective area is reached which is low in comparison to the usual costs.

ENERGY PERFORMANCE

Annual Fuel Use:	MJ
Space heating:	257 775
/m² gross	183
/m² heated	522
Hot water:	128 888
/m² gross	92
/m² heated	261
Electricity:	80 470

Energy Costs:

Gas	0.53 DM/1
Electricity	0.17 DM/kWh

A reliable statement regarding the use of energy, the saving of solar energy and the solar gains is only possible after two to three heating periods. Estimates indicate an energy saving of 40% to 50% compared with conventional buildings where preplanned vacuum solar collectors have been taken into consideration.

periode Jan. 12.–30. 87 temperatures

day		12.	13.	14.	15.	16.	19.	20.	21.	22.	23.	26	27.	28	29	30.
outside	max	−12	−16	−12	−12	−10	−5	−3	−3	−3				0	−1	−6
	min	−15	−21	−15	−12	−12	−7	−7	−7	−8				−8	−9	−14
inside (foyer)	max	−6	−8	−5	−5	−3	+1	+1	+1	0				+3	+4	+1
	min	−7	−10	−7	−6	−6	−3	−1	−1	−3				−2	−3	−8
inside (terrace)	max	−5	−6	−3	−4	−3	0	+1	+1	0				+4	+3	+7
	min	−6	−9	−7	−6	−6	−3	−3	−2	−4				−2	−3	−9

HUMAN FACTORS

The intentions of the 20 inhabitants of the ESA are mainly expressed in the unusual appearance of the building, its relaxed architecture and the concept of a community orientated life-style. Especial interest was taken in the integration of the entire planning and building concept into the course of studies as well as the opportunity of designing, building and living in an unconventional building. It presented the opportunity of personally examining the potential and experiencing the practical use of a solar concept and living in concert with nature.

The house-in-(glass)house concept enables the experience of the various seasons sheltered from rain, snow and storm. The climate (especially the temperatures) is becoming a decisive factor for the domestic way of living. Incidental radiation at the end of Feb./beginning of March 87 was sufficient to raise the room temperature to 19-22°C with an outdoor temperature of 3-5°C. This caused the inhabitants to extend their living space into the green house area (first sunbathing Feb. 24.87).

Daylighting of individual rooms is dependant on their location within the building; some rooms on the ground-floor have daylighting problems during winter. The temperature of the free floating thermal envelope creates as a rule a climate condusive to health - low temperatures near freezing point in the unheated zones are easier coped with during winter than extremes of 50°C occuring during summer. Shading installations have been installed quite recently. The advantage of the cost-effective U.V. permeable Teflon membrane of the roof is little noise disturbance during rain; this is opposed by a lot of noise disturbance during storms and lack of thermal quality (loss of heat, condensation). These problems, however, are overcome by the exceptional high quality of living, the relaxed concept of building and the integration of climate and plants.

Design Occupancy:
20 occupants
15-25 m^2 per head

Functions:
Dwelling
Living
Working

Time of Occupancy:
24 hours per day
7 days per week

CONCLUSION

On the whole the aims of the projects were realised. The interest shown in the concept and the actual building exceeds all expectations. Future times of building operation and performance will show which conceptional and energetic strategies can be improved to encourage similar following up projects.

INFORMATION

Documentation: in "Alternative Konzepte 57, Wohnbiotop", Verlag C. F. Müller Karlsruhe (dec. 87)
Contact: Prof.Dipl.-Ing. H. Eissler, Kaiserslautern, Dipl.-Ing. W. Hoffmann, Neustadt.

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on behalf of
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D

ST. MONIKA PALM COURT

Building Type:
Nursing hostel for the elderly

Passive features:
Atrium
Daylighting: indirect

Main entrance of Haus St. Monika

Occupant Date: July 1984

Floor Area:	m^2
Gross:	17 644
Heated:	15 674
Unheated:	1 970

Building Costs:	
DM	59.0 Mio
ECU	26.4 Mio

Annual Delivered Fuel:	MJ
Dist. Heat:	10 906 488
Elect.:	3 368 420

Client:
Caritasverband Stuttgart

Design and Construction Supervision:
Zinsmeister + Scheffler, Freie Architekten BDA

SUMMARY

This home for the elderly, in Stuttgart - Neugereut is arranged in three parts: the hostel and the nursing home with the service centre in the main building, the staff quarters, and the home which houses 275 occupants. In this study the main part only will be described with its semi-public atrium (palm court) which represents an attractive centre. It has become a landmark and is generally admired.

For the occupants who are no longer able to leave the home this semi-public area to some extent represents life outside the home.

The palm court was not intended to save energy. In a large building complex it presents a cultivated area which is made attractive throughout the year by plants, water, light and sun.

PROJECT DESCRIPTION

The concept of this centre for the elderly is based on the idea of creating centres which fulfill services for its occupants and for the elderly living in the catchment area. Among others the following facilities have been provided: a hall for public functions, a cafeteria, facilities for therapy such as a small swimming pool with "Kneipp" equipment, a gymnasium, a workshop and hobby rooms.

The buildings had to be fairly low (maximum 4 storeys) in order to blend into the surroundings and to enable the occupant to communicate with the outside from the room or the balcony.

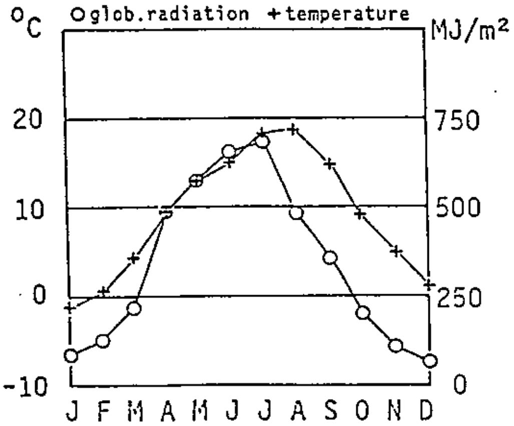
Roof gardens compensate for the loss of valuable open space lost due to building.

Its transitory character makes the atrium the focal point of the centre as it is located between the public areas, service centre and the home.

The entrances to the various parts of the home are located in the central hall from where the facilites of the service centre are also easily accessable.

SITE AND LOCATION

The building is located in a suburban residential area of Stuttgart.



BUILDING FORM

The home for the elderly, St. Monika at Stuttgart-Neugereut contains a total of 275 places provided as single-room units and double-room apartments. In the basement of the nursing home and hostel there are tradesmen entrances, secondary rooms for technical equipment, storage rooms and utility rooms. Kitchen and dining room are located on the rusticated basement as well as a pool for therapy with an adjoining gymnasium therapy and rest room and facilities for larger groups and the personnel. Apart from various secondary rooms and administration offices the ground floor houses mainly apartments for the elderly. Single room apartment staff rooms as well as therapy and utility rooms are located on the 1 - 3 floor. A cafeteria and a large hall are located on the first floor. The palm court forms the centre of the building which is four storeys high and covered by glass canopy. Passages at the side of the hall lead to the apartments and recreation rooms.

Environmental Design:
Gesswein +Roth, Freie Landschaftsarchitekten

Statics:
Dipl.-Ing. Walter Burger
Stuttgart
Beratende Ingenieure
Peter+Lochner

Service Ingeneer:
Ingenieur-Büro
Rentschler + Riedesser

Electrical Engeneer:
Ingenieur Büro Schwarz

Site Data:	
Latitude:	48.8°N
Altitude:	280 m

Climate Data:	
Degree Days:	
September to May:	3 434
Annual:	3 555
Global Radiation:	MJ/m²
September to May:	2 203
Annual:	4 016
Sun hours:	
Actual:	1 763
Actual/theoretical:	0.40
Average temperatures:	°C
Winter:	6.2
Summer:	17.4
Annual:	9.0

Volume:	m^3
Gross:	57 120
Heated:	41 780

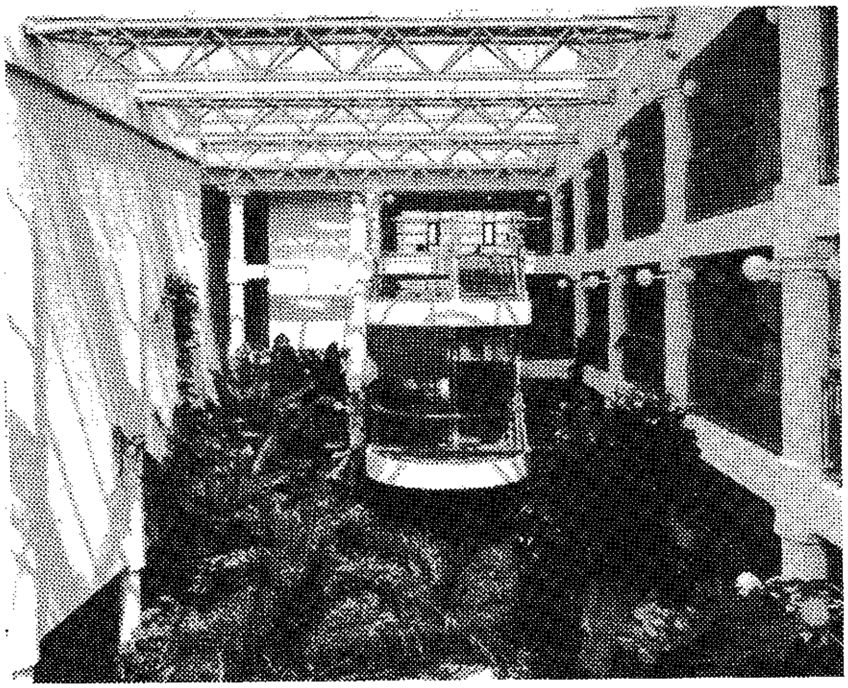
Surface Areas:	m^2
Ground floor:	ca 5 200
Envelope:	18 389
A/V	0.32 m^{-1}

Window Area:	m^2
Glazing area:	2 985
Glas roof:	560

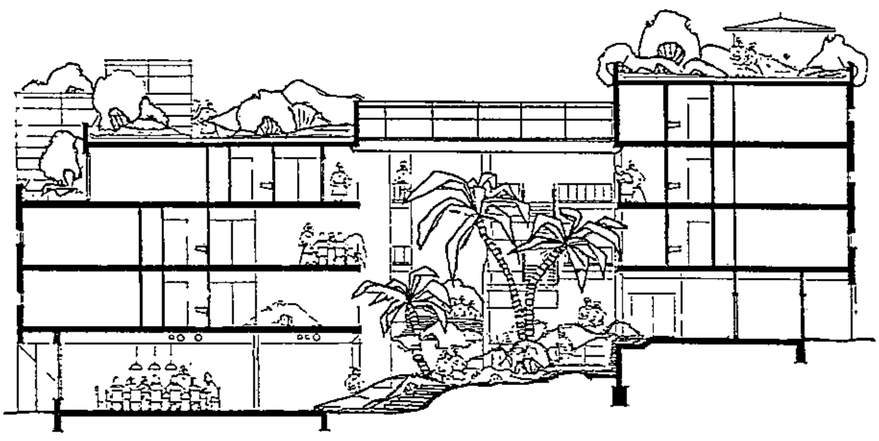
U-values:	W/m²K
Exterior walls:	0.52
Roof construction:	0.44
Basement ceiling:	0.76
Basement floor:	0.90
Basement walls:	0.83
Glazing:	
Window:	3.5
Atrium:	3.0
Envelope Heat Loss:	kW/K
Transmission:	18.4
Ventilation:	17.4
air change	69 700 m^3/hr
average acr	6-8/hr

BUILDING CONSTRUCTION

The building is a skeleton structure with heavy concrete panels, concrete supports and concrete walls. The exterior walls are either simply fiber cement panels-covered or fiber cement panels - covered and mounted on concrete with intervening air cavity. All windows are insulating double glazed, the frames are made of wood or thermally separated heat insulated metal frames. In rooms with relatively high humidity (e.g. tropical hall, pool, kitchen, laundry) windows, glass-doors and glass roofs with thermally separated metal profiles are planned, so that damage due to condensation can be prevented. The curved glass surfaces in the corridors are made of acrylic glazing. All flat roofs of the hostel and nursing home are roof gardens for actual use. The vaulted ceiling of the tropical hall is made of glass.



Interior view into the palm court



Section through the palm court

BUILDING SERVICES

Heating for the building is supplied by the power station Stuttgart- Münster by means of district heating newly installed by Technische Werke Stuttgart (TWS).

Calculation of the heat used is carried out by meters which are installed on the return run at the respective exchange stations.

During peak periods the amount of water required is supplied via a long distance pipe line; during winter 83/84 this amount of water was reduced to 12 000 l/h which corresponds to the actual heating requirements.

Sanitary installations as well as the pipe line's interchange points, a bank of control points for various heating and ventilation units are accommodated at this station.

At this station the following banks with the respective wattage are installed:

		kW
a)	south/west	331
b)	north/east	332
c)	interchange floor	12
d)	kitchen	12
e)	heating of glass canopy	69
f)	floor heating, gymnasium	6
g)	floor heating swimming pool	15

Installed Capacity: kW
Room heating: 1 448
(including ventilation)
Elect.: 1 013

Design Conditions:
Room temperatures: 20°C

PASSIVE SYSTEMS

Rather, the goal was to provide a large building complex an attractive space rich with plants, water and sunlight.

Various problems which had been expected did not occur: the air in the hall is clean and additional supply of air was not necessary. The air supply which is transmitted into the hall via the main entrances, exits on the roof etc. is entirely sufficient and even when the sky lights are opened during extreme sunshine in summer, a greenhouse climate does not occur. These favourable conditions were created without sun protection above and below the glass canopies. A shading system, however, was installed as a safety measure; it is obvious that this was not necessary. Even during winter the influence of cold air did not lead to draught. The convector belts which have been installed above the beams are apparently efficient enough to neutralize any influx of cold air near the sky lights.

BUILDING COSTS

Building Costs 1987: /m²

DM	2 400
ECU	1 158
Comparitive costs:	
DM	2 300 - 2 400

The building costs of the entire centre for the elderly amounts to approximately DM 59 millions. Differentiation of the costs according to the various complexes is not possible.
Further calculations have shown that the cost of the atrium amounts to approximately one percent of the total costs. This is lower than other less attractive institutions.

ENERGY PERFORMANCE

Annual Fuel Use: MJ/m²
(exclusively hot water)

Gross:	717
Heated:	910
Electric:	221
Reference:	
Stuttgart area	933

FUEL TYPE	FUNCTION	DELIVERED FUEL (MJ) total	per m²(gross)
Dist. Heat	space heating	10 906 488	717
Dist. Heat	hot water	1 727 640	100
Dist. Heat	all	12 634 128	817
Elect.	all	3 368 420	221
Dist.Heat and elect	all	16 002 548	1 038

HUMAN FACTORS

Design Occupancy:
155 elderlies
120 employees
40 temporarily

Functions:
Living
Communication
Nursing
Office

Time of Occupancy:
24 hours per day
7 days per week

For inhabitants and visitors alike the palm court represents a most important and spectacular building element.

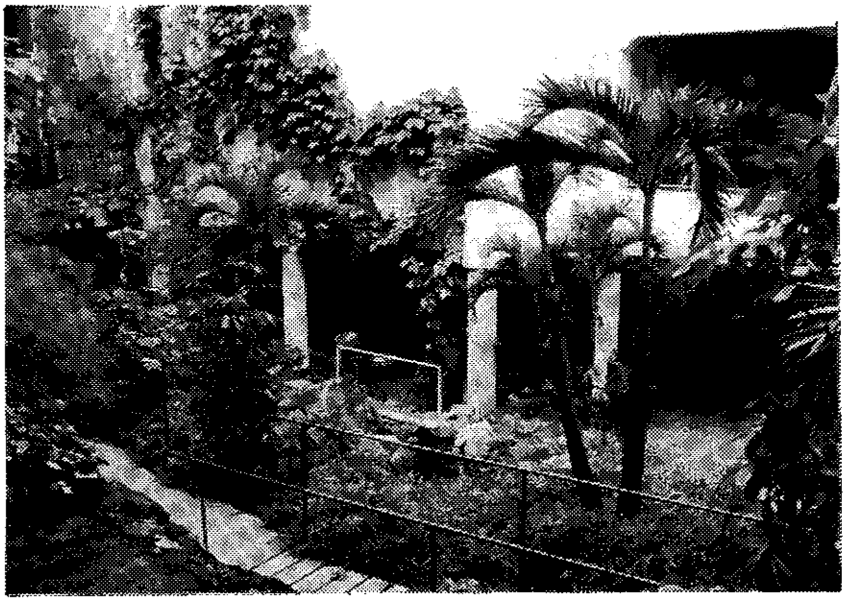
As well as admiration it has attracted criticism regarding the building and maintenance costs and the possible effect on rent. Further calculations have shown that the cost of the palm court amounts to approximately one percent of the total costs, e.g. when the enclosed palm court is compared with the alternative of a usual open interior court yard. Its costs are below the cost of the roof garden, the centre's swimming pool and other installations which do not offer the same facilities to the inhabitants.

Although there is no basement it was at first difficult to keep the plants alive in normal soil. The planned `drop-irrigation' from perforated pipes below the surface did not give maximum performance because of the difference in gradient in the hall; dry areas occured on the higher levels while excess water collected in the lower levels. Pest control on plants also presents a problem in a enclosed space.
The inhabitants enjoy using the hall very much which functions as a meeting place and also attracts the inhabitants on their daily stroll through the building. In addition it is their `representative object', an attraction with which one easily identifies with and which after all is part of the inhabitants' new home, demonstrating an increase in the quality of life.

This space shows an amazing change of atmosphere. Depending on the season, time of day and the wheather changes of light occur which give the room unusual qualities, never bordering the dull or monotonous. Monotony is also prevented by the sounds in the hall, the rippling water of the stream, the waterfall and the bird population.

CONCLUSION

The hostel for the elderly at Neugereut enjoys great popularity in the Stuttgart area, likewise among the elderly and all those who professionally care for old people. Its identification mark is the palm court which has helped in furthering the positive image of the hostel.



"Palm court" with view to the restaurant, -cutting from the hostels'postcard

INFORMATION:

Architects:
Professor Rainer Zinsmeister
Dipl.-Ing. Giselher Scheffler, Freie Architekten BDA

Address of project:
Altenwohnanlage Stuttgart-Neugereut
Haus St. Monika, Seeadlerstraße 9-11
D-7 000 Stuttgart- Neugereut

Gesellschaft für Umweltplanung Stuttgart:
"Altenwohnanlage Stuttgart-Neugereut:
Energieuntersuchungen Teil 1, Grobanalyse", Juni 85
im Auftrag des Caritasverbandes für Stuttgart e.V.

Bearbeiter:
Ing.grad. F.Braasch, W. Gärtling, M. Hönuger, Dipl.-Ing Kerschkamp, Dipl.-Inf. (FH) Kraner, E. Seidl.

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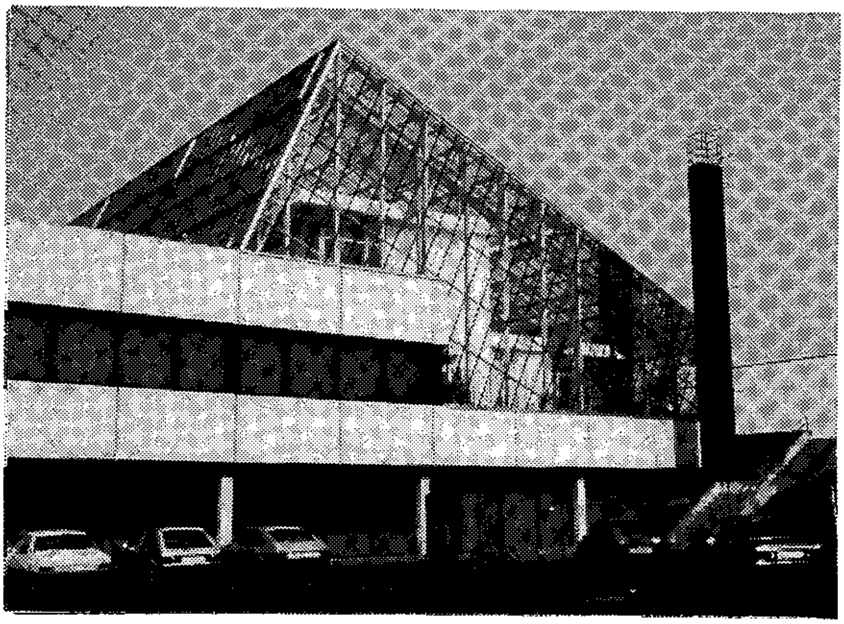
D

TEGUT BUILDING

Building Type:
Offices

Passive Features:
Solar heating:
direct, indirect
daylighting:
direct, indirect



South-west view

SUMMARY

The project deals with the extension of the administrative building from the seventies which belongs to the Tegut company in Fulda. In agreement with the principles of Green Solar Architecture (GSA) office pavillions were arranged on terraces and covered by a large glass structure (thermal envelope). By means of luscious vegetation this presents an attractive, temporary extension of the effective office space. Energetically the thermal layer acts as a buffer zone and solar gain system, which helps to reduce heating energy consumption.

From the architect's point of view the project presents an innovation office building design. An essential step towards "humanisation" of working areas has been made by applying creative dimensions. Users reaction's show the success which also confirms the validity of the concept.

Occupant Date:	1985
Floor Area:	m^2
Gross:	1 000
Heated:	537
Unheated:	463
(t min=5 °C)	
Building Costs:	
DM	1 600 000
ECU	718 675
Delivered Fuel:	MJ
	270 382
(1.9.1986-31.5.1987)	

Client:
Fa. Tegut, Fulda

Architects:
LOG ID, Tübingen
Dieter Schempp
Fred Möllring
Winfried Klimesch
Jürgen Frantz

Constr. Supervision:
Heinz Wolf, Fulda

Coordination:
Hoßfeld, Fa. Tegut

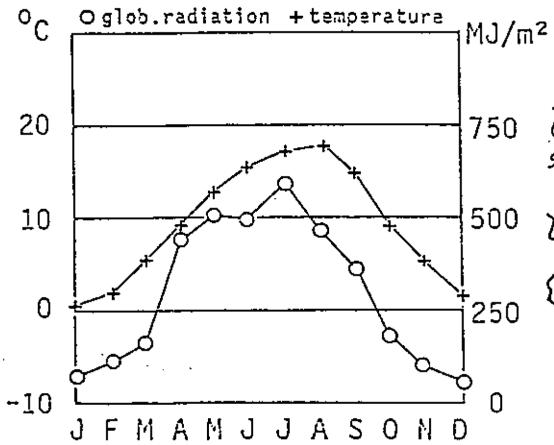
Monitoring:
Prof. Dr.-Ing. G. Hauser

DESCRIPTION OF PROJECT

An existing office building - plannned as an open plan office and fitted with air conditioning - had to be extended. The open plan office found approval but not the air conditioning. The new architecture should include ecological and environmental features. The company management wanted an architectural design oriented towards the future. However, the costs had to be competitive with conventional building concepts. The extension was to accommodate 40 working places. Plants were an important factor in the improvement of the air and the climate. The glass house is used for solar gain, which reduces the energy requirements of the building.

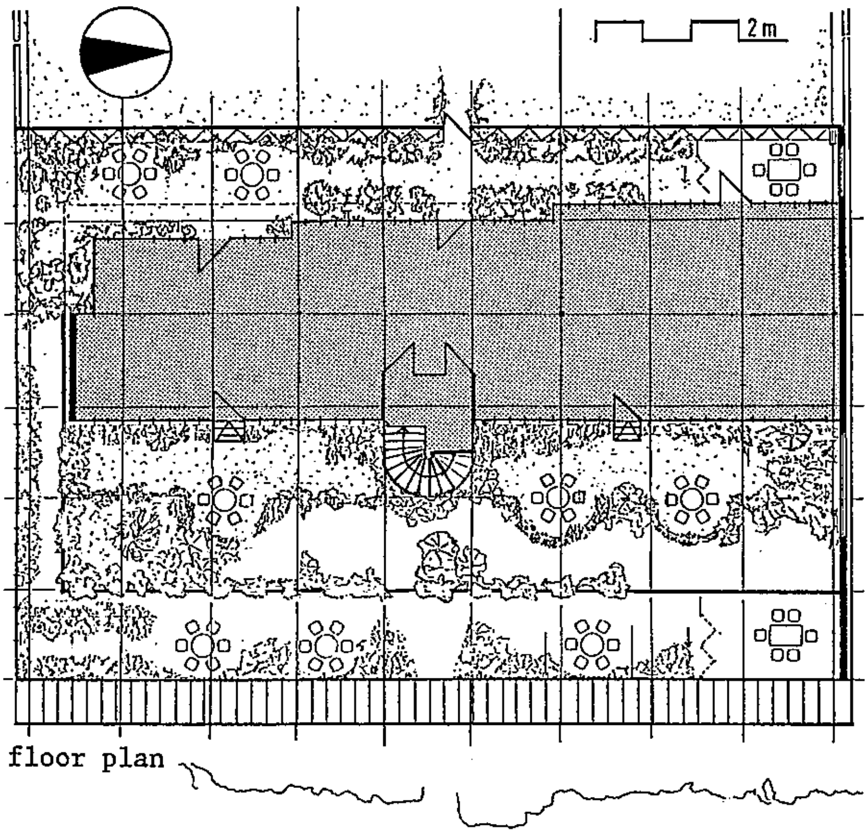
SITE AND LOCATION

The administrative building of the Tegut company is located in the industrial park at the outskirts of Fulda.



BUILDING ORGANISATION

The plot available was not large enough for the building and therefore it was planned on two levels. To gain sufficient height a glass cube was placed at a slant and mounted onto the existing roof, touching it with one edge only. For energy reasons the larger part of the northern wall is closed off and only few windows allow a glimpse across the countryside.



floor plan

Site Data:	
Latitude:	50°30' N
Altitude:	280 m

Climate Data:	
Degree Days:	
September to May:	4 060
Annual:	4 300
Global Radiation:	MJ/m²
September to May:	2 104
Annual:	2 787
Sun hours:	
Actual:	1 600
Actual/theoretical:	0.36
Average temperatures:	°C
Winter:	6.6
Summer:	16.6
Annual:	9.1

Volume:	m³
Gross:	4 785
Heated:	1 170
t min = 5 °C:	3 615

Surface Areas:	m²
Ground floor:	1 000
Envelope:	1 247
Walls of pavillions to greenhouse	377

Glazing Area:	m²
Exterior:	1 116
Interior:	243

Window Fractions:	%
Lower office	30
Upper office	57

According to the latitude a special concept was developed for the Green Solar Architecture which is the combination of a good heat-insulated house and a glass house. The glass house also represents a thermal layer, housing the office pavillions which are not affected by weather influences.

On both floors an open plan office has again been created. The working areas are screened off optically by sound-insulated dividing walls. Individual lighting underlines the separation of the various working areas. The two open plan offices are separated from the glass house by glass walls. Weather permitting, glass panels are opened and the effective area is increased by paths, conference area and the cultivated areas.

By means of the reciprocal use and the varied impressions, an interesting and ever changing space is created. Not only is its visual impression changing, but also its climate, humidity level etc. are undergoing changes.

BUILDING CONSTRUCTION

U - values:	W/m^2K
Partition walls	0.55
Roof of pavillions	0.56
Floor of pavillions	0.56
Walls of envelope	0.36

Glazing:	
Envelope	3.5
Windows of pavillions	3.0

Calculated Heat Demand:	
Greenhouse	121 kW
Pavillions	25 kW
Total	146 kW

(related to greenhouse temperature of 10 °C)

The exterior envelope of the building is a tin-coated steel structure with double-glazing. The strapping consists of lattice work to give a less solid effect. The glass cover has ventilation flaps in the roof and the east and west walls. The use of healthy, non-poisonous materials was encouraged; consequently all girders are made of wood. Apart from glass, other components of the building were also made from wood. For scumbling and painting the wood only non-poisonous paints were used. All paths in the glass house are tiled.

The glass house contains relatively robust, subtropical vegetation and the plants were planted directly into the soil.

In this area we find evergreen plants as well as deciduous plants. Consequently, with careful planning, efficient shading can be achieved during summer and in winter light can reach the building directly. In the glass house the evergreen plants create an visually pleasant atmosphere during winter apart from creating oxygen.

These subtropical plants also require little care. Apart from bi-annual pruning and annual fertilisation they hardly require any work. An automatic irrigation system takes care of this which administers sufficient water to the plant roots. This is controlled by moisture sensors in the soil. The correct choice of plants is a prerequisite for the functioning and the independance of this biotop.

BUILDING SERVICES

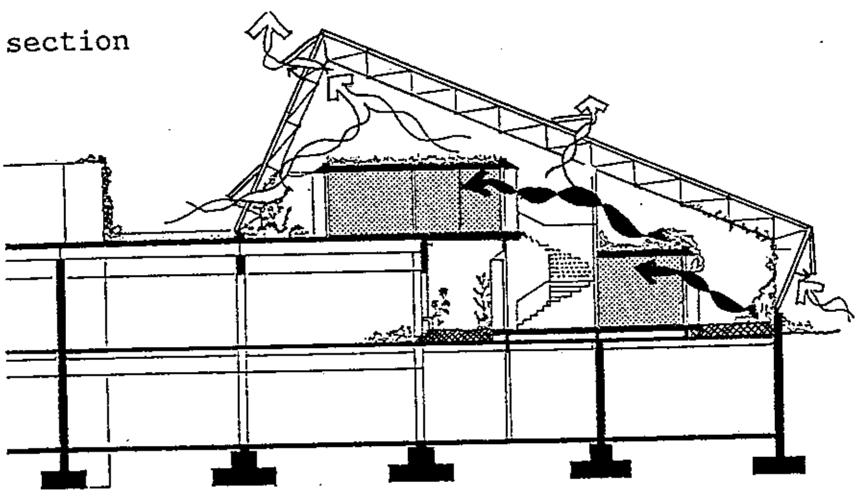
The heating system of the old building could be used for the extension as well because these two gas furnaces had been oversized (total capacity 1500kW). The existing heating system is being operated by a maximum temperature level of 75-80 °C. The building extension is seperated into two heating sections: pavillion and greenhouse. The system is designed as a dual system served by external temperature control. Both sections are zoned seperately in each floor. The pavillions are equipped with radiators whilst the greenhouse heaters are thermostatically controlled convectors. Reversely operating and revolve controlled ventilators are integrated into the partition walls of the pavillions acting for heating in winter and for cooling in summer as well. Electrical valves are installed for free ventilation between offices and greenhouse.

Spot-lights and hanging lamps above the conference tables provide the glass house with a pleasant light. For the offices indirect lighting is used in addition to desk lamps. Halogen lamps directed light onto the ceiling. In addition the amount of light required can be directed individually.

PASSIVE SYSTEMS

Air heated by solar energy is transmitted into the offices by opening the doors. In addition the office walls are fitted with ventilators which suck in thermostatically heated warm air. The heating units in the offices adjust themselves accordingly. On days without sun - providing the doors are closed - only the offices are heated and the glass house temperature is allowed to drop to 10°C. This has the advantage that only a small air volume has to achieve the temperature required for work; the outside temperature will never fall below 10°C.

section



Installed Capacity:
Room heating: 226 836MJ

Design Conditions:

Room temperatures:		°C
Pavillions	day	20
	night	12
Thermostat setting 18°° - 6°°		
Greenhouse	day	10
	night	5

For the central heating, thermostatically controlled radiators were chosen which can be adjusted individually. These also show a fast reaction to sunlight. To prevent overheating during summer large air vents were fitted into the upright walls and the ceiling; these can be opened and closed automatically by a heat sensor. In addition, the effects of the plants - through their shading and perspiration - is that of a climate control. The roofs of the offices are well insulated and also cultivated.

The combination of all these factors makes it possible to maintain a temperature in the glass house close to the temperature outside. It is even possible to achieve an indoor temperature a few degrees below outdoors.

COSTS

The total costs of the alteration amounted to approx. DM 1.6 Millions -, which is DM 3 200/m² for the office space, DM 1 600/m² for the effective area, DM 40 000 per working place.

ENERGY PERFORMANCE

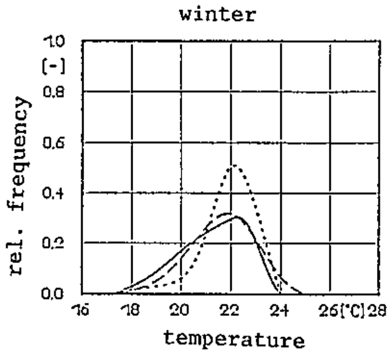
Accurate data of energy consumption are not available at the moment because there is no separated data recording of the new and the old building part. However, the results of the monitoring phase will give detailed information about the energy performance within the reported Advanced Case Study.

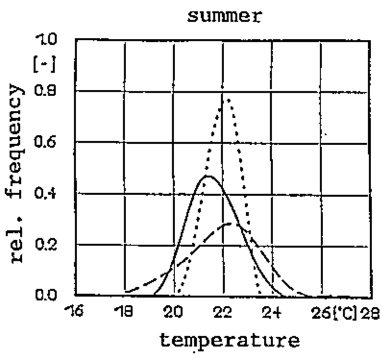
Building Costs:	/m²
Office area:	DM 3 200
	ECU 1 437
Effective area:	DM 1 488
	ECU 668
Reference	DM 1 765

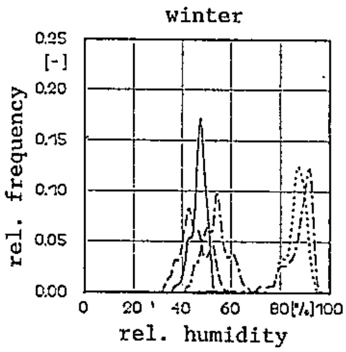
Annual Fuel Use:	MJ/m²
Gross:	270
Heated:	503
Reference	1 224

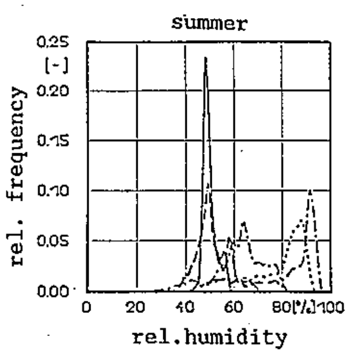
Relative Humidity:	%
Pavillions:	40-65
Glasshouse:	up to ambient

Content of Oxygen:	%
Pavillions	21









HUMAN FACTORS

This unique, so far, concept of an office building is also affecting its users. The plants liberate oxygen - which has a positive effect on the human organism - they attract dust and - depending on the type of plant - give off pleasant scents. In February the relaxing atmosphere is enhanced by butterflies and during summer by birds. The climate should be conducive to good health and reduce stress. The varying temperature strengthens the circulatory system and helps to prevent illnesses such as colds, fatigue etc.

The atmosphere in the glass house changes according to the season, depending on the various types of plants, growth and blossoms. The offices themselves present the required, relevant space for work. The interplay of both rooms and the atmosphere help to create a humane mood which stimulates creativity and enjoyment of work.

In four successive interviews the main differences between the original and the new open plan office could be established.

Design Occupancy:
40 persons

Functions:
Office, work

Time of Occupancy:
8°° to 18°°
flexible working times
5 days per week

CONCLUSION

On the whole it was possible to maintain the advantages of an open plan office and to improve its disadvantages which were caused by climatisation. The succes shows that the principles of Green Solar Architecture may also be applied to buildings other than single family homes.

The project is a research project which is supported and surveyed by the Ministry of Research and Technology (BMFT), Bonn. To establish the effective use of solar energy in office buildings of this type the temperatures have been measured and will be presented within an Advanced Case Study of IEA.

In addition research was carried out to establish the users conditions and consequent impressions of work to find out occupants acceptance. Questions regarding the sickness quota were also posed. The results gained will be applied to future buildings.

INFORMATION

LOG ID: Grüne Solararchitektur, "Firma Tegut", a documentation of the building.
Prof. Dr. Martin Krampen: Final Report about Investigations of Users Acceptance, R+D Report Nr.03E 8574A.
Prof. Dr Gerd Hauser: Report about Investigations of Energy Performance, R+D Report Nr.03E 8574A.

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Nobelstraße 12
D - 7000 Stuttgart 80

D

ENERGIELABOR

<u>Building Type</u>:
University Laboratory

<u>Energy Systems</u>:
passive/activ
Atrium, solar collector
photovoltaics, CHP-unit,
wind energy

<u>Occupancy Date</u>:Feb. 1982

<u>Floor area</u>:	m^2
Gross:	500
Heated:	250

<u>Building Costs</u>:

DM	2 100 000
ECU	885 878

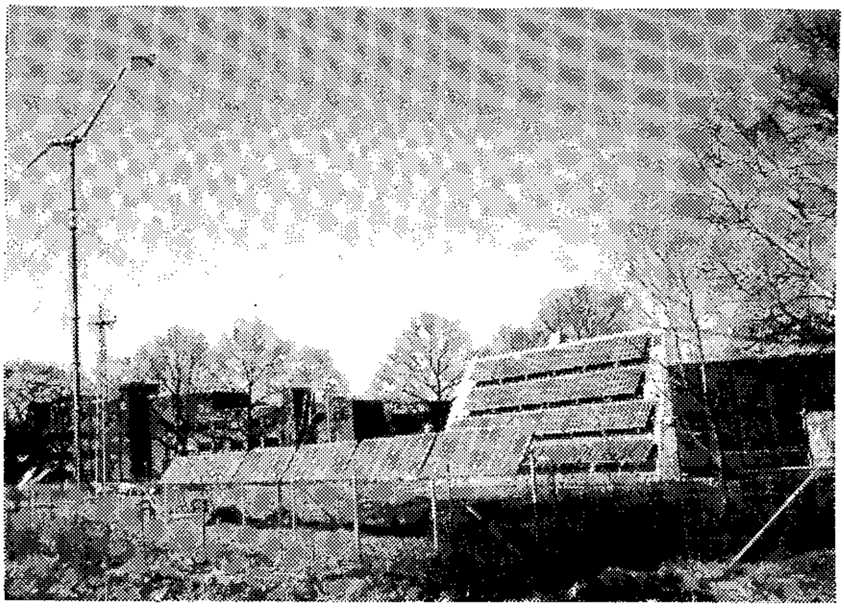
(including all technical facilities)

<u>Annual Delivered Energy</u>:
90 000 MJ
including 22 000 MJ from nonrenewable energy sources (gas)

<u>Client</u>:
County of Niedersachsen

<u>Architect</u>:
Jörn Behnsen
University of Oldenburg

<u>Monitoring</u>:
Renewable Energy
Research Group
Department of Physics
University of Oldenburg



South view

<u>SUMMARY</u>

The Energielabor of Oldenburg University is intended to be entirely independant of external sources of energy. It is not connected to municipal energy supply systems. There are passive and active uses of solar energy and wind energy.

<u>PROJECT DESCRIPTION</u>

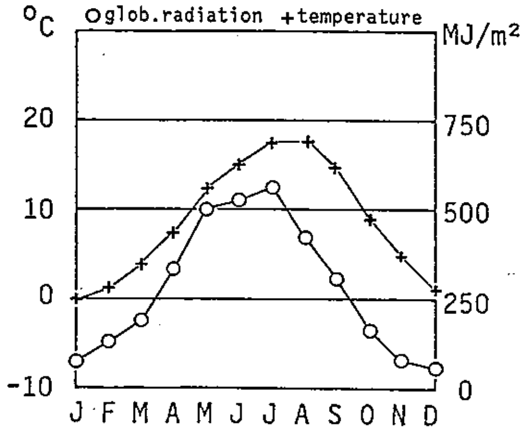
The planning and the architectural design were a joint effort of a working group of the University departments of physics, biology and planning. The participants are also, at present, occupying the building. Construction was carried out due to the extension of the Departments of Natural Sciences of the University; thus the budget was fixed according to the cost standards of scientific facilities.

The main emphasis of the clients' demands was a demonstration building as an experiment in which various kinds of renewable energy (sun, wind) are integrated into one single supply system (thermal and electrical). The building should be suitable for teaching purposes (practicals and seminars) as well as research e.g.:

- monitoring the peformance of the wind energy converter and the photovoltaic system
- monitoring of the energy flows (electrical) in the entire system
- survey of meteorological data on location for several years (hourly assessment)
- climate under radiation in a glass covered atrium
- simulation and modelling of hybrid electrical supply systems

SITE AND LOCATION

The building is situated on the outskirts of Oldenburg between the University sports grounds and the parking lots.



Site Data:

Latitude:	54°N
Altitude:	5m

Climate Data:

Degree Days:	
Heating season:	3 782
Annual:	3 800
Global Radiation:	MJ/m²
Heating season:	1 828
Annual:	3 420
Sun hours:	
Actual:	1 532
Actual/theoretical:	0.35
Average temperatures:	°C
Winter:	6.0
Summer:	16.4
Annual:	8.6

BUILDING FORM

After comparative energetic analysis of the building concept and considering the criteria of energy storage a circular shape of building - oriented towards the centre - was chosen.

The glass-covered atrium in the centre of the building helps to stabilize the temperature of this buffer zone (10°-12°C during winter). The exterior thermal envelope is folded to increase the solar collector surface for active systems. The main laboratories are housed in an octagonal, circular building surrounding the atrium.

In the outer buffer zone secondary rooms are located such as storage rooms for the lead acid battery and for the scientific appliances.

On cultivated embankment of north, east and west, a vegetation of creepers and climbers and various ponds increase the exterior micro climate.

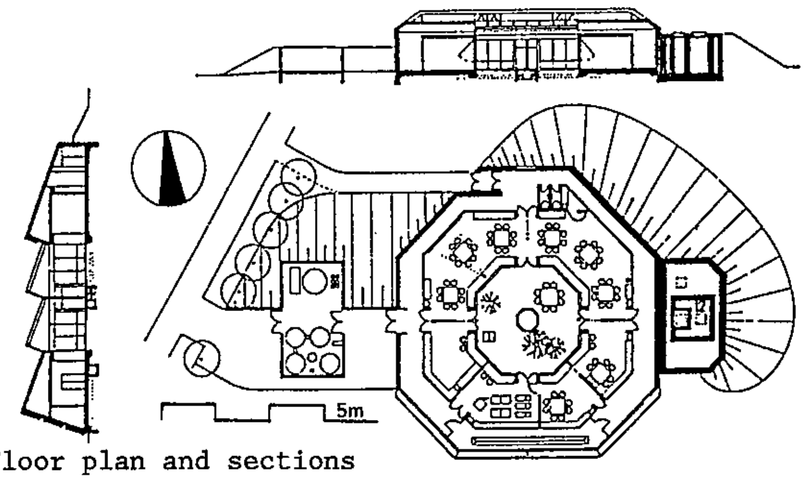
Volume:

	m^3
Gross:	2 000
Heated:	750
Sunspace:	350
Bufferzones:	900

Surface Areas:

	m^2
Ground floor:	1 425

Window area:
5% related to exterior walls plus
18% of roof (Atrium glazing)



Floor plan and sections

U-values: W/m²K
Envelope: 0.2
Glazing: 1.6

Envelope Heat Loss: W/K
Transmission and infiltration: 280
(considering an average value of 1 kW by internal heat sources)

Design Conditions:
Internal temperature of labs and working areas: 18-19 °C
Temperature of atrium: 10-12 °C

Installed Capacity:	kW
Photovoltaic panels	6.3
Wind converter	5.0
CHP-unit (elect.)	10.0
Lead acid battery:	208 V 800Ah

BUILDING CONSTRUCTION

The construction of the building is a kind of double envelope which contains a core area designed for 19°C surrounded by a second buffer area designed for 12°C. The external envelope covers the total floor area and main core spaces and creates the weather resistant layer of the building. Their exterior walls and roof contain the collectors (70° tilt angle) from south-east to south-west. The roof is a light weight construction made out of wood and 20 cm mineral wool for insulation. The exterior wall is a sandwich construction of masonry 24, insulation 20, airspace 4 and exterior brickwork of 11.5 cm. The interior wall consists of a light weight timber framework containing super insulated spandrel walls, thermopane glazed doors and double glazed window boxes, providing an air duct for heat recovery from the core spaces.

BUILDING SERVICES

Remark: The energy supply systems of the Energielabor are at present being modified (summer 1987). Technical data will be supplied for the new configuration.

Electricity supply: Wind energy and solar energy are combined in a hybrid system. The energy supply for five days may be stored in a lead acid battery. As back up source of electricity a combined heat and power unit (CHP-unit) is installed.

Heating: is from floor heating in the net floor area and is supplied by a 5 m^3 water storage tank into which the following heat flows end:

- heat from a field of 21 m^2 highly efficient collectors (evacuated tubular collectors)
- heat from a CHP-unit
- deep soil heat exchangers and heat pump

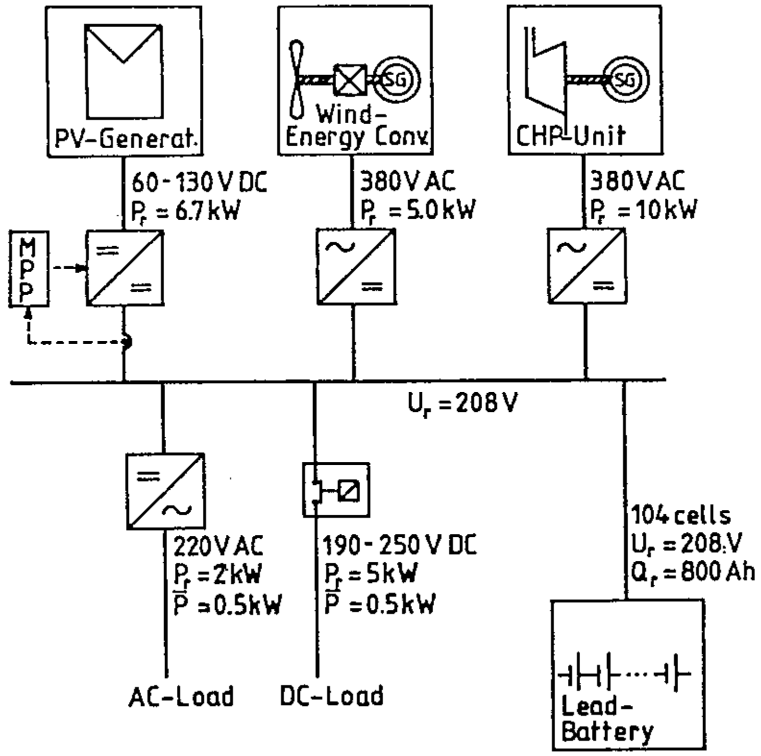
Daylighting: via the atrium.

Ventilation: is carried out by opening the windows and doors leading to the atrium.
An active cooling system has not been installed.

Domestic hot water: warm water for domestic use is produced by a heat exchanger in the heat storage unit.

During extreme weather conditions or technical failure of the systems due to experiments an additional air heating system can be operated.

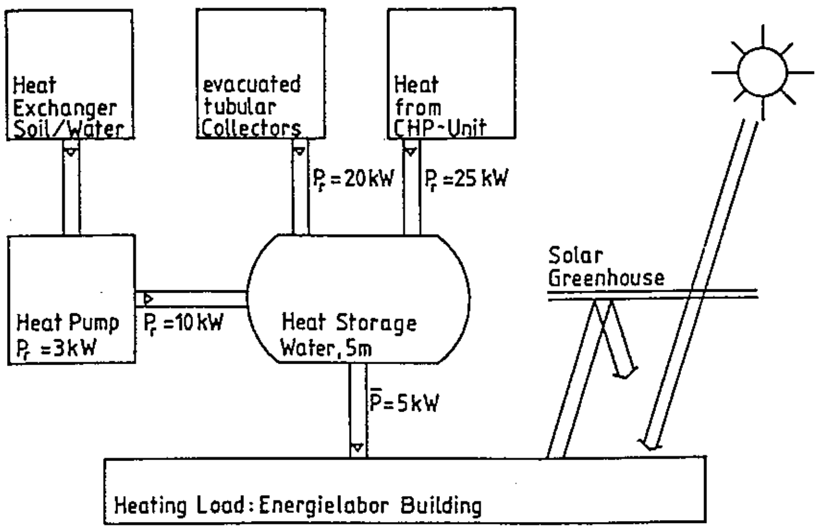
Room temperatures: are controlled by thermostats.



PASSIVE AND HYBRID SYSTEMS

- Radiative solar gain of the building via the glass covered atrium (passive).
- Highly efficient collectors and a warm water storage system for heating purposes (active).
- According to the requirements of the supply system for electricity, waste energy is produced which finds further use in the heating system. (CHP-unit).
- A heat pump and soil heat exchangers may be used to raise the temperature in the heat storage tank.

Systems are either operated automatically or manually.



Features:
Active collector area 21 m^2
Active storage volume 5 m^3
Rated electrical power of the heat pump: 3 kW
Rated thermal power of the CHP-unit: 25 kW

BUILDING COSTS

Building Costs 1982:	/m²
DM	4 200
ECU	1 770

At completion the building costs amounted to 2.1 million DM inclusive of technical systems and technical equipment.

ENERGY PERFORMANCE

Electrical Energy Delivered / Load

SOURCE	MJ/a	FUNCTION	MJ/a
Wind energy	22 000	Lighting and appliances	40 000
Solar (PV)	23 000	Losses	2 000
Gas through CHP-unit	2 000		
Total	47 000		42 000

The heat from the CHP-unit as well as the difference between the electrical energy delivered and the (electrical) load are utilized for the heating of the building.

Thermal Energy eelivered / Load

SOURCE	MJ/a	FUNCTION	MJ/a
"Waste heat from electricity production *	10 000	Heating	48 000
Solar collectors *	16 000		
Gas through CHP-unit and heat pump	22 000		
Total	48 000		48 000

* utilizable share of energy only, i.e. heat from the solar collectors produced during the summer will not be utilizable for heating in winter.

Total annual energy production from nonrenewable sources (propane gas):
To produce 2 000 MJ of elect. energy plus 22 000 MJ of thermal energy through the CHP heat-pump system, a total of 21 000 MJ = 450 kg of propane gas is consumed. The munerical values are calculated with a model of the Energielabor energy system based on experimentally validated models of the subsystems (energy converters and storage devices) and the result of energy balances taken over several months.

HUMAN FACTORS

The Energielabor is a place to work which is of high attractivity for students and scientists for several reasons.

The glass covered atrium in the centre of the building has been successfully planted with green vegetation. The view from the working rooms through the windows in a view towards the daylight and towards luxurately growing plants.

The Energielabor offers the room to retire for some hours from the buisy University situation into a pleasant surrounding. This is appreciated and used extensively for conferences or quit reacting hours. Students and scientists working in the building are responsible for the accurate working of the technical systems for energy supply. This leads to a special awareness of actual conditions related to the energy situation, wheather, energy consumption, state of change of energy storage devices as well as to a high degree of pesonal identification with the building and its technical problems.

Design Occupancy:
10 scientists and students
25 m^2/occupant

Time of Occupancy:
8 h per day
6 days per week
50 weeks per year

CONCLUSION

The aim of the project has been achieved, namely: to set up of a demonstration building for the use of renewable energy and for research into renewable energy which is also available for ordinary University courses.

The University of Oldenburg is provided with a unique research facility by this Energielabor

The experimental character of the building and the complexity of the supply systems as well as the standard of the technical units available at the time of construction causes comparatively high maintenance efforts.

If asked for a good advice for any future project without experimental character we would answer: "Keep it simple".

INFORMATION

Behnsen, J., Energielabor der Universität Oldenburg. Bauwelt 25 (1985)
Gabler, H., J.Luther, M.Nolte, Coupling of heat and electricity production in renewable energy systems. Proc. Int. Conf. North Sun'86 Kopenhagen (1986)
Gabler, H, J.Luther, Wind-solar hybrid electrical supply systems. Results from a simulation model and optimization with respect to energy pay back time. Solar & Wind Technology Vol.5, No 3 pp.239-247 (1988)
Contact: Dr. Hansjörg Gabler, Renewable energy research group, Department of Physics, University Oldenburg.

Report prepared by:
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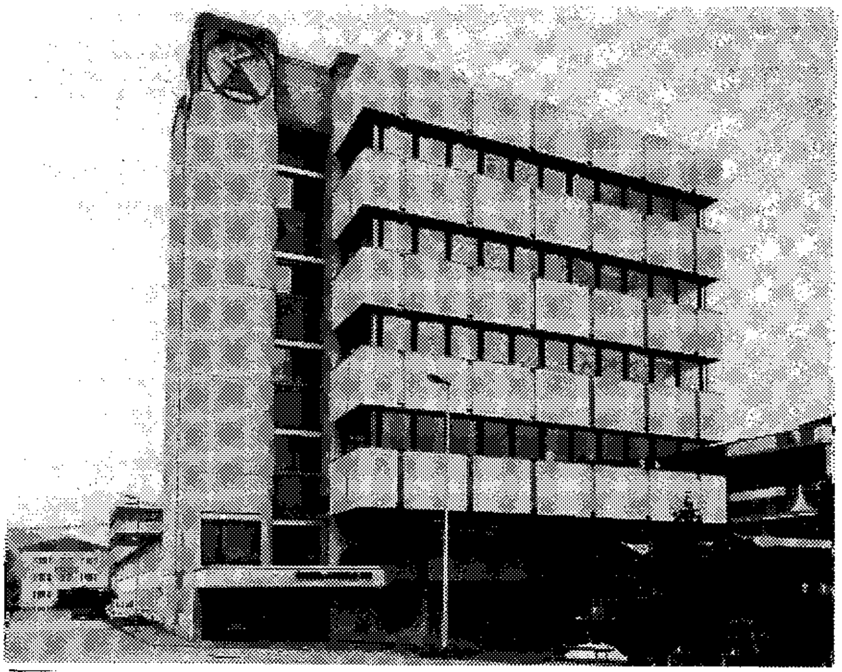
D

ZIEHL-ABEGG

Building Type:
Office Building

Passive-Hybrid Features:
Natural Ventilation



South-east view

SUMMARY

In this building with open plan offices of the Ziehl-Abegg Company in Künzelsau the goal was to prove whether a building like this could dispense with a conventional mechanical air conditioning system. The concrete slabs are not only constructed with regards to static requirements, but thermal points of view are considered as well. The concrete ceilings are used as heat - storing components in which the internal heat loads of the offices are temporarily stored. Compared to traditional air conditioning systems, this "system using internal masses" is extremely economical in terms of energy consumption and it leads to great contentment for owners and occupants.

Occupancy Date:	1976
Floor Area:	m^2
Gross	3 200
Office	2 500
Building Costs:	1976
DM	2 800 000
ECU	944 000

Annual Delivered Fuel:
30% saving comparitative to common constructions

PROJECT DESCRIPTION

Client:
Ziehl-Abegg KG
Künzelsau

Architect:
Walter E. Fuchs

Monitoring:
Walter E. Fuchs

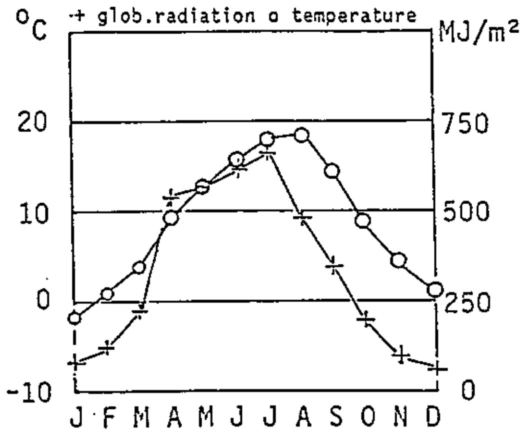
The planning task required the realisation of a 6-stories office building providing 3200 m^2 floor area and 150 working places. The main requirements by the client were the following in serie of order:

- creation of physiologically optimized working areas
- reversible layout of floor plan
- cost-effective realisation of the project
- low total running costs

Physiological comfort for the working space had many-sided influences on the overall design. A conventional air conditioning system had to be avoided to prevent against burdening monotony of indoor climate.

SITE AND LOCATION

The building site is situated at the edge of the middle-sized town of Künzelsau. This location offers an encourageable pre-condition for this hybrid ventilation system because of the minor emission loads of outdoor air quality.



Site Data:	
Latitude:	49°17'N
Altitude:	218m

Climate Data:	
Degree Days:	
Heating season:	3 767
Annual:	3 883
Global Radiation:	MJ/m²
Heating season:	2 203
Annual:	4 016
Sun hours:	
Actual:	1 740
Actual/theoretical:	0.40
Average temperatures:	°C
Winter:	6.2
Summer:	17.4
Annual:	9.0

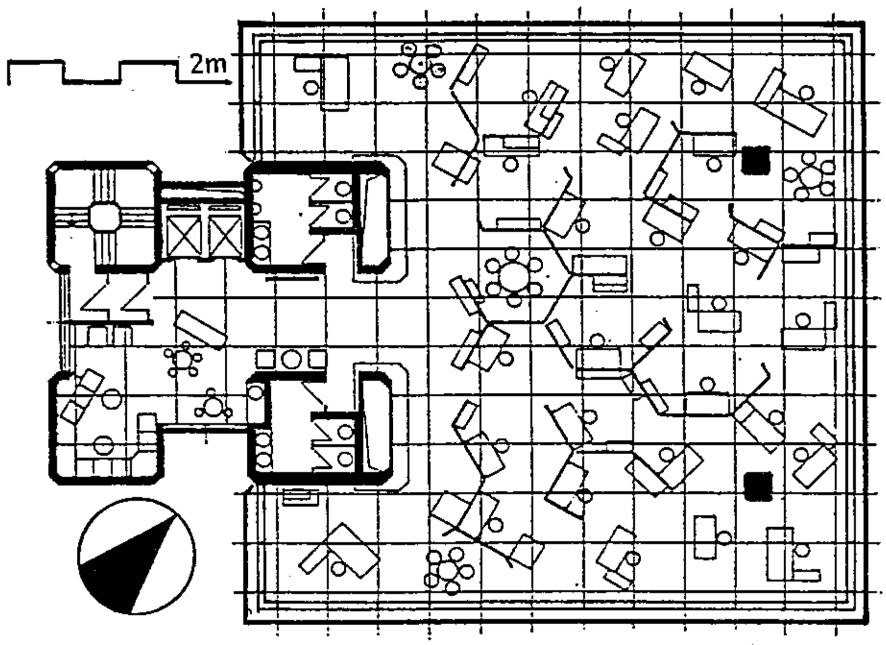
BUILDING FORM

The client tended towards a concept of open plan offices: The requirements of communication and function should be directed most favourable and flexible correlated to a high level of space comfort. However, a reversible basic layout should allow future structural modifications to provide arrangements of individual offices or clusters in case of demand. The "core" of the building including vertical development, secondary rooms and rest areas, is actually disconnected from the real office spaces. As an appendix of the south-west facade it provides a reduction of thermal loads in summer.

Volume:	m³
Gross, Heated	1 420

Surface Areas:	m²
Ground Floor	570
Roof	570
Wall	1 895
Window	835

Window-to-Wall-Ratio:	
South-west Facade	20%
Others	42%
Average	36%



Floor plan

U-Values:	W/m²K
Floor	0.62
Wall	0.65
Roof	0.62
Window	3.5

Envelope Heat Loss:	W/K
Transmission:	5 332
Ventilation:	1 335

Installed Capacities:	
Room heating:	450 kW
Electricity:	45 kW
Roof fans:	3 x 2.2 kW

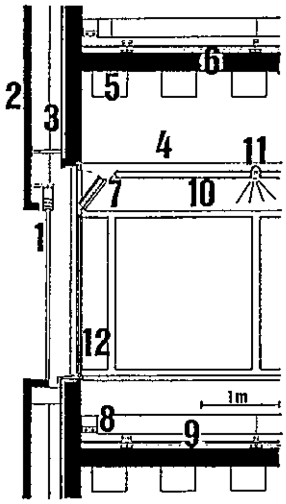
Design Conditions:	
Office spaces:	20 °C

Illumination levels:

Zone	W	lx	W/m²
I	2 500	550	18.0
II	1 500	550	19.7
III	1 500	550	19.7
IV	1 500	550	16.5
V	320		7.0

BUILDING CONSTRUCTION

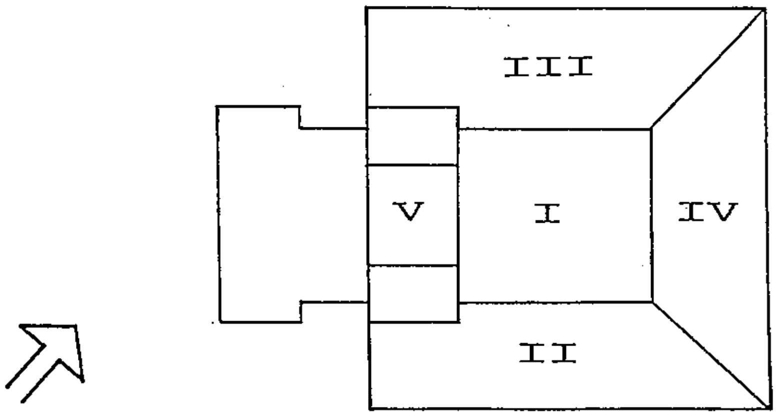
The open plan offices of level 2 to 5 are exactly the same in term of layout and size as wellas the technical execution of thermal interior components, interior design elements, building envelope, and the sizing of glazing. The building construction like supporting pillars and ceilings are made of cast-in-place concrete. The main storage mass is represented by the ceiling system of pierced joists to provide reasonable air movement beneath the ceiling. The ventilated sandwich facade is a prefabricated concrete curtain wall.



1 exterior shading
2 ventilated prefab curtain wall
3 insulation
4 joist
5 ventilation
6 ceiling mass storage
7 air intake valve
8 convector
9 elect. in-slab system
10 suspended acoustic insulation
11 lightening system
12 aluminium window system

BUILDING SERVICES

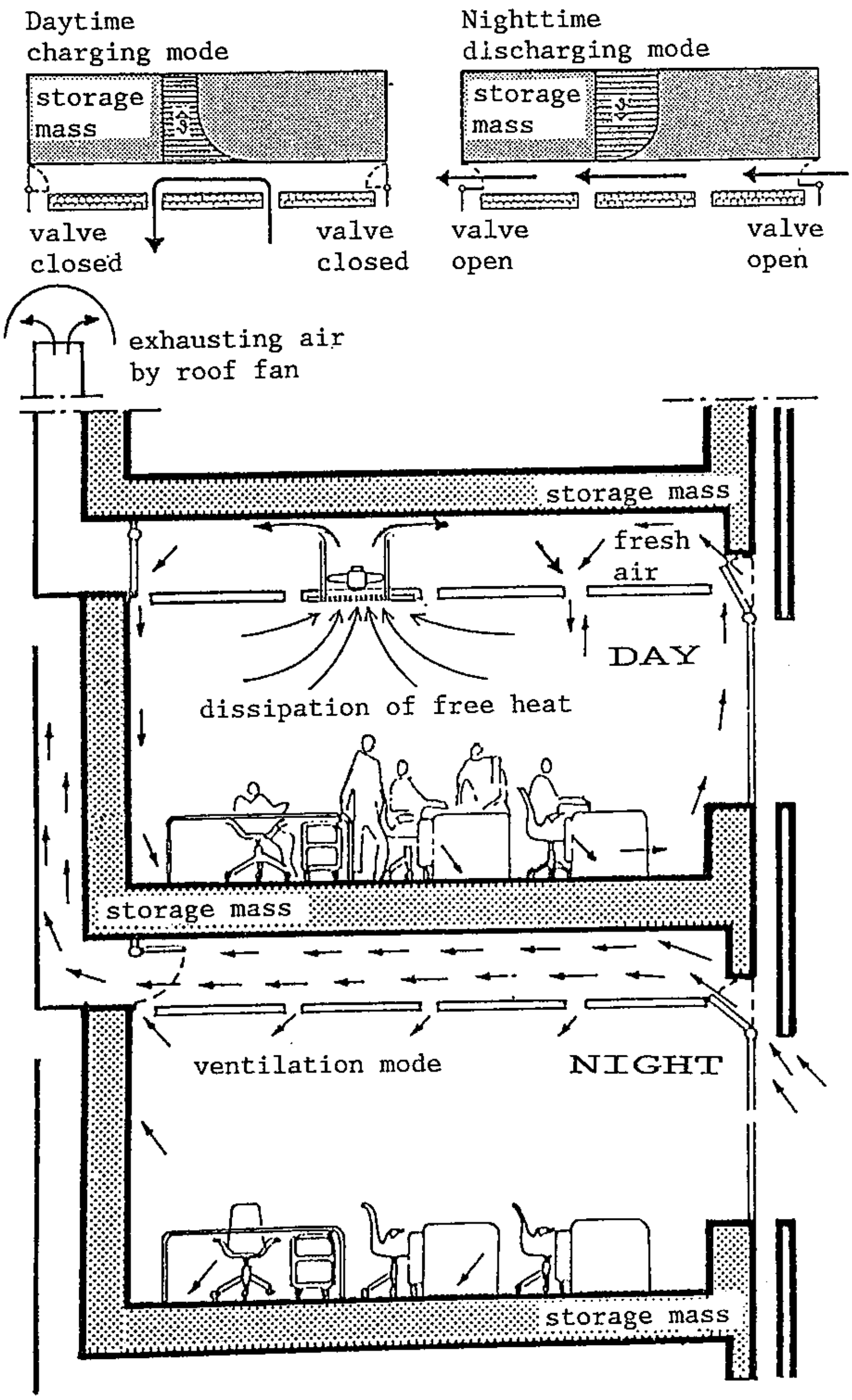
Particularly the requirements of the technical equipment of the functional open plan office on climate, acoustics, and daylighting had to be solved architecturally. The precariousness concerning the success of the new concept at the very beginning of the design process led to a consideration of a mechanical air conditioning system as an alternative. Only cost - saving - comparisons turned out the ventilation system to be the most favourable.



Different zones of illumination levels

HYBRID SYSTEM

In this ventilation system the undesirable internal heat loads will be charged temporarily into the interior building mass during daytime in summer. During cool nights the stored heat will be discharged and dissipated by powerfull fans on top of the building. During daytime, ambient air will be drawn to the discharged ceiling elements to pre-cool fresh air for the office. The most important pre-condition for this concept is an effective sun control to minimize solar thermal loads.



Building Costs:	/m²
DM	875
ECU	310
Reference DM	1 765

COSTS

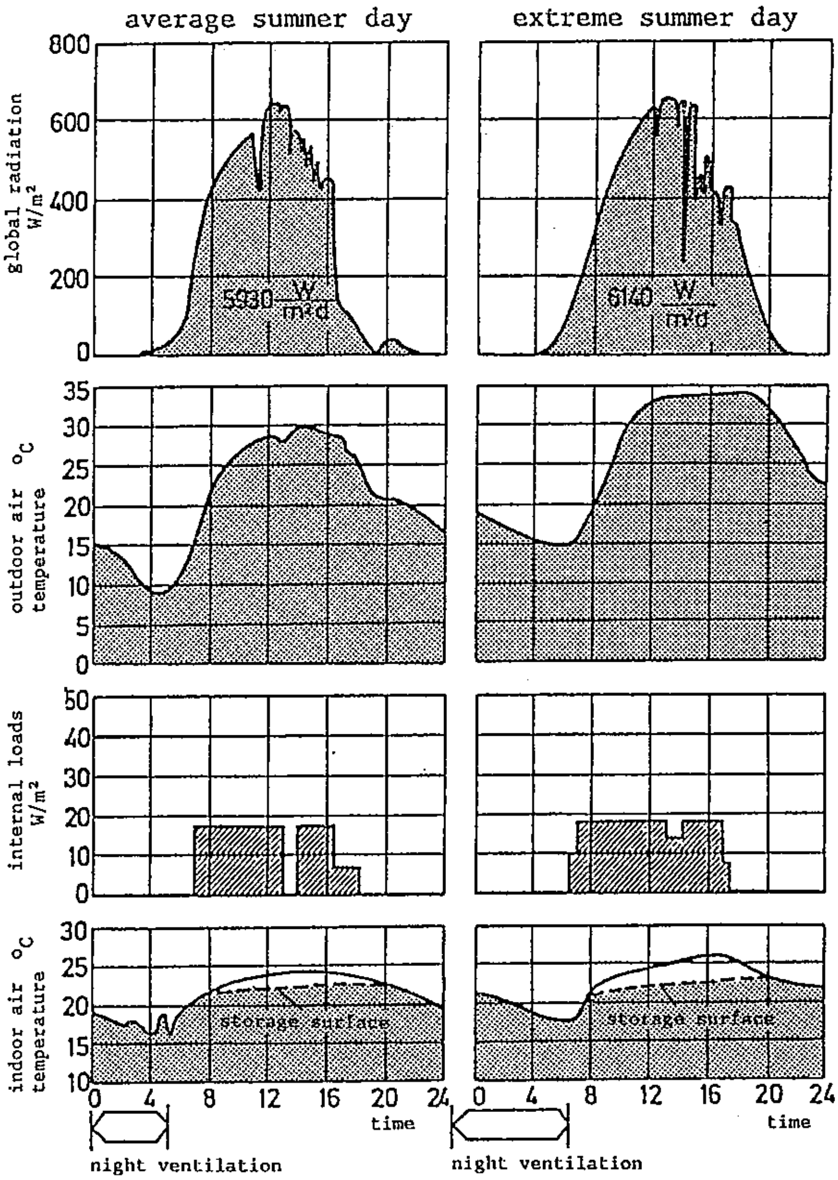
For this project the cost aspect of the plant is most interesting. In comparison with a conventional air conditioning system (DM 260/m², ECU 93/m²) the hybrid system reduced the inuitel costs to 25 % (DM 63/m², ECU 22/m²).

Annual Fuel Use:	kWh/m²
Total	217
Heated Area	173
Lighting	30
Fans	11
Cooling	0
Reference:	**kWh/m²**
Total	340
Heated Area	230
Lighting	30
Fans	37
Cooling	37

Fuel Costs:	DM
Gas:	0.03/kWh
Electricity:	0.11/kWh
	0.07/kWh
Oil	0.26/l
Water	2.50/l

ENERGY PERFORMANCE

The standards of today require an optimization of the building envelope by improving the U-values. By this means, in concert with heat recovery, the energy performance could be improved as well.



Comparison of air and storage surface temperature development with previous discharge of storage mass according to corresponding meteorological data and internal gains.

HUMAN FACTORS

The most important aspect for the occupants of the offices is the favourable indoor climate without draft-air-effects caused by too high air velocities. Thus, the typical infects of summer sicknesses do not occur.

The windows are not operable, fresh air enters into the space between the ceiling construction and the suspension system by valves. The system is operated by the occupants, one person responsible on each floor.

In case of demand a more powerful venting will run during working breaks. Thus, the noise level caused by the fans can be limited during the working hours. The low ventilation demand, caused by a rigorous smoking prohibition in the working areas, facilitates this system operation.
As an improvement of the system the owner suggests a more decentralized modification of the shading device due to each floor and according to the individual orientation, and the application of a storage programmable control system for all building services.

Design Occupancy:
250 People

Function:
Office

Time of Occupancy:
6^{00} - 18^{00}
Flexible Working Hours

CONCLUSION

According to meteorological investigations at the site location only 10% of the summer nights do not meet the conditions of the requested low temperature levels required for the nocturnal heat discharging process. However, practice shows that the sequences of those conditions occur only for two or three nights. Moreover the thermal stability of the internal storage mass is sufficient to balance those effects. The resulting rise of indoor temperature occurs only once or twice a year and is less than 0.5 K.

The space conditioning system using internal storage mass for reducing internal thermal loads provides an important aspect of energy saving. Moreover, the system costs and the running costs make only 30-40% of comparable common air conditioning systems. Thus, the system is very reasonable for cost-effective planning tasks.

The experience of more than 10 years has shown that the hybrid system meets occupants requirements in its entirety. However, the system can not be switched on or off as a conventional mechanical air conditioning system can easily be operated.

INFORMATION

Walter E. Fuchs
"Beeinflussung des thermischen Raumklimas in Bürogebäuden durch Ausnutzung der Wärmespeicherfähigkeit interner Massen".
Dissertation 1980, Institut für Baustofflehre, Bauphysik, Technischen Ausbau und Entwerfen der Universität Stuttgart.

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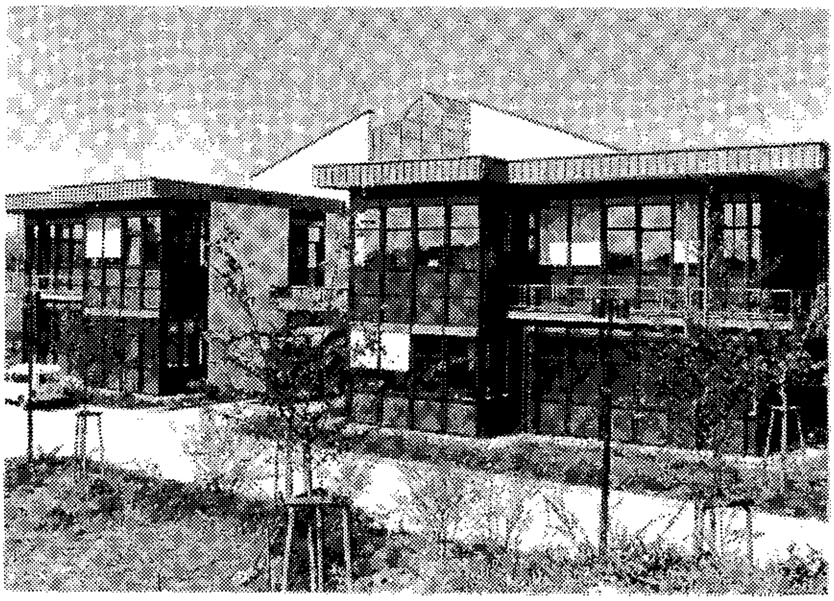
TECHNOLOGIE-ZENTRUM

Building Type:
Offices and production

Passive Features:
Atrium, Daylighting



East view and main entrance

Occupant Date: 1985

Floor Area:	m^2
Gross	4 206
Heated	3 676
Unheated	530

Building Costs:

DM	13 000 000
ECU	5 837 000

Annual Delivered Fuel:

District Heat	484 MJ/m^2
Electricity	197 MJ/m^2
Total	681 MJ/m^2

Client:
Landeskreditbank
Baden-Württemberg

Architect:
Rödl + Kieferle
Stuttgart

Monitoring of daylight:
Fraunhofer-Institut für Bauphysik, Stuttgart

SUMMARY

The Technologie-Zentrum Stuttgart is an office and laboratory building dedicated for individual firms. It serves as a starting point for the foundation of companies focussing on development and preparation to mass-production. It is intended to home technology-related scientists, ingeneers and firms for a maximum stay of 5 years. Moreover, a close coperation with the University of Stuttgart and other research institutions in close neighbourhood is taken aim by a collective revenue of facilities covering the field of research and the demand of resources.

The building is characterized by a glazed linear atrium to which the adjacent rooms of the two levels are facing to. The atrium serves as a communication area and provides daylighting and fresh air supply for the parent spaces.

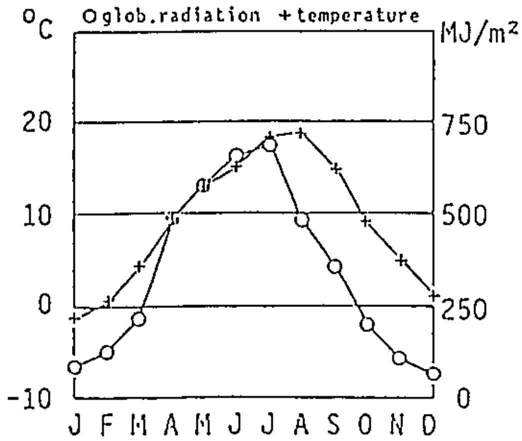
PROJECT DESCRIPTION

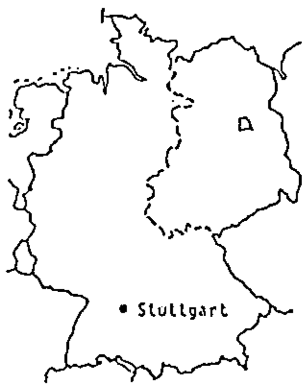
The premise for the usable floor area was to meet a 200 m^2 space demand for each of the 20 enterprises.

One of the main requirements was the flexible size of each floor space within the overall building. This means that differently sized units should be able to be realized according the spacial demands of each firm. Extension or shrinkage should also be possible for each second section in case of demand. The building concept allows to be used by acceptance of a research institution as well.

SITE AND LOCATION

The plot of land is in possession of the county of Baden-Württemberg. Close to the university facilities the site of the building was determined by this beneficial advantage of the location.





Site Data:

Latitude	48°48' N
Altitude	460 m

Climate Data:

Degree Days:	
September - May:	3 434
Annual:	3 555
Global Radiation:	MJ/m²
September - May:	2 203
Annual:	4 016

Sun hours:	
Actual:	1 763
Actual/theoretical:	0.40
Average temperatures:	°C
Winter:	6.2
Summer:	17.4
Annual:	9.0

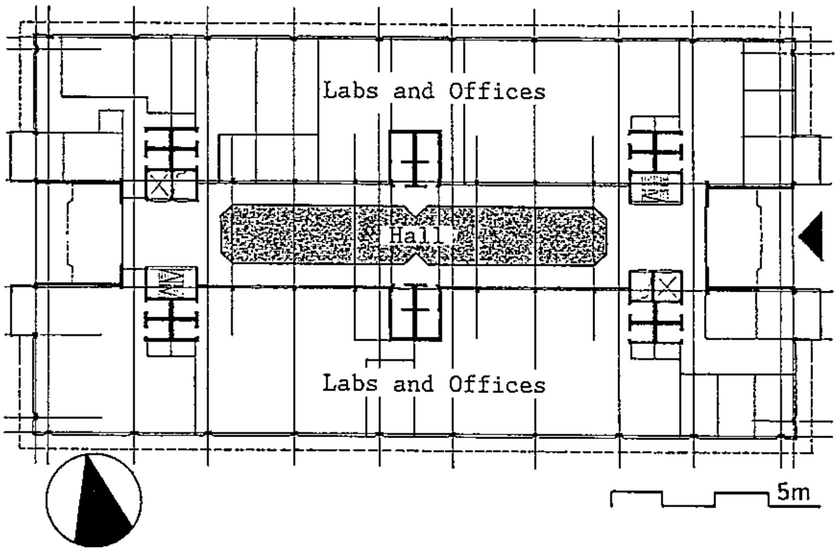
BUILDING FORM

The building is subdivided into two two-level wings connected by a glazed centre span.

The development for people and goods is provided by roofed access areas at the fronts which also home the "central services" and the "information" desk.

The vertical development of the building is taken over in pairs of two "cores" containing elevators, stairways, and shafts with installed services.

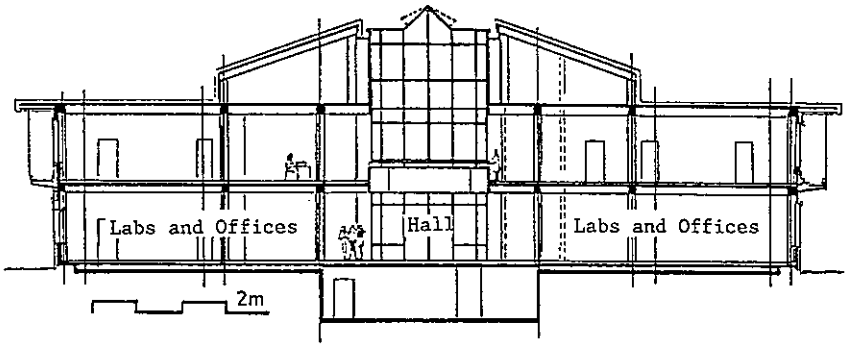
The access to labs and production units through the hall and the size of the units should provide a flexible use of the building in cases of demand.



Floor plan

Volume:	m^3
Gross	30 406
Heated	ca.25 000
Unheated	ca.5 300

Surface Areas:	m²
Floor Area	2 731
Roof	ca. 3 850
Facade	ca. 2 660
Wall	ca. 1 060
Window	ca. 1 600
Window/wall ratio	ca.0.6



North-south section

BUILDING CONSTRUCTION

U-values:	W/m²K
Floor	1.00
Wall	0.45
Roof	0.40
Window	3.00

Envelope Heat Loss:	W/K
Transmission	330
Ventilation	90

The spatial flexibility of building use is realised by a reinforced concrete construction (cast pre-stressed concrete compound units) spanned by a TT-ceiling system of 7.2m (8.4m) collumn grid pattern. Filler walls are made of solid sand-lime brick and fair-faced masonry work, light-weight partitions consist of gypsum board walls. The facades are designed in a heat and sound insulated timber construction (Meranti), the roof construction is a non-ventilated flat roof with a gravel filling.

BUILDING SERVICES

Installed Capacities:	kW
Heating	330
Electricity	500

Design Conditions:	°C
Offices and Labs	20
Toilets	15
Atrium	unheated

Illumination Levels:	lx
Offices, average	500
Secondary rooms	150

The requirements of buildings' flexibility were also related to the building services since the occupants and their individual demands were unknown from the beginning and should be modified. The possibility of replacement of media due to the actual requests had to be fulfilled.

Heat supply is provided by district heating and heat exchanger. The flow temperatures are designed ambient temperature-controlled for -15/120°C (130°C) flexible, and for +8/60°C constant. The secondary part of the heating system is a closed dual pipe system containing the sections heating/ventilation 60/40°C and two ambient temperature-controlled circuits of 80/40°C. Local heat-transfer elements are weather-controlled and equipped by thermostatic valves. Thermostate setting is directed at night and for the week-ends. Hot water is provided by an electrical pressure type water heater at the attic.

PASSIVE SYSTEM

Glazing Properties:	
Insulating Glazing	2x8mm
Exterior Pane	ESG

Atrium Glazing:	
Wired clear glazing	7mm

The unheated atrium acts as a buffer space for circulation, development, and communication purpose. It is intended to supply the parent spaces with fresh air and by daylighting.

View into the hall

COSTS

In comparison to other buildings of this kind, the total costs of DM 2950/m² seem considerably high. The reference costs have been established by average cost analysis of seven similar "Technologiezentren".

ENERGY PERFORMANCE

A heating cost analysis (1987) related to the corresponding building location of each firm has shown that the northern wing requires approximately 13% more energy consumption than the southern wing.

HUMAN FACTORS

Since the individual firms potentially compete with each other, autonomous units have been requested, containing their own administration and labs. On the other hand, the spirit of this institution should encouragean internal communication as well, intended by collectively usable service facilities like plenary hall and "central service".

Practise has shown that the atrium has not been adapted as it was intended - in fact, activities are limited to exhibitions and social events due to the intermediate temperature conditions of the hall.

CONCLUSION

The width of the hall seems to be not big enough to provide sufficient daylighting. Galeries and overhangs reduce the illumination levels which will be investigated by future daylighting measurements.

INFORMATION

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"Technologiezentrum Stuttgart - Pfaffenwald"
Landesentwicklungsgesellschaft Baden-Württemberg mbH
(LEG) Katharinenstr. 20, 7000 Stuttgart 1

Building Costs:		/m²
Total	DM	2 950

Reference Costs:		/m²
Total	DM	1 765

1987 Fuel Use: MJ/m²		
District Heat		484
Electricity	day	134
	night	63
Site Energy		681
Reference		1 224

Fuel Costs:	DM/MJ
District heat total	0.03
Electricity	0.58

Design Occupancy:
200 People
170 Full time, 30 freq.

Function:
Offices and labs
ca. 20 m²/person

Time of Occupancy:
8^{00} - 20^{00}, 6 days/week

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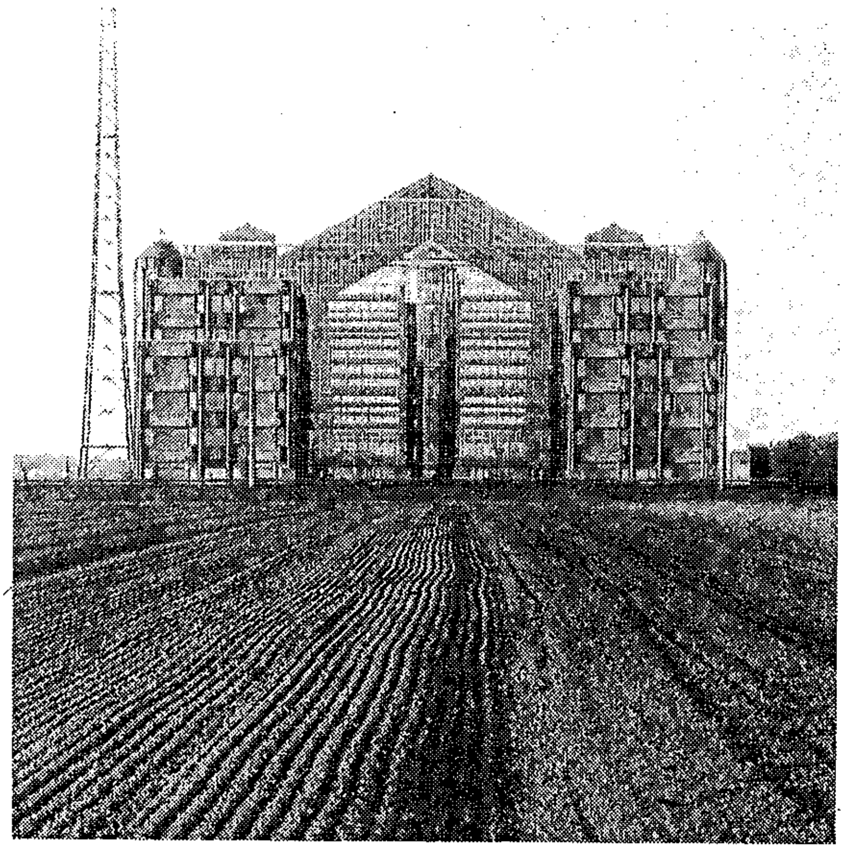
ZÜBLIN-HAUS

<u>Building Type</u>:
Office

<u>Passive Features</u>:
Atrium



North view

<u>Occupant Date</u>: 1984

<u>Floor Area</u>:	m²
Gross	19 867
Heated	18 427
Unheated (atrium)	1 440

<u>Building Costs</u>:

DM	42 800 000
ECU	19 123 000

<u>Annual Delivered Fuel</u>:	MJ
Total	8 411 000
Gas	4 030 000
Elect.	4 381 000

<u>Client</u>:
Ed. Züblin AG
Hauptverwaltung

<u>Architect</u>:
Gottfried Böhm, Köln

<u>Monitoring of daylight</u>:
Fraunhofer-Institut für Bauphysik, Stuttgart

<u>SUMMARY</u>

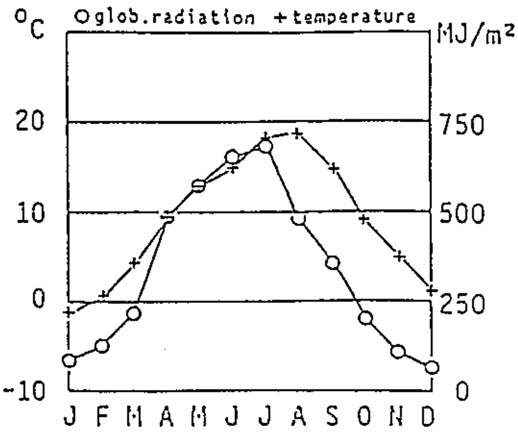
The Headquarter of the Züblin office building is a two-winged development related to a linear atrium of 33m height. This unheated and free-floating space acts as a buffer space housing exhibition and circulation areas on the ground floor and walkways connecting the upper seven storeys. This glazed hall is the biggest atrium building in Germany up to now and daylighting measurements will be carried out in the very near future.

<u>PROJECT DESCRIPTION</u>

The Züblin building company is settled in Stuttgart since 1919. Increasing expansion led to an unpleasant situation for employees being distributed over different places all over the city. The new building was intended to house the offices of the Head Office, the Overseas Department Stuttgart, the branch office Stuttgart, and the subsidiary companies with a total capacity for approximately 700 people. It was to contain individual offices considering a high flexibility of spatial arrangements and natural ventilation. The prime structure had to be designed predominantly of precast reinforced concrete elements.

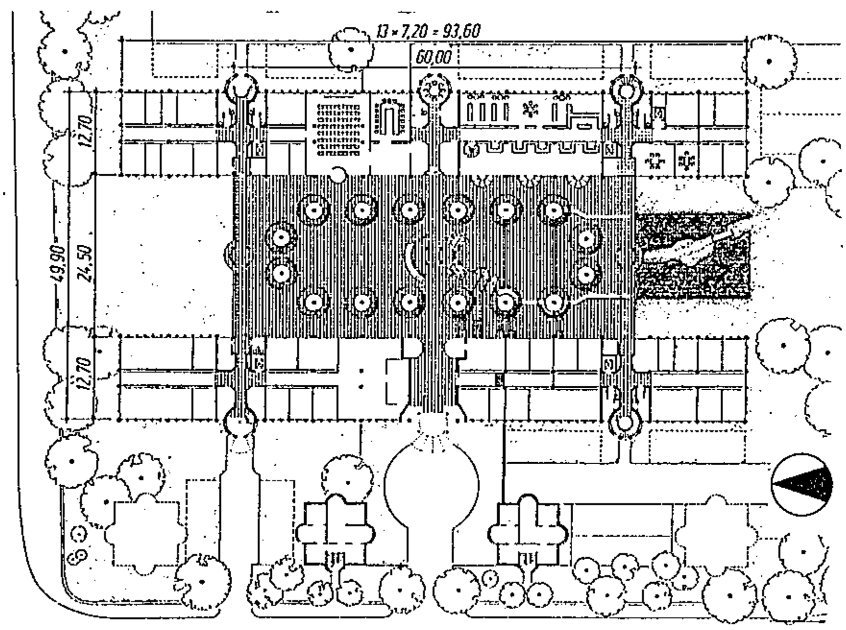
SITE AND LOCATION

The Züblin building is situated on the outskirts of the city in Stuttgart-Möhringen on a site of 1.6 ha.



BUILDING FORM

The building concept is characterized by two 7-storey office wings with two additional underground storeys move to (the overall length of the building is approximately 94 m) the two wings are spaced 24 m apart and are divided by three core areas. All floors of both wings are connected by a walkway system (skywalks) between these cores. The walkways are spanned by a saddle-shaped glass roof. This is connected to the glazed gable ends forms a 60m long glass hall (atrium) incorporating the office blocks. A single and double deck underground car park with 150 parking spaces is located beneath the glass hall.



Floor plan

Site Data:	
Latitude:	48.8°N
Altitude:	430 m

Climate Data:	
Degree Days:	
September - May:	3 434
Annual:	3 555
Global radiation:	MJ/m²
Annual	4 016
September - May	2 203
Sunshine hours:	
Actual:	1 763
Actual/theoretical:	0.40
Average temperatures:	°C
Winter:	6.2
Summer:	17.4
Annual:	9.0

Volume:	m^3
Gross	121 714
Heated	75 634
Unheated	46 080

Dimensions of atrium:	
Floor:	60m x 24m
Span of roof:	28m
Ridge height:	north 31m
	south 33m

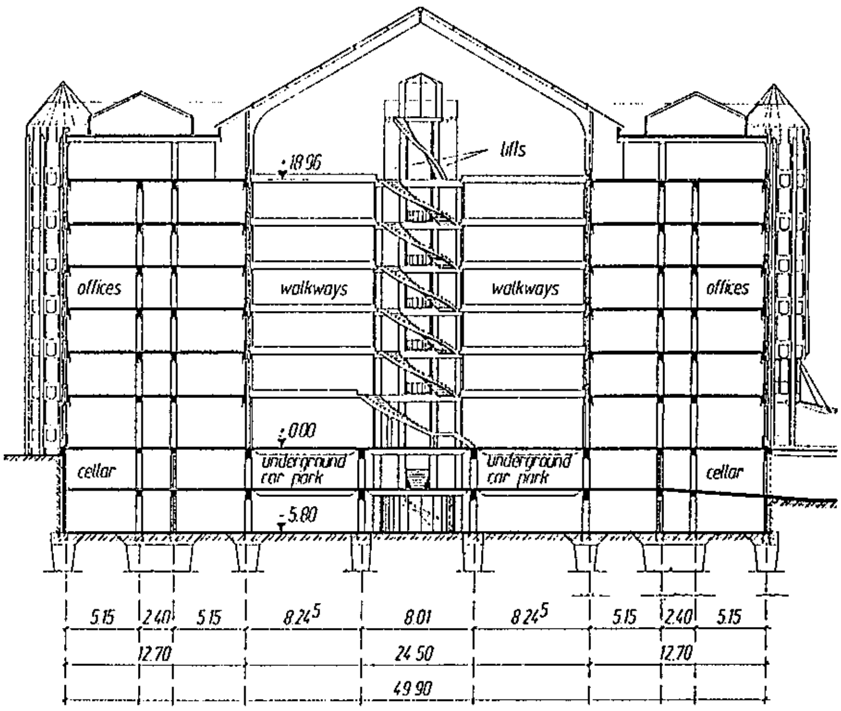
Surface Areas:	m²
Ground:	2 500
Atrium:	2 550
Roof	2 400
Wall	4 700
Window	4 700

U-values:	W/m^2K
Wall	0.7
Roof	0.5
Window	3.0
Atrium glazing	5.0

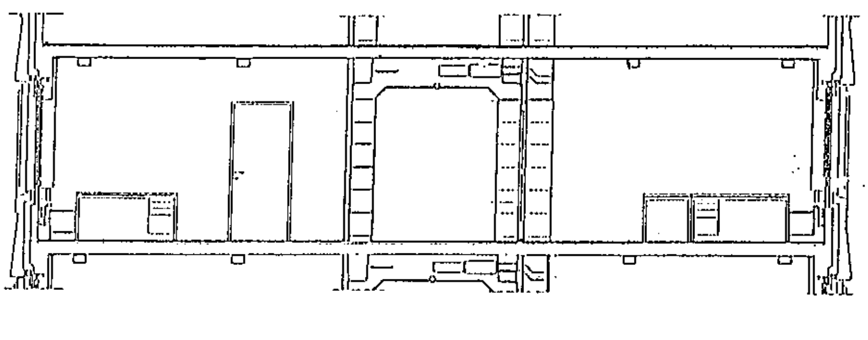
Envelope Heat Loss:	W/K
Transmission:	18 590

BUILDING CONSTRUCTION

The main requirements on the building construction included the design of a concrete facade, the development of 7 office levels within the given restrictions of building height, and the most far-reaching prefabrication of building components. Consequently the individual storey heights had to be minimized to 3.0 m causing a ceiling construction of only 16 cm deep. This was realized by using a continuous girder construction for the ceilings and the loadbearing concrete facades. The main structure system of the atrium roof contains triple jointed reinforced concrete ties. The longitudinal weight-carrying structure for the puttyless roof glazing itself consists of steel binding rafters in a 2.4m grid.



Section



Typical section through an office unit

BUILDING SERVICES

The centralized hot water heating system consists of a gas over-pressure plant by two high efficiency furnaces of 1500 kW in total. Optimum adjustment is provided by revolve-controlled pumps and weather-compensated thermostatic sensors for both, the atrium and the outdoor climate. Hot water preparation in summer will take heated air from the atrium by heat pumps, and the resulatant cool air will provide ventilation for the galeries of the hall. Electrical power supply is taken over by a 10 kW switch-plant. The luminous ceiling system of the offices contains energy-saving fluorescent lamps. For maintenance and service of the roof glazing. the heated rainwater gutter, and the external ventilation openings, a movable maintenance runway has been installed. From the inside, maintenance work will be carried out by a vehicle.

Installed Capacities:	kW
Room heating:	1 500
Electricity:	630

Design Conditions:	
Room temperature:	°C
Offices:	20
Atrium:	free floating

PASSIVE SYSTEM

The free-floating atrium serves exclusively as weather protection for circulation areas without spaces for permanent occupancy. The roof of the atrium is
made by single compound glazing. Ventilation is provided by inlet flaps situated in the gable ends and there are 60 pneumatically controlled outlets (1.6 x 1.5 m) in the roof which ensure natural thermal currents and serve as smoke vents as well. Furthermore the atrium acts as a buffer space, preheating fresh intake air for the adjacent offices and reducing heat losses in winter. All windows are equipped with individually adjustable shading devices and glare protection. Thus, the atrium itself could dispense with a general solar control system.

Glazing Properties:
Roof of atrium:
Puttyless single safety glazing, 80x240cm grid
Gable of atrium:
Upper section: float
Lower section: safety

COSTS

In comparison to the total costs of the office building, which were DM 42.8 millions, the costs for the atrium seem relatively low, ranging from about DM 1.5 millions (ECU 672 000) or 3.5% of the total. Related to the glazing construction and area the equivalent costs per m^2 were approximately DM 450 (ECU 201).

The user of the building states that the atrium does not produce any maintenance costs with the exception of cleaning the glazing from the inside due to the cleaning routines of the total building.

Building Costs:	/m^2
	DM 1 228
	ECU 548
DM 61 143 /working place	
Reference	DM 1 765

Annual Fuel Use:
422 MJ/m^2
Reference 935 MJ/m^2

Energy Costs:
Electrical: DM 0.028/kWh

ENERGY PERFORMANCE

Thermal pre-calculations during the design phase predicted overheating for extremely hot summer conditions, solar shading devices for the atrium have nevertheless not been installed,and the apprehensions about overheating problems in the atrium space have not occured.

The electrical lighting system has no automatic response to the daylighting illuminance level. Also, the building is illumiated throughout the nightime for presentation purpose.

FUEL TYPE	FUNCTION	DELIVERED FUEL (MJ) total	per m^2(gross)
Gas	space heating	4 030 000	202
Elect.	all	4 381 000	220
Total	all	8 411 000	422

Design Occupancy:
700 employees

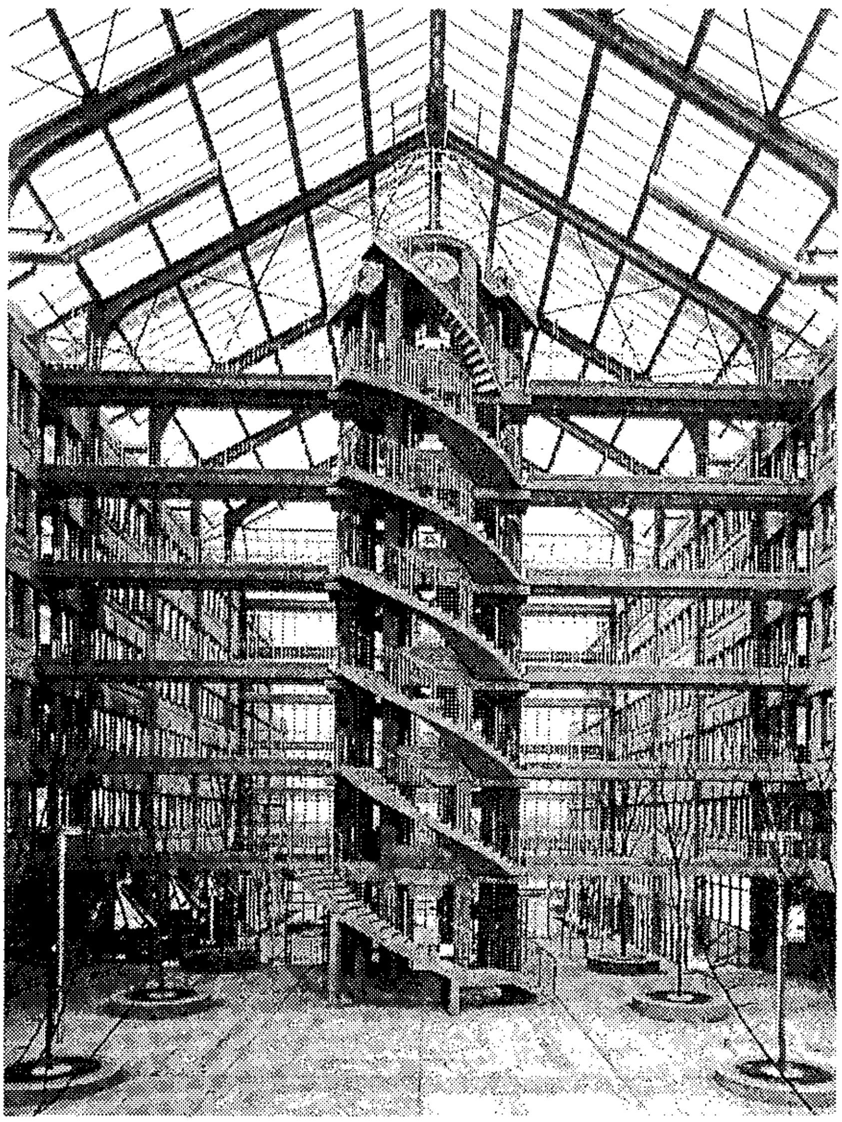
Function:
Offices

Time of Occupancy:
7:15 - 17:45

HUMAN FACTORS

The employees state that there are no disadvantageous opinions concerning thermal comfort and/or daylighting conditions. The louvers at each office space and the shading devices of the upper floor provide glare protection and are individually adjustable, operate without any problems. The vegetation however, the devices, have caused some problems due to pests and premature stripping of foliage.

The multiple functions of the atrium also contain cultural events like exhibitions, music concerts and opera for the public. The atrium offers a permanent stage and the technical equipment to cover the floor for dancing performances in case of demand. In fact, the Züblin-Haus has become wellknown and favourable as a "place of performance".



Interior view of the atrium

CONCLUSION

Aside from the intended function of presentation of its own office building, the Züblin company demonstrated a unique construction of red concrete prefabrication technology. The impressive size and dimensions of the atrium space in concert with the cultural events has successfully attracted the public's attention to the building. From the thermal energy and daylighting point of view, however, a more effective and more reasonable approach is desirable.

INFORMATION

Ed. Züblin AG, Stuttgart: "Züblin Haus",
Karl Krämer Verlag, Stuttgart 1985
ISBN 3-7828-1486-x

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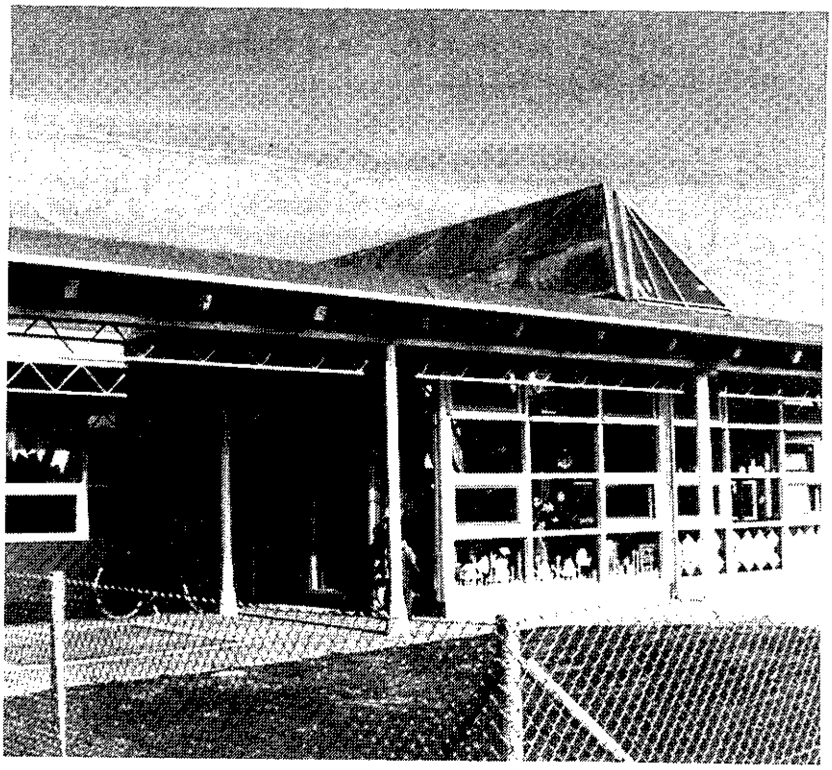
D

SCHOPFLOCH KINDERGARTEN



Building Type:
Education

Passive Features:
Solar heating:
direct, indirect
Daylighting:
indirect

Occupant Date:
April 1988

Floor Area: m^2

Gross:	270
Heated:	250

Building Costs:

Building:	DM	800000
	ECU	370400
Solar System:		
	DM	20000
	ECU	9300

Annual Delivered Fuel: MJ
(Prediction)
Heat consumption
203832
Electric Consumption
38448

Client:
Stadt Leonberg

Architect:
Dipl.-Ing. Bela Bambek
Freier Architekt

SUMMARY

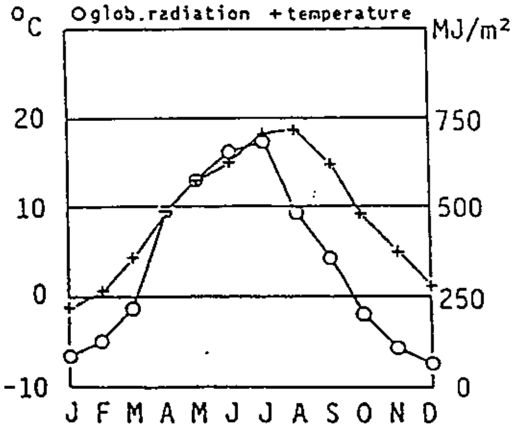
The Schopfloch Kindergarten has been designed as a 1-class kindergarten with gymnastic hall. It's a single-storey flat roof building with a shed in the east-west direction over the whole roof. This shed serves with the total glazing on the north side for daylighting in the rooms and is fitted with air-collectors for space heating on the southern slope. Large glazing walls on the west, south and east surfaces ensure a good optical contact to the green surrounding. Energy savings in space heating during the transitional period are expected using air collectors (38 m^2) and a 20 m^3 rock-bed storage. The hot air floor and wall heating system is an old Roman principle, called Hypokaustenheizung.

PROJECT-DESCRIPTION

The kindergarten was planned with the view to high gains of passive and active solar energy. The light building construction supportes a quick space heating through direct gains and causes a good reacting auxiliary heating system. This has been built as a hot air floor and wall heating system, using the advantages of low heating temperatures without the disadvantages of a direct air heating system - like dry air or air movements.

SITE AND LOCATION

The building is located in Leonberg-Ezach in the centre of new erected buildings.



Site Data:

Latitude:	47°50′
Altitude:	400 m

Climate Data:

Degree Days:

Oct. to April, incl.	3 729
Annual (base 20)	3 908

Global Radiation:

G_H	1 307 MJ/m²

Sun hours:

Actual	598

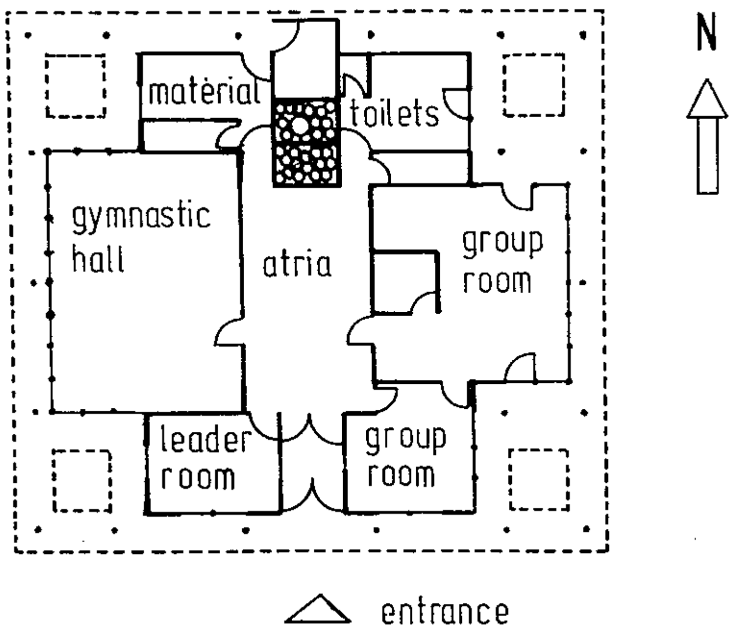
Average temperatures:	°C
Winter:	6.2
Summer:	17.4
Annual:	9.0

BUILDING FORM

The one-storey building has a square ground area, using the corners as an outdoor playground. Through the entrance the visitor enters in a central atrium, which serves as a cloakroom and additional indoor playground during raining periods. The two group rooms are located on the east side of the building and the western part is the gymnastic hall. Material, service and sanitary rooms are situated on the north of the kindergarten. The U-shaped rockbed storage, divided in two chambers, has a central position in the building. Its losses - heat transmission through the 100 mm thick insulation - are passive gains for the surrounding rooms.

Volume: m³	
Gross	805

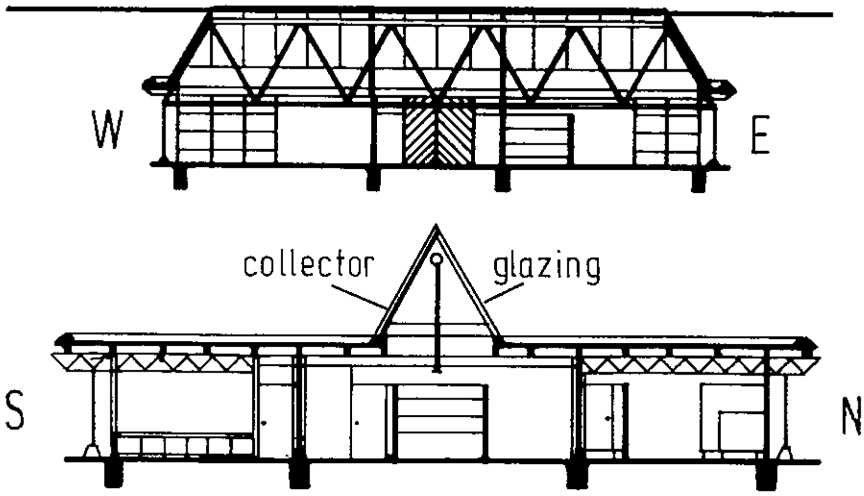
Surface Areas: m²	
Ground floor:	270
Envelope:	638
Walls:	200
Windows:	157



Window Data: %

Glazing factor=glazing/exterior surface

East	70
West	52
South	61
North	31



W-E and N-S cross section of the building

U-values: W/m²K	
Floor:	0.589
Wall:	0.445
Roof:	0.336
Windows:	
Glass and frames	3.0

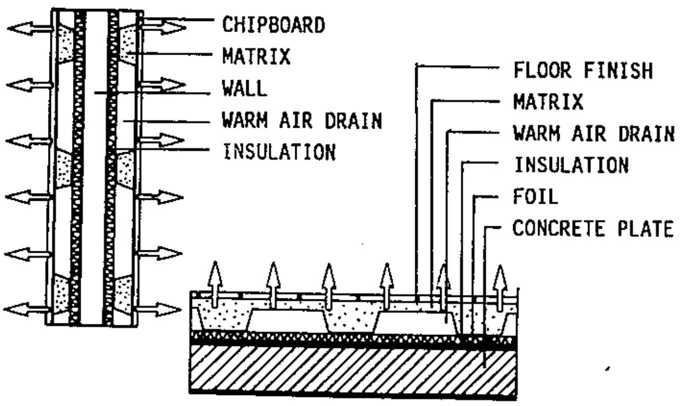
Air collectors:
Absorber Area 38 m²

Storage:
Volume: 20 m³
Thermal Mass: 54 MJ/K

Envelope Heat Loss: W/K
Transmission: 752

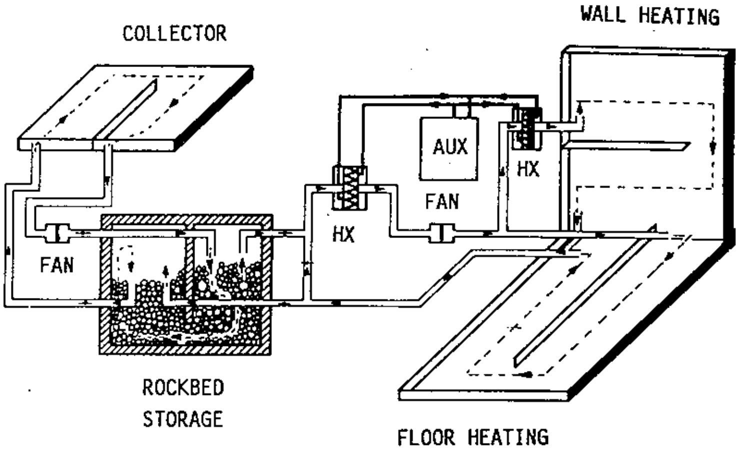
BUILDING CONSTRUCTION

The Schopfloch-Kindergarten is a steel construction with prefabricated wall elements. The elements are a double shell wood construction including a 80 mm rockwool insulation. The inner surface has a sound reductive coating. The windows and the glazed wall elements are timber framed with double glazing.
The shed-type roof is a self-supporting steel construction with insulating glazing on the northern slope. The southern slope serves for mounting air collectors with a timber frame construction. The black plastic absorber foil is mounted on a 10 cm insulation and the 15 cm air gap is double covered. This covers are Polytetrafluoräthylen foils (Hostaflon) with a thickness of 50 µm inside and 150 µm outside.
The floor and parts of the inner walls serve for heating area of a hot air heating system.



construction of floor and wall heating elements

BUILDING SERVICES



Installed Capacity:

Auxiliary Heater	100 W/m^2
Hypokausten Fan	
1. Step	0.5 kW
2. Step	2.5 kW
Collector Fan	0.25 kW

Design Conditions:

Room Temperature	19.5°C

The space heating system of the kindergarten is designed for direct use of solar collector gains (38m^2) for the floor and wall heating. Direct heating without storage is possible. If the collector output is lower than the heat demand, a gas driven auxiliary heater supplies heat to a water-air heat exchanger. Solar gains which are not needed for heating are charged in a rockbed storage consisting of Serpentinit rocks - grain size ca. 50 mm -. An additional water-air heat exchanger allows an overheating of the wall surfaces to heat up the rooms quickly in the morning.
Air tight flaps in the charging and discharging ducts of the storage prevent an uncontrolled discharge to the collectors or the heating system.

PASSIVE SYSTEM

The large north faced slope of the shed-roof with a glazing area of about 40 m^2 and the white diffuse reflecting inner surface on the southern slope gain maximal daylight to the rooms without the danger of overheating. The overhang of the roof (ca. 1.20 m) partially shades the large glazed wall surfaces on the East, South and West and avoids overheating of the rooms in summer. No additionally shading devices are needed.

Building Costs:	/m^2
Total Building:	2960 DM
	1370 ECU
Solar System:	75 DM
	34 ECU
per child:	32000 DM
	14820 ECU

Annual Fuel Use: MJ/m^2
(Prediction)

Gas:	
Heating	815.3
Electric:	
Lighting/Heating	153.8

Energy Costs:

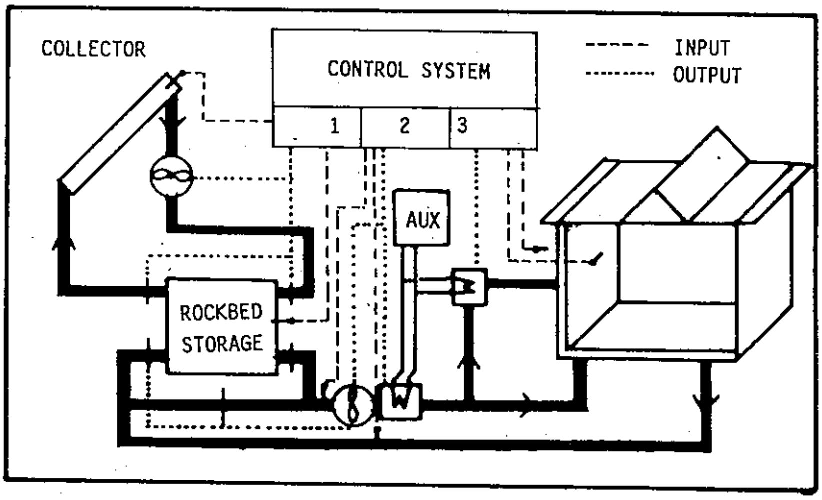
Gas:	
Total	0.53 DM/m^3
	0.25 ECU/m^3
Electric:	0.40 DM/kWh
	0.19 ECU/kWh

BUILDING COSTS

The additional costs of the active solar system - including collectors, rockbed storage and piping - amounted to 5% of total cost.

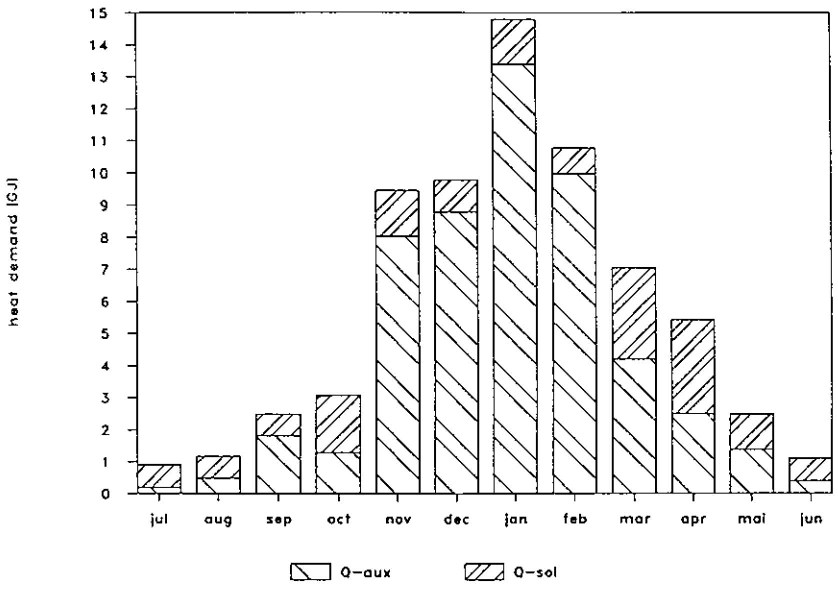
CONTROL SYSTEM

The whole heating and active solar system is controlled by a programable control device. Heat from air collectors or from the store is prefered against heat from auxiliary. The hot air is additionally heated if the actual inlet temperature deviates from the set point, which is influenced by the ambient temperature. The additional overheater for the wall inlet air is activated if the room temperature decreases below 19.5 °C. A sensor in the outlet pipe of the floor heating system measures the air temperature of the outlet flow and the controller opens a bypass flap if this temperature is higher than the maximum storage temperature.
Manual controlled ventilation flaps in the northern slope of the shed-roof allow an individual conditioning in summer according to the user's requirements.



ANNUAL ENERGY PREDICTION

Parametric studies with a validated simulation program used at the Institute of Thermodynamic and Heat Transfer of the University of Stuttgart show the following results for a direct air heating system:
For an exposed building with flat roof and a floor area of 100 m^2 an annual heat demand about 66.9 GJ is calculated, which depends on weather and material data. With the parameters of the solar air heating system - 40 m^2 collector area and 20 m^3 volume of the rockbed storage - the annual solar fraction of the space heating and domestic hot water demand is calculated to ca 25%.



Calculated amounts of solar and auxiliary heat

Prediction:
Annual Solar Fraction of Heating 25 %

HUMAN FACTORS

The first months since the date of occupancy have shown a good resonance for the bright building by adults and children. During high insolation in September and October a quick increase of the room temperature can be observed.
The high ventilation losses by opening the windows during long periods of the day will influence the heating balance.
A separate room temperature control for the group rooms and the gymnastic hall would be helpful, because the gymnastic hall needs lower temperatures.

Design Occupancy:
Frequently 25 children
2 adults

Function:
Working
Playing
Education

Time of Occupancy:
9 hours per day
5 days per week

CONCLUSION

The concept and system size promise to gain a significant part of the heating demand with the passive and active use of solar energy. After some modifications in autumn 1988 now the system works properly. The monitoring has started 1. November and the results of the first heating period will be published in the "advanced case study" issue.

INFORMATION

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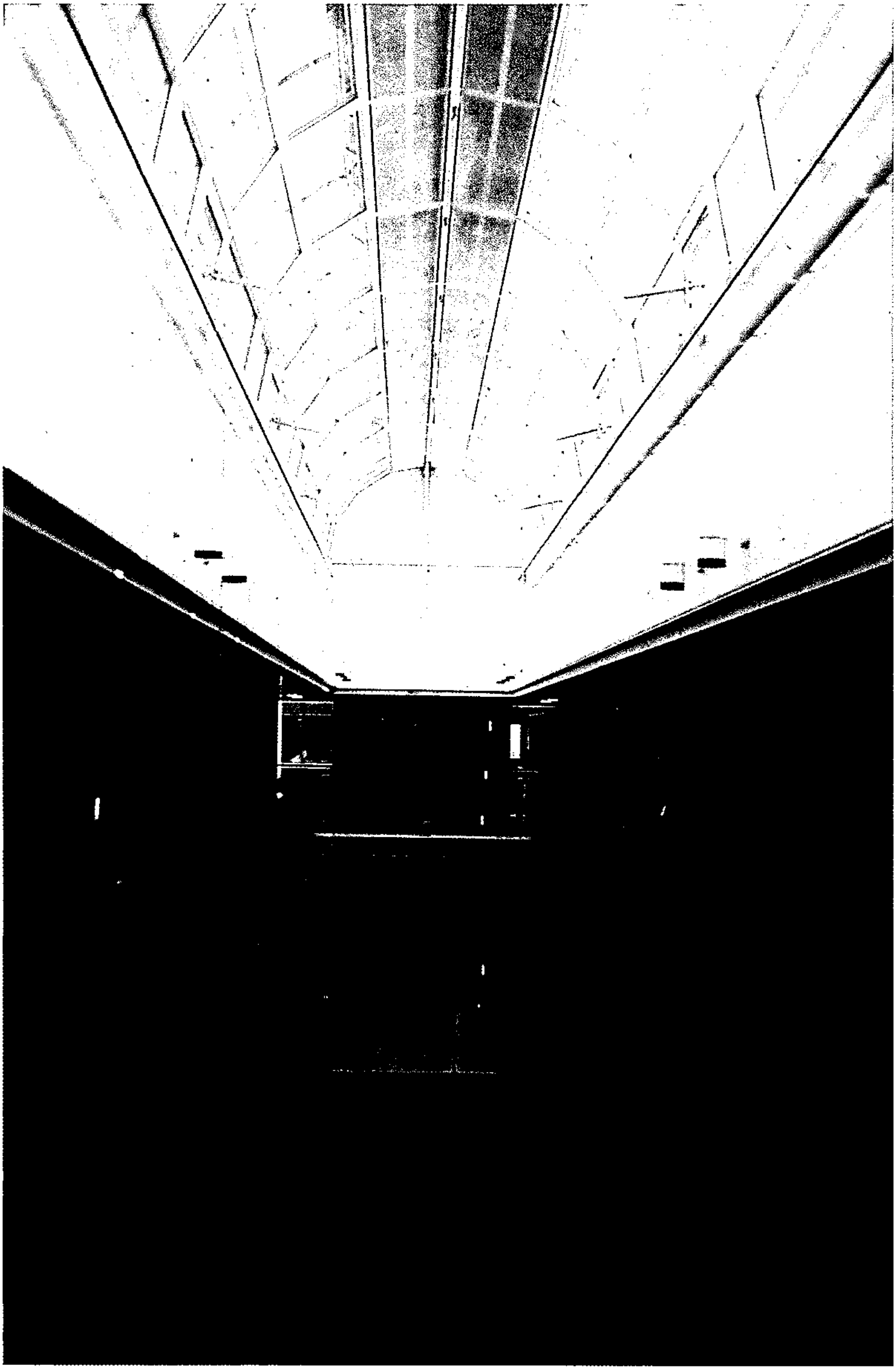
Tel. 0711 / 685 32 25

(DK) DENMARK

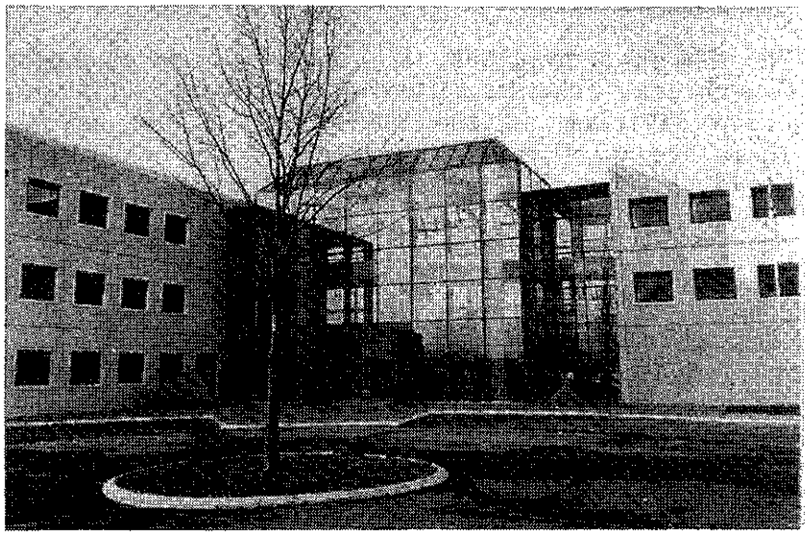
BCS No.	Building Title
21	TIME / SYSTEM
22	BRF HEADQUARTER



BRF HEADQUARTER

DK

TIME/SYSTEM



Building type:
Office

Passive features:
Solar Heating:
Direct

Occupancy date:
July 1987

Floor area:

Gross -	7100 m^2
Heated	7100 m^2
including Glass Entrance Building	220 m^2

Cost: (1987)
Office Building:

dkr	30 000 000
ECU	3 750 000

Total delivered fuel:

Electricity	858 700 kWh
Gas	62 578 m^3

Gas & Elect.
- 780 MJ/m^2 gross

Client:
TIME/SYSTEM, Ole Berg

Architect:
I/S Salling-Mortensen tegnestue

Contractor:
C.G. Jensen A/S

Consulting engineer:
Crone & Koch K/S

SUMMARY

Part of the office building in the Danish plant of Time/System International A/S has been selected for case study in IEA Task XI.

The glass entrance building (220 m^2) is 11 m high and has 500 m^2 windows in the face of the building.

A preliminary simulation study has shown that the special glazing in the windows reduces the transmission loss in the entrance building by 40%. The simulations, not taking ventilations losses into account, also show that about 33% of the transmission loss of the entrance building will be covered by passive solar energy.

PROJECT DESCRIPTION

Among the newest commercial buildings in Denmark the office building of Time/System International A/S appeared to have some features of interest for the studies within the IEA Task XI.

Time/System produces and sells planning calendars on a worldwide market.

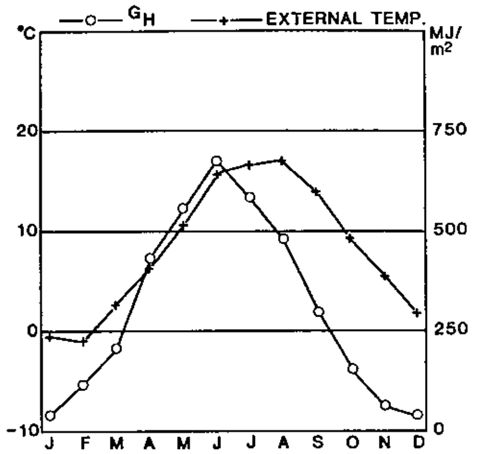
The design of the Time/System office building was, according to the wishes of the owner, influenced by an Italian/American style of architecture.

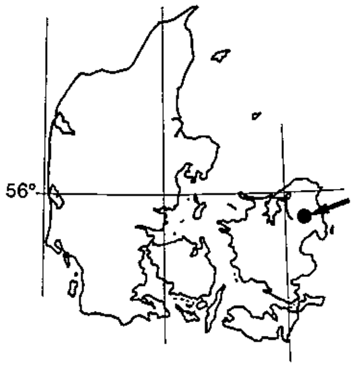
Two 3-storeyed wings of the office building were linked together by an entrance building primarily constructed in glass. Inspirations were taken from the Trumph Tower in New York.

The basic case study will deal exclusively with this glass entrance building.

SITE AND LOCATION

The Time/System plant is located 25 km north of Copenhagen. The buildings are situated in a sub-urban district on the outskirts of the suburb. There are no shadows from neighbouring buildings.





Site data:
Latitude: 55.4N
Altitude: 48 M

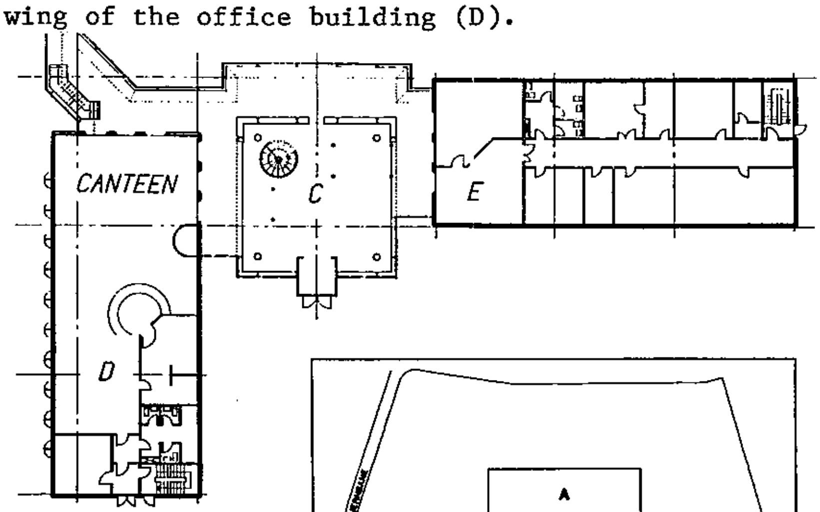
Climate data:
Oct. to Apr. inclusive
Degree Days - 3 719
(base 20)
G_H - 1098 MJ/m^2
Actual Sun Hours -596
Actual/Theoretical -0.28

Annual:
Degree Days - 4 344
(base 20)
G_H - 3666 MJ/m^2

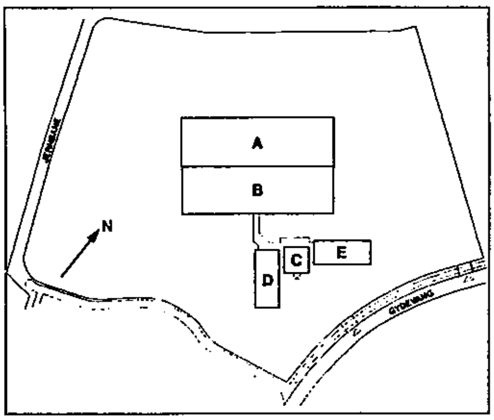
BUILDING FORM

The figure below shows the lay-out of the plant. Building A and B contain storage and printing plant.

The office building consists of two 3-storeyed wings (D and E) attached to the central entrance atrium (C) containing the reception area and the stairways. There is direct access to the plant canteen located on the first floor of the west wing of the office building (D).



FIRST FLOOR



Volume: (m^3)
Glass entrance
building: 2 200

Dimensions: (m)
Floor to ceiling
Glass Entrance
Building: 11

Surface Areas: (m^2)

Glass Entrance Building:	
Ground floor	220
Roof	220
Wall (excl. windows)	0
Windows	500

Window data:
Glass Entrance
Building:
Glass 450 m^2
Glass area is 90% of facade

U-values: (W/(m²K))

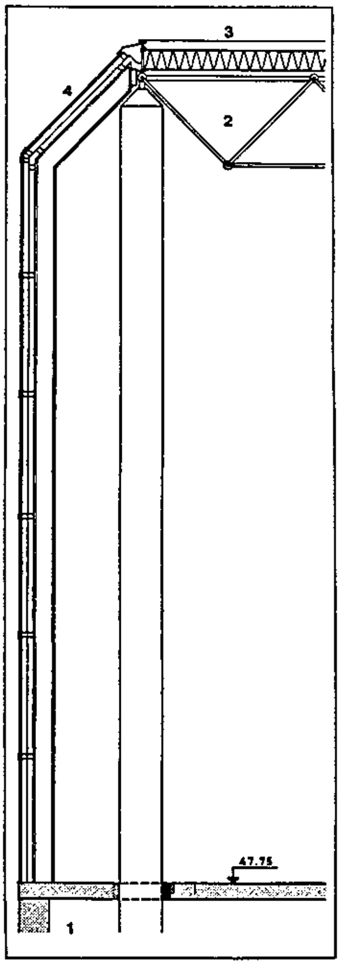
Floor	0.50
Wall	0.25
Roof	0.20
Window:	
Glass	1.60
Frames	2.50

Envelope heat loss: (kW/K)

Glass entrance building:
Transmission 1.00
Infiltration 0.37
(Mechanical ventilation 3.33 not considered)

BUILDING CONTRUCTION

The office building is constructed with prefabricated concrete components in a modular grid of 2.4 m. The basement (1) is cast in situ concrete. The central entrance building is framed with a steel skeleton consisting of 14.2 m columns tied together by roof trusses (2). The roof structure consists of wooden panels (3) resting on a beam grid. The building faces are clad with sealed double glazed windows with low U-value (1.6 W/m^{2}K) composed of light green solar controlled glass on the outside and low emissivity glass on the inside. The top of the outside walls is sloped 45° and contains a window (4) which may be manually opened on hot summer days and for smoke evacuation in case of fire.



Installed capacity:
Space heating - 750 kW (office and production)

Design conditions:
Internal temperature 21°C

BUILDING SERVICE

The office wings (D&E) are heated by a one pipe radiator system. The room temperatures are controlled by thermostatic valves.

The glass entrance building is heated by a ventilation system which includes a fan capable of mowing 10,000 m^3/h, corresponding to 4.5 times the volume of the entrance building. The glass entrance is additionally heated by (electric floor heating). The ventilation system is connected to a watch, and the exhaust air is treated in a rotating economiser (efficiency 0.7). In periods without heating demand, the economiser stops. In the near future, controls for optimal start/stop will be installed. A heat exchanger adjusts the inlet temperature of the ventilation system.

The canteen in the west wing contains a separate ventilation system.

PASSIVE SYSTEM

In the glass entrance building, the passive solar contribution to the heat balance is of great interest. For architectural reasons, the entrance building was designed in glass and steel, thus making the transmission losses considerably larger than conventionally. It will be interesting to compare the initial measurements showing a marked stratification with the computer simulations.

ENERGY PERFORMANCE

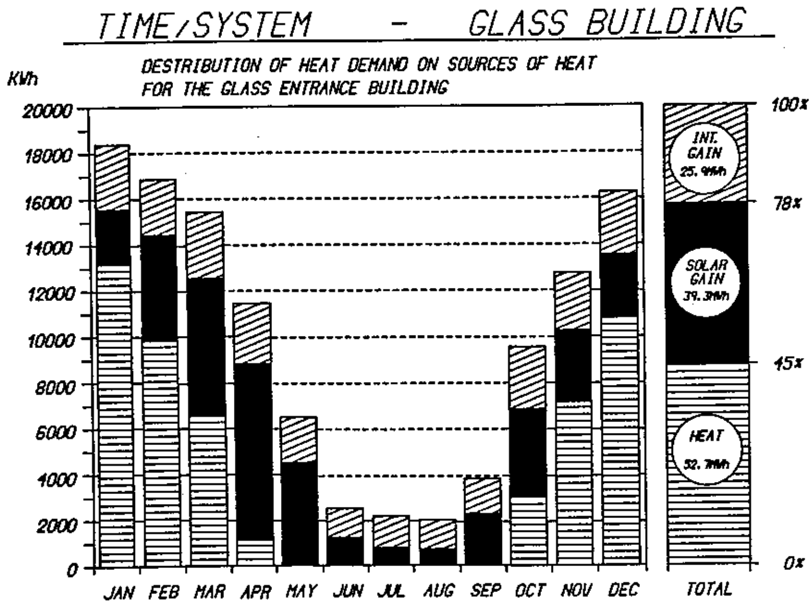
The glass entrance building has been studied by simulations and measurements. As for the measurements, the temperature stratifications have especially been of interest.

Simulation Studies

Preliminary simulations with the Suncode program using the Danish Test Reference Year show the following coverage of the heat demand by the available heat sources, not taking ventilation loss into account:

Internal gain	22%
Passive solar energy	33%
Heating	45%

The use of sealed double glazing with special glass shows a reduction in transmission loss of 40% according to preliminary simulations.



Glazing properties:
Sealed double glazed windows with low U-value composed of light green solar controlled glass on the outside and low emissivity glass on the inside

U-value = 1.6 W/(m^2K)
Daylight transm. = 68%
Solar transm. = 48%

Heating supply in glass entrance building:

Internal Gain	22%
Passive Solar Energy	33%
Heating	45%
Heat demand	100%

Special windows save 40% compared to traditional double-glass windows

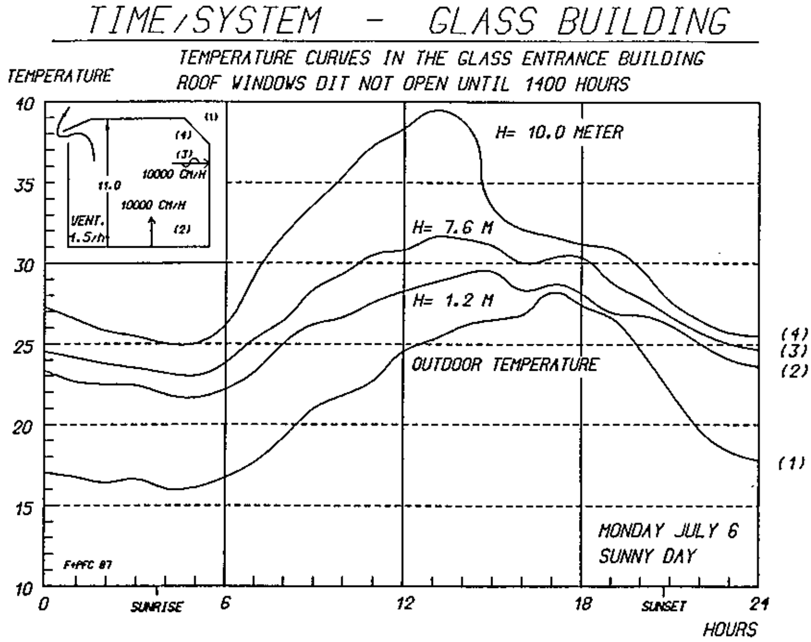
Measurements:
30. June to 6. July 1987

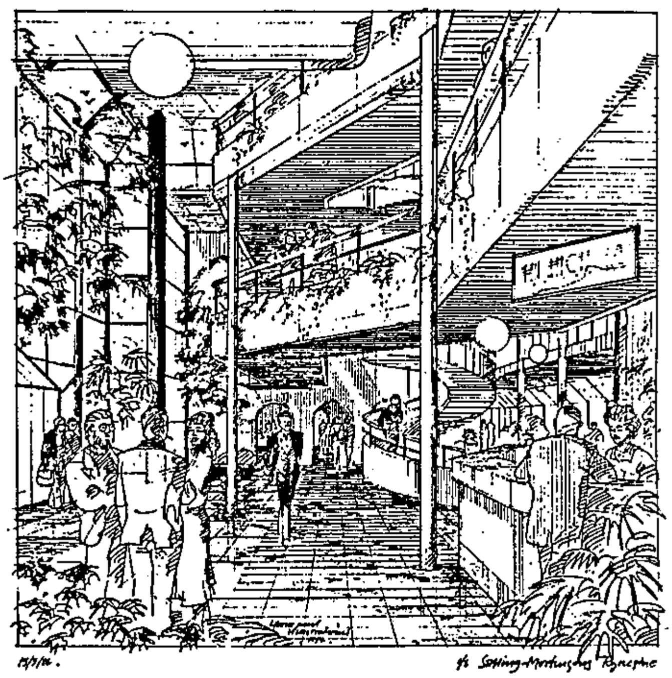
Measurement Studies

Just before the building was occupied in the summer 1987, some preliminary measurements were undertaken in the glass entrance building.

Internal air temperatures at 5 different levels as well as the outside air temperature and insulation were recorded. The figure shows an example of the stratification in the air temperatures in the entrance building on a sunny day when the ventilation system was operated with no heat, and the top windows were opened at 1400 hours.

The curve at 10 m elevation records the temperature above the level of the outlet to the exhaust. Only this temperature is strongly affected by the open windows.





BUILDING COST

The building cost of the Time/System office building is due to a particularly high building standard, much higher than the cost of a conventional office building.

The total cost of the office building is 30,000,000 dkr. The entrance building to the office building constitutes 6,000,000 dkr hereof.

Building cost (1987):
Office Building:

dkr	30,000,000
ECU	3,750,000

Glass Entrance Building:

dkr	6,000,000
ECU	750,000

ENERGY PERFORMANCE

The annual use of energy for the entire office building is not available as it has only been occupied for a few months. Computer simulations with the Suncode program using the Danish Test Reference Year have shown an annual net heat loss of 52.7 MWh for the glass entrance building under the assumption of a conventianl design with recirculation and air change of 0.5 vol/hour. Renewal of the air content in the glass building 4.5 times per hour is expensive, but may allow the use of the entrance building as a greenhouse without major condensations on the windows during winter months.

Annual fuel use: (MJ/m^2)

Heating, DHW:	340
Electricity :	440

Fuel Costs: (1987)

Gas	dkr 30.50
Elect. (average)	dkr 99.00

HUMAN FACTORS

The combination of concrete components in the two wings of the office building with the glass and steel in the centre entrance building has been successful. The extensive use of glass in the entrance building is not without problems. Manual operation of the window openings is required during the summer, and the large volume of air renewed each hour to secure against condensation on window panes in the winter demands a large amount of energy in this part of the building.

Working hours:
08.00 to 16.30 hours in Glass Entrance Building

CONCLUSIONS

Computer simulations show that the transmission loss in the glass entrance building is reduced by 40% by the use of sealed double special glazing instead of normal double glazing, in addition a simulation shows that 33% of the heat demand of the glass entrance building is covered by passive solar energy, when the discarded air volume is not taken into account.

INFORMATION

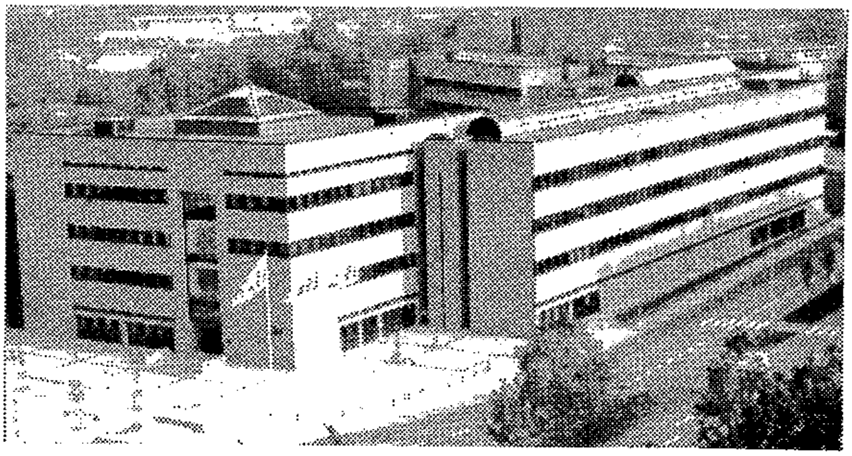
Jørgen Erik Christensen, Peter Carlsson and Finn Carlsson provided the information for this paper.

Article in: Byggeindustrien, No 4 1987, p. 12-19. "TIME/SYSTEM" by Dr H.E. Hansen.

Contacts:
Thermal Insulation Laboratory, Technical University of Denmark,
Bldg. 118,
DK-2800 Lyngby
Tel: 2-88 35 11
Telex: 37 529 DTHDIADK

DK

BRF HEADQUARTER



Building type:
Office

Passive features:
Daylighting direct
Solar control-shading

Occupancy date:
Nov. 1, 1986

Floor area:
Gross - 16970 m^2
Net - 10112 m^2

Costs (1986):
Dcrs 200 million
ECU 25 million

Annual delivered fuel:
Gas: 6 100 000 MJ
Electricity:
Electricity for cooling, lifts and central computer room:
7 200 000 MJ
Electricity for lighting:
3 900 000 MJ

Client:
BRF
Klampenborgvej 205
2800 Lyngby

Architect:
Gunnar Gunnarsen
Krohn & Hartvig Rasmussen
Teknikerbyen 7
2830 Virum

Engineers:
Jørn Kofoed Andersen
and
Gunnar Ørum Sørensen
Birch & Krogboe
Teknikerbyen 34
2830 Virum

SUMMARY

In the new BRF Headquarter, the offices are linked together by staircases and balconies in glass covered central atria open through all four stories.

Artificial lighting is provided by compact high-efficiency flourescent tubes. When sufficient daylight is available on a given floor in the atrium, artificial lighting is automatically switched down.

Energy consumption for space heating is also low due to very well insulated external surfaces and to the fact that most windows have three pane glazing.

All offices and the glazed atria are protected from overheating from the sun by external movable blinds controlled by the central computer. The blinds in front of the office windows can also be operated manually on an individual basis.

PROJECT DESCRIPTION

BRF is a financing institute for property mortgages. The brief for their new headquarter called for the utilization of natural daylight for the benefit of the working environment and in order to reduce electricity consumption for artificial lighting.

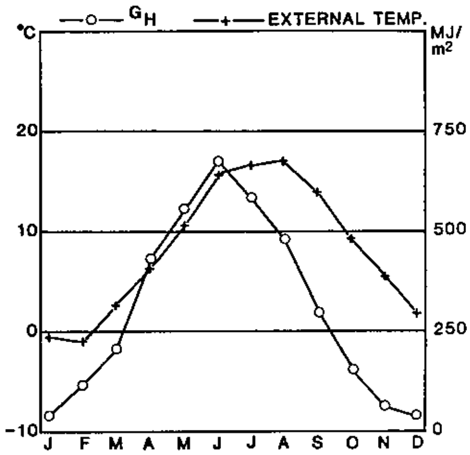
The headquarter is the place of work for 600 people.

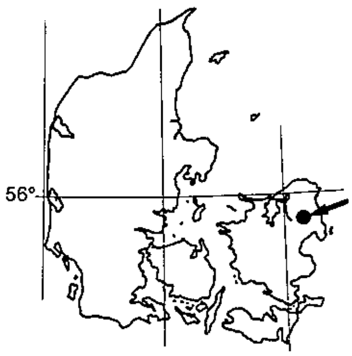
The provision of daylight to central circulation areas and in the offices, coupled with the use of solar shading to eliminate the need for mechanical cooling, has proved successesful.

SITE AND LOCATION

The building is situated in a suburb of Copenhagen near a major shopping centre, 10 km north of Copenhagen City.

Site data:
Latitude: 55.7 N
Altitude: 20 m





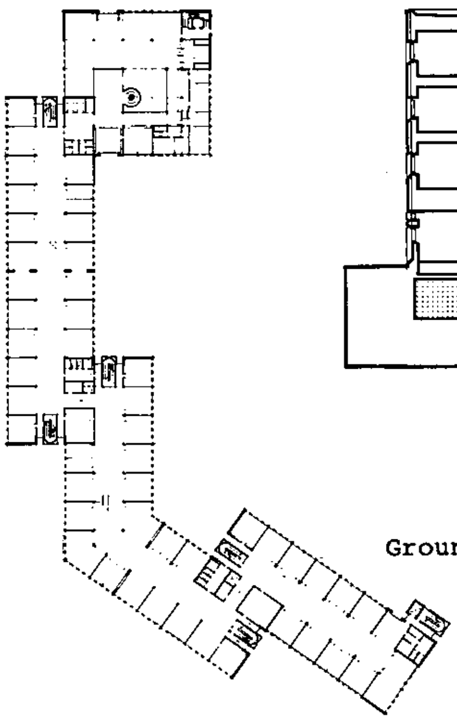
Climate data:
Oct. to Apr. inclusive-
Degree Days 3 719
(base 20°C)
G_H (MJ/m^2) 1 098
Actual sun hours 596
Actual/theoretical 0.28

Annual -
Degree Days 4 344
(base 20°C)
G_H - 3666 MJ/m^2

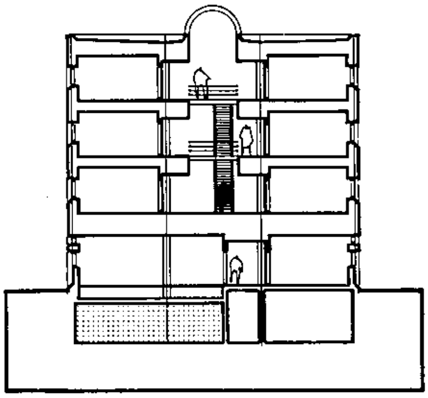
BUILDING FORM

The four story main building has a central atrium, and the three office blocks are equally of four stories and have a central glass-covered arcade.

Circulation in the house goes via balconies and staircases in the open atrium and the arcades. The lifts are situated at the end of each block.



Ground floor



Section

Volume: (m^3)
78 880

Surface areas: (m^2)
Ground floor: 4 318
First floor : 4 181
Second floor: 3 834
Third floor: 3 834

Net space amounts to 52% of the total area, circulation areas amount to 30%, service areas etc. amount to 18%.

BUILDING CONSTRUCTION

U-values: (W/m^2K)
Roof : 0.15
Wall : 0.23
Floor : 0.24
Windows : 2.20 and 1.90
(Three pane glazing)
and 3.10
(two pane glazing)

Envelope heat loss:
(kW/K)
10.2

The main module of the building is 6x6 metres with a sub-module of 1.5 metres in the offices.

Pre-fabricated columns and girders form the structural framework of the building. The pre-fabricated concrete elements in the facade are part of the main structural system as well. The facade has a finish of brickwork, and it is very well insulated with mineral-wool between the brickwork and the concrete elements.

All windows have three pane glazing, except for the rooflights that have two pane glazing.

BUILDING SERVICES

Design temperatures:
Offices and Cirkulation areas:
20°C

Lighting capacity:
100 lux circulation
250-300 lux offices

Space heating is covered by a conventional radiator system with thermostats on each radiator. Space heating and hot water is supplied from a joint heating plant, the fuel being natural gas.

Mechanical ventilation is provided only in meeting rooms, toilets, canteen and the central computer room. The offices have natural ventilation via multiposition windows. Mechanical cooling is provided only in the central computer room. The HVAC systems are monitored by an Energy Management System.

Artificial lighting in the glass covered atrium and the arcades is controlled according to available daylight by a computer connected to a weather station. Artificial lighting is set individually on each floor depending on the available daylight level outside the building.

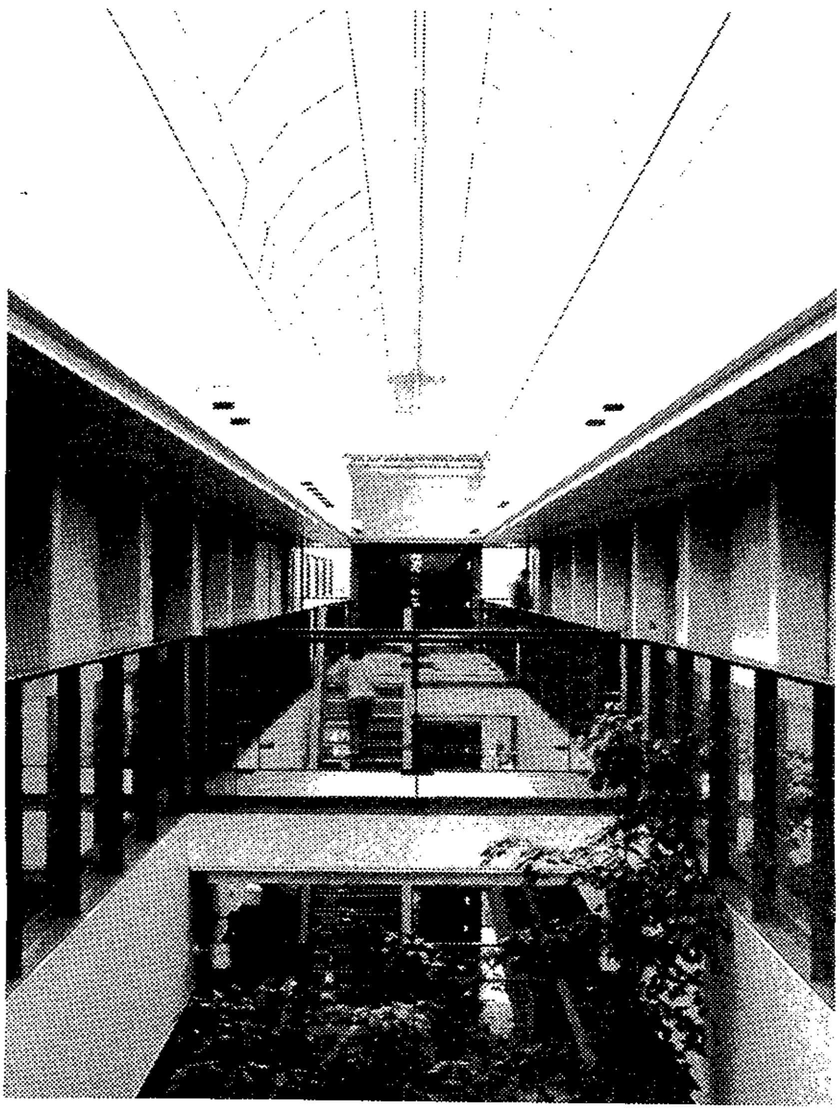
The computer also operates the exterior blinds above the rooflights of the arcade and the atrium, and it operates the exterior blinds of the office windows. The later function can, however, be overruled from the individual offices.

Finally the computer will close the blinds of the office windows and put off most of the artificial lighting during nighttime, 20.00-05.00 hours, to reduce overnight cooling of the building.

High efficiency flourescent tubes are used both in the circulation areas and for ceiling lighting in the offices.

PASSIVE SYSTEMS

The arcades of the office blocks and the atrium of the main building have rooflights. Natural daylight is used to improve the working environment and to save electricity for artificial lighting.



Rooflight in the arcade

Glazing in arcades and atrium:
double glazing
U = 3.10 W/m^2K
normal transmittance:
light - 0.79
solar - 0.76

Glazing in offices:
Triple glazing
U = 2.20 W/m^2K
and
1.90 W/m^2K
(gas-filled cavity)
normal transmittance:
light - 0.72
solar - 0.67

The artificial lighting is controlled on/off on each floor of the arcades and the atrium, depending on available daylight outside the building and following a pre-set model for penetration of daylight down into the building from the rooflights.

Excessive solar input and glare from daylight is controlled via exterior blinds in the rooflights and exterior horizontal blinds in front of the windows. The operation of all the blinds are controlled by a central computer connected to a weather station. The blinds in front of the windows can also be controlled manually on an individual basis.

COSTS

Building costs 1986:

10 200 Dcrs/m^2 gross

1 270 ECU/m^2 gross

The total costs of the buildings with 19 600 m^2 gross floor area have been 200 million Dcrs (25 million ECU), corresponding to 10 200 Dcrs per m^2 (1 270 ECU per m^2); all costs excluding VAT 22% in Denmark.

The total costs including purchase of the site, furnishing and financing costs have been 292 million Dcrs (36 500 ECU); VAT not included.

Building costs for office buildings in Denmark start at 6 500 Dcrs per m^2 for very basic buildings.

It is not possible to deduce the extra costs for the utilization of daylight in the circulation area since it is an integrated part of the building design. Furthermore, the benefits of daylight utilization are more than that of saving electricity, i.e. improving the working environment for the people employed in the building.

ENERGY PERFORMANCE

The annual fuel consumption for the first year of operation, December 1986 - November 1987 has been:

	Delivered fuel/MJ Total	per m^2
Lighting	3 900 000	200
Electricity for computer room, lifts, airconditioning	7 200 000	370
Natural gas for space heating and DHW	6 100 000	310

Electricity consumption for lighting in the circulation areas is not monitored seperately, consequently is it not possible to asses the reduction in electricity use due to utilization of daylight. However, as part of the IEA TASK XI work, it is intended to monitor the performance of the daylighting system to arrive at a figure for Daylight Displaced Electrical Energy for the BRF building on an annual basis.

Until then, a preliminary rough estimate of what is saved in the arcades is 34 200 MJ/year assuming that artificial lighting (4.2 kW) is put off 50% of 250 working days in the period 06.00 - 20.00.

Annual fuel use: (MJ/m^2)
Lighting : 200
Computer, lifts, airconditioning : 370
Heating, DHW : 310

Reference energy:
15 000 000 MJ

HUMAN FACTORS

Utilization of natural daylight was one of the prime design criterias set up by the building owner since lack of daylight was a penalty at the previous headquarters of BRF.

The building seems very compact and closed from the outside, but inside it is very open and friendly, mainly due to the open circulation areas with rooflight.

Occupancy: 600
17 m^2 office space per person.
28 m^2 gross floor space per person.
130 m^3 gross per person.

The people employed are generally very satisfied with the building and the indoor environment. There are no major complaints about the daylighting system. However, it has been argued that the reaction of the exterior blinds above the rooflights might be less nervous to sudden changes in the daylight level. Sudden changes in cloud cover is very common in Denmark during summer.

Overheating has proved not to be a problem, and glare has not been a problem either.

CONCLUSION

The owner, the architect, the engineer and the users agree that the design with emphasis on daylight utilization has been very successful.

The working environment benefits very much from the daylight areas in the middle of the buildings, and, as an extra benefit, electricity for artificial lighting is saved.

Daylight utilization improves the working environment - and saves energy.

INFORMATION

As yet there are no publications about this building but it will be monitored during the autumn 1988.

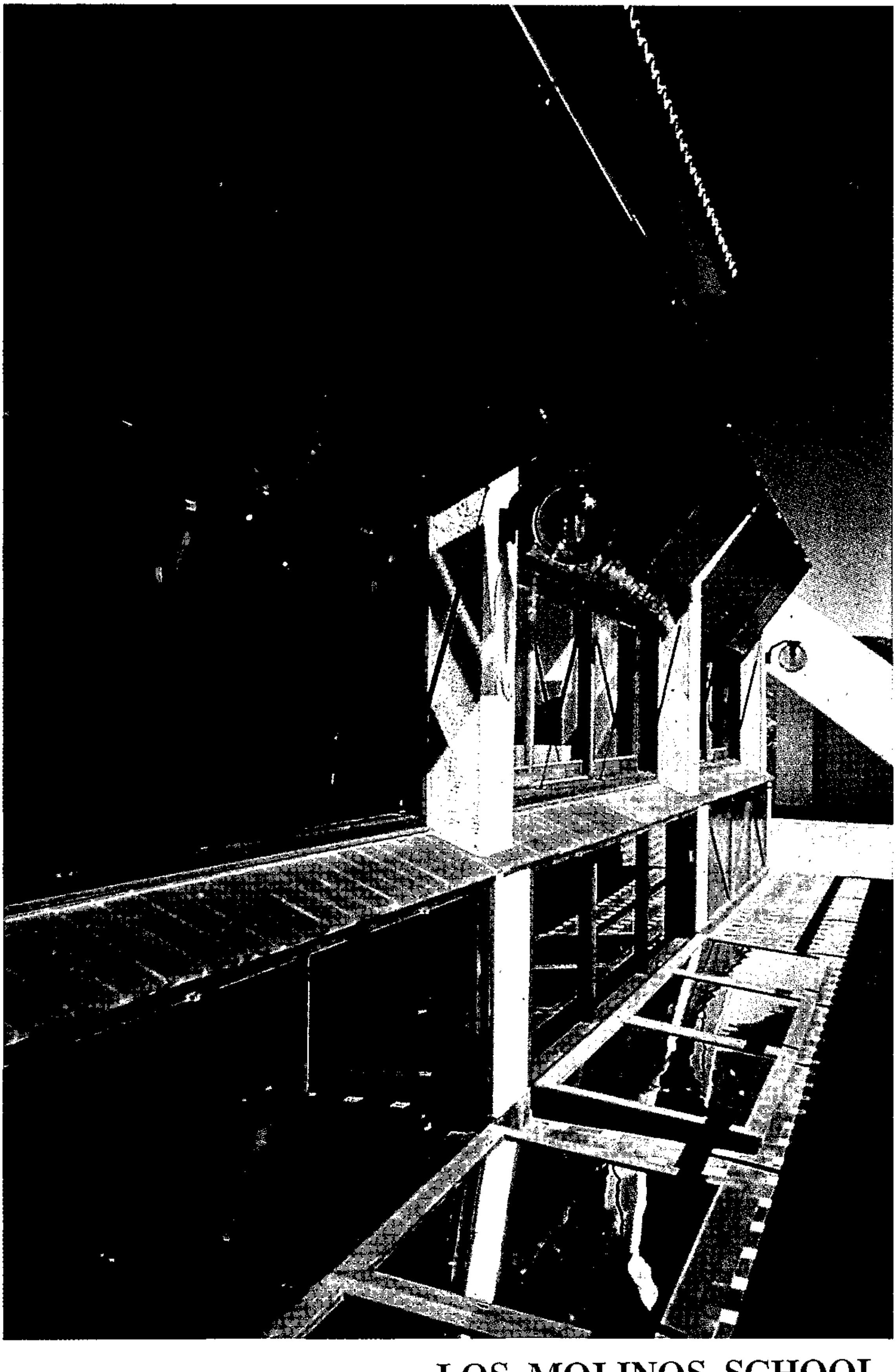
This report was prepared by

Poul E. Kristensen
Esbensen,
Consulting Engineers
Havnegade 41
1058 Copenhagen K
Tel.: 1 11 42 24
Telex: 16039 planumdk

with kind assistance of
Aage Thomsen BRF

(E) SPAIN

BCS No.	Building Title
23	SCHOOL IN ALMERIA
24	SCHOOL IN GUILLENA
25	LOS MOLINOS SCHOOL
26	POLYSPORTIVE ESTERRI



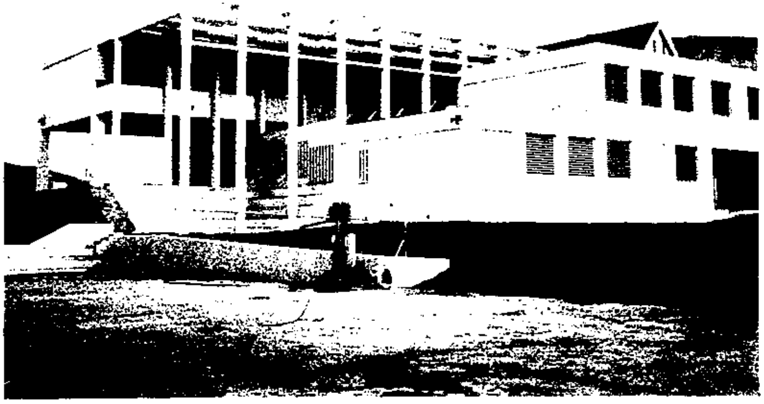
LOS MOLINOS SCHOOL

E SCHOOL IN ALMERIA

Building type:
Education

Passive features:
Daylighting:
- direct
- indirect
- atria

Thermal:
- direct gain
- indirect gain
- natural cooling
- solar control



Occupancy date:
April 1987

Floor area:

Gross -	2071 m^2
Heated -	1686 m^2

Cost (1984):

Pts.	56.952.500
ECU	412.102

Annual delivered fuel:
(for heating)

Electrical	0 MJ / m^2
Oil	0 MJ / m^2

Client:
Consejería de Educación
Junta de Andalucia

Architect:
Pilar Alberich Sotomayor

Bioclimatic Consultant:
Seminario Arquitectura Bioclimática. Sevilla.

Monitoring:
S.A.B. & Valeriano Ruiz
E.T.S.I.I. Sevilla.

SUMMARY

The school is designed for the maritime mediterranean subclimate in Andalucia. Minimum energy consumption, low maintenance, durability, adequate lighting and acoustic control are the main features for the building.

The educational use was considered in the design; in the daily cycle without night-time occupancy and in the yearly cycle without summer-use, or a very reduced one. Thus winter night heating and summer cooling are minimized.

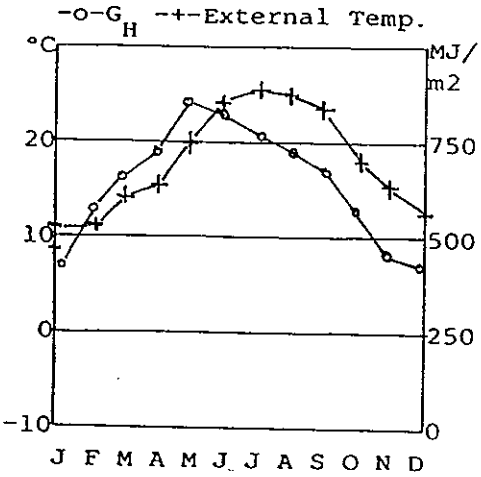
Lighting level is provided during daytime by daylighting.

Ventilation in the classrooms is an important feature to provide due to their high occupation, 40 persons/57m^2.

PROJECT DESCRIPTION

The building is composed by two parallel south facing volumes. The first one is lower than the second allowing controlled solar radiation.

The atria in between, becomes the main environmental control element: capturing sun radiation in winter, protecting from it and activating ventilation in summer.



Site data:
Latitude: 36 N
Altitude: 0,0 m

Climate data:
Oct. to April inclus.:
Degree Days (Base 15) 317 , 7
G_H 2684(MJ/m^2)
Actual sun hours: 1900

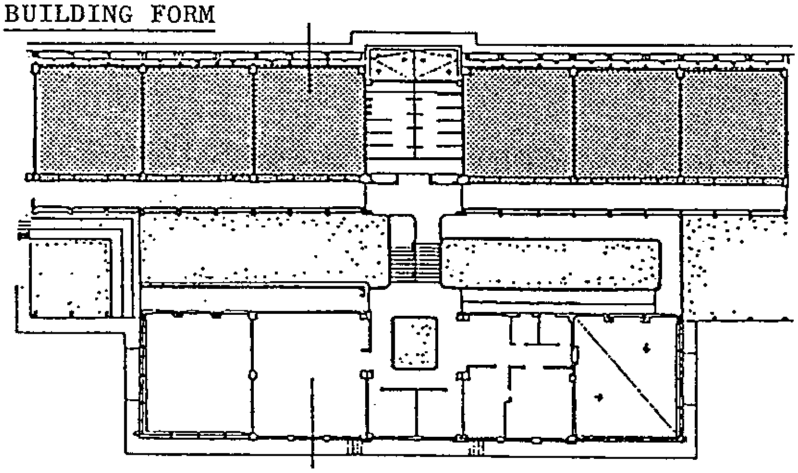
Annual:
Degree Days (Base 15) 319
G_H 6100(MJ/m^2)

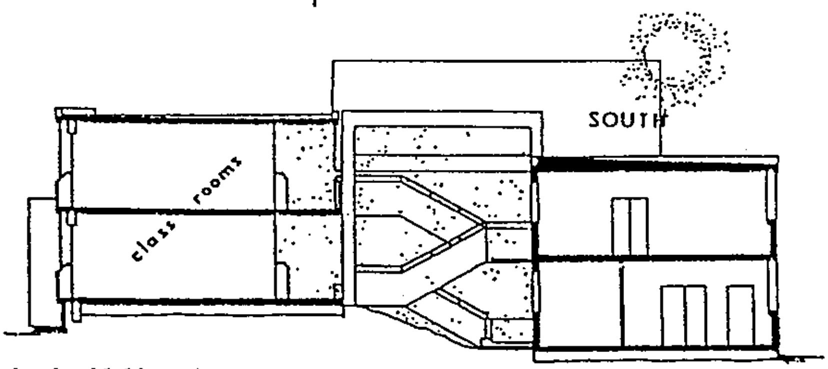
SITE AND LOCATION

External conditions are during the whole period of school use inside the comfort area. Winter early mornings are slightly underheated and from april on solar protection is desiderable.

The location is urban on south-facing slope. Winds mainly blow in the east-west direction. Winds coming from the the sea bring rains and freshness in summer. Winds coming from the land are cold in winter and hot in summer.

BUILDING FORM





Volume: (m^3)
Heated: 201,6m^3/classroom

Surface areas: (m^2)
Ground floor: 2071
Roof: 743
Wall: 983,7
Windows: 268,4

Surface to volume ratio: (m^{-1})

$$\frac{\text{Surface}}{\text{Volume}} : \frac{2820}{4694} = 0{,}60$$

The building is composed by two parallel southfacing and stepped volumes. The atria in between is open to outside. A fix concrete blind system performs the desired sun control depending on solar altitude. In summer ventilation

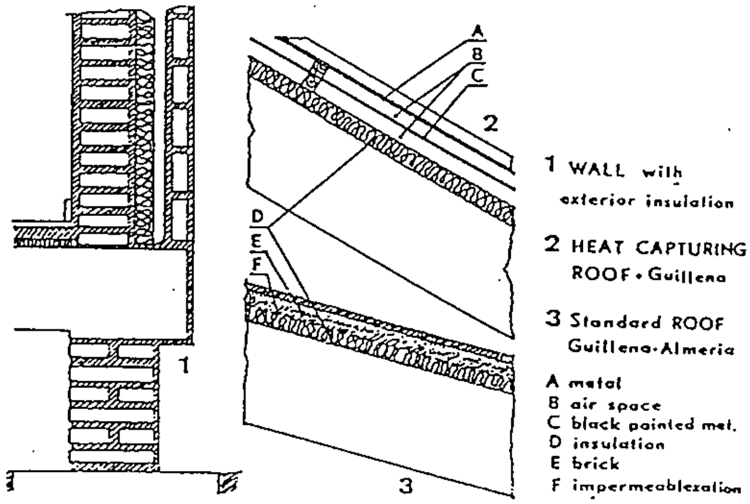
U - values: W/(m^2K)

Floor :	0,37
Roof :	0,47
Wall :	0,50
Window	
Glass and frames:	5,8

and solar protection are provided.

BUILDING CONSTRUCTION

Local construction methods and materials are used: steel reinforced concrete brick, ceramic flooring tiles, and standard insulation, like polystyrene board.

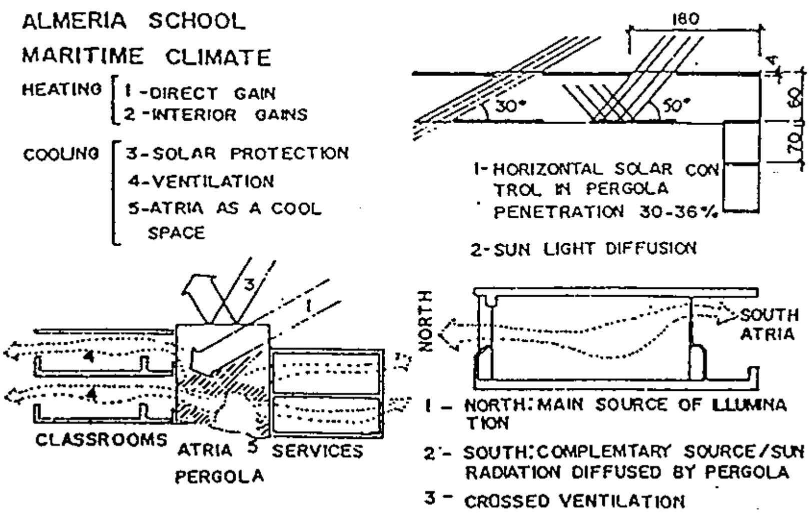


PASSIVE SYSTEMS

Thermal: Underheated periods take place just in the first hours of the winter morning. Admitted solar radiation through the fixed blind system, plus occupancy heat covers the heating energy demmand.

Cross ventilation in classrooms avoids overheating at the end of the morning. Solar protection, together with the atrium as an intermediate cool space, cross ventilation prevent summer overheating.

Daylighting: This has been specially studied for the classrooms. there is a predominance of north diffused - light coming from the left side. In the deeper areas of classrooms there is south illumination diffused by the atrium's white concrete blinds. White interiors homogenize illumination.



COSTS

The building is developped and constructed with similar prices as standard educational buildings, set by the Government.

ENERGY PERFORMANCE

The research programme estimated a priori that heating in energy efficent buildings could be completely provided by passive systems. Monitoring of the buildings is planned in order to verify predictions and design guidelines.

HUMAN FACTORS

The building adapts itself to the local culture and can be inmediately understood. The atria pergola space offers communication and relation possibilities, at the same time as environmental control . It has become,as well, the most important symbolic space in the school.

The environmental features are especially recommended for a school, where they can have a useful educational function.

CONCLUSIONS

The research programme is still in progress. Confirmed predictions should be taken into account by government and individuals in order to reform traditional and irrational school design. In this field fundamental environmental objectives seem cheap and easy to achieve, considering the peculiar characteristics of the educational use, mainly the cycles of occupancy and amount of internal gains.

Site and location have to be at the same time carefully studied because they modify the environmental control programme.

Analysing the particular use and climatic varieties , the Seminario de Arquitectura Bioclimática(S.A.B.)will offer the guidelines for the design of energy efficent schools in Andalucia identifying three basic climates : mediterranean maritime, continental and mountainous.

INFORMATION

EstudioBioclimático de Centro de Enseñanza General Básica (E.G.B.) de 10 unidades.

Seminario de Arquitectura Bioclimática (S.A.B.).

Building costs:(1984)
Pts. 27.500/m^2 (Gross)
ECU. 199/m^2 (")
Typical cost (1984):
26.000/m^2

Predicted performances:
Heating:
Passive systems: 100%
Cooling(during school period): 100%
Daylighting: 100%

Number of occupants:
400 children:10 groups(40)
4,4m^2 / child

Period of occupancy:
9:00 - 1:30 h
15:00 -17:30 h
holidays: Jun-Sep
Dec-Jan

School use has to be considered for its peculiar characteristics:

- cycles of occupancy daily and yearly.
- at the same time analysing climatic requirements for the different locations.
- easy and effective guidelines are obtained.

Report prepared by:
Seminario de Arquitectura Bioclimática.
Avda.Reina Mercedes,S/N
41012-SEVILLE.Spain
Tel. (54) 61 26 00

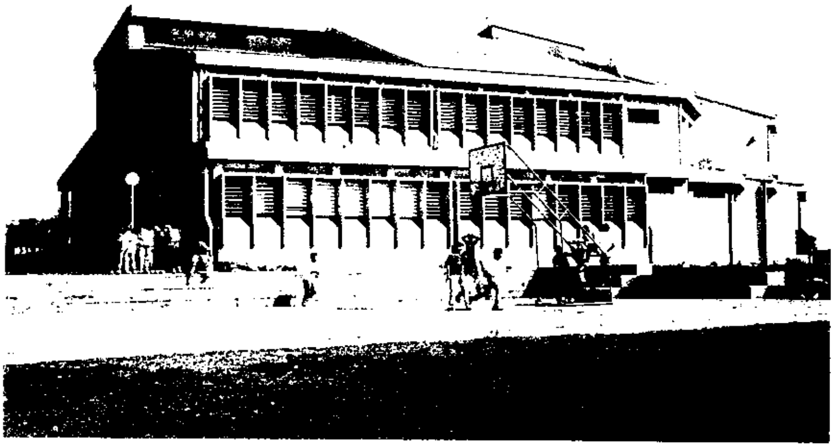
E

SCHOOL IN GUILLENA

Building type:
Education

Passive features:
Daylighting:
- direct
- indirect
- atria

Thermal:
- direct gain
- indirect gain
- natural cooling
- solar control



Occupancy date:
November 1987

Floor area:

Gross :	1832 m^2
Heated :	1620 m^2

Cost (1987):

Pts.	65.000.000
ECU	467.625

Total delivered fuel:
(for heating)

Electrical	75(MJ/m^2)
Oil	0(" ")

Client:
Consejería de Educación
Junta de Andalucía
Architect:
Pilar Alberich Sotomayor
Bioclimatic Consultant:
Seminario de Arquitectura Bioclimática. Sevilla
Monitoring:
S.A.B. & Valeriano Ruiz
E.T.S.I.I. Sevilla.

SUMMARY

This school is designed for the continental subclimate in Andalucia. Minimum energy consumption low maintenance, durability, adequate lighting and acoustic control are the main features for the building.

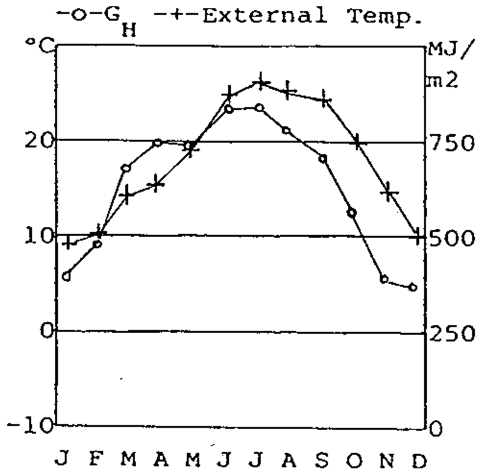
The educational use is considered for its peculiarity; in the daily cycle without night time occupancy and in the yearly cycle without summer use, or a very reduced one. Winter night heating and summer cooling are minimized.

Lighting level is provided during daytme by daylighting.

Ventilation in the classrooms is important due to their high occupation density.

PROJECT DESCRIPTION

The building is composed of two parallel south facing volumes. The first one is lower than the second, allowing controlled solar radiation. The atria in between becomes the main environmental control element: capturing sun radiation in winter protecting from it and activating ventilation in summer.

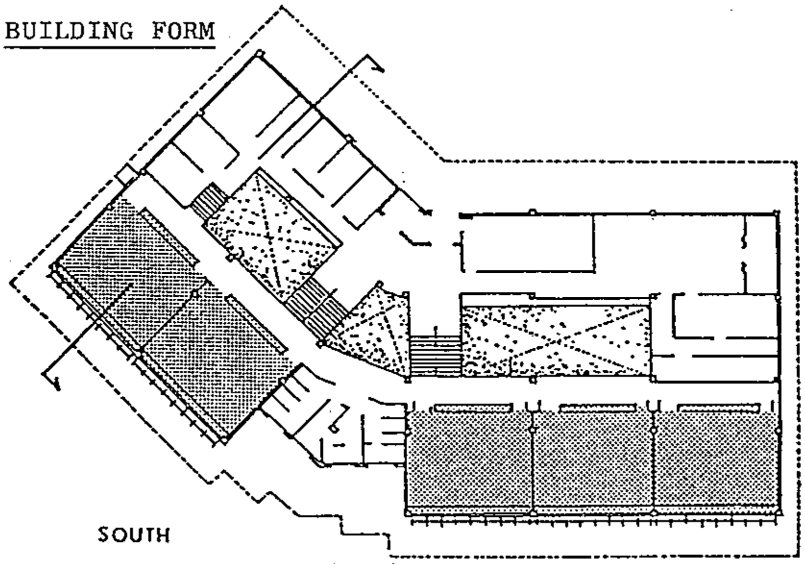


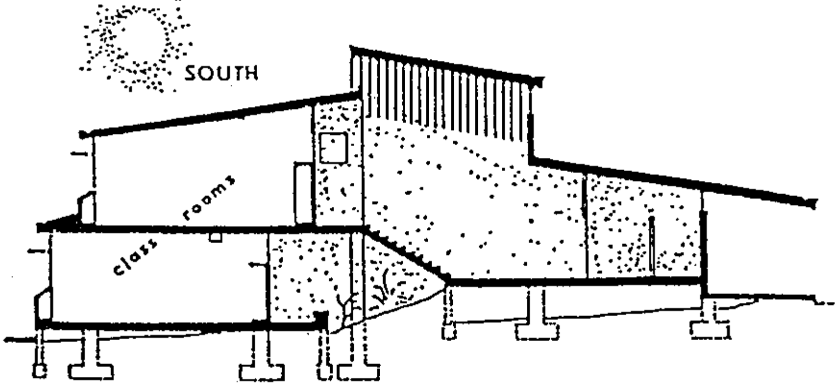
SITE AND LOCATION

External conditions sometimes become extreme with underheated and overheated periods. Differences between daily maxima and minima temperatures are considerable.

Winds mainly blow in the east-west direction.

BUILDING FORM





The building is composed of two parallel south facing and stepped volumes. The atria in between is partially covered by a glass roof capturing solar radiation in winter. In summer, ventilation and solar protection is provided.

Site data:

Latitude:	37 N
Altitude:	23 m

Climate data:

Oct. to April inclus.:

Degree Days(Base 15ºC) 576

G_H 2602(MJ / m^2)

Actual sun hours:1475

Annual:

Degree Days(Base 15ºC) 580

G_H 5914(MJ / m^2)

Volume: (m^3)

Heated: 6668,6/total - volume

Surface areas:(m^2)

Ground floor:	1620
Roof:	1046
Wall(Excl. windows):	710,8
Windows:	304,5

Surface to volume ratio (m^{-1})

$$\frac{\text{Surface}}{\text{Volume}} = \frac{3212,6}{6668,0} = $$

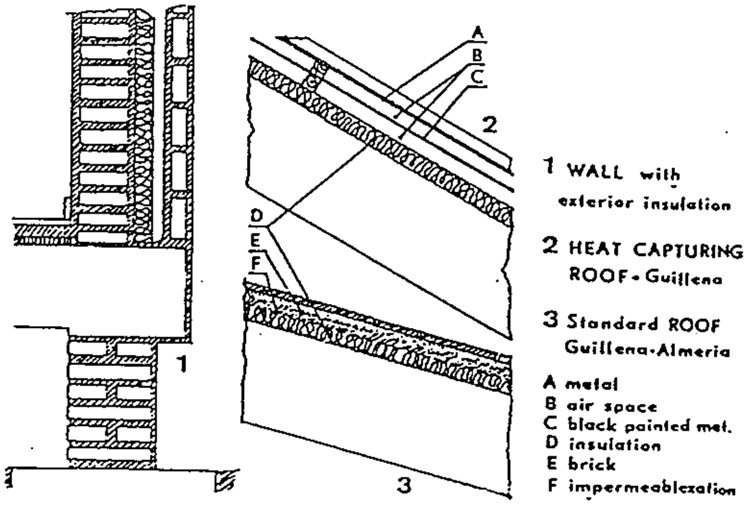
$$= 0,48$$

U - values: (w/m^2K)

Floor:	0,37
Roof:	0,47
Wall:	0,50
Window	
Glass and frames:	5,8

BUILDING CONSTRUCTION

Construction methods and materials are used: steel reinforced concrete brick, ceramic flooring tiles, and standard insulation, like polystyrene board.



Heat pumps capacity:

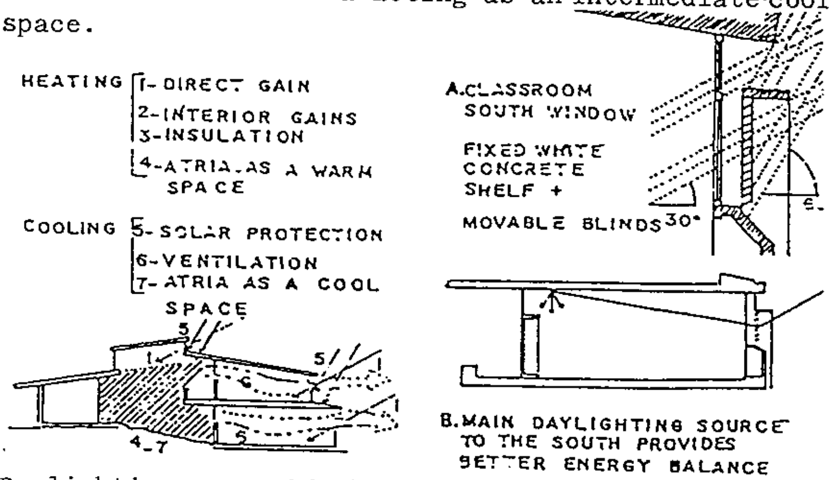
Lower floor:	50 w/m^2
Upper floor:	60 w/m^2

BUILDING SERVICES

Auxiliarly Heating/Cooling. Two heat pumps that work with direct gain back-up. The same pumps can be used for cooling if needed.

PASSIVE SYSTEMS

Thermal: Underheated periods work in a hybrid way. High insulation and direct gain complemented by active systems. Overheated periods, minimized due to holidays, are prevented by solar protection, cross ventilation and the atria acting as an intermediate cool space.



Daylighting: This is specially studied for the classrooms. The main light source is to the south in order to have a better energy balance. Direct radiation is diffused by white blinds at the exterior of the window. In the deeper area of classrooms diffused illumination from the atria is helpful.

COSTS

The building is developped and constructed with a similar price as standard educational buildings given by the government, and being equivalent to these of the social housing programmes.

ENERGY PERFORMANCE

The research programme estimated a priori that 75% of heating in energy efficent buildings could be provided by passive systems. The daylighting is estimated to be able to provide 100% of daytime needs.

Monitoring of the building is planned in order to verify predictions and design guidelines.

HUMAN FACTORS

The building adapts itself to the local culture and is inmediately understood. The atrium space offers communication and relation possibilities, at the same time as environmental control. It has become, as well, the most important symbolic space in the school.

The environmental features are especially recommended for a school, where they can have an important educational function.

CONCLUSIONS

The research programme is in progress. Confirmed predictions should be taken into account by government and individuals in order to reform traditional and irrational school design. In this field, fundamental environmental objectives seem cheap and easy to achieve, considering the peculiar characteristics of educational use mainly the cycles of occcupancy and the amount of internal gains.

Site and location have to be at the same time carefully studied because they modify the environmental control programme. Analysing the particular use and climate varieties, the Seminario de Arquitectura Bioclimática (SAB) will offer guidelines for the design of energy efficent schools in Andalucia, identifying three basic climates: Mediterranean maritime, continental and mountainous.

INFORMATION

Estudios Bioclimáticos de Centros de Enseñanza General Básica, E.G.B. de 10 unidades.

Seminario de Arquitectura Bioclimática (S.A.B.).

Building Cost: (1987)

Pts. 35.480/m^2 (Gross)

ECU 255/m^2 (")

Typical cost (1984):

Pts. 34.500/m^2 (Gross)

Predicted Performances:

Heating:

Passive systems: 75%

Cooling (during School Period): 80%

Daylighting: 100%

Number of occupants:

400 children in 10 groups of 40.

4,4 m^2/child

Period of occupancy:

9:00 – 1:30 h

15:00 – 17:30 h

Holidays: Jun -- Sept

Dec -- Jan

School use has to be considered for its peculiar characteristics:

- cycles of occupancy daily and yearly
- at the same time analysing climatic requirements for the different locations
- easy and effective guidelines are obtained

Report prepared by:
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41012-Seville (Spain)
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LOS MOLINOS SCHOOL

Occupancy date:
March 1984

Floor area: (m^2)
Gross: 579
With passive
solar systems 330

Cost: (1984)
Pta 25 000 000
ECU 177 574
(1 ECU = 140.8 Pta)

Annual delivered fuel:
Electricity for lighting and pump: 2700 MJ
Fuel for space heating 0
Total 4.7 MJ/m^2 gross

Building type:
Education

Passive features:
Solar Heating:
Direct and Indirect
Natural cooling
(Ventilation chimneys)
Daylighting:
Direct and Indirect
Solar Controls:
Shading
Movable Insulating
Reflectors
Ventilation Control:
Ventilation shutters
Other: Patio

Client:
Caja de Ahorros del Mediterráneo

Architect:
I. Blanco

Monitoring:
Dept. de Termodinàmica
Universitat de València

SUMMARY

The classroom building of Los Molinos school is a didactic building on solar passive systems. It is cost-effective as regards building cost (4.2 % less than a conventional building) and fuel use (15 MJ/m^2month of fuel saving in winter).

Measured data show that the classroom building is of zero energy and that the building parameters are in the confort zone all the year. Classroom building seems to be not sensitive in summer to the large amount of solar energy it receives.

When designing Los Molinos the architect had the opportunity to develope a new passive system fitting the traditional local architecture (the Blanco wall). Blanco wall makes the building aesthetically pleasant and allows also a conventional window distribution on the south façade that joins rooms and outside.

PROJECT DESCRIPTION

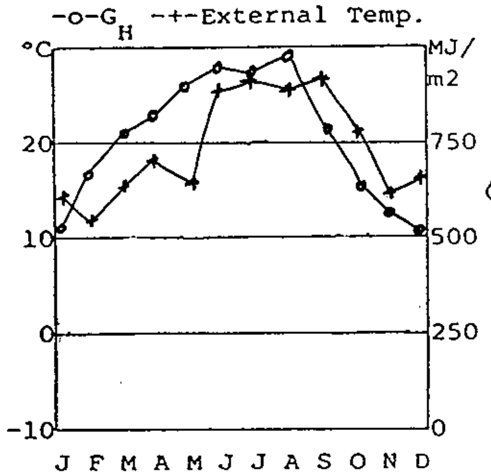
'Los Molinos' School of Environmental Sciences was founded by the Social Work of CAM (Caja de Ahorros del Mediterraneo, a savings bank) in 1979. The centre teaches environmental sciences, including renewable energy sources.

The school classroom building was intended to be a passive solar building being itself a didactic example of various passive systems. The architect in charge of project, I. Blanco, has integrated passive solar concepts with Mediterranean rural architecture uses. The building, designed to be of zero energy for heating and cooling, was ready for use in March of 1984.

The building monitoring, supported by IER (Instituto de Energias Renovables), began in March 1987. The monitoring scheme is macrostatic as required by CEC MONITOR program, but a macrodynamic approach can also be used.

SITE AND LOCATION

The site is near Alicante, on the south-east of Iberian peninsula, 20 km from the coast on a slope 300 m above sea-level. The building is under the action of strong winds. There is little shelter and little site obstruction.



Site data:
Latitude 38º 15'N
Altitude 300 m

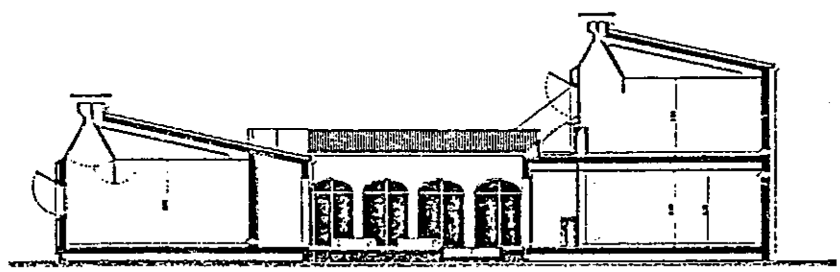
Climate data:

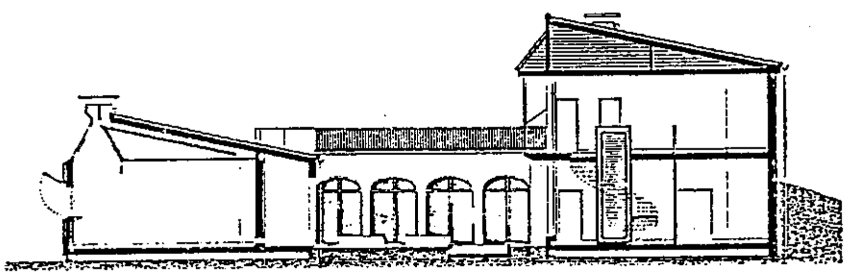
Oct. to Apr. inclusive:
Degree Days (base 20): 1421
Solar Irradiation (Gh): 2636 MJ/m^2
Actual Sunshine (hours) 1404
Relative Sunshine 59% (Actual/Theoretical Sun Hours)

Annual:
Degree Days (base 20) 1514

BUILDING FORM

The building consists of three wings around a patio open to the east; north wing has two floors and is partially earth sheltered to protect it against north winds. The patio with a water pond and a little garden is a fundamental element in the building spatial organization. The west wing is transversal to the other two ones and joins them. The hall, secretary's office, services, workshop and stores are located in this wing. In the first floor, also facing south, there is a classroom and a control room in which meteorological and building monitoring data are collected.





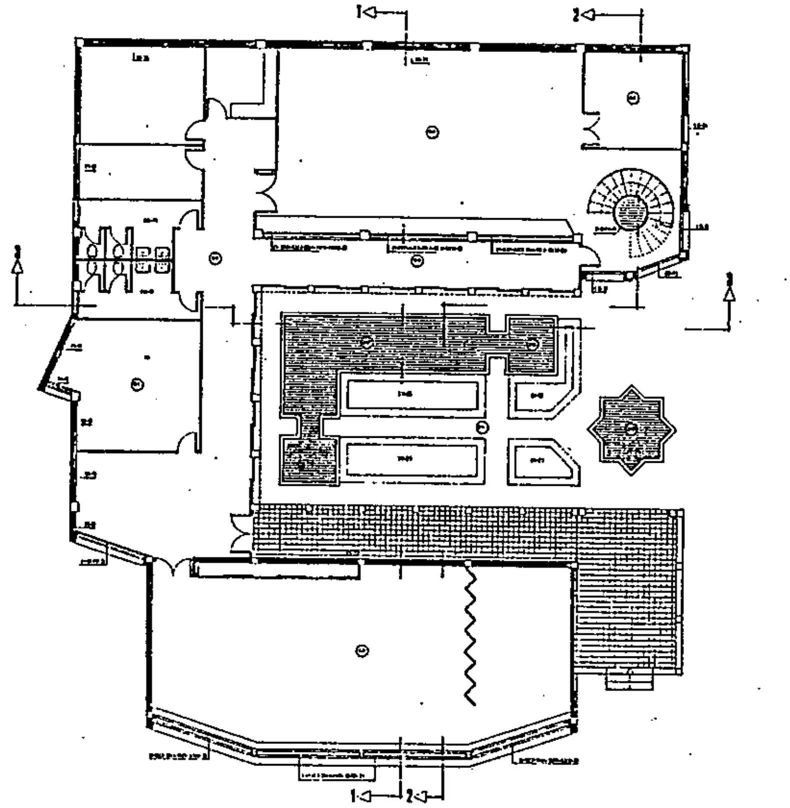
Volume: (m^3)
Gross 2000
Rooms with passive systems 1253

Dimensions: (m)
Ceiling heigth 3.6
Floor heigth 0.5
Perimeter 127

Surface areas: (m^2)
Ground floor 469
Roof 485
Solid wall 541
Windows:
Total 152
28% of glazing in wall

U-values: (W/m^{2}K)
Floor 1.4
Wall 0.6
Roof 0.6
Glass:
Single
without shutters 6.4
with shutters 1.9
" and reflectors 0.9
Double 3.0

Envelope heat loss:
(kW/K)
Transmission 2.2
Infiltration and Ventilation
$\geq$ 0.45
(Ventilation is a passive feature of building)



A new passive system, Blanco wall, is the main passive system in the building. It is composed of slanting windows, internal reflectors and internal thermal mass accumulator, and preserves white external texture of Mediterranean architecture.

Besides the Blanco wall, other passive systems such as ventilation chimneys, a sun-space and a patio open to the eastern winds have been provided in the building.

BUILDING CONSTRUCTION

Installed capacity
(W/m^2):
Space heating 0 (zero)
Lighting 12

Construction is traditional: brick and wood assembly with fiber-glass insulation on external walls and tiled pitched roof. South facing walls have an internal thermal mass of concrete 30 cm thick, and wooden and aluminium elements in the inside, fiber-glass isolated, reflect solar energy onto the thermal mass. Glazing has been highly biased to the south façade.

Design conditions:
(Type: classroom)
Internal temperature 18ºC
Illumination 300 lux
Ventilation rate 0.5 ach

BUILDING SERVICES

The classroom building of "Los Molinos" has no auxiliary systems for heating, cooling or ventilation. Electric energy is only used for lighting (low consumption fluorescent tubes), for some demostration devices (video, diapositive projector) and for a low power pump (fountains in the patio).

The building has 7 m^2 of solar collectors to provide hot sanitary water.

PASSIVE SYSTEMS

BLANCO WALL: Main elements are slanting south facing windows, internal shutters acting as reflectors, internal thermal mass accumulator (included in the wall), isolation placed in the outer side of the wall and a selective absorber in the internal surface of the wall. The wall thermal mass is heated by solar radiation coming in through slanting windows and reflected by means of moving insulator panels. Los Molinos Blanco wall has an external white texture that improves reflection in summer. Operating modes are:

- Winter day:

Tilted-window shutters remain open reflecting solar radiation on the wall thermal mass.

- Winter night

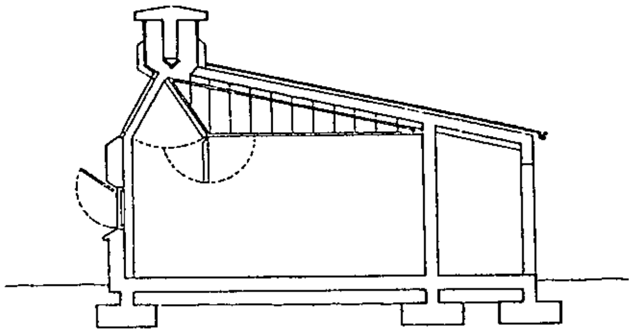
Tilted-window shutters remain closed. Thermal insulation provided by 4 cm thick glass fiber insulation inside the panel.

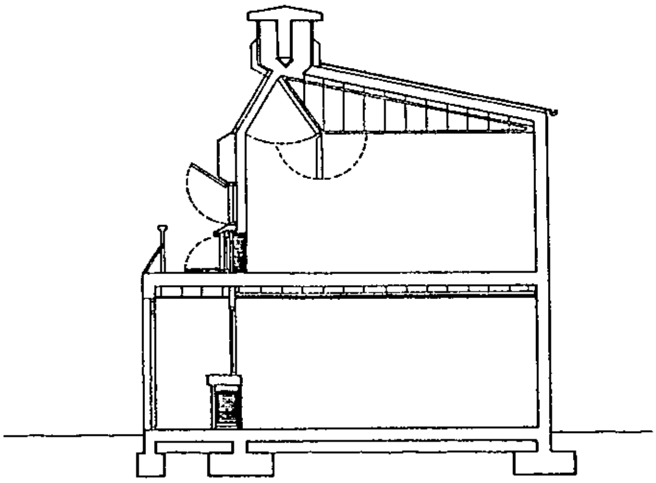
- Summer day

Tilted-window shutters remain closed. Thermal insulation provided by 4 cm thick glass fiber insulation inside the panel. Shutters of Blanco Wall conventional windows remain open acting as shading devices.

- Summer night

Tilted-window shutters in the open position increase thermal losses. Blanco Wall conventional windows and its shutters may be opened to increase ventilation.





Classroom collector area: (m^2)
Window, single glazing 75.0
Window, double glazing 25.9
Shutter protected window, 34.3
Total Collector Area, 100.9

Classroom Heat Storage: (MJ/K)
Primary (direct):
Thermal Capacity 27.9
Secondary (indirect):
Thermal Capacity 38.6

Sun Space Heat Storage (MJ/K)
Primary Heat Storage:
Thermal Capacity 49.8
Secondary Heat Storage:
Thermal Capacity 6.6

PATIO: Open to the east to collect the breezes prevailing in summer in order to provide a suitable microclimate. Air can be humidified by the water in a pond.

Other passive systems like sunspace or solar chimneys operate in a conventional way.

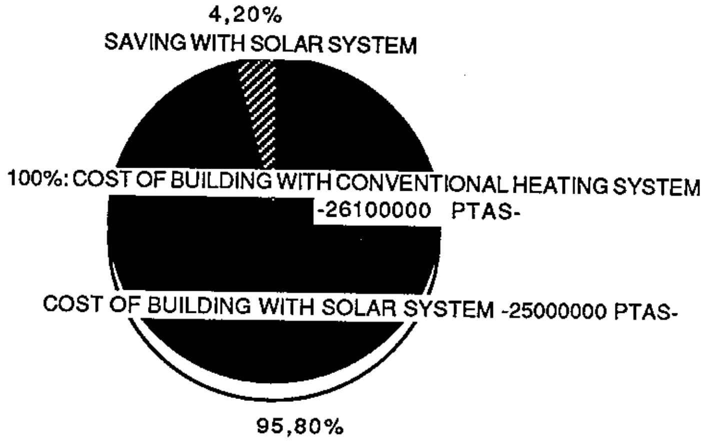
BUILDING COST

Building cost: (1984)
Pta/m² 43 200 gross
ECU/m² 307 gross

Conventional building cost: (1984)
Pta/m² 44 900 gross

The total extra-over cost of solar components (collectors, storage and controls) amount 6973 EUA (1984 prices, 140.8 ptas/EUA). The total extra cost of building elements amount 1688 EUA. The cost of a conventional heating system for the building (1984 prices) amount 16982 EUA. Bearing in mind that the average solar radiation reaching the ground in Crevillente is more than necessary for heating the building along the whole year, no auxiliary heating system has been included in the building's project. Therefore, the saving due to the use of passive solar elements amount 8300 EUA (4.2 % of saving over a similar conventional building).

COST OF BUILDING AND SOLAR DESIGN (1984 PRICES)



ENERGY PERFORMANCE

Annual fuel use:
Electricity for lighting,
4.7 MJ/m² gross

FUEL TYPE	FUNCTION	DELIVERED FUEL TOTAL (MJ)	FUEL/AREA (MJ/m²)
Electricity	Light & projector	810	2.45
Electricity	Pumps (active syst)	1890	5.73
-----------	Space heating	0	0

(Modelled data: the classroom building has not separate meters. Electricity cost is 10 pta/kwh).

During occupation hours artificial light is scarcely needed and mostly in some winter months. Electricity is used also for some demostration devices like slide projector and video.

The building has not any auxiliary heating system; 100% of the heating needs are provived by solar energy. Comparison with a modelled conventional building (conventional glazing ratio and conventional glazing distribution over the building; building materials, shape and isolation the same) gives 20170 MJ savings over the year.

HUMAN FACTORS

The client was aware of the importance of education on renewable energy sources and called for an educational building about solar passive concepts with a confortable working environment for staff and pupils and low maintenance cost.

Design occupancy:
90 pupils aged 11 to 17 and 3 staff

Space 3.2 m^2/pupil in the classrooms

Operating hours:
Civil 09.00 to 18.00
Monday to Friday

The architect is a specialist in solar passive design. When designing Los Molinos he had the opportunity to develope a new, aesthetically pleasant passive system fitting the traditional local architecture (the Blanco wall) and to design a zero energy building.

The pupils arriving at Los Molinos stay there for short periods (usually a week) and so, the user response refer to educators staying there for the whole year. User response has been positive relative to thermal comfort and aesthetics. The ventilation design is efficient. Solar and lighting gains suffice all over the year. The building agrees with traditional local architecture.

CONCLUSIONS

Heat balance of measured data shows that the classroom building is of zero energy. The passive systems provided allow the measured building parameters to be in the confort zone all the year. Classroom building can collect, along the year, more energy than needed and seems to be not sensitive to the large amount of solar energy reaching the building in summer.

Analysis of measured data shows:
- The building is of zero energy
- The thermalconfort indexes are in the confort interval for the whole year

Los Molinos passive solar building is cost-effective as regards building cost (4.2 % less than a conventional building) and fuel use (15 MJ/m^2month of fuel saving in winter).

INFORMATION

* Casanovas, A.J. and Martinez-Lozano, J.A. "First evaluation of the Blanco wall passive system" PLEA (Passive and Low Energy Architecture), Energy and buildings for temperate climates, Porto, July 28-31, 1988, Paper Number 2.1.108. Edited by Pergamon.
* Casanovas, A.J. and Blanco, I. "Analysis of the Blanco wall passive system in Los Molinos design" PLEA, Energy and buildings for temperate climates, Porto, July 28-31, 1988, Paper Number 2.2.172. Edited by Pergamon.

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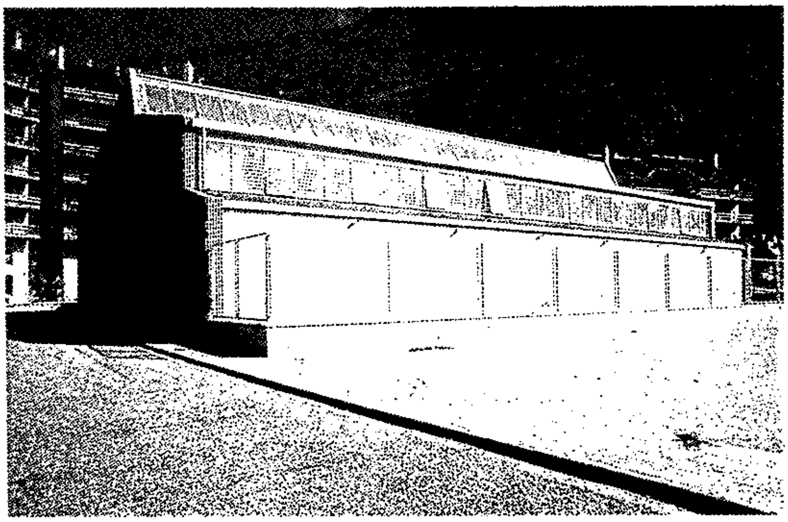
POLYSPORTIVE ESTERRI



Building type:
Sport and social

Passive features:
Solar heating:
- direct

Daylighting:
- direct and indirect

Solar control:
Shading

Occupancy date:
1985

Floor area:

Gross	–	900 m^2
Heated	–	818 m^2

Cost: (1984)

Pts.	33.600.000
ECU	254.545

Client:
Esterri d'Aneu Municipality

Architect:
Francesc Sotomayor i Rodríguez

Services Consultant:
Jocelyne de Botton and Francisco Penella Ros

Monitoring:
Departament d'Industria i Energia.
Direcciô General d'Energia. - Catalunya.(Spain)

SUMMARY

The client the Community of Esterri d'Aneu wanted an indoor sports and social centre because the winter climate is too harsh for outdoor sports.

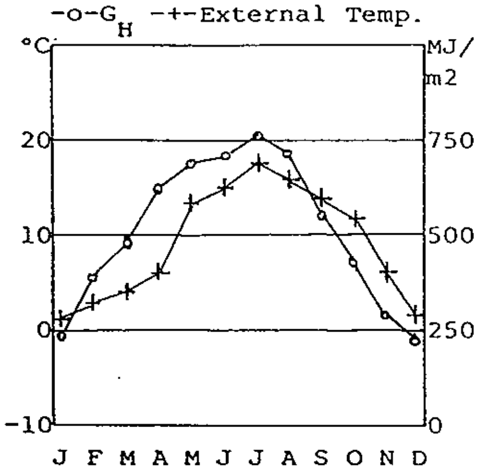
The design had to obtain maximum benefit from the clear sunny winter days and to reduce construction and maintenance costs. It was decided to rely on solar and internal gains to avoid any auxiliary heating system.

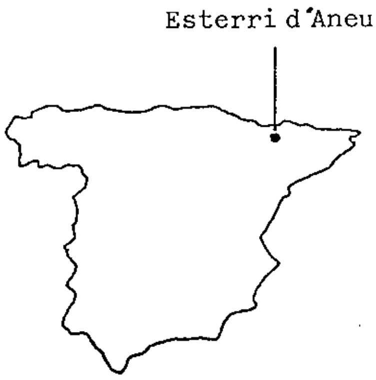
The passive solar design is estimated to add 14% to the cost of the building of a saving of 41,571 kWh / year.

PROJECT DESCRIPTION

The polysportive is a general purpose sports hall , mainly for school children, in a small Catalan village of 550 inhabitants in the Pyrenees. By careful passive solar design, no heating system is required in the sports hall.

So, the aims of this project are:
- Low cost and low maintenance building relying on passive solar for 70% of its space heating demand.
- Passive solar gain increased 20% by use of automatically operated reflecting shutters which also provide insulation to the sunspace at night and in the summer.
- Natural daylighting and natural ventilation reduce capital and maintenance costs.





Site data:

Altitude:	950 m
Latitude:	42º35'
Longitude:	1º07'

Climate data:

Average ambient temperature:

Winter:	7,0ºC
Jan :	1,9ºC
July:	18,8ºC

Degree days (base 18) 2870 dg. days

Global radiation on horizontal: 1557 kWh/m^2

Sunshine hours: 2589 h /yr

SITE AND LOCATION

Esterri d'Aneu is a small town of 550 inhabitants located at the centre of an agricultural district in the Pallars Sobirà region in the catalan Pyrenees. It is 950 m above sea level and has sunny but cool summers. The site has good solar access being on a south facing slope and sheltered on the north side by an apartment block and some mountains. The east side of the site is partially shaded in the morning by the mountain range and the Polysportive was there-fore placed on the north west corner of the site.

BUILDING FORM

The building, which has a heated area of 818 m^2 and volume of 3750 m^3, has been planned on two levels to suit the slope of the site. The lower level contains the sunspace and sports hall and the upper level on the northern side contains the seats and locker rooms. This upper level has been extended all the way to the east side as to emphasize the entrance and provide a place for storage. The 60º roofpitch is designed to provide daylighting and solar gain into the building.

The building has a low surface/volume ratio and is planned to have service rooms and small windows on the north side and large areas of glazing on the south side.

There is a sunspace along the south elevation with a massive wall at the rear for heat storage. To the front of the sunspace are fitted bottom hinged shutters which reflect additional solar radiation into the sunspace when open, and act as insulation when closed. Direct heat gain, daylighting and natural ventilation is introduced by carefully positional windows.

Volume: (m^3)

Gross –	3750
Sunspace:	136

Surface areas: (m^2)

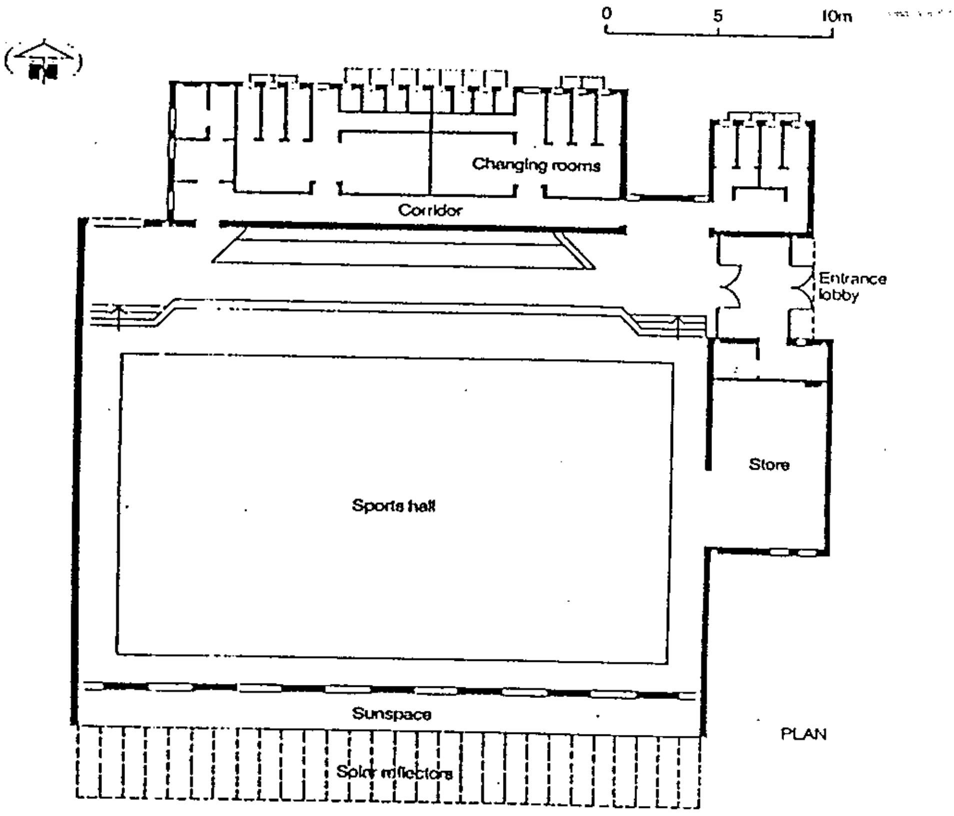
Floor area:	818
Roof :	564
External wall:	545
Windows: Total area:	188
South : (80%)	150
North : (20%)	38

Surface areas of sunspace: (m^2)

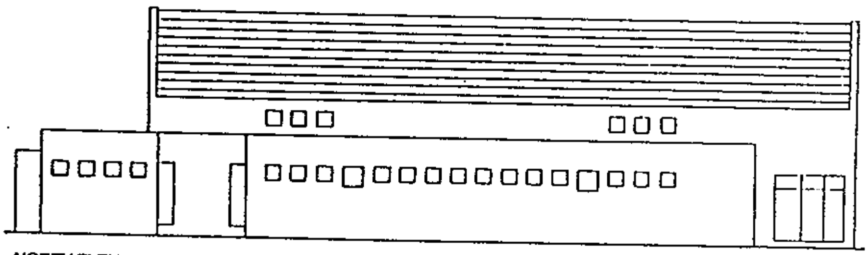
Floor area:	40
Wall area: glass	63
solid	65

Surface to volume ratio (m^{-1})

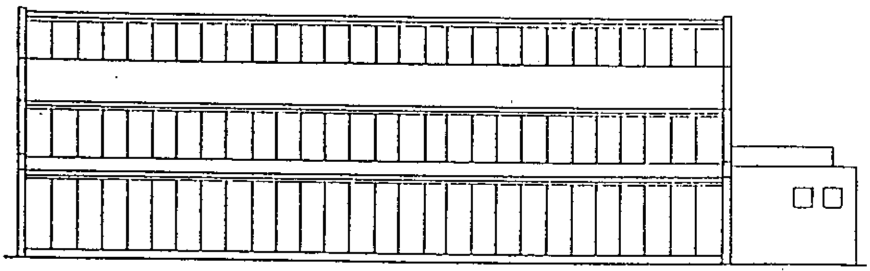
$$\frac{\text{Surface}}{\text{Volume}} = \frac{2115}{3750} = 0{,}56$$



PLAN



NORTH ELEVATION



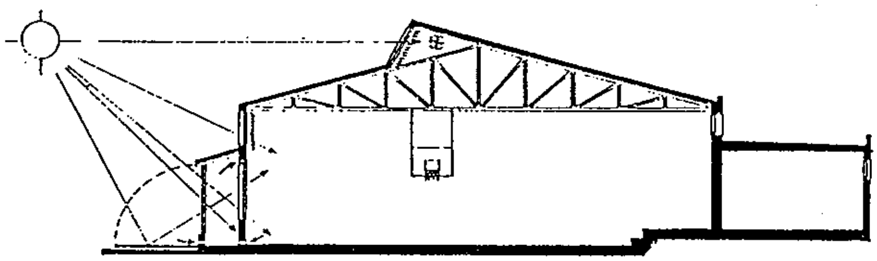
SOUTH ELEVATION

U values: (W/m^{2}K)

Floor:	0,28
Roof :	0,26
External walls:	0,25
Windows:	3,2

BUILDING CONSTRUCTION

The basic construction of the building comprises a 380 mm wide cavity wall and a pitched roof covered with metal composite panels. The outer leaf of the walls is 200 mm concrete block rendered with sandcement and the inner leaf is 80 mm hollow concrete blocks with 100 mm of fibreglass filling the cavity. The holes in the blocks of the inner leaf have been filled with sand in order to improve thermal inertia. The U value of the wall is 0,25 $W/(m^2K)$. The roof panels have 100 mm of expanded polystyrene as insulation and there are 70 mm expanded polystyrene slabs under the floor. The roof U value is 0,26 W/m^2K. The windows have galvanised iron frames and those facing north, having an area of 28 m^2, are double glazed.



BUILDING SERVICES

The only auxiliary system for heating consists of electric pannel radiators in the changing rooms. There is no system in the sports hall. Ventilation in winter is produced by two fans positioned at the top of the east and west walls. In summer the ventilation is natural using the windows and ventilation openings. Hot water is provided by electricity. The reflector shutters are controlled by a photovoltaic cell which lowers or raises the shutters according to the intensity of the light. The cell can be over ridden manually by a button. The venetian blinds to the upper windows are controlled manually as are the ventilation openings.

PASSIVE SYSTEMS

The sunspace stretches across the length of the south elevation and is the lowest part of the building. In front of the vertical glazing are fixed composite pannels; these are hinged at the bottom and when lowered, the stainless steel surface reflects additional solar radiation into the sunspace.

At the bottom of the conservatory wall, below the glazing, there are vents which bring outside air under the floor and up through vents and the base of a 350 mm concrete wall at the back of the sunspace. There are vents at the top and bottom of this wall, which stores and evenly distributes heat by radiation and convection into the sports hall.

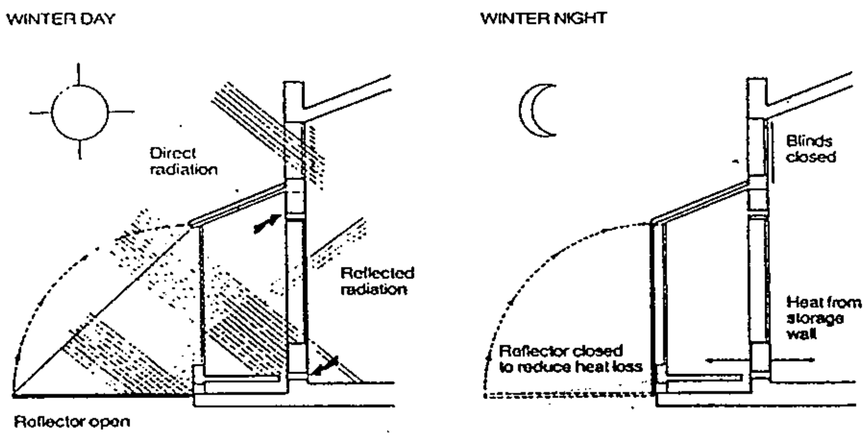
In order to increase solar gain, the upper part of the south façade has two rows of windows. Both rows are glazed with 16 mm twin walled plexiglass and are fitted with internal venetian blinds to control the amount of daylight and solar penetration.

Mean U value: (W/m^2K))
0,5

Global heat loss coefficient:
16,7 w /ºC

During the winter, when days are generally sunny but cold, the reflector shutters are automatically lowered in order to admit both reflected and direct radiation. At night these shutters are automatically closed to act as insulation to the windows in order to retain the solar gains stored in the concrete wall at the rear of the sunspace.

During the summer, the shutters are lowered half way in order to let in light to exclude direct solar radiation, and prevent the sunspace from overheating. At night they are lowered completely for radiactive cooling of the building. Summer ventilation is natural and achieved by opening the ventilators and windows.



Building Costs:
Whole building:
Pts.: 36.600.000
ECU: 254.545

Solar features:
Pts.: 4.100.000
ECU : 31.061

Cost of electricity:
Pts.: 10/kWh
(without standing charge)
ECU : 0,076/kWh

Average temperature:
ranges from:
14ºC December and March
to
21,5ºC in October

BUILDING COST

Assessment of cost effectiveness is difficult because some of the passive features are an integral part of the building. However, the polysportive has been compared with another one of similar size designed by the same architect in a nearby district and it was established that the cost difference is about 4.100.000 pts.(31.060 ECU) which represents an additional cost of 14% for the passive design. The cost of the sunspace has been calculated at 1.420.000 pts.(10.760 -- ECU) and of the reflector shutters at 2.680.000 pts. (20.300 ECU). For this expenditure, the annual solar contribution to space heating was 41.571 kWh(150 GJ) which represents a cost saving of 420.000 pts/year, (3.182 ECU/year).

ENERGY PERFORMANCE

During the heating season the solar contribution to the space heating load was 94,4 %.

The energy required for the auxiliary heating electric radiators was minimal -the internal gains from lights and people contributed 6 times more to the hea ting requirement than these electric radiators.

In normal weather conditions the temperatures inside the sports hall during sports sessions ranged from about 14ºC in December and March to 21,5ºC in October, which were considered tolerable for sports activity. The thermal inertia of the wall moderated the temperature fluctuations so that whilst the outside daily temperature fluctuated on average by 15ºC(even 20-25ºC on clear days), the internal temperature fluctuation maintained an average below 6ºC.

But there were two aspects which were not as anticipated:

Ventilation problems arose sometimes in summer. The problem was ventilation by fans was not enough in summer periods to avoid overheating and windows were not openable. The solution was to modify the south facing windows so that they can be opened.

The infiltration rate was higher in the winter and much colder than predicted.

Solar radiation is increased by reflectors in: 19,6 %

HUMAN FACTORS

Both the client, Esterri d'Aneu Municipality, and the school children, who are main users of the building, are enthusiastic about the passive solar design in terms of its novelty, appearance and its comfort conditions. At the same time the client is pleased with achieving the proposed objective of having a building with low maintenance costs and acceptable comfort levels.

Function:
Polysportive

Working hours:
8 to 21 hours
Flexible working times

INFORMATION

Services Consultant: Jocelyne de Botton/Francisco Penella Ros.// Rocafort, 244,7è.// 08029-BARCELONA.

Monitoring Organisation: Departament d'Industria i Energia. Direcció General d'Energia. Catalunya.Spain

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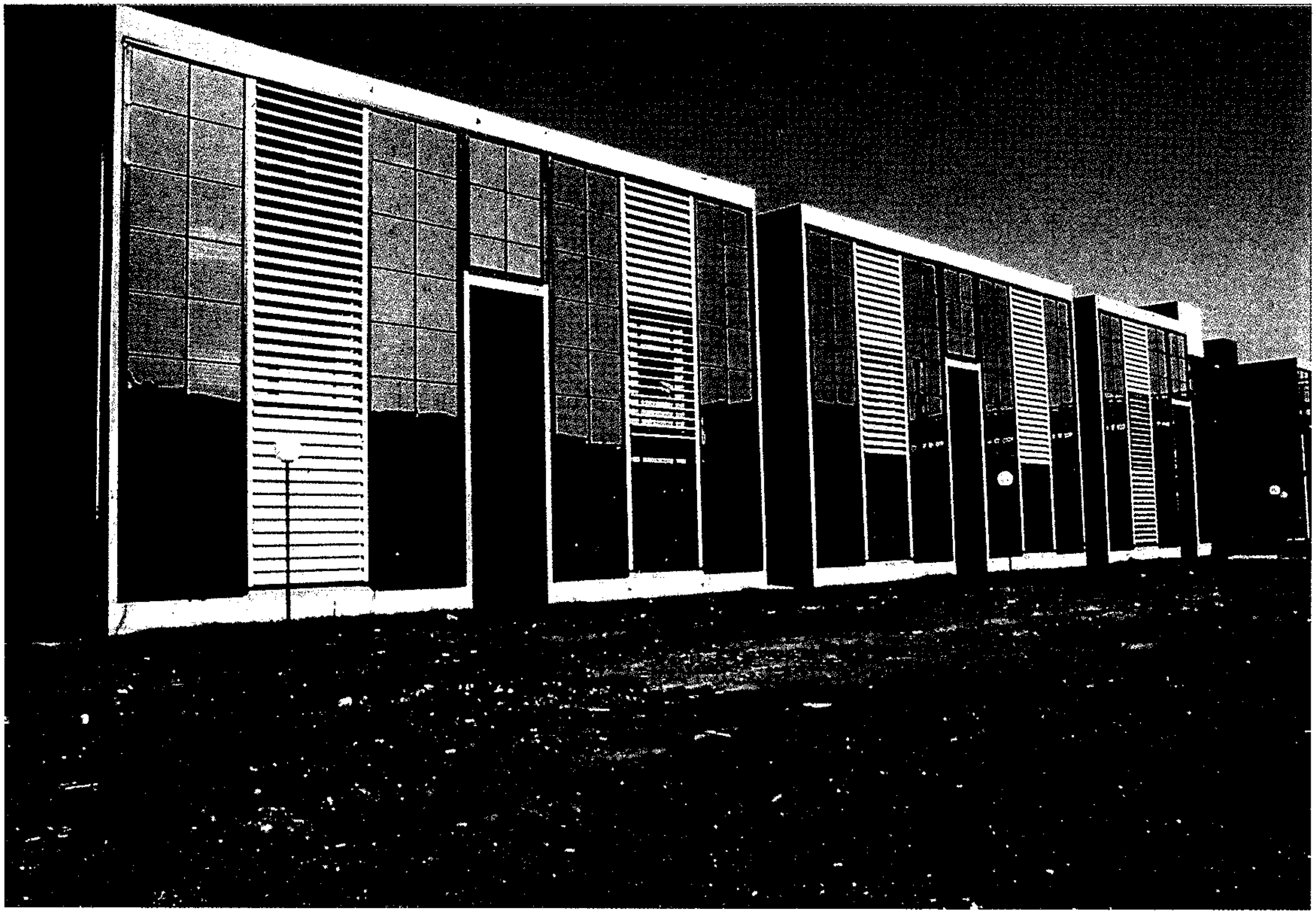
(I) ITALY

BCS No.	Building Title
27	MONTEFIASCONE SCHOOL
28	SOGECA OFFICE BUILDING
29	ENEA OFFICE BUILDING



MONTEFIASCONE SCHOOL

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MONTEFIASCONE SCHOOL

Building type :
Education

Passive features :
Solar heating:
Direct gain
Sunspace
Solar control:
Shading

Occupancy date :
September 1982

Floor area :
Gross - 5 500 m²
Heated - 3 260 m²

Cost: (1982)
It ML - 1 800 000
ECU - 1 200 000

Annual delivered fuel :
Gasoil - 1 230 000 MJ
Elect. - 430 000 MJ

Client :
Amministr. Provinciale di Viterbo

Architect and Energy Consultant :
N. Ceccarelli, R. Meli, E. De Santis, A. Meloni M. Arduini, P. De Santis

Monitoring :
ENEA

SUMMARY

Three solar energy collection technologies are integrated in the south facade:

- direct gain through classroom windows; movable reflective brise-soleil for solar gain and lighting control;
- air collectors for pre-heating of ventilation air;
- sun-spaced entrance hall.

Air temperature is controlled in each classroom.
Computerized system control and energy storage strategies were designed but not realized for various reasons.
Discomfort has been recorded in the corridors and classrooms (too cold) and in the upper floor (too hot in summer and autumn).
Solar contribution has been measured as 11.7% of the heating demand.

PROJECT DESCRIPTION

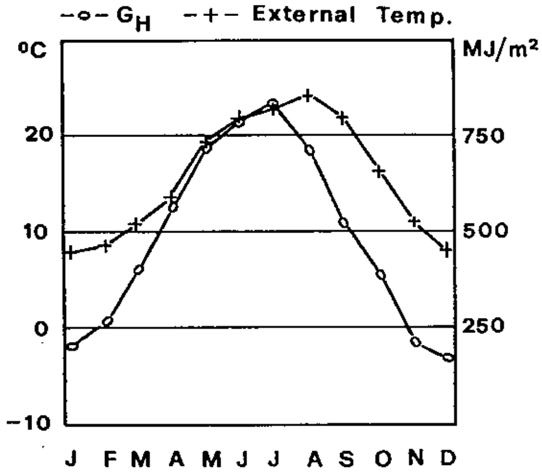
The client's aim was to have a school designed with energy conservation measures and solar energy use as important features, with minimum increase in capital cost.
Architect's design aim was the low cost, nice looking and effective integration of solar and conservation technologies in the building envelope.
The monitoring system was designed for giving detailed information about the energy performance of the building and of its components. Measurements

range from air flow and temperature of solar collectors to water flow and temperature of heating system; from room air temperature to solar radiation and wind velocity, etc.

SITE AND LOCATION

The site is a peripherical area of Montefiascone, a little town which lies 100 km north from Rome.

Site data :
Latitude - 42.2 N
Altitude - 590 m



Climate data :
Degree Days (base 20)
Nov. to Apr. inclusive
1804
Annual
2030
Global horiz. radiation
Heating season
G_H - 2005 MJ/m²
Annual
G_H - 5755 MJ/m²
Actual Sun Hours - 882
Actual/Theoret. - 0.41

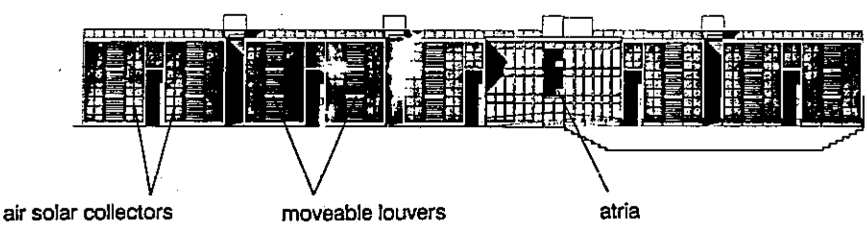
BUILDING FORM

The three storey school building lays with its long axis in an east-west direction and it is naturally sheltered from north winds both because of the topography and trees.
The building is divided into blocks, each maximizing south glazing and minimizing north heat losses.
South windows are protected with reflective-coated and hand-movable brise-soleil. When the sun shines, glare is avoided in the class-rooms by reflecting the sun's rays onto the ceiling.
South walls are air collectors, used for ventilation air pre-heating.
The entrance hall is a sunspace acting as the main buffer zone; other buffer zones are the corridors, the uppermost being illuminated and heated by means of a rooflight extended along all the building.
Wall insulation is internal for a quicker response of the building at daily start up.

Volume : (m³)
Heated: 16 500
Sunspace: 780

Surface areas :(m²)
Ground floor - 360
Roof - 360
Wall
(excl. window) - 1774
Windows - 556

Window data :
Glass area is 24 %
of total facades



South elevation

U values : (W/m² K)

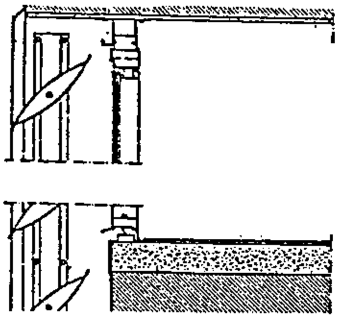
walls
south: .45
north: .41
east-west: .72
roof: .72
floor (ground): .70
glazing: 3.4

Envelope heat loss : (kW/° C)
fabric: 10.1
ventilation: 15.8

BUILDING CONSTRUCTION

South:
a) prefabricated, three-layers, insulated walls.
b) double glazed aluminum frame windows;
c) solar air collector = a) + b).

North, east and west: prefabricated, three-layers, insulated walls.



Window and movable shutters

Installed capacity :
Space heating:
Heated areas - 115 W/m²

Solar collectors :
76 m²

Storage tank :
2.5 m³

BUILDING SERVICES

Space heating is provided by means of two boilers (185 kW each). The air is distributed in the building after conditioning in four units, each rated for 11000 m³/h of air and 175 kW.
The fresh air is first pre-heated in the solar collectors and then mixed with return air in the air-conditioner units serving the four zone heating system. In these units humidity control and pre-heating is performed. Air temperature control is provided in each classroom, by means of a thermostat acting on individual post-heating coils (one per classroom).

South glazing :
389 m²

Sunspace :
100 m² vertical glazing
50 m² tilted 45°
volume 780 m³

PASSIVE SYSTEMS

The design concept is based on energy conservation, by maximizing the efficiency of all (passive and active) technological systems:
1) air collectors used for pre-heating fresh air (energy requirements for ventilation are 61% of total) maximize their efficiency;
2) corridors and main atrium are sunspaces used as buffer zones, maximizing the passive utilization of solar radiation;
3) internal insulation layer, by reducing active thermal inertia, allows a quick start up procedure.

Building cost (1985) :
It ML 330/m²
ECU 220/m²

Typical cost (1985) :
It ML 300-350/m²

BUILDING COSTS

The project was chosen by the client because it was cheaper than other more conventional options.
Both the building methods and the materials used were selected to keep the capital cost low.
The air collectors' cost was 65 It ML/m².

ENERGY PERFORMANCE

Annual energy consumption per heated surface is 50% lower then similar schools in the same area.
The overall energy performance of the building was never modelled. An evaluation of the air collectors was made, using TRNSYS, and the simulation was not too far from the reality.
The contribution of air collectors, as measured, was 11.7% of the heating demand.
The energy performance could have been better but:
- the air flow across the collectors was not optimized, because of incorrect assembly of the fan system;
- the horizontal position of storage tanks, imposed by space reasons, was a severe obstacle to stratification of water, and the supply temperature to the water-air heat exchanger was very low. It proved necessary to bypass all the storage system;
- the microprocessor, for various reasons, was never installed.

During very cold weather electric heating is also used.

Annual fuel use :
300 MJ/m²

Typical schools:
700-900 MJ/m²

HUMAN FACTORS

The occupants accepted easily and willingly the energy conservation innovations introduced in the building, but where partially dissatisfied for thermal discomfort during cold and hot season.
They showed also a strong dissatisfaction for "formal" innovations, like the show of polychromatic piping and ducting. Students comment: "are we in an oil refinery"?

Design occupancy :
700 students
2.1 m²/person

Working hours :
08.00 to 14.00 hours
mon - sat

CONCLUSIONS

Many of the designer's aims have been realised:
- integration of solar component in the building
- reduced energy consumption
- no, or negligible, extra cost

The main failures are to be found in the comfort conditions in the corridors both in winter and in summer. Particularly unsuitable showed to be the skylight, which heavily contributes to the creation of an uncomfortable environment in summer.
Some modifications to the original design are being made: in particular solar protection for the skylight and the sunspace and optimization of the air flow across solar collectors.

INFORMATION

* Sennato, G. and Cecere, C., 1985, "Istituto tecnico commerciale a Montefiascone, Viterbo", L'Industria delle Costruzioni, 162, 12-22.
* Funaro, G., Fanchiotti, A. and D'Errico, E., 1985, "116 Edifici Solari Passivi in Italia", ENEA report, ENEA, Roma, Italy

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SOGECO OFFICE BUILDING

Building type :
Office

Passive features :
Solar heating:
Solar chimney
Daylighting:
Direct
Solar control:
Shading

Occupancy date :
September 1984

Floor area :
Gross - 1500 m^2
heated - 1380 m^2

Cost (1984) :
It. ML - 900 000
ECU - 600 000

Annual deliverd fuel :
Elect. - 44 160 MJ

Elect. - 47 MJ/m^2 gross

Client and architect :
SO.GE.CO

Energy consultant :
Tommaso Costantini

SUMMARY

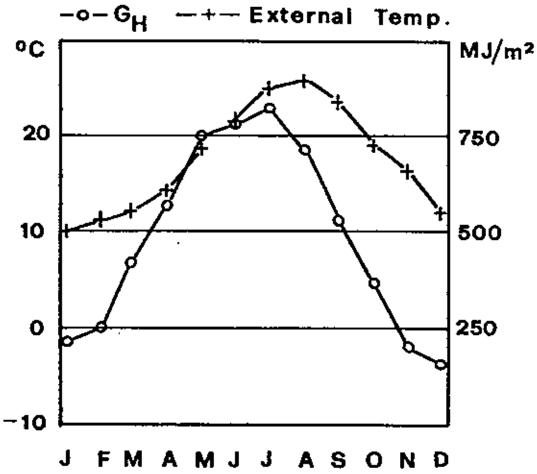
The office building has been designed as an example of near-zero energy office in one of the mildest parts of Europe. An elongated compact structure has been choosen both for energy reasons, and for daylighting. The basic solar feature is a solar chimney, covering about 30% of the south facade, coupled with ceiling storage (Barra-Costantini system).
Auxiliary heating is electric, and energy consumption is very low.
Some overheating occurred in summer and night forced ventilation has been proposed to overcome this problem.
The user, who is also the designer and the owner of the buiding, is largely satisfied.
The extra cost is very low because the use of the passive system permits the displacement of the conventional heating system.

PROJECT DESCRIPTION

The owner's aim was to have an office designed with energy conservation measures and solar energy use as important features, with minimum increase in capital cost. This was obtained by shifting costs from the heating system to the passive features.
Monitoring of summer conditions is planned.

SITE AND LOCATION

The site is Giarre, a little Sicilian town that lies on the slopes of Etna volcano, near the sea.

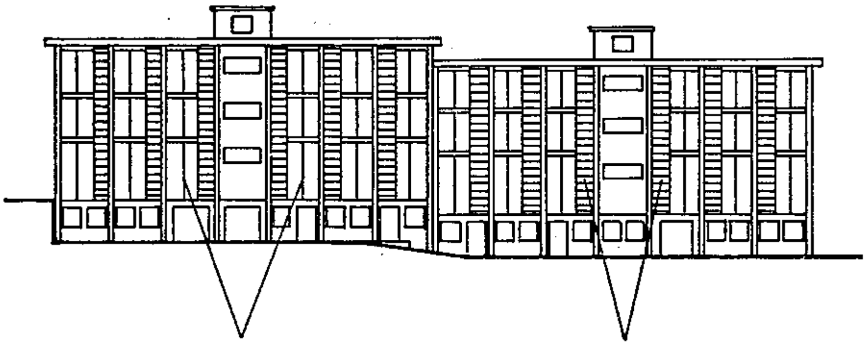


Site data :
Latitude - 37.4N
Altitude - 50 m

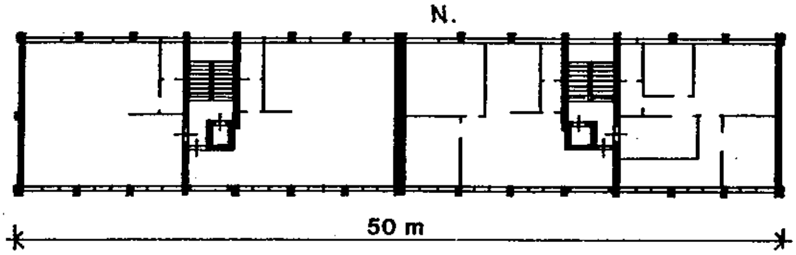
Climate data :
Degree Days (base 20)
Nov. to Mar. inclusive
1205
Annual
1493
Global horiz. radiation
Heating season
G_H - 1232 MJ/m²
Annual
G_H - 6257 MJ/m²
Sunhours:
Actual/Theoretical - 0.45

BUILDING FORM

The three storey office building lies with its long axis in east-west direction.
The southern facade is occupied by the solar collectors and by small windows shaded by external, moveable louvers, while the northern facade has relatively large windows for daylighting.
Shops are located at ground floor; first and second floors are used as offices.



south elevation



plan

Volume : (m³)
Gross: 4915
Heated: 4378

Dimensions :
Floor to ceiling height
Ground floor - 4.0 m
First floor - 2.7 m
Second floor - 2.7 m

Surfaces areas : (m²)
Ground floor - 500
Roof - 500
Wall
(excl. windows) - 970
Windows - 230

Window data :
Glass area is 23% of facade viewed from inside

BUILDING CONSTRUCTION

U - values : (W/m² K)
Roof 0.58
Wall 0.51
Window 2.0

Envel.heat loss : (kW/K)
Transmission - 1.24

The building is made out of an in-situ cas reinforced concrete, load bearing skeleton frame. External cavity walls are filled with 30 mm polystyrene; 40 mm of the same material externally insulate the roof.
All windows are double glazed.

BUILDING SERVICES

Installed capacity :
Space heating:
heating area - 11 W/m²

Design condition :
Internal temperature:
19 °C

Installed capacity :
lighting (offices):
Ceiling - 11 W/m²
Task Lighting-16 W/desk

Design conditions :
Lighting (offices):
250 lux

The building has no central heating system.
Space heating is provided, when necessary, by electric heaters manually activated.
Lighting is based on incandescent flood lights, activated only at night (natural lighting is reported to be sufficient also in the majority of cloudy days).
During summer conditions some of the offices use air conditioning systems, while others use natural ventilation, activated opening windows, to achieve thermal comfort.
A very interesting opportunity of this system, the use of forced night ventilation in the air-core ceiling, will be installed in the offices that use the natural ventilation.

PASSIVE SYSTEMS

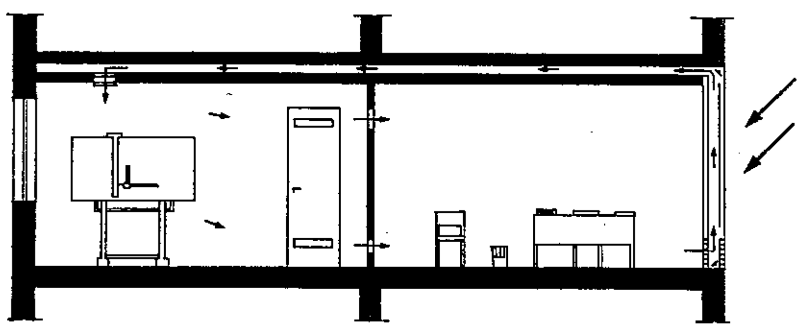
Glazing properties :
Double glazed
No night insulation

Ceiling/storage :

Channels :

Height 120 mm
Width 450 mm

The solar system, called Barra-Costantini, is based on a solar chimney integrated in the south facade with storage in the ceiling. The solar chimney is single glazed, and the absoption plate is fixed in the middle of the air gap, for maximizing the heat exchange surface. The hot air coming from the air collectors is channelled in the ceiling that becomes a radiative surface.
Air flow through the solar chimney can be controlled by means of manually operated dampers that are used to set the system for winter or summer functioning. During summer months the solar chimney is vented to outside.



Section of the office rooms heated by the solar system, showing the airflows

COSTS

The cost of the building is within the range of typical costs for similar offices. The extra-cost due to passive features is estimated to be 3 % of total. Thirty percent of this extra-cost has been compensated by tax incentives. The passive system permitted moreover to avoid the installation of a central heating system.

Building cost : (1984)
It ML - 600 m^2
ECU - 400 m^2

Typical cost : (1984)
ECU 350 - 400 m^2

ENERGY PERFORMANCE

The only auxiliary system used is electring heating that is activated for about 30 days during the heating season. Normalized annual energy consumption is around one fifth of similar buidings in the same area.

Annual fuel use :(MJ/m^2)
21 (gross space)
23 (heated space)

Typical office buildings
Existing - 100

Fuel costs :(1987)
Electricity 1.3 It ML

HUMAN FACTORS

During the heating season the system's performance is quite satisfactory.
During summer months the building appears to be hotter than similar buildings, expecially in the top floor, because of the insufficient insulation of the roof.
The maintainance and management of the passive structure showed to be quite easy.
As the owners are also the designers and constructors of the building there is a high degree of involvment in the experience.

Design occupancy :
No. 60

Functions :
Administrative
Engineering
Shops

25 m^2 office space per person

Working hours :
08.00 to 20.00 hours

CONCLUSIONS

Many of the designers aims have been reached:
- integration of solar component in the building
- reduced energy consumption
- negligible extra cost

INFORMATION

* Funaro, G., Fanchiotti, A. and D'Errico, E., 1985, "116 Edifici Solari Passivi in Italia", ENEA report, ENEA, Comitato Nazionale per la ricerca e lo sviluppo dell'energia nucleare e delle energie alternative, Roma, Italy.

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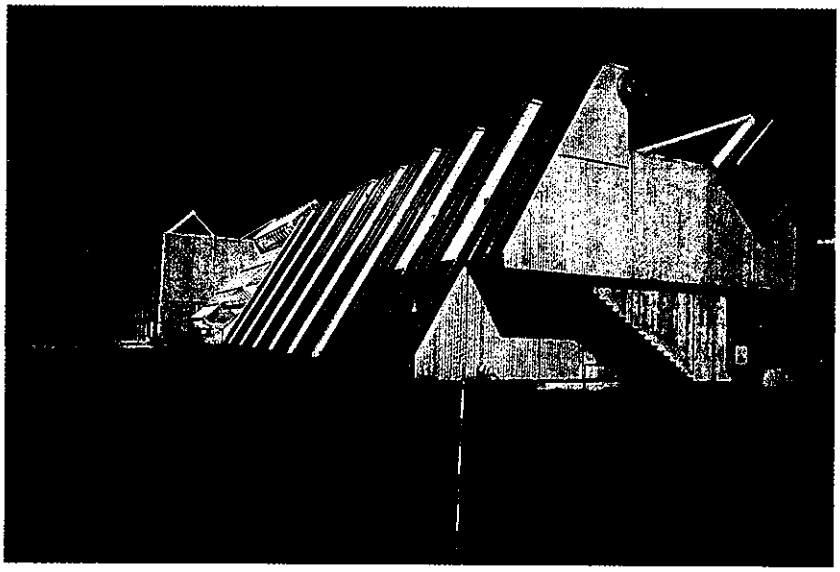
ENEA OFFICE BUILDING

Building type :
Offices and laboratories

Passive features :
Solar heating:
Solar chimney
Daylighting:
Direct
Solar control:
Shading



SUMMARY

The new office building of ENEA (Italian Agency for Nuclear and Renewable Sources of Energy) at Ispra incorporates a mix of innovative solar technologies in order to achieve a low energy office building and to test the efficiency and reliablity of different solutions.
The solar systems that have been used are inexpensive but at the same time the solutions have been studied in order to guarantee reliable thermal performances.

Occupancy :
November 1987

Floor Area :
Gross - 3 500 m²
Heated - 2 700 m²

Cost (1987) :
It. ML 4 600 000

Annual Delivered Fuel :
Estimated:
Elect.
- 320 000 MJ (heat pump)
- 150 000 MJ (lighting)
Fuel
- 570 000 MJ

Client :
ENEA
Dept. Fare

Architect :
Sin/Arch

Energy Consultant :
Ing. G. Rossi
Enea Fare Dept.

Services Engineer :
Ing. G. Rossi

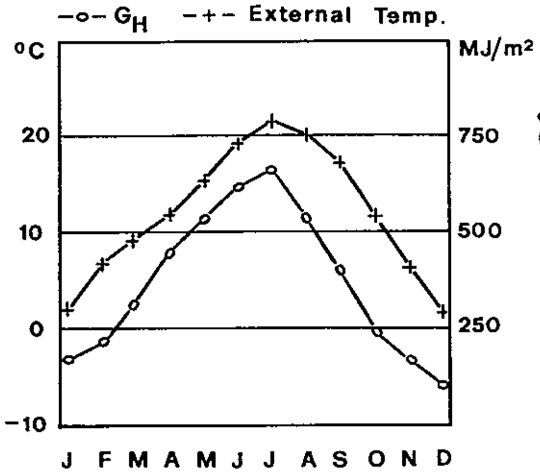
Monitoring :
ENEA/Dept. Fare
Corlab-Dim1 Lab.

PROJECT DESCRIPTION

ENEA wanted to apply solar passive and active systems in its new offices and laboratories of the solar branch that has been built at the J.R.C. Euratom Center of Ispra.
The solar storage components are intended to be interchangeable in order to verify the performances of innovative systems. The collector components are highly integrated in the building structure.
A very detailed monitoring system has been installed.

SITE AND LOCATION

The site is a peripherical area of Ispra a little town at the border of the Maggiore lake.

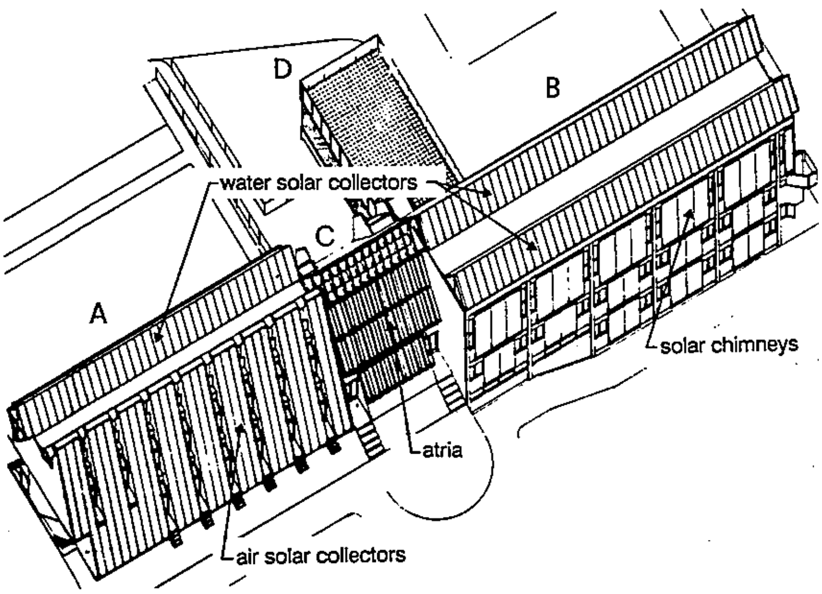


Site data :
Latitude: - 45.8 N
Altitude: - 257 m

Climate Data :
Degree Days (base 20)
Oct. to Apr. inclusive
2857
Annual
3094
Glob. rad. (heat. season)
G_H: - 1 661 MJ/m²
Glob. rad. (annual)
G_H: - 4 354 MJ/m²

BUILDING FORM

The plan comprises two buildings (A, B) elongated on the West-East axis, connected by an atrium (C) and a technological hall (D).
The buildings have three levels with the first one partially underground.
The block A has a 60° inclined south facade that is occupied by a large solar active air collector.
The block B has vertical solar chimneys integrated in the southern facade.
The southern facade of the atrium is made by a three polycarbonate layers surface, 45° sloped, protected with a structure that in future will be covered by vines or sheets in order to protect from solar radiation in summer.
The south pitch of the roofs sheds of the two office blocks are covered with water solar collectors.



Volume : (m³)
Gross: 12 171
Heated: 10 600

Dimensions :
Floor to ceiling height
offices: - 2.7 m
laboratories: - 6 m

Surfaces areas : (m²)
Block A - 410
Block B - 610
Block C - 160
Block D - 170

Windows : (m²)
total - 625
Glass area is 15% of facade

Block A:
South - 42
North - 20
Shed (45° N) - 84

Block B:
South - 70
North - 35
Shed (45° N) - 200

Block C:
South (45°) - 120
North - 24
Shed (45° N) - 30

BUILDING CONSTRUCTION

An in-situ concrete frame has been used. The north wall has an external 80 mm polystyrene layer, while east and west walls have internal 80 mm polystyrene layer.
The southern facade incorporates passive and active solar components through an innovative structural prefabricated building component, called GRC (Glassfiber Reinforced Concrete).
The GRC structural component is very thin, 15 mm and for its low weight (50 kg/m², 15% compared with a conventional reinforced concrete panel) is easy to transport and to install.
Windows are double glazed.

U - values :W/(m²K)
Opaque surfaces:
0.35
Transp. surfaces:
3.7

Envel. heat loss :(kW/K)
Transmission - 3.7
Infiltration - 1.6

BUILDING SERVICES

The climatization system is composed of two solar active system (air and water), by the solar chimneys (described below) and by a heat-pump.
Air collectors are integrated in the tilted south facade of the block A using prefabricated building component of GRC, thermal insulation and single glass, with air flowing under the absorbing plate.
Thermal storage for the air collectors is a 60 m³ volume that will be filled with different materials (rocks, bricks, etc...).
Solar water collectors on the roofs are single glazed and are connected to an annual water storage of 300 m³, that is only insulated in a large area around the top of the storage.

Winter operations:
The heat from the water collectors goes to the annual storage.
The heat pump uses as heat sink the solar water thermal storage or the lake according to which one has the higher temperature.
Air collectors store heat in the rock bed that is used as a preheater of external air for ventilation purpose.

Summer operation:
The heat pump and water collectors heat the annual water storage.
The cold sink of the heat pump is the water in the storage; when storage temperature reaches condensation temperature, lake water is used instead.
Air solar collectors are cooled with forced external air.
A microprocessor regulates all the control functions of heating and cooling system.

Installed capacity:
Space heating:
Heated areas - 60 W/m²

Design conditions :
Int. temperature - 20 °C

Installed capacity :
Lighting (offices):
Ceiling - 15 W/m²

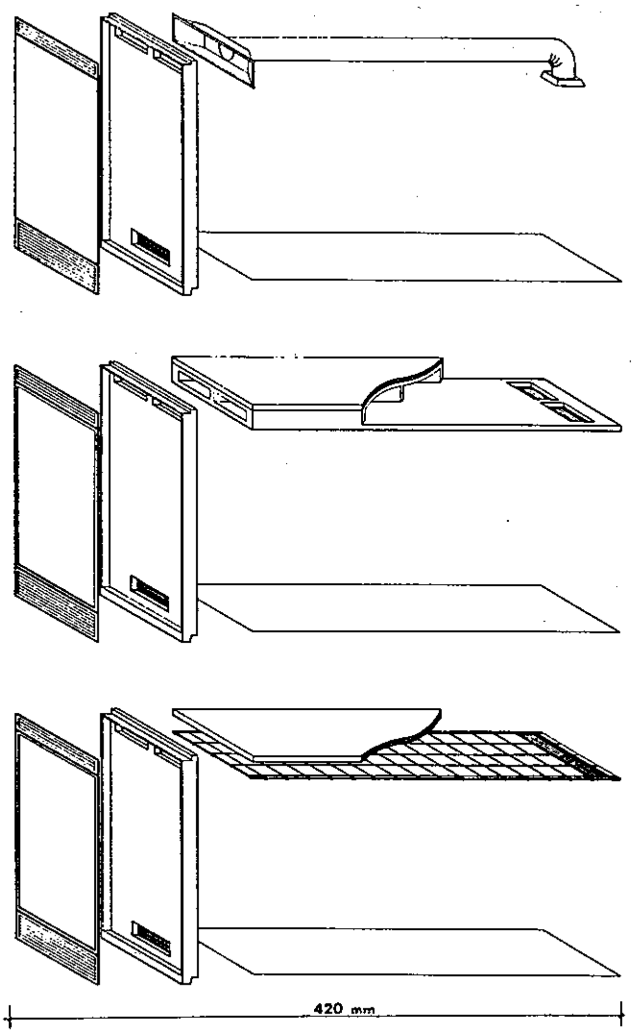
Design conditions :
Lighting (offices):
250 Lux

Active system :
Water collectors:
300 m²
Air collectors:
290 m²
Water storage:
300 m³
Rock bed storage:
60 m³

Glazing data :
Single glazing
Tilt - 60°
Area - 250 m^2

PASSIVE SYSTEMS

The south facade of the building B is designed as an integrated solar-chimney and windows, using a prefabricated GRC component.
Three different distribution and storage systems have been istalled. In the ground floor the hot air is channeled in a metal false ceiling, in the first floor ducts have been created in the concrete ceiling and in the second floor metal pipes are used.
Warm air is channelled to north facing rooms.
The southern offices use also some direct gain.
Return air to solar chimneys is provided through openings at the low level of the doors.
Some acoustical problems may arise from this interconnection between the offices.
In order to avoid reverse thermocirculation mechanical dampers regulated by sensors are used.
The same approach is used for changing from winter to summer operation.
In summer external air is circulated in the solar chimney in order to avoid overheating.



Solar chimney and heat distribution system at different floors

BUILDING COST

The cost of the building is slightly higher than the average cost for similar office buildings. The extra-cost due to solar components is estimated to be 7% of total. Considering the high energy contribution of the solar system, the extra-cost is quite low. This is due to the highly integrated concept for the passive and active solar components.

Building Cost (1986):
1 200 ML/m²

Reference Costs (1986)
1 100 ML/m²

ENERGY PERFORMANCE

Energy consumption data are not yet available. The estimate for annual electricity consumption of the heat pump is 320 000 MJ.

Annual fuel use:
300 MJ/m² gross

Typical offices:
800 MJ/m² gross

HUMAN FACTORS

During the monitoring process also human factors will be evaluated.

CONCLUSIONS

The use of passive and active solar systems permits highly reduced heating energy consumption. This objective is achieved through the construction of low cost integrated solar components. The office complex is conceived as a demonstration building, very well monitored, with the possibility to change some storage components in order to make a comparison of different solutions.

INFORMATION

G. Scudo, A. Seassaro, G. Rossi, "Innovative solar components and systems integrated into office buildings", Proceedings of Passive and Low Energy Architecture, Pecs, Hungary, 1986

G. Scudo et. al., "Architettura ed energia", De Luca Ed., 1987

G. Funaro, G. Rizzi, G. Scudo, A. Seassaro, "Edificio solare per uffici e laboratori dell'Enea di Ispra", L'industria delle costruzioni, march 1988

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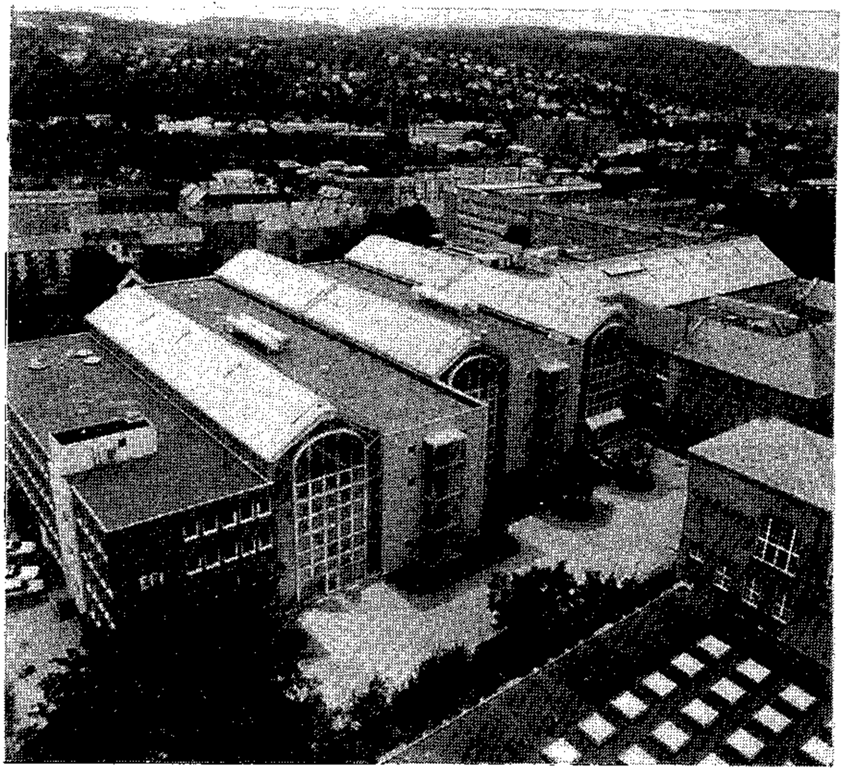
(N) NORWAY

BCS No.	Building Title
30	TECHNICAL UNIVERSITY
31	DRAGVOLL UNIVERSITY
32	DAY CARE CENTRE
33	SOLAR DAIRY

DRAGVOLL UNIVERSITY

N TECHNICAL UNIVERSITY



Building type:
Education

Passive features:
Atria

Occupancy date:
September 1986

Floor area:

Gross		
New	-	15 000m²
Total	-	40 000m²
Heated		
Offices	-	13 000m²
Atria	-	2 000m²

Cost (1986):

NOK	163 000 000
ECU	21 447 000

Fuel use data: MJ

New Building		
Gas	-	3 456 000
Elec	-	2 484 000
Total	-	5 940 000

Client:
The Directorate of Public Construction

Design team:
Per Knudsen A/S
A.R.Reinertsen
Gjettum A/S

Monitoring agent:
Gjettum A/S
SINTEF div.15/HVAC

SUMMARY

The extension to the electrical engineering department at the Norwegian Institute of Technology consists of several new office and laboratory buildings connected to each other and to the existing buildings with glazed spaces.

These glazed, intermediate spaces give lower total annual costs for the building complex than similar spaces without glazing would have done.

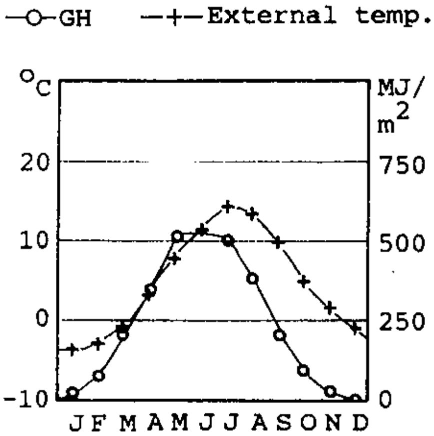
PROJECT DESCRIPTION

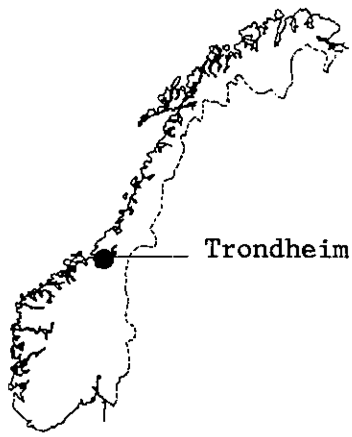
The buildings were planned to accommodate an additional 250 students and 200 researchers. Energy considerations were originally secondary, and the glazed atria, an early design aim on the part of the architect, were primarily wanted because of their amenity value. Preliminary energy and cost calculations showed that the energy aspect was significant, however. Consequently, detailed studies on this were carried out.

The buildings are now used in a major national research project. Extensive monitoring of energy consumption, temperatures, ventilation rates, and daylighting levels is being carried out, and the users are being interviewed about usage of the glazed streets, daylighting conditions, and thermal comfort.

SITE AND LOCATION

The buildings are located on the university campus in the city of Trondheim. The campus, which is quite densely developed, is situated on a plateau inside the city, and the new buildings are placed on the edge of this plateau. They have free horizon to the west, while there are other buildings of approximately the same height on the east, south, and north sides.





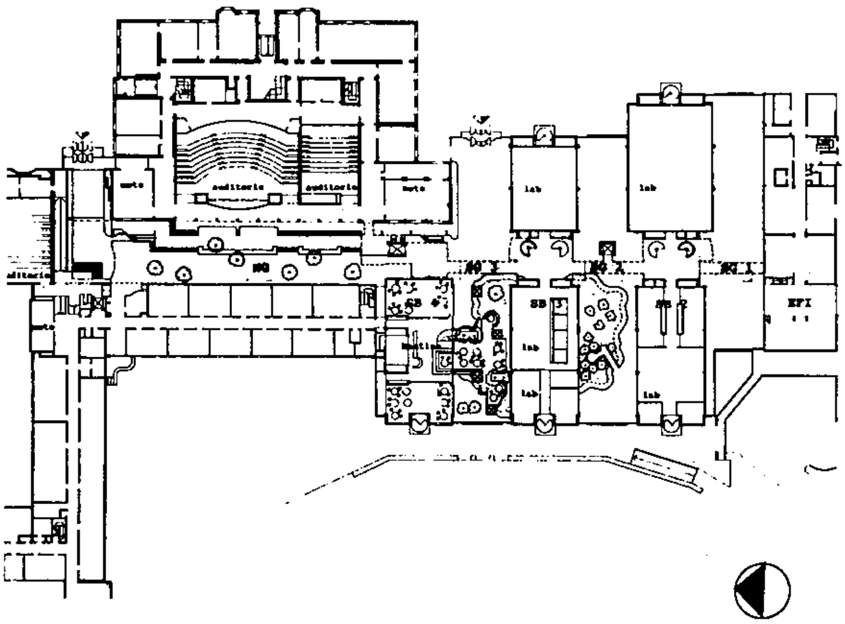
Site data:
Latitude - 63.3N
Elevation - 50m

Climate data:
Oct. to Apr. inclusive:
Degree days (base 20) - 4180
GH - 800 MJ/m^2
Actual sun hours - 467
Actual/theor. - 0.25

Annual:
Degree days - 5512
GH - 2935 MJ/m^2
Actual sun hours - 1352
Actual/theor. - 0.30
Average temp. - 4.9°C
Design temp. - -19.0°C

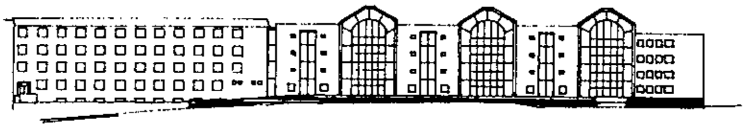
BUILDING FORM

The building complex consists of three new, four-story buildings and three existing, partly altered buildings. Four glazed streets connect all of these.



Ground level plan

East elevation



West elevation

BUILDING CONSTRUCTION

U-values(w/m^2k):
Atrium glazing - 2.1
Windows in exterior walls - 2.1
Walls (incl.windows) facing atria - 3.2

The buildings are constructed with concrete columns, beams, and hollow core slabs. The glazed spaces are constructed with steel frames. These are covered with double pane, low emissivity glazing. The parts of the buildings facing these spaces have single glazing, while the exterior facades have double glazing.

BUILDING SERVICES

Heating:

The buildings are heated by radiators connected to a central hot water plant. The heating capacity installed in the offices is rather small, as the heat loss, due to the high temperature in the glazed spaces, is low, and as the heat gain from people, lighting, and equipment is high.

The glazed spaces themselves have two types of auxiliary heating. There are convectors on the glass facades to compensate for down drafts, and there is a small amount of radiant heat placed in the horizontal, opaque part of the roof. This radiant heat is only used in extremely cold weather.

Ventilation:

Design conditions:
Temperature in offices - 20°C
Minimum temperature in atria - 15°C

The buildings have mechanical ventilation, while the glazed spaces are ventilated solely by infiltration. The fire ventilation hatches in the glass facades and roof can be used for natural ventilation to cool the spaces.

The glazed spaces function as service zones for pipes and ducts. All pipes and ducts are placed there, and as the minimum temperature will be kept at +15°C, the ducts need not be insulated.

Lighting:

The amount of glazing in the facades facing the atria is relatively large, but there is no differenciation between higher and lower levels. Only rules of thumb were used for daylighting considerations during the planning stage, and the buildings have standard artificial lighting.

PASSIVE SYSTEMS

The glazed streets utilize solar gains through the glazing, heat loss from the surrounding buildings, and a certain amount of auxiliary heating to maintain a minimum temperature of 15°C. Excess heat is vented by roof hatches.

Typical street/atrium

COSTS

Building costs (1986):
NOK 10 867/m^2 new area
ECU 1 430/m^2 " "

Typical cost (1986):
Other university buildings
NOK 11000-12000/m^2 gross

The total capital investment for the building complex includes both construction costs for new buildings and the cost of various degrees of alteration of existing ones. One of the existing laboratories was for instance changed into a large auditorium, and the cost of this is included. Total construction cost is therefore of limited interest.

ENERGY PERFORMANCE

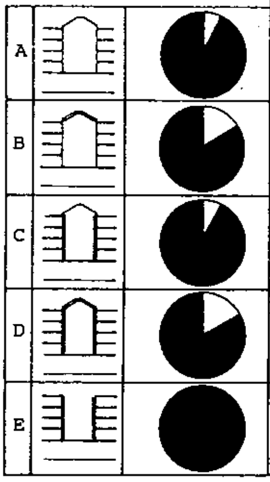
Measured annual heating load:
Office block -350 MJ/m^2
Office block and atrium -280 MJ/m^2

The results are provisional as they are based on 5 months of monitored data not yet thoroughly analysed.

Reference energy:
940 MJ/m^2

The effect of using glazed spaces was extensively investigated during the design phase. The studies showed that annual energy consumption, and annual costs, would be lower if there were glazed spaces rather than conventional streets between the buildings. They also indicated that there would be no significant difference in energy demand whether the spaces were kept at a minimum temperature of +5°C or +15°C. A minimum daily average of 15°C was consequently chosen.

The annual energy demand was calculated for several alternatives for a part of the project consisting of one office block and one atrium. The following figures refer to this part only.



	% of E	GJ/yr
A	92	1880
B	82	1678
C	91	1854
D	81	1660
E	100	2048

A - Double glazing in roof and gable walls, single in facades.
B - Double, low-e glazing in roof and gable walls, single in facades.
C - Double glazing in all.
D - Double, low-e glazing in roof and gable walls, double in facades.
E - No glass roof, triple glazing in facades.

Case B was chosen for the constructed project.

Energy performance and costs - case B:

Predicted heating load - 410 MJ/m^2
Reduction in heating load - 20 %
(relative to case E)

Capital cost (1985) - NOK 5 488 170
Fuel cost - 55.0/GJ
Annual cost - 115/m^2
Reduction in annual cost - 14 %
(relative to case E)

HUMAN FACTORS

The buildings are occupied by a variable number of persons, as most of them are researchers and students with flexible working hours. These occupants are now being interviewed about their workspaces.

There has been a number of complaints about the climate in the offices on the upper floors facing the atria, and also about the temperature in the cafeteria zone in one of the atria. These problems are now being investigated. Aside from that, the users are giving very favorable comments about the atria.

Working hours:
07:00 to 21:00 hours
Flexible working hours

Design occupancy:

Students	-	1300
Staff	-	170

CONCLUSIONS

As the buildings only have been occupied one year, and as the total complex was not complete at the time of occupancy, few conclusions can be drawn at this time. The monitoring and evaluation projects will, however, provide a significant amount of data within the next two years.

Glazing the streets reduced life cycle cost.

INFORMATION

* Prosjekteringsgruppen for NTH-ELA, 1985, "Overdekket gate. Bygge- og energikostnader", NTH-ELA reports no.11 and 12, Trondheim, Norway.
These, and other details, can be obtained from the architect:
Per Knudsen A/S, Fjordgata 7, N-7000 Trondheim.

Results of the monitoring and evaluation projects will be published by SINTEF in 1988 and 1989.

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DRAGVOLL UNIVERSITY

Building type:
Education

Passive features:
Atria

Occupancy date:
September 1978

Floor area:
Gross - 24 900m^2
Heated - 13 300m^2
Atrium - 1 620m^2

Cost (1978):
NOK 79 951 644
ECU 10 519 953

Annual delivered fuel:
Oil -27260 GJ
Electricity - 5005 GJ
Oil & elect. -1296 MJ/m^2gross

Client:
The Directorate of Public Construction

Architect:
Arkitekt Henning Larsens Tegnestue A/S

Consultants:
Arne R. Reinertsen
Gjettum A/S, HVAC
IGP, Electro

Monitoring agent:
Gjettum A/S
SINTEF Div.62

SUMMARY

The university center at Dragvoll consists of several office and classroom buildings connected by a glazed street. The building complex was not specifically designed for energy conservation, but the total cost of the complex was calculated to be lower than it would have been if the street was not covered. The most important reason for this is the fact that the adjoining buildings would have had to be larger, and that their facades would have had to have a higher technical standard.

The glazed street is considered a success, especially as it often is compared to the traditional corridors of the other university buildings. It is much used both formally and informally, and the users have expressed no negative experiences. They specifically have no problems with thermal comfort.

PROJECT DESCRIPTION

The Danish architect Henning Larsen won the first prize in a Nordic architectural competition for the center in 1969/70. It was planned as a relatively large campus, with a total floor area of 500 000 m^2 with space for 30 000 students and 5 000 employees. Only a small part of this is built so far.

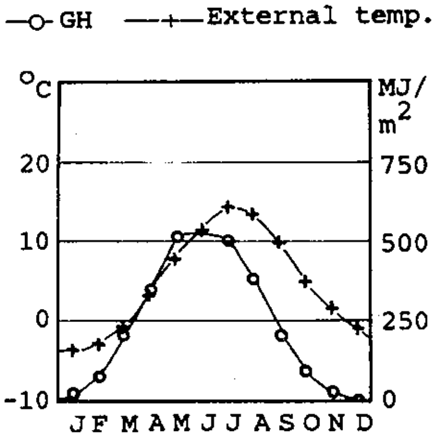
As the buildings were planned before the oil embargo of the mid-seventies, energy conservation was not an issue for the designers. Daylighting, on the other hand, was considered important, and studies of this were carried out during the design stage.

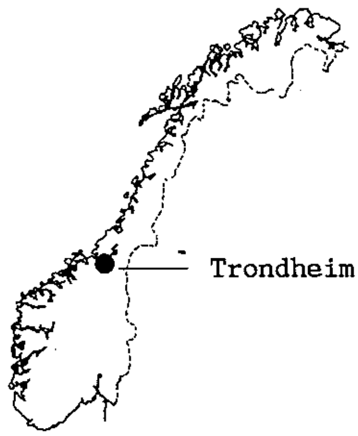
There has been only limited monitoring of energy performance, while there has been detailed monitoring both of daylighting conditions and of temperatures in the glazed street. In addition, there has been extensive user evaluation of the street.

SITE AND LOCATION

The center is situated on farm land outside the city itself. The site is fairly flat, bordering on a partly wooded area on the south side. On the north side there is view to the city and the fjord in the distance.

There is no shading of the sun on the site itself, while the woods shade from the strong winds.





Site data:
Latitude - 63.3N
Altitude - 150m

Climate data:
Oct.to Apr. inclusive:
Degree days - 4180
(base 20)
GH - 800 MJ/m^2
Actual sun hours - 467
Actual/theor. - 0.25

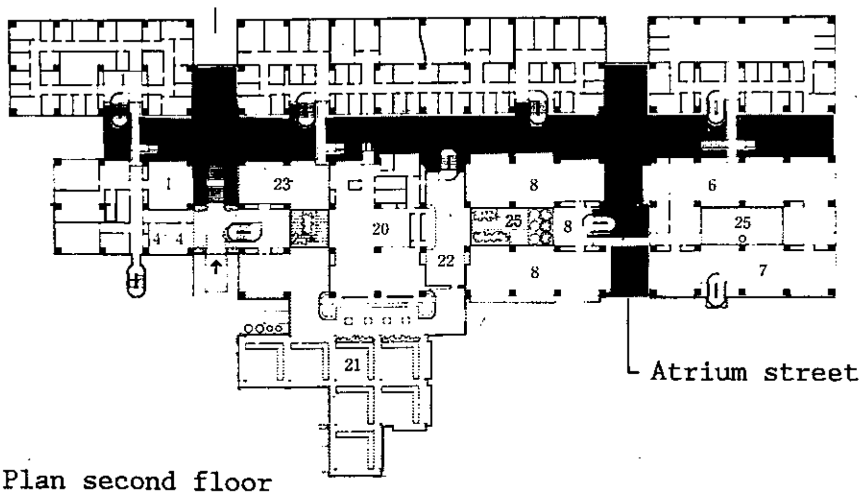
Annual:
Degree days - 5512
GH - 2935 MJ/m^2
Actual sun hours -1352
Actual/theor. - 0.30
Average temp. - 4.9°C
Design temp. - -19.0°C

BUILDING FORM

The center is planned with covered streets on a grid structure of 100 m, which is comparable to the grid structure in the old city itself. The streets are 8.4 m wide, with buildings planned on a structural grid of 8.4*8.4 m.

General functions, such as auditoriums, shops, etc. are placed on the street level, while seminar rooms and offices fill the upper floors. The buildings are connected on the upper levels with bridges across the street, and staircases and elevators are all placed in the street. The street also functions as a lobby for the auditoriums.

Volume:
Gross - 102 700m^3
Atrium - 20 590m^3



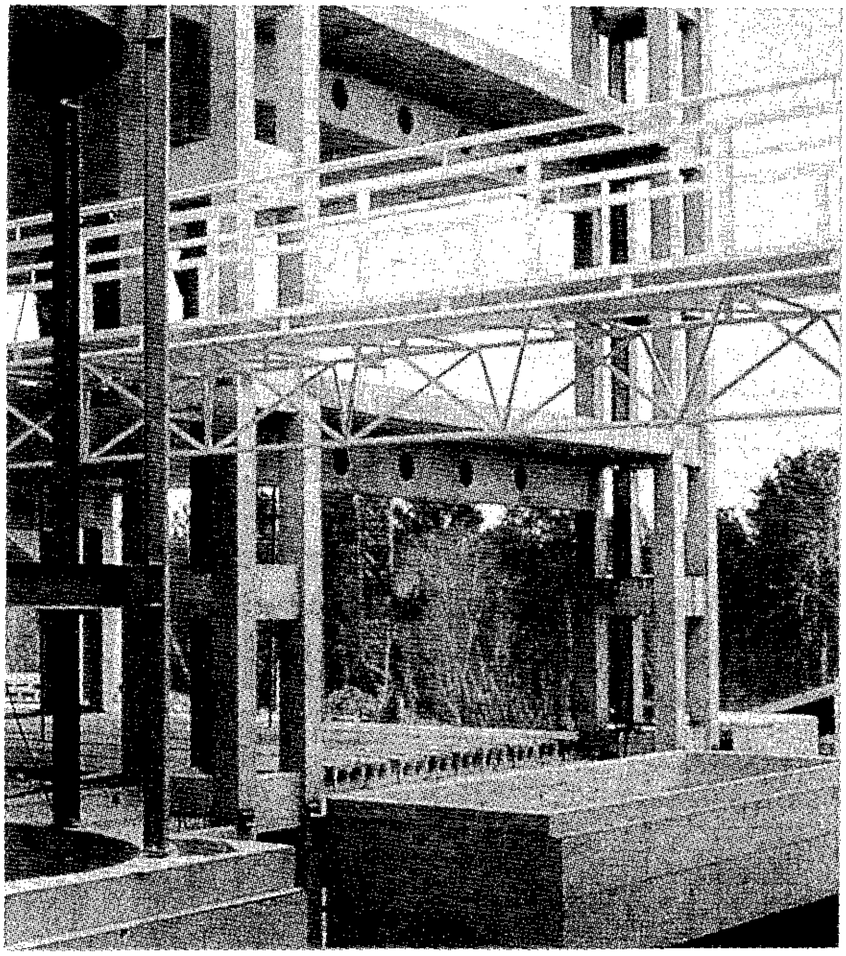
Plan second floor

U-values (w/m²K):

Walls	- 0.40
Windows	- 3.00
Roof	- 0.35
Windows facing atrium	- 3.85
Walls facing atrium	- 0.90

BUILDING CONSTRUCTION

The buildings are constructed with precast concrete posts, beams, and hollow core slabs. The structural elements in the street are all steel, and a steel frame supports the glazing. The walls facing the atria have perforated aluminium cladding covering mineral wool insulation, and single glazed windows. The other windows, as well as the street roof and gable walls, have double glazing.



Design conditions:
Temperature in heated space - 21°C
Minimum temperature in atrium - 5°C

Lighting (offices) - 500 lux

Ventilation rate:
Air change - $10m^3/m^2h$
Operating 10 hours/day

BUILDING SERVICES

The buildings are heated by electric space heaters, while the ventilation air is heated with hot water from a central plant. The street is not heated directly, but the ventilation air is exhausted via the street, thus heating it to a certain extent.

The ventilation system is based on utilizing varying amounts of recirculation. At 5°C and below, the system runs with 70 % recirculated air. At 20°C and above, it runs with no recirculation, and the exhaust air is bypassed the street. When the street temperature falls below 8°C, the ventilation system operates at all times.

PASSIVE SYSTEMS

The glazed street was not planned as a passive solar system. It does function as a buffer for the adjoining buildings, but energy gained on sunny days is not utilized.

Exhaust air vented via the street is let out through the quite leaky glass roof, and excess heat is vented by opening 40% of the roof. This manually operated, sliding glass system works quite well, and there has never been a problem with overheating. In general, the temperature in the street stays between 10° and 20°C all year, with a thermal climate that is acceptable for temporary occupancy.

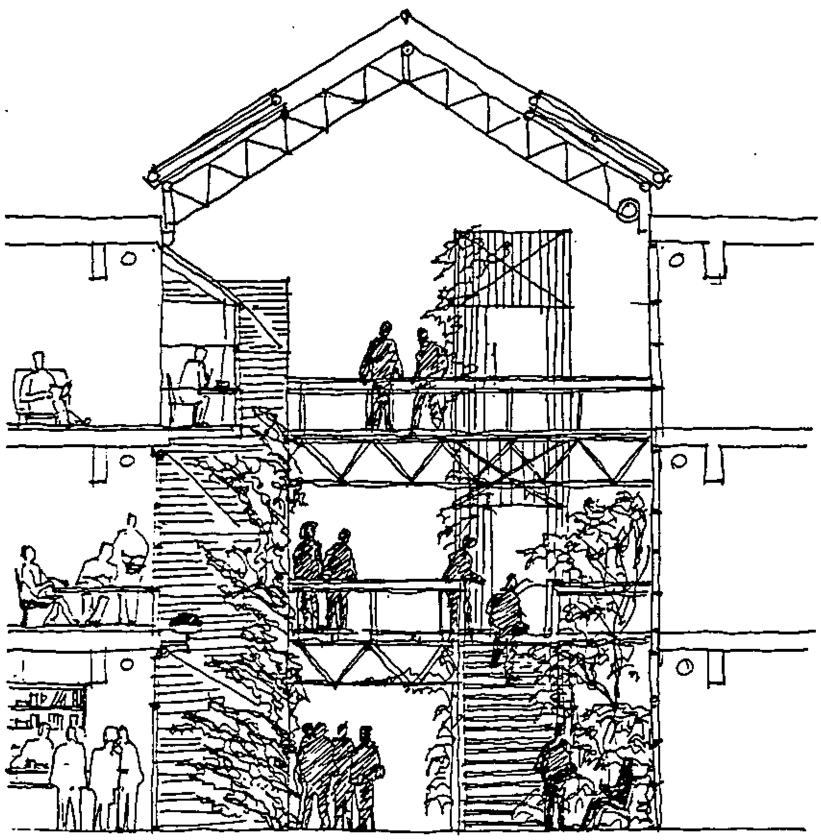
U-values -atrium(w/m^2K):

Gable walls	- 3.00
Roof	- 3.00
Floor	- 1.00

Envelope heat loss:
Atrium - 11.0 kw/°K

Glazed area of facades facing atrium:

Level 1	- 90%
Level 2	- 70%
Level 3	- 40%



COSTS

The life cycle cost of the building complex is lower than what it would have been if the street was not covered. An uncovered street would have required: larger adjoining buildings to include lobbies for the many auditoriums, a higher technical standard on the facades, more maintenance costs in terms of snow removal and cleaning, and more heating of sidewalks and entrances. The reductions obtained is significant and compensates for the somewhat higher heating costs.

Building costs (1975):
NOK 3210/m^2 gross
ECU 422/m^2 gross

Cost due to glazing of street - NOK 70/m^2 gross

Typical cost (1975):
Other university buildings
NOK 3000-3500/m^2gross

ENERGY PERFORMANCE

Annual fuel use:
Dragvold-1296 MJ/m^2 gross
Other university buildings-955 MJ/m^2 gross

Atrium temperature:
10 - 15°C above ambient

The measured total energy consumption is higher than average for that type of buildings. The centre was planned before energy conservation was an issue, and it has a low insulation standard. In addition, the glazed street is incorporated in the ventilation system in a quite wasteful way.

Due to the recirculation system, the amount of warm air supplied to the street is at a minimum when the temperature is low. To keep the plants from freezing, the system is therefore often operated also when the buildings are not occupied. The HVAC consultant recommends a separate ventilation system for the street, or at least the introduction of heat exchangers, but no changes have been made so far.

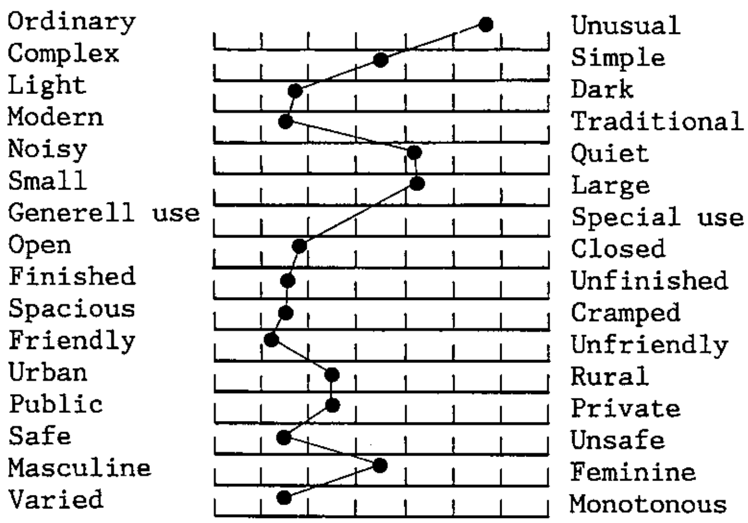
HUMAN FACTORS

Design occupancy:
Students - 1500
Staff - 200

Working hours:
08:00 - 16:00
Monday-Friday for employees,
Flexible hours for students

The glazed street has been extensively evaluated for its user friendliness. All employees and 25% of the students were questioned about the street itself and about the offices facing the street. An overwhelming majority was clearly positive to all aspects of the street.

It was found to be pleasant, light, and a nice place to stop and chat, and it is often used for informal meetings and performances. The offices facing the street were also found acceptable, with few problems with daylighting, noise, or ventilation.



Results of a semantic description of the street

CONCLUSIONS

Despite its poor energy performance, the university center at Dragvoll has been a source of inspiration for the designers planning similar, but more energy efficient buildings in the later years. The lessons learned about the positive aspects of the glazed street, as well as about the problems related to such streets, have been noted and used.

The glazed street has a particularly high amenity value.

INFORMATION

* Cold,B., "Evaluering av den overdekte gaten på universitetssenteret på Dragvoll", SINTEF-report no. STF62 A84007, Trondheim, Norway.

* Gunnarshaug,J., "Erfaringer fra glassoverdekninger i Trondheim", SINTEF-report no. STF62 A85013, Trondheim, Norway.

Both reports are written in Norwegian. Additional information can be obtained from: Per Knudsen A/S, Fjordgata 7, N-7000 Trondheim.

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N

DAY CARE CENTER

Building type:
Education

Passive features:
Atria
Direct gain

Occupancy date:
August 1987

Floor area:
Gross - 490m^2
Heated - 410m^2

Cost (1987):
NOK 3 822 000
ECU 502 740

Fuel use data:
Not yet available

Client:
The Student Union
in Alta

Design team:
SINTEF division 62

Monitoring agent:
SINTEF

SUMMARY

This building is a day care center where the main solar feature is a large, centrally located sunspace that acts as a preheater of ventilation air.

The glazed space is expected to reduce the energy consumption in the rest of the building and at the same time provide additional space for the children. As the conditions for outdoor play are rather poor parts of the year, such an intermediate space is greatly desired. The savings potential, in combination with the amenity value, therefore present an attractive option for this type of building.

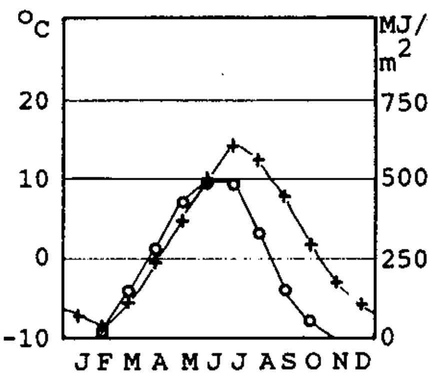
PROJECT DESCRIPTION

The project is part of the Norwegian Ministry of Oil and Energy's prototype program for energy conservation. Its purpose is to investigate both the energy savings potential and the amenity value of such glazed spaces in day care centers.

The prototype was built in the small town of Alta in northern Norway during the spring of 1987. It will be extensively monitored during the heating seasons 1987/88 and 1988/89. At the same time, use of the glazed space will be recorded, and the users will be interviewed.

SITE AND LOCATION

The building is located on a relatively flat site in a residential area outside town. The site is protected on the north side by a small forest, while it has full exposure to the sun on the east, south, and west sides. South of the building the site also slopes slightly downwards.



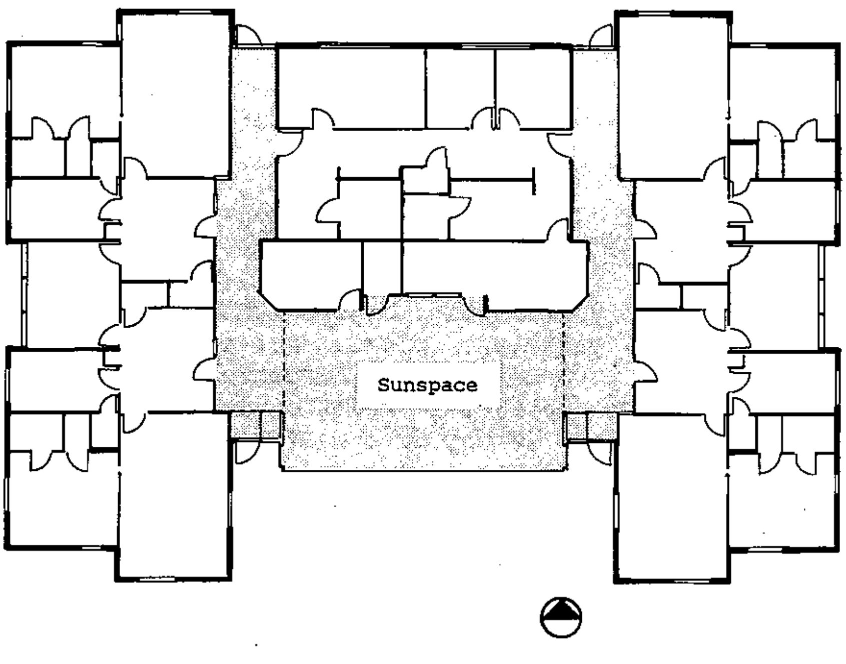
Site data:
Latitude - 69.6N
Altitude - 80m

Climate data:
Oct.to Apr. inclusive:
Degree days - 5092
(base 20)
GH - 390 MJ/m^2
Actual sun hours - 523
Actual/theor. - 0.35

Annual:
Degree days - 6600
GH - 2391 MJ/m^2
Actual sun hours -1606
Actual/theor. - 0.35
Average temp. - 1.7°C
Design temp. - -22.0°C

BUILDING FORM

The building is planned for 4 identical groups of children, two on each side of a central zone. This zone contains a service area with offices, a common kitchen, etc. to the north, and the glazed space to the south. All the entries are located in this semiclimatized zone, which also serves as the link between the different groups.



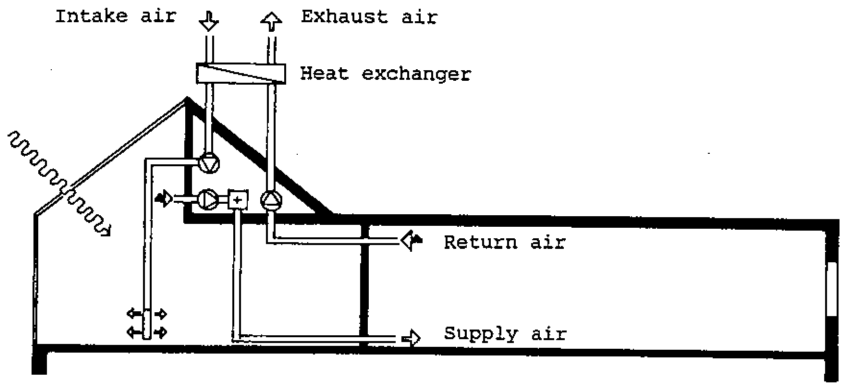
Plan

Volume:
Gross - 1275 m^3
Semiclimatized - 250 m^3

Window data:
Glass area is 18% of facade viewed from the inside.
Glass area is the same in all directions.

PASSIVE SYSTEMS

The semiclimatized, glazed space reduces the energy consumption in the rest of the building by acting as a buffer zone and thus reducing heat loss. The heat gained in the space is in addition used to heat the rest of the building. This is done by supplying all the fresh air to the building via the glazed space and thus obtaining a certain preheating effect.



Air flow diagram

BUILDING CONSTRUCTION

U-values (w/m^2K):
Floor - 0.15
Walls - 0.26
Windows - 2.00
Roof - 0.15

Envelope heat loss ($w/^oC$):
Transmission - 473
Infiltration - 234

As the building is only used in the daytime, and not on weekends and vacations, a low mass building was chosen.

The building is constructed in wood. Insulation levels are relatively high, with 150mm mineral wool in the exterior walls, 250mm in the ceiling, and triple glazing. The glazed space has a laminated wood structure with aluminum profiles and double glazing.

BUILDING SERVICES

Design conditions:
Temperature in heated space - 21^oC
Temperature in glazed space - floating

Ventilation:
Air change - 2250m^3/h
Heat exchanger efficiency - 80%

The basic heating system is radiant floor heat based on electricity. This is supplemented by a small number of electrical space heaters.

The ventilation system passes air through a heat exchanger and into the glazed space. The air is then heated and distributed diffusely to the rest of the building. When the temperature in the building is too high, the air is bypassed both the heat exchanger and the glazed space, and the glazed space is vented manually.

The ventilation system is only operated when the center is in use.

COSTS

Preconstruction calculations show that the energy savings potential is not quite high enough to make the system cost effective. Glazing systems available on the Norwegian market are too costly, and the energy price too low. When taking the amenity value into account, however, the total cost is considered acceptable.

The total cost of the atrium itself, excluding all mechanical equipment, was NOK 250 000. That price, NOK 3125/m^2 floor area of atrium, is quite representative for atria of that size at the moment. The total cost, NOK 7800/m^2 gross floor area, is also quite representative.

Building costs (1987):
NOK 7800/m^2 gross
ECU 1026/m^2 gross

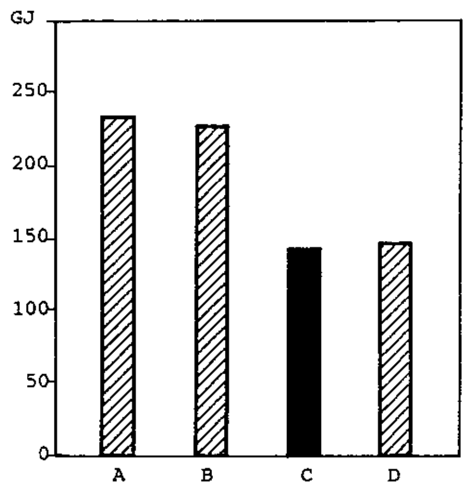
Reference cost:

NOK	8000/m^2
ECU	1052/m^2

Fuel cost (1987):
Elec NOK 97/GJ

ENERGY PERFORMANCE

Preconstruction calculations indicate a heating load for the building of 142 900 MJ. This represents a reduction of 40% compared to a reference building of the same type and shape, but without the glazed space.



Heating load for different alternatives

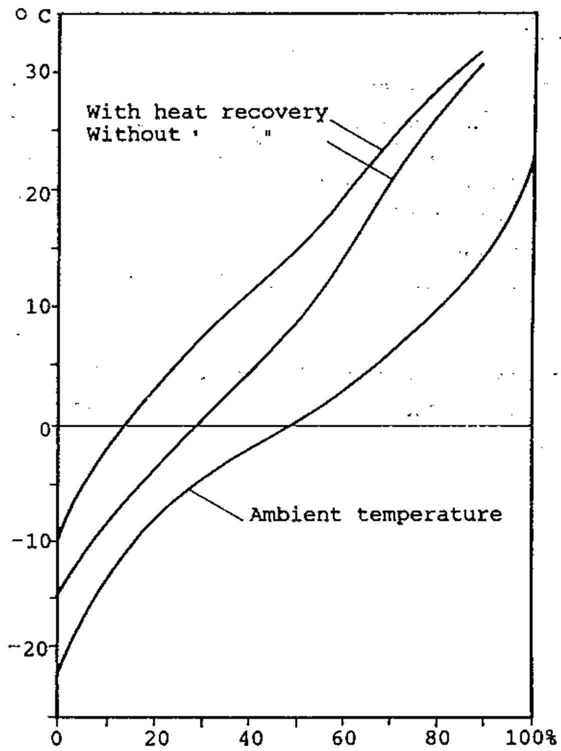
A - Reference building.
B - Solar building without heat recovery and nighttime setback.
C - Solar building as built.
D - Solar building with 0°C minimum temperature in glazed space.

The energy consumption increases by less than 3% if the minimum temperature in the glazed space is kept at 0°C. This can be achieved by installing a simple, thermostat controlled space heater.

Heating loads:
Solar bldg. - 292 MJ/m^2
Ref. bldg. - 480 MJ/m^2
Other day care centers - 720 MJ/m^2

Reduction in heating load: - 40%

Glazed space temperature:
10 - 15°C above ambient



Cumulative temperatures in the glazed space over the year

HUMAN FACTORS

Design occupancy:
Children
(age 0-7years) - 48
Adults - 15

7.8 m^2 space/person

Working hours:
08:00 - 16:00
Monday-Friday

The main idea behind the project is to provide additional space for the children to play. Norwegian day care centers are rather small, and the Norwegian climate quite severe at times, so additional indoor space is expected to be greatly welcomed both by the children and by the personnel. This is especially the case in the northernmost parts of the country where this day care center is built.

Certain activities, such as dressing and undressing dirty rainclothes and boots, playing with water and sand, and rougher types of play, can just as well take place in a semiclimatized space as in a fully climatized one. Certain activities, such as making things grow, can better take place there. Besides, at certain times of the year the temperature outside is so low that the children are required, by law, to stay inside.

CONCLUSIONS

As the building is just completed, no monitored data is available, and no user experiences have been recorded. The case study will be supplemented with this at a later stage.

INFORMATION

* Brattset,O., Hestnes, A.G., 1985, "Energiøkonomisering med halvklimatiserte soner i barnehager", SINTEF-report no. STF62A 85005, Trondheim, Norway.
* Bryn,I.,1986, "Energi- og temperaturanalyse av barnehage Romemyra", SINTEF-report no.STF62A 86006, Trondheim, Norway.
N.B.: Both reports are written in Norwegian.

As the building is just completed, only the results of preconstruction calculations have been published. Reports on the finished project will be available in 1988 and 1989.

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N

SOLAR DAIRY

Building type:
Office

Passive features:
Solar heating:
Direct and indirect

Occupancy date:
August 1981

Floor area:
Gross - 1 250m²
Heated - 1 250m²

Cost(1981):
NOK 9 000 000
ECU 1 184 000

Delivered fuel:	MJ
Gas -	0
Elec -	652 000

Total - 522 MJ/m²

SUMMARY

The office building for the milk processing plant has used standard building components for a cost-effective solar system. Its main feature is a double glass facade on the south side containing absorbing/reflecting Venetian blinds and a salt hydrate heat storage.

The building is well liked by its users because of its light and open qualities. The solar system is found to be somewhat complicated, however, with a control system incapable of handling the many modes of operation. A more sophisticated control system would have been appropriate.

The energy savings has been difficult to measure, as there has been a number of problems throughout the monitoring period. It does appear to be significant, but possibly not large enough to make the building as cost effective as originally expected.

Client:
Indre Østfold Meieri

Architect:
Meierienes Bygnings-kontor, in cooperation with GASA arkitektkontor

Consultants:
Kristoffer Apeland
Lars Myhre, HVAC
Kåre Nybø, Electro

Monitoring agent:
Institute for Energy Technology

PROJECT DESCRIPTION

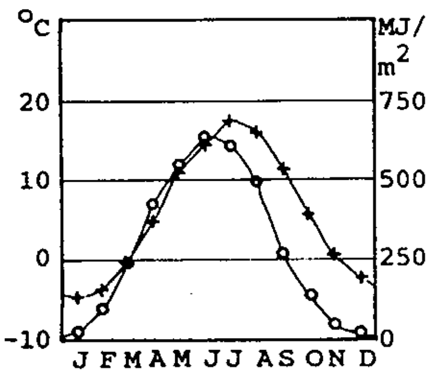
The project started as a thesis project at the Oslo School of Architecture. It was commissioned by the Dairy Association's Building Office, with one of their own architects functioning as project leader. The building was also built by them.

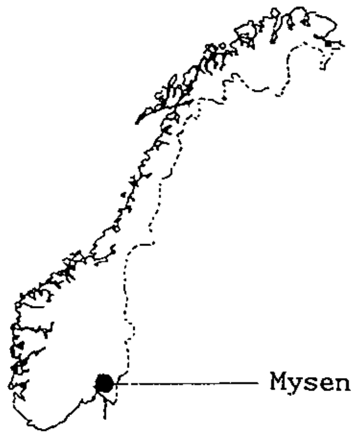
After completion, a certain amount of funding was procured from the National Research Council for monitoring its performance. This was done during the period 1983-84.

The project was given an award of merit in the competition organized in connection with the Passive Solar Conference in Knoxville in 1982.

SITE AND LOCATION

The building is situated next to the milk processing plant in the small community of Mysen in Indre Østfold, approximately 100 km south of Oslo. The site, which lies outside the community itself, is flat, open, and with very little shading.





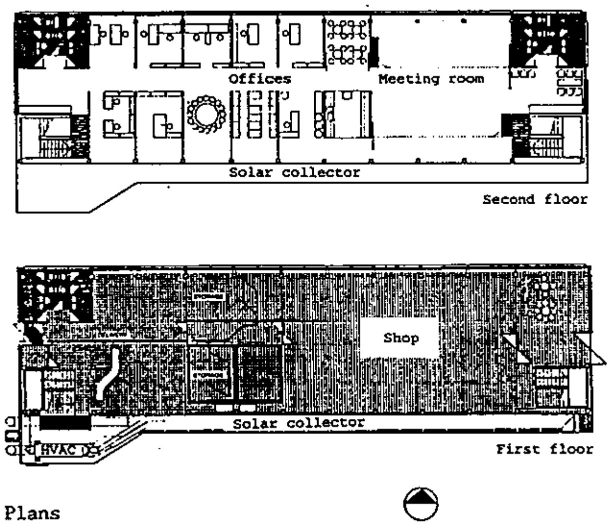
Site data:
Latitude - 59.3N
Elevation - 150m

Climate data:
Oct. to Apr. inclusive:
Degree days - 4215
(base 20)
GH - 1009 MJ/m^2
Actual sun hours - 596
Actual/theor. - 0.30

Annual:
Degree days - 5134
GH - 3570 MJ/m^2
Actual sun hours - 1756
Actual/theor. - 0.39
Average temp. - 5.4°C
Design temp. - -21.0°C

BUILDING FORM

The building has a simple, rectangular form, with a uniform height of two stories. The first floor contains a shop for retail sale of dairy products, while the second floor contains offices and meeting rooms. The southern part of the second floor is kept open as a circulation space.



Plans

Volume:
Heated - 3400m^3

Dimensions:
Ceiling height - 2.7m

Window data:
Total glass area - 60% of south facade

BUILDING CONSTRUCTION

The building has a reinforced concrete frame and hollow core concrete slabs. It is enclosed on the south side with panels of low-emissivity glass, and on the east, west, and north sides with stainless steel elements with 200 mm mineral wool insulation.

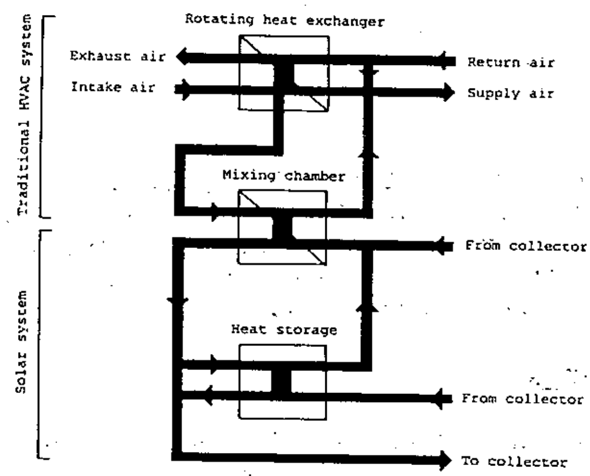
U-values (w/m2k):
Exterior walls - 0.25
Windows - 3.00

Design conditions:
Internal temperature:
08:00-16:00 hours -22°C
16:00-08:00 hours -18°C

BUILDING SERVICES

The building has a forced air heating system connected to the solar system and also to the ventilation system. Auxiliary heating is provided by an electrical aggregate in this system. In addition, there are thermostat controlled electrical space heaters in the offices on the north side.

The ventilation system has a rotating heat exchanger, and also a cooling aggregate.



Integration of HVAC and sunspace/solar system

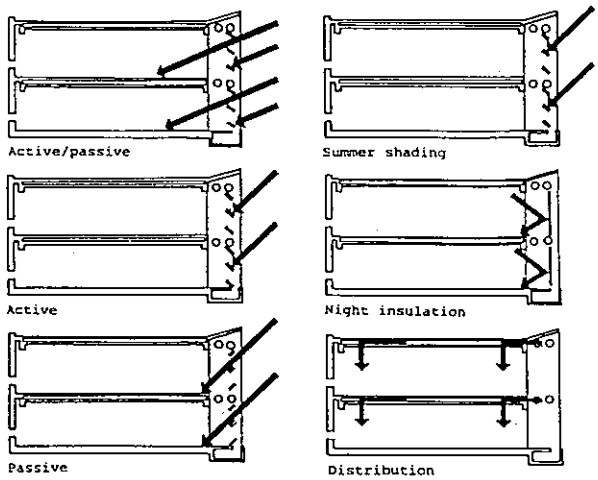
Double glass wall:
Facade area - 130m^2
Distance between glazings - 1.6m
Volume - 550m^3
Type of glazing - double, low emissivity

Heat storage:
Type - $CaCl_2 \cdot 6H_2O$
Volume - 4.6m^3
Capacity - 1440MJ
Melting point - 27°C

PASSIVE SYSTEMS

The major elements of the solar system zone, which runs across the two-story south facade of the building, are a series of absorbing/reflecting Venetian blinds. They are placed between two double-glazed curtain walls. The blinds are reflective on one side and absorptive on the other, thus making it possible to vary the amount of transmitted, absorbed, and reflected light.

The air ducts within the zone are linked to an HVAC system at one end, and to an isolated ground level salt hydrate heat storage unit at the other.



ENERGY PERFORMANCE

Preconstruction calculations of energy performance indicated a reduction in the heating load due to the solar system of app. 33 %. The savings due to the heat exchanger is not included in this.

There are only inconclusive monitoring results, as the monitoring period in large parts was spent searching for faults in the system. The control system proved to be too simple, and some of the mechanical equipment was of poor quality. One of the main problems was a large number of leaky valves. Short term monitoring results indicate that the direct gain component is a larger part of the solar gain than predicted.

Heating load (MJ/m^2):
Solar building - 280
Reference - 396

Solar fraction of total heating load - 33 %

COSTS

The total cost of the building was somewhat larger than average cost for similar buildings at the time of construction. No differentiation between the cost of construction of the conventional building and the cost of the solar system was made.

Building cost (1981):
NOK 7200/m^2
ECU 950/m^2

Reference cost:
11 000 - 12 000 NOK/m^2

HUMAN FACTORS

The client wanted the building's function s exposed to a public area to its south. The architect's challenge was therefore to combine an entirely open south facade with low energy consumption. The resulting building is well liked by its users and by its neighbors. Some of the users have wanted to open the blinds during the day independent of the solar situation, however, and this has interfered both with the efficient operation of the system and with monitoring.

Design occupancy:
Staff - 18

Functions:
Administrative
Accounting
Sales

CONCLUSIONS

The building is now, after six years of operation, functioning satisfactorily. It has been concluded that the solar system could have been made simpler without much loss in efficiency, and with higher cost effectiveness. It does save energy, however, and it is liked by its users and admired by architects. Consequently, it has had a favorable impact on the public attitude towards solar architecture in Norway.

The solar system is complicated and difficult to operate.

INFORMATION

* Borgen,D., 1983, "Solar Dairy", Progressive Architecture 4:83, Reinhold Publ., Cleveland, Ohio.

* Dahlsveen,T., 1983, "EDB og Solenergi", Norsk VVS 5:83, Skarland Press A/S, Oslo.

* Sekkesæter,H., "Energimålinger ved Indre Østfold Meieri", Report published by Institute for Energy Technology, N-2007 Kjeller.

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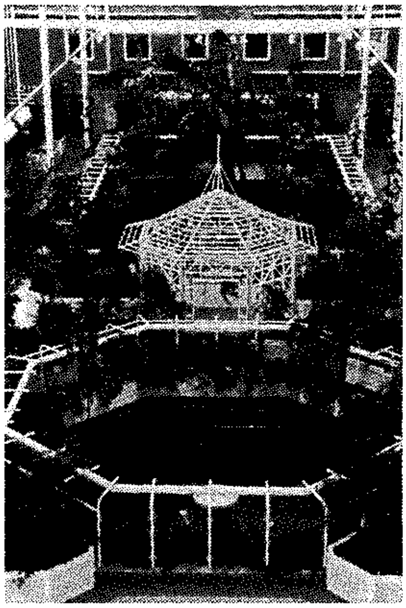
(S) SWEDEN

BCS No.	Building Title
34	WASA CITY
35	BODBETÄNTEN BUILDING
36	SKÄRHOLMEN SHOPPING CENTRE

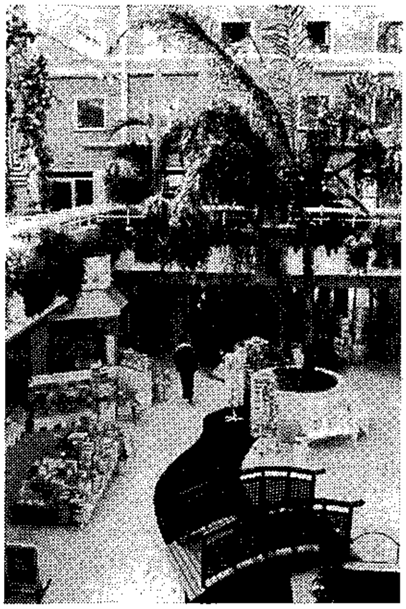
WASA CITY

S

WASA CITY



First floor



Ground floor

Building Type:
Office
Commercial
Residential

Passive features:
Atrium
Direct solar gain
Direct daylighting
Curtains and natural ventilation against overheating

Occupancy date:
1964
Retrofit : 1987

Floor area: m^2
Gross : 16 800
Heated: 16 800

Cost (1987):
SEK 43 000 000
ECU 6 323 529

Energy consumption:

Heating	7 224 000 MJ
Elec	3 864 000 MJ
Total	11 088 000 MJ

Client:
Wasa Insurance Company

Architect:
Thurfjell arkitektkontor

Contractor:
Heidenberg and Olofsson

SUMMARY

A courtyard of a central block in Gävle was covered by glass to create a attractive shopping centre on the ground floor. The retrofit ideas were not appreciated by all apartment tenanants. Some of their balconies came under the glass cover and daylight was reduced in several rooms. On the other hand a winter garden was created for them on the first floor so after completion the attitudes in general have turned positive.

Because heat is recovered from the exhaust air the increase in energy consumption due to heating the courtyard is relativly small.

Peoples attitudes to glass coverings are especially interesting to study here since the tenants have experienced the environment here both with and without the glazed roof. Nobody so far has moved because of the retrofit.

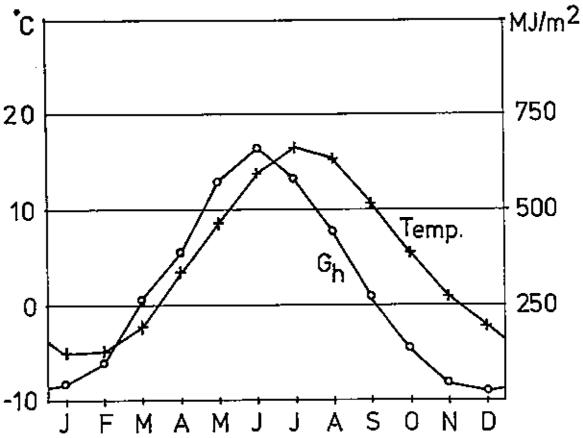
PROJECT DESCRIPTION

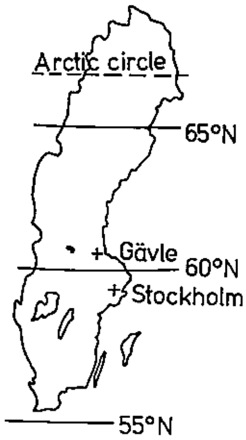
To create an attractive shopping centre and a winter garden an existing courtyard in a central area of Gävle was glazed over. The courtyard has two floors, the lower being smaller and enclosed with shops, the upper enclosed with apartments and having two large openings to the lower floor.

The upper floor is currently only accessible by the residents, and includes benches and considerable vegetation. Several of the apartment balconies have been glazed in through the retrofit. The shops on the ground floor have access to the lower courtyard, and there is a restaurant with tables in the courtyard.

SITE AND LOCATION

The building is adjacent to the central square of Gävle, a town with a population of 80,000, on the Baltic coast some 200 km north of Stockholm. Surrounding buildings are 5 storeys high. No significant shadows fall onto the glass from these.





Site data:

Latitude	60°41'N
Altitude	11 m

Climate data:

Degree days (base 20)

Annual	-	5 050
Sept-Apr	-	4 150

Temperatures : °C

Annual average	5.0
Design minimum	-18.8

Global irradiation: MJ/m²

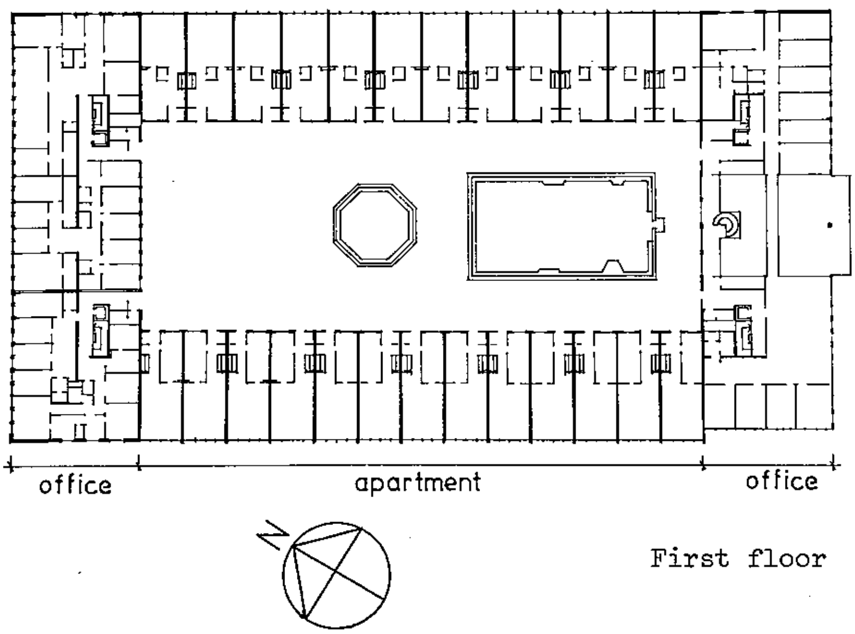
Annual av.	3 530
Sept-April	990

BUILDING FORM

The building is rectangular and measures 90 x 50 m. The glass courtyard roof is 23 x 60 m and covers 30% of the block area. The openings to the courtyard from the upper floor are 20 x 12 m and 9 x 9 m.

The southern part of the building has 5 floors, the north has 4 floors, and the long sides against the east and west have 3 floors of which the top two upper floors comprise two-storey apartments.

The glass roof comprises mainly a saddle roof but rounded off with a part-tower with a monopitch roof facing the south. The slope of the saddle part is 30° and of the tower part 45°.



First floor

Volume: m³

Building	73 500
Atrium	16 000

Dimensions: m²

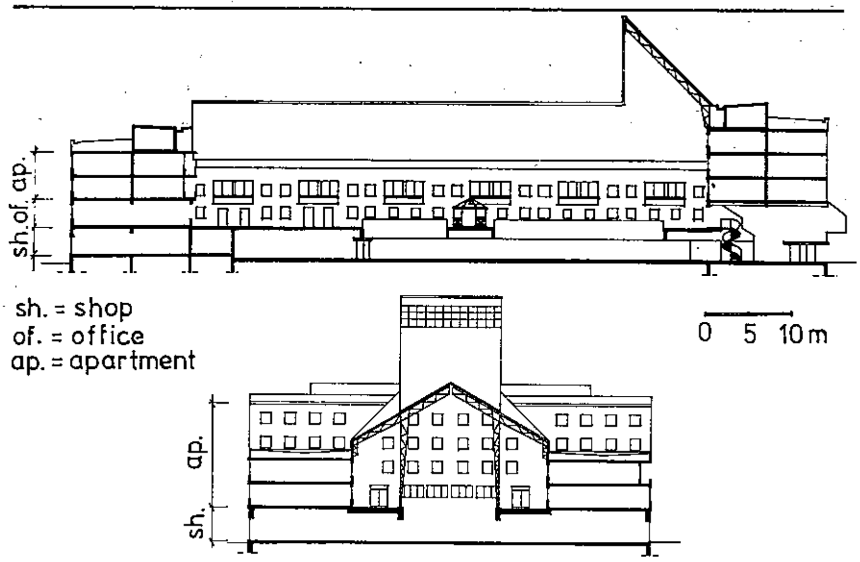
Total floor	16 800
Offices	1 200
Shops	3 500
Apartments	5 400

Courtyard:

Ground floor	385
First floor	1 070
Height	15/24m

Glass roof (atrium):

Area:	1 380m²



BUILDING CONSTRUCTION

U-value:
Inclined glass roof
2.0 W/m^{2}K
Vertical glass roof
1.6 W/m^{2}K

The framework is concrete with marble facing in the ground floor and yellow brickwork above. The windows are double glazed. The glass roof is triple glazed on a steel framework, the distance between ridges being 2.2 m. The vertical glass areas of the tower part have sealed triple glazing.

BUILDING SERVICES

Minimum temperatures:
Apartments/shops 20^{o}C
Courtyard 10^o - 18^{o}C

Maximum Temperatures:

Courtyard, ground floor
Ambient temp.
Courtyard, first floor
Ambient temp. +8^{o}C

The building is connected to the District Heating system and is mainly equipped with hot-water radiators. The glazed courtyard is provided with under-floor heating. The offices and apartments are heated to 20^{o}C and the courtyard to 18^{o}C during working hours and 10^{o}C other times. According to calculations, the temperature in the lower floor of the courtyard will never exceed the outdoor temperature. In the upper floor the temperature will never exceed the outdoor temperature by more than 8 degrees.

Automatic illumination:
Plants:
Tropical: On 8.00-20.00 when daylight level < 2 000 lux
Nordic: On 8.00-20.00 when daylight level < 1 000 lux
General:
On when outdoor daylight level < 1 000 lux

The courtyard is fan ventilated with exhaust ducts in the yard eaves. Heat is recovered from the exhaust air. Incoming air is obtained directly from the shops to provide base heating supplemented by one centrally placed inlet, distributing slightly cooled air.

Incoming air through the outer doors is restricted by the use of revolving doors.

To avoid overheating of the courtyard there are ten sliding shutters in the glass roof (300 m^2) and 20 hinged shutters (30 m^2) in the vertical part of the tower. Light curtains acts as sun protection. They are governed by an internal daylight sensor.

PASSIVE SYSTEMS

Because heat is recovered from ventilation air from the glazed courtyard a large proportion of the solar heat and surplus heat from the shops can be utilized. This enables the establishment of a winter garden with year-round summer conditions at low energy costs.

COSTS

Renovation and retrofitting cost a total of 43 million SEK (3 800 SEK/m^3). These costs must be seen in relation to the improved business opportunities in the new environment.

ENERGY PERFORMANCE

The energy consumption has increased from former average 1 800 MWh to 2 000 MWh, i.e. 10%.

HUMAN FACTORS

Glazing in the previously open courtyard has resulted in both positive and negative reactions. Most appear to appreciate the new environment once they had become used to it. No tenants had moved as a result of the glazing in.

Initially there were some problems in renting out all the shops. Today these are all occupied and the shopping level is well-utilized and appreciated.

The attitudes of users will be studied in more detail later.

CONCLUSION

By glazing in a centrally located housing and shopping area it is possible to raise the quality of environment and facilities without considerably increasing energy requirements, though this is achieved at a fairly high price. Originally there was some scepticism expressed towards the plans by the tenants, but afterwards most were positive about the change.

INFORMATION

Claesson A C, Jernström K, Lundqvist V, Nordanberg A C — Interior Climate in a glazed in yard. (Thesis in Swedish), Polhem School, Gävle 1987

Carlsson P O, Lindqvist E — Practical experience concerning glazed in spaces. Report R36:1988, Swedish Council for Building Research, Stockholm.

Retrofit cost (1987):
SEK 2 560/m^2 gross
ECU 361/m^2 gross

Typical cost (new office 1987):
SEK 7 000/m^2 gross
ECU 987/m^2 gross

Fuel use: MJ/m^2
District Heating 430

References:
Existing office 400
New office 220

Electric:
Typical office 220

Working hours:

Daily	8.15 - 18.30
Saturday	9.00 - 14.00
Sunday	closed

Report prepared by:
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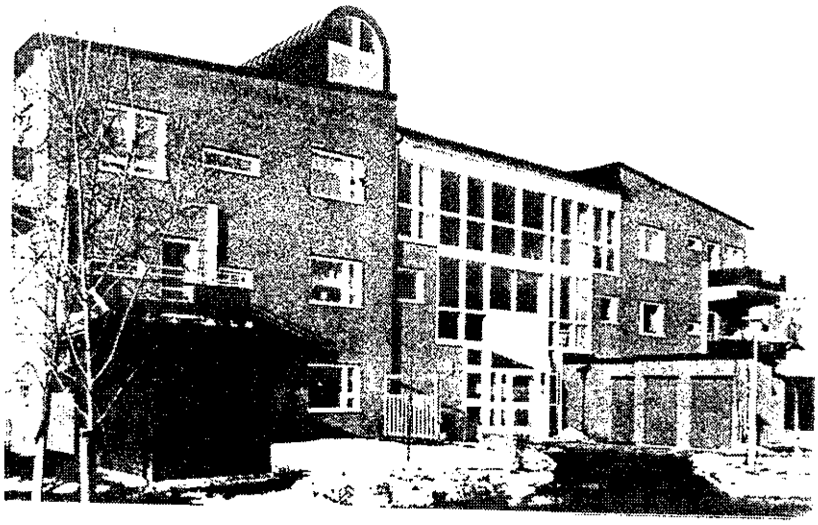
SIB, Box 785
S 801 29 Gävle
Sweden

BODBETJÄNTEN OFFICE & APARTM. BUILD.

Building type:
Office (and residen tial)
Solar technology:
Atria



Date of occupation:
April 1985

Floor areas:
Offices: 2 710m²
Apartments: 5 340m²
Atria: 650m²

Client:
ABV
Design team:
CAN Arkitektkontor
ABV-teknik
LOA Andersson

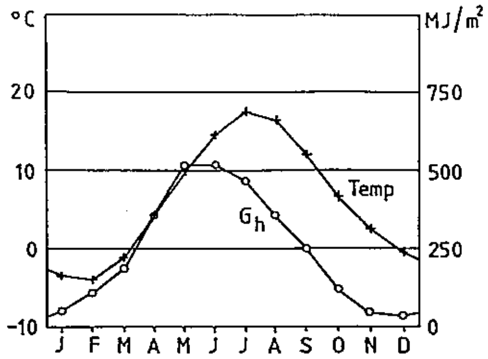
SUMMARY
The building contains north-facing offices and east-, west-, south-facing apartments plus two atria. The main experimental energy principles are two: 1) Surplus heat from offices is transported by the exhaust ventilation air partly through the atria, partly through ducts in the concrete slabs of the apartments. 2) The atria act as buffer zones and for passive solar gains. A heat pump and short time thermal storages are also included.

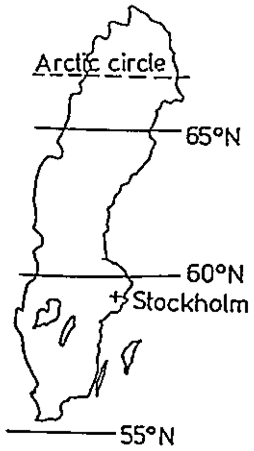
PROJECT DESCRIPTION
"Bodbetjänten" is one of six experimental buildings within the "Stockholm Project", initiated by the city of Stockholm, supported by the Swedish Council for Building Research and evaluated by the Project Group for Energy Conservation in Buildings, an annex institution of the Royal Institute of Technology in Stockholm. The monitoring is of a high level. Extensive main frame computer simulations were carried out during the design phase.

SITE AND LOCATION

The building is located on a flat site in a residential area south of Stockholm. The site is fairly unshaded.

Latitude: 59°16'N
Longitude: 18°05'E
Altitude: 35m



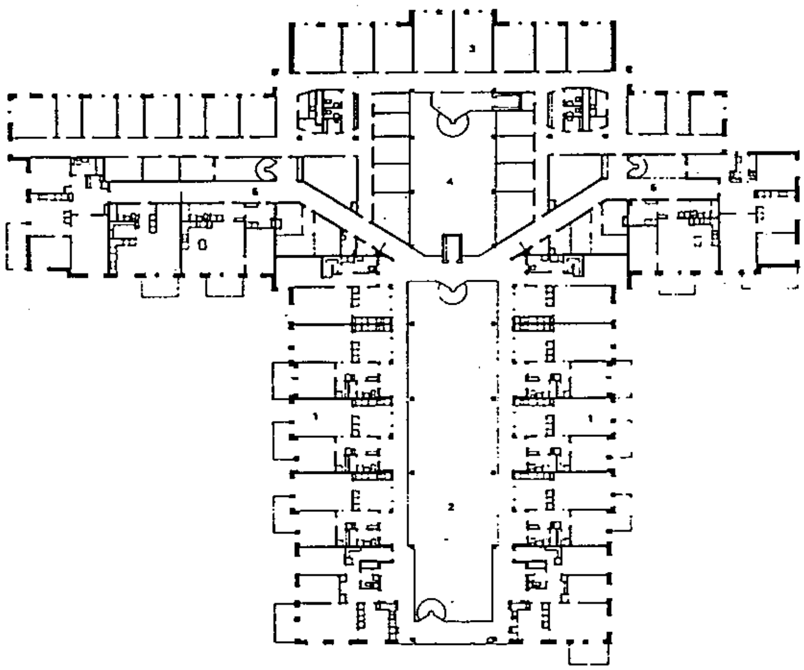


Degree days (18C)
Heating: 3 720
Cooling: 0
Temperatures:
Annual average: 6,9C
Design: -18C
Horizontal global irradiation (heating season): 1 260MJ/m²

BUILDING FORM

Out of 47 apartments 30 are of balcony access type on three floors grouped around an atrium. The rest, on four floors, have conventional stair-well entrances. The offices, all facing north, are distributed on four floors surrounding a small glazed atrium. All atrium glazings are vertical. The roof parts of the atria contain a fan room.

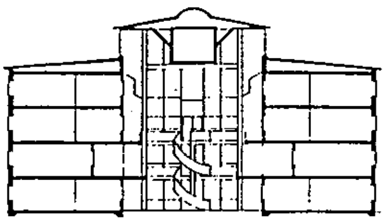
Total building volume thermally connected to atria: 24 200m²
Atria volume: 6 200

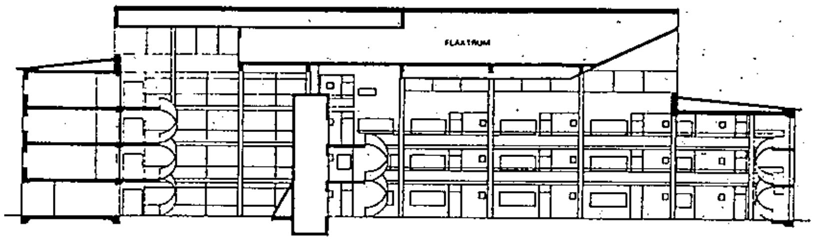


U-values (W/m^2K)
External walls 0,27
Atria walls 0,35
Roof 0,13
External windows 1,8
Atria-facing windows 2,8

BUILDING CONSTRUCTION

The structure is prefabricated concrete. All outside walls are in red brick. The apartment walls facing the atrium is red brick and painted gypsum board. The office walls facing the smaller atrium are of light-weight constructions covered by steel sheets. The floor slabs of the apartments contain ducts for ventilation air. External windows have three panes (2+1), while windows facing the atria have two sealed panes. Atria floors are brick paved.





BUILDING SERVICES

In the heating system a continously working heat pump (32/90 kW) takes heat from:

- heat exchanger of residential exhaust air (all year)
- heat exchanger of residential atrium circulating ventilation loop (sunny winter days)
- heat exchanger of office supply air (summer).

The heat pump loads heating water storage tanks. The stored heat is used (through heat exchangers) for:

- domestic hot tap water production
- office supply air heating when needed
- convector heating in apartments.

The heat pump capacity alone covers the needs most of the year. As back-up an immersion heater (105kW) is installed. Draught from office windows (at ambient temperatures below +3C) is eliminated by electric resistance heaters. Storage tanks and heat storage in residential floor slabs maximize off-peak loading.

The office ventilation system interacts with the duct loading of residential floor slabs. During office hours in winter supply air is taken from the residential atrium. At night the entire ventilation supply is recirculated air, heated when need be. During summer outdoor supply air, when needed /possible heat exchanged with heat pump circuit.

The office atrium is ventilated by fans and automatically opening vents.
The apartment supply air is taken in through slit valves behind convectors under windows. Exhaust air is fan operated and heat exchanged to heat pump circuit all year.
In the residential atrium a slight excess in air pressure is kept to counteract leak ages from outside and from apartments. Sunny winter days air circulation fan feeds heat exchanger to heat pump system. In summer, when needed, the atrium is cross ventilated.

PASSIVE AND HYBRID SYSTEMS

The atria act as buffer zones and passive solar collectors. The heat loading of the apartment floor slabs by office exhaust air may also be looked upon as a passive hybrid device. See detailed building services description above.

COSTS

The cost effectiveness of the experimental parts of the project has not yet been calculated. All conventional parts of the building and building servises systems are covered by regular loans.

ENERGY PERFORMANCE

The evaluation of actual energy balances is in progress and will be reported during 1988. So far only simulation results are available. They are as follows:

HUMAN FACTORS

The technical evaluation of the project is completed by extensive sociological investigations, which so far indicate that the tenants are pleased with their living standard and that the atrium is appreciated for its amenity.

CONCLUSIONS

Results are only preliminary, but the evaluation group look upon Bodbetjänten as a successful item within the Stockholm Project. Not least is the very dedicated engagement of the contractor, who is also the client, judged as exemplary.

INFORMATION

"Bodbetjänten. Combining office and residential facilities in one building." BFR S 10E:1985.

Isfält,E; Johnsson,H: "Stockholmsprojektet - effekt- och energisimuleringar med datorprogrammen BRIS och DEROB." BFR R59:1986.

ENERGY BALANCE

Specific energy requirement, kWh/m² mother area, year

Free Energy:	
heat pump regain	35
occupants	10
passive solar	10
	55
Purchased Energy:	
immersion heater	15
heat pump drive	20
fans	10
domestic & office electricity	30
draught elimination in offices	5
	80
Total	135
Energy Losses:	
transmission	30
air leakage	15
exhaust ventilation	25
waste water	25
fans, pumps, lighting	40
Total	135

S

SKÄRHOLMEN SHOPPING CENTRE

BUILDING TYPE
Commercial

SOLAR TECHNOLOGY
Atria

Date of completion
November 1984

Floor area:
Gross: 4 000m²
Heated: 4 000 m²

SUMMARY
This is a retrofit glazing project covering narrow streets between shopping and occice blocks built in 1964. The main purpose was to create better ambient conditions and thus improve decreasing commercial activities. Main climatizing through transmission losses from adjacent buildings and solar gains. Plus heating through piping in floor coupled to return circuit of district heating system.

Client:
AB Svenska Bostäde

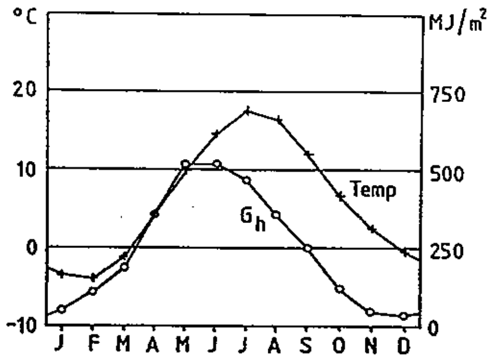
Design team:
JM Byggnads och Fastighets AB thr AB Citybyggen; Kempe-Ljunglöf Arkitekter AB; Tyréns AB

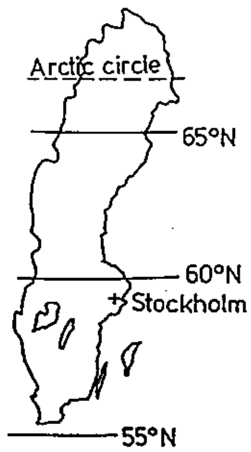
PROJECT DESCRIPTION
The monitoring and evaluation of the project has been supported by the Swedish Council for Building Research and carried out as an interdisciplinary research project by the Division of Building Technology of the Royal Institute of Technology in Stockholm in collaboration with JM Byggnads och Fastighets AB.

SITE AND LOCATION

The premise is located on a flat site in a residential area south-west of Stockholm No shading on the site apart from by the comprised buildings.

Latitude: 59°16'N
Longitude: 17°55'E
Altitude: 45m





Degree days (18C):
Heating: 3720
Cooling: 0

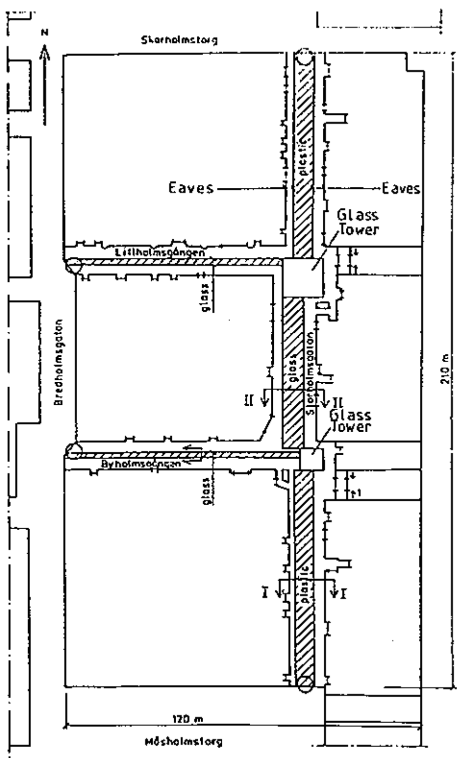
Temperatures:
Annual average: 6,9 C
Design: -18C

Horizontal global irradiation (heat season): 1260MJ/m²

BUILDING FORM

The retrofit glazing covers 4 000m² of streets between four blocks containing shops and offices, comprising some 50000m² of heated floor area. The covered streets are surrounded by heated buildings on both sides of their entire lengths. All entrance doors to the streets are double and automatically operated. During shopping hours most shop doors are kept open to the street

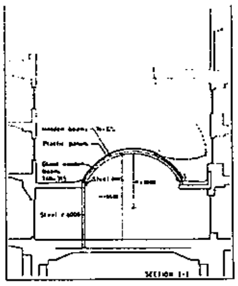
Total building volume thermally connected to glazes areas: 73000m³
Total volume of covered streets: 25 000m³

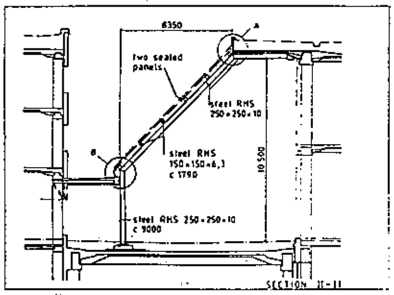


U-values (w/m²c):
Adjacent walls 0,6
Glass covering 2,0
Eaves 0,3

Envelope transmission losses of covered streets (w/C): 5 800

BUILDING CONSTRUCTION
The shop and office buildings are constructed in concrete. The street coverings are of three types: two pane sealed sheet glass on steel constructions 1 740m²; opal plastic panels on glued wood constructions; 945m²; retrofit insulated concrete eaves 1 315m². The original brick paving has been replaced by marble.





BUILDING SERVICES
The basic heating system of the original buildings is preheated ventilation air (2/3) and radiators (1/3). The covered streets are heated by 16 000m of piping below the marble tiles at temperatures between 20 and 38C.

The heat sources are district heating and recovered heat from refrigerators and freezing equipment of stores. The piping system of the streets is connected to the return circuit of the total heating system

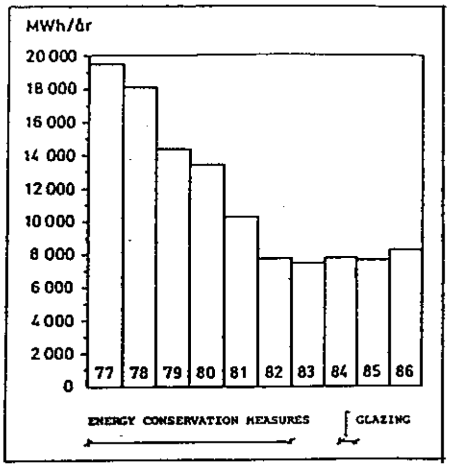
The ventilation system is mechanical, but no heat recovery equipment is installed. Considerable heat preservation is, though achieved through data-operated reduction of ventilation rates during non shopping hours.

PASSIVE SYSTEMS
The glazed volumes act as bupper zones between buildings and out-door space. The solar gains are estimated as fairly low as compared to the buffer effect of transmission losses from buildings through glazed volumes.

COSTS
The retrofit covering of the streets, including heat piping and marble floor cost some 6 000 SEK/m². The cost-effectivness must be judged in terms of increased turn-over from the entire stock of commercial premises in the centre. No calculations are so far available, but a preliminary estimation is that the project is a success. 35% of shop owners report big increases in business and 52% report "certain" increases.

ENERGY PERFORMANCE

The temperature corrected energy demands for heating and hot tap water production 1977-86 show that energy conservation measures up to 1982 - mainly careful regulation of ventilation rates - did decrease the demands to 40% of the original figures. The covering of the streets, on the other hand, did not change the demands at all, which is to say that the amenity of 4 000m² indoor street area has been achieved without any additional heat supply.



HUMAN FACTORS

Extensive measuring of temperatures, air velocity, humidity and accoustics have been completed by interviews with shopowners, employees and customers. Comfort has been judged as excellent most of the year and as quite acceptable both during extremely cold periods and during hot and sunny days.

CONCLUSIONS

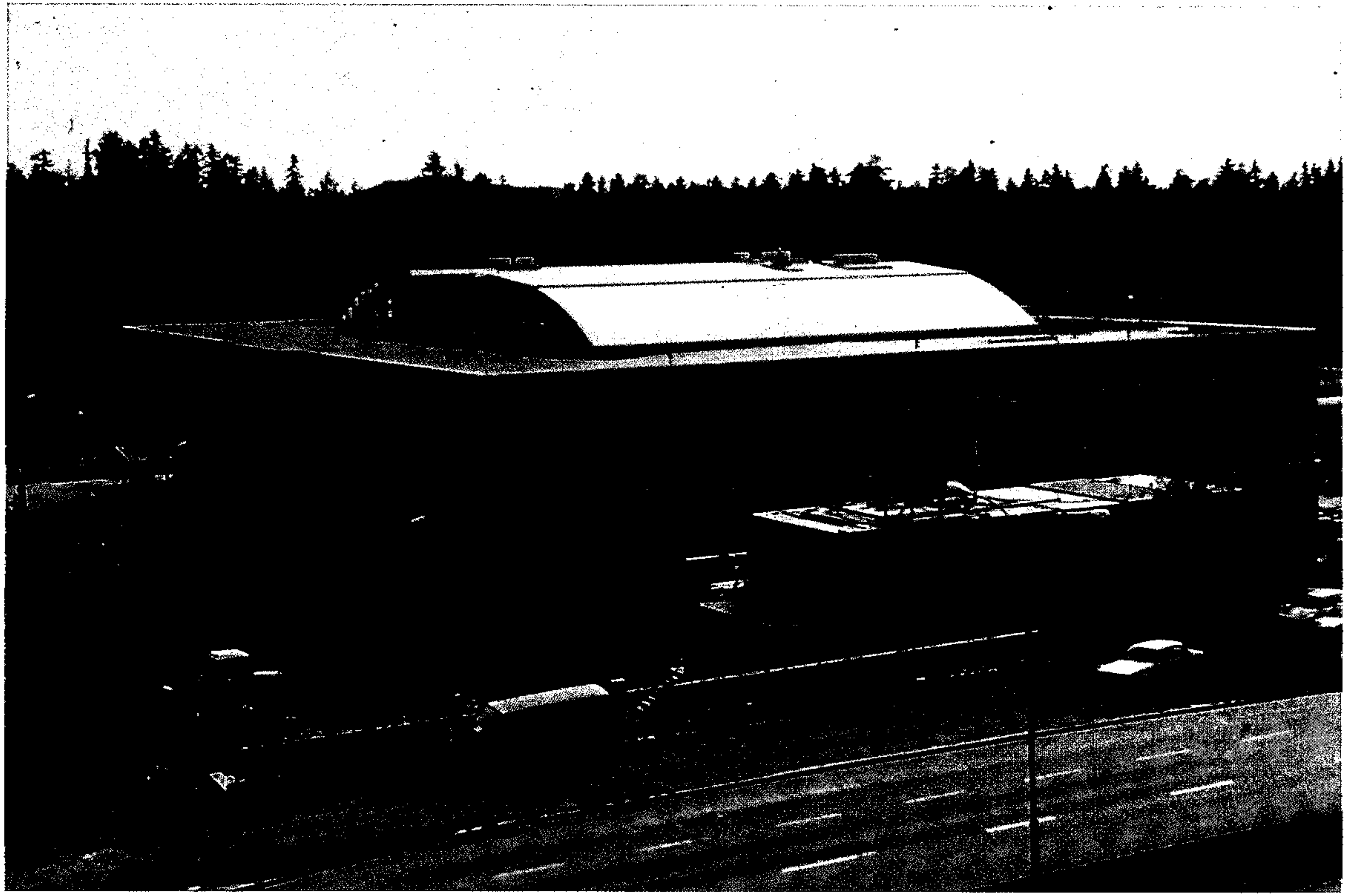
The introduction of retrofit glazing of shopping centres in Sweden has increased considerably during the last five years. Skärholmen is the only monitored and carefully evaluated project, but it seems reasonable to assume that this type of improvement is generally profitable, and that it could be achieved without any increase of energy demands.

INFORMATION

Höglund,I; Ottoson,G; ÖMAN,R; 1987:"Överglasning av stora byggnadsvolymer - Skärholmens Centrum".

(SF) FINLAND

BCS No.	Building Title
37	PI-GROUP HEAD OFFICE



PI-GROUP HEAD OFFICE

SF

THE PI-GROUP HEAD OFFICE

Building type:
Office

Passive features:
Solar Heating:
direct
Daylighting:
direct
Atrium

Occupancy date:
September 1985

Floor area:
Gross 10180 m^2
Heated 9868 m^2

Cost: (1985)
FIM 35 000 000
ECU 6 910 000

Annual delivered fuel:
District heat 4150000 MJ
Electricity 6180000 MJ
Dh & Elect:
1015 MJ/m^2 gross

Client:
The PI-Group

Architect:
Yrjö Mansnerus
Kaupunkisuunnittelu Ltd

Energy consultant:
PI-Consulting Ltd

Services engineer:
PI-Consulting Ltd

Monitoring:
PI-Consulting Ltd

SUMMARY

The PI-Group is a rapidly growing consulting company with long traditions in the design of industrial plants and office facilities. One of PI's recent experimental research projects has been performed on its own new office building located just outside Helsinki. Completed in 1985, the building is a demonstration of energy efficiency.

Two storeys of office space are wrapped around two 366 sq.m atria. The atria are used as plant rooms and they provide daylight to the office room, that surround them. In addition, an indirect lighting system which uses 150 W metal halide lamps was chosen for high colour rendition, high efficiency, and long lifetime.

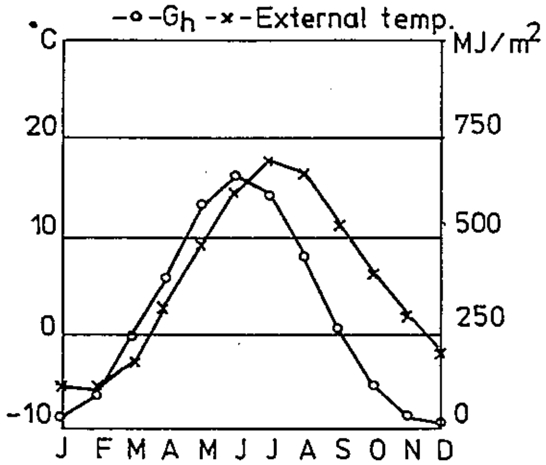
The ground floor of the building is for public and commercial services. There is a bookstore (454 m^2) in one corner, one supermarket in the other corner (1370 m^2) and a restaurant (548 m^2) in the third corner. The 4th corner is an unheated parking space.

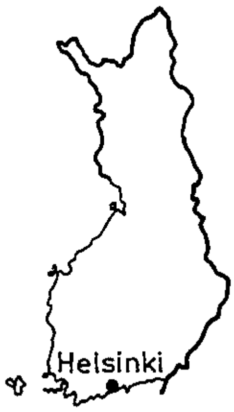
PROJECT DESCRIPTION

The PI-Group is a consulting company in a number of engineering fields and its head office had to symbolize and demonstrate the company's image and know-how. In recognition of this, there was close cooperation within the design team. The use of atrium spaces as well as the use of hollow concrete slabs for air conditioning ducting has provided savings in investment costs and attracted much attention. Use of an extract air window system, utilization of building structures as short period heat storage, use of daylight, optimum use of solar energy, efficient illumination by indirect lighting system, controlled make up air volumes and heat recovery from exhaust air and evaporators together with optimum control strategies have made the building energy efficient.

SITE AND LOCATION

The site is a growing commercial and residential center of tight 3-7 level buildings in the western part of the city of Vantaa about 15 km to the north west of Helsinki.





Site data:

Latitude	60° 10′ N
Altitude	28.6 m

Climate data:

Oct. to Apr. inclusive

Degree Days (base 20)	4407
G_h	904 MJ/m^2
Actual Sun Hours	540
Actual/Theoretical	0.27

Annual:

Degree Days (base 20)	5329

BUILDING FORM

It is a 3 storey rectangular building, 60.8 m long, 53.6 m wide and 11.4 m high. Two atria of 366 sq.m are located symmetrically in two centres of the building and office spaces are wrapped around them. One of the atria is on the ground floor level and the other one on the first level. The attic between the two atria is an executive area with a conference room, dining room, kitchen, services and two saunas. The basement of the building is used for shelters, storage, hobby and social areas and technical rooms.

Volume: (m^3)

Gross:	30700
Atriums:	
with south facing skylight	4850
with north facing skylight	3550

Dimensions: (m)

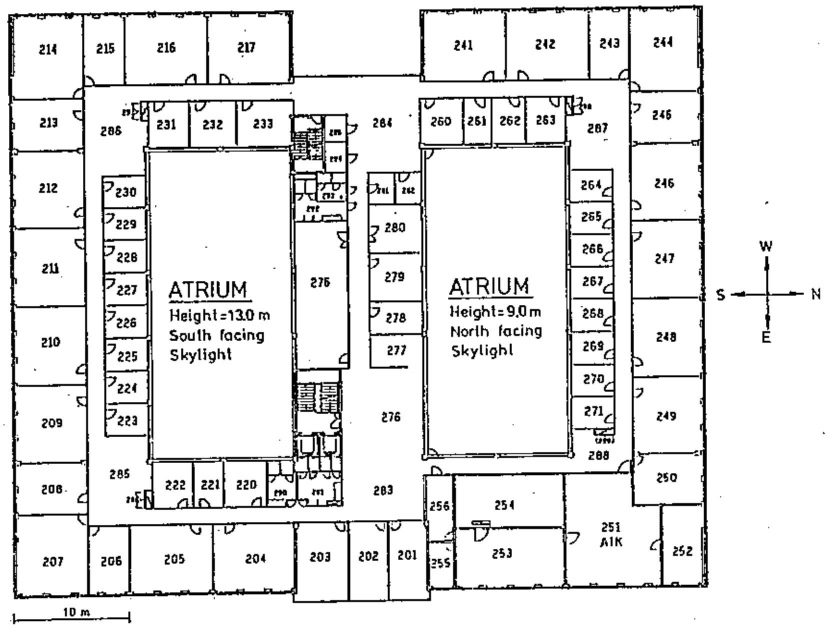
Plan:	60.8 x 53.6
Height:	11.4
Floor to ceiling height:	2.8
Floor to floor:	3.1

Surface areas: (m^2)

Basement:	2030
Ground floor:	
heated	2400
heated atrium	366
unheated (parking space, storage)	312
First floor: (excl. atrium)	2470
atrium	366
Second floor:	2470
Attic:	410
Roof: (excl. skylights)	2470
Skylights (each)	400

Window data:

Glass area is 40% of facade viewed from inside to outside and 65 % viewed from inside to atria.



FLOOR PLAN OF OFFICE SPACES

U-values: (W/(m^{2}K))

Floor	0.36
Ceiling	0.25
Wall	0.30
Window	1.90
Skylight	1.85

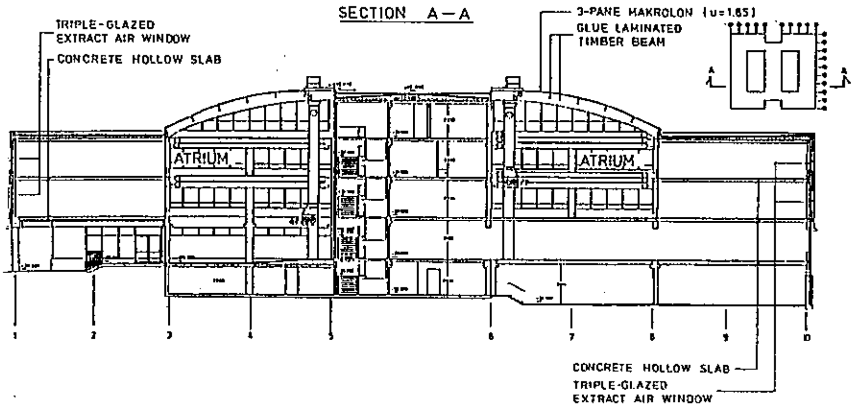
Envelope heat loss: (kW/K)

Transmission	1.9
Ventilation	10.8

BUILDING CONSTRUCTION

It is a reinforced-concrete frame with facing brick finish. The external walls include 140 mm mineral wool. The walls surrounding the atriums are uninsulated brickwalls and the windows on these walls are single-glazed. All other windows are triple-glazed and in the first and second level (office spaces) they are extract air system windows. The floor slabs are hollow concrete and they are used for ducting of office spaces.

The skylights in both atria are made of 3-pane plastic panels (Makrolon 60 x 88 mm) and they are opal. Both primary and secondary beamgirders of the skylights are glue laminated timber beams.



Installed capacity:
Space heating:
Heating areas 49 W/m^2

Design conditions:
Internal temperature:

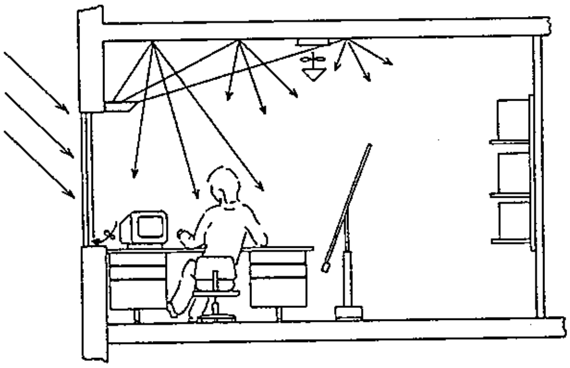
Offices	20 °C
Atria	17 °C

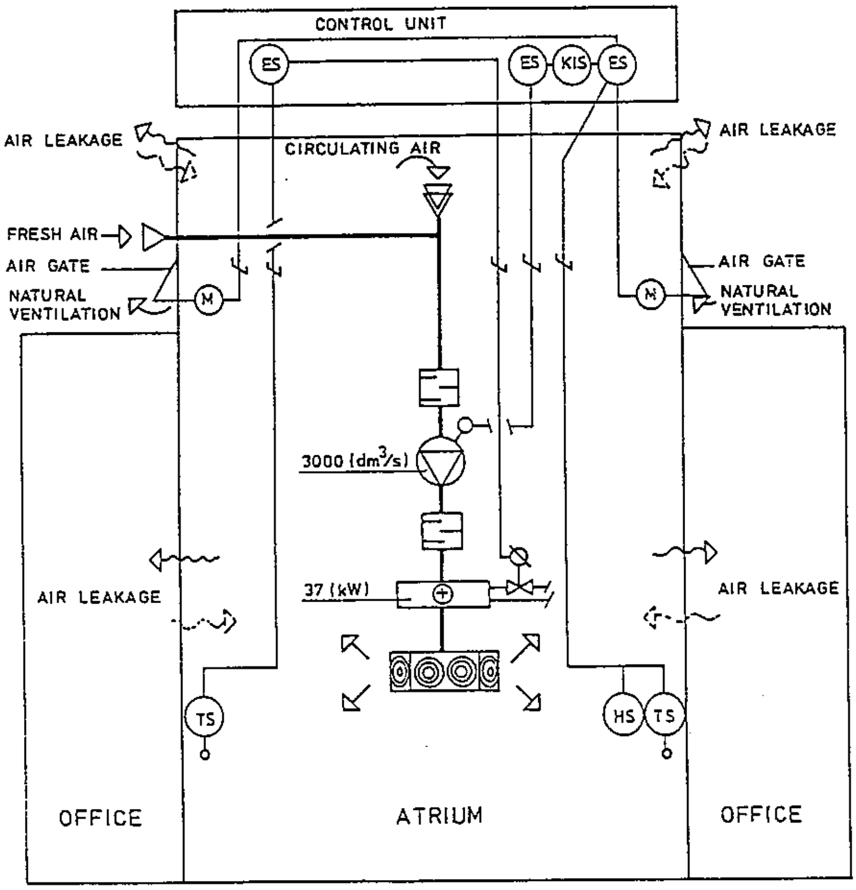
BUILDING SERVICES

Heating and ventilation:
The building is connected to the district heating network and heated by a forced air heating system which performs well compared to other similar low energy buildings. The air conditioning system of the office spaces has 2 zones, one serves the south and west facades and the office spaces around the atria and is equipped with both cooling and heating facilities. The other zone, which serves the north and east facades is equipped with only heating facilities. In addition, there are split air-handling units in the computer suite, the text editing unit and the copying unit. The attic space, the super market, the bookstore and the restaurant each have their own air conditioning units. The atria are heated by separate airhandling units and the temperature in the atria is controlled by thermostats. During summertime, the atria are naturally ventilated by openings in their fully glazed east and west external walls. These openings are also controlled by thermostats.

Lighting:
The atria, together with windows, provide daylighting in office spaces. In addition, an indirect lighting system which uses 150 W metal halide lamps was chosen for high colour rendition, high efficiency and long lifetime.

Installed capacity:
Lighting (offices): 20 W/m^2





PASSIVE SYSTEMS

The atria provide daylight in the inner zone of the building. In addition, the atria, together with their skylights, operate as passive solar collectors and reduce heating energy use during the heating season. Efficient air circulating units in the atria minimize the thermal stratification in the heating season, when the temperatures in the atria are controlled by thermostats. An optimal target temperature in the atria optimizes the heating energy use in the atria and in the spaces wrapped around them.

Glazing properties:
Windows:
Triple-glazed clear,
u = 1.90 W/m^2K,
Daylight trans. = 68 %
Solar trans. = 68 %

Skylights:
3-pane Makrolon opal,
u = 1.85 W/m^2K,
Daylight trans. = 68 %
Solar trans. = 68 %

During the summertime, the air circulating units in the atria are stopped in order to enlarge the thermal stratification and optimize the efficiency of the natural ventilation provided by temperature controlled air gates. In addition, the internal shadings are used in the office spaces and the attic space.

BUILDING COST

Building cost: (1985)
FIM 3438/m^2 gross
ECU 678/m^2 gross

Typical cost: (1985)
FIM 3746/m^2
ECU 739/m^2

The building cost compares well with typical costs for similar office buildings. The glazing costs of the atria are covered by savings in floor area volume of the office building by using the atria for ducting. Savings in the construction of the inner envelope of the atria, which is a light structure with single-glazed windows in comparison with an open courtyard, are also significant.

ENERGY PERFORMANCE

Annual fuel use: (MJ/m^2)
District heat & elect.:
The PI-Group's spaces (incl. office spaces & atria & basement & attic spaces) 878 (gross)

The whole building (incl. the PI-Group's spaces & bookstore & supermarket & restaurant) 1015 (gross).

Typical office buildings:
Existing 1300
Best new 1000
Low energy 750

Fuel costs: (1985)
District heat
FIM/m^2 18.8
FIM/GJ 49.0

Electricity
FIM/m^2 41.4
FIM/GJ 68.2

Fuel Type	Function	Delivered fuel (MJ) total	/m^2
1. The PI-Group's spaces:			
District heat	Space heating	2579040	330
District heat	Hot water	145229	19
District heat	All	2724269	349
Electricity	Lighting	630000	80
Electricity	Other	3503478	449
Electricity	All	4133478	529
2. The whole building:			
District heat	Space heating	3897720	383
District heat	Hot water	257760	25
District heat	All	4155480	408
Electricity		6178320	607
Dh & Elect.		10333800	1015

These figures include all heat and electricity used in the building and for the lighting outside the building during the first year of use. The target temperature for both of atriums during the first heating season was 17 °C.

HUMAN FACTORS

The Finnish building standards demand direct daylight into working spaces. These standards usually lead to design of open courtyards in order to provide daylight into the inner zone of the buildings, if these spaces are occupied during working hours. These standards together, with the client's demands for an efficient space design, a comfortable working environment and energy efficiency led to the solution with two atria functioning as plant rooms and providing day light into office rooms in the inner zone of the building. The client was also aware of the importance of a suitable lighting system in the working environment, where the staff work continuously with display terminals and drafting boards.

The lighting design team of the PI-Group developed an indirect lighting system, which uses 150 W metal halide lamps, with high colour rendition, high efficiency and long lifetime, which provides a uniform light and minimize the disturbance of both glare and shading.

The confidential inquiry, which was performed by the design team of the building, shows a deep satisfaction on the part of the building users and the client.

PI-Group's spaces:

Design occupancy:
300

Functions:
Senior management
Marketing
Accounting
Designing
Researching
Computing, etc.

15 m^2 office space/person

Working hours:
8 hours / day
07.00 to 17.00
Flexible working time

CONCLUSIONS

The use of an atrium as a passive solar collector can reduce heating energy use during the heating season. During the cooling season the atrium may increase the cooling energy use unless this heat gain is reduced. The study of the PI-Group's head office shows that the achievement of atrium energy economy is based on the following factors: ....

The case study shows an atrium heat loss saving of 15 % over the corresponding open courtyard envelope when the target temperature in the atrium is 17 °C during the heating season. It also shows a cooling energy use increase of 5 % over the open yard alternative during the cooling season when the atrium is ventilated naturally and the target is 25 °C for the rooms around the atrium.

Atrium energy economy factors:
- Target temperature
- Ventilation
- Technical realization
- Geometry
- Envelope construction

INFORMATION

Atriums in office buildings, Report D:130, Government Printing Center, P.O. Box 516, SF-00101 HELSINKI, 1987 (in Finnish)

The authors would like to acknowledge and thank the design team for their help and participation in this study.

This study was financed by the Energy Department of the Ministry of Trade and Industry of Finland.

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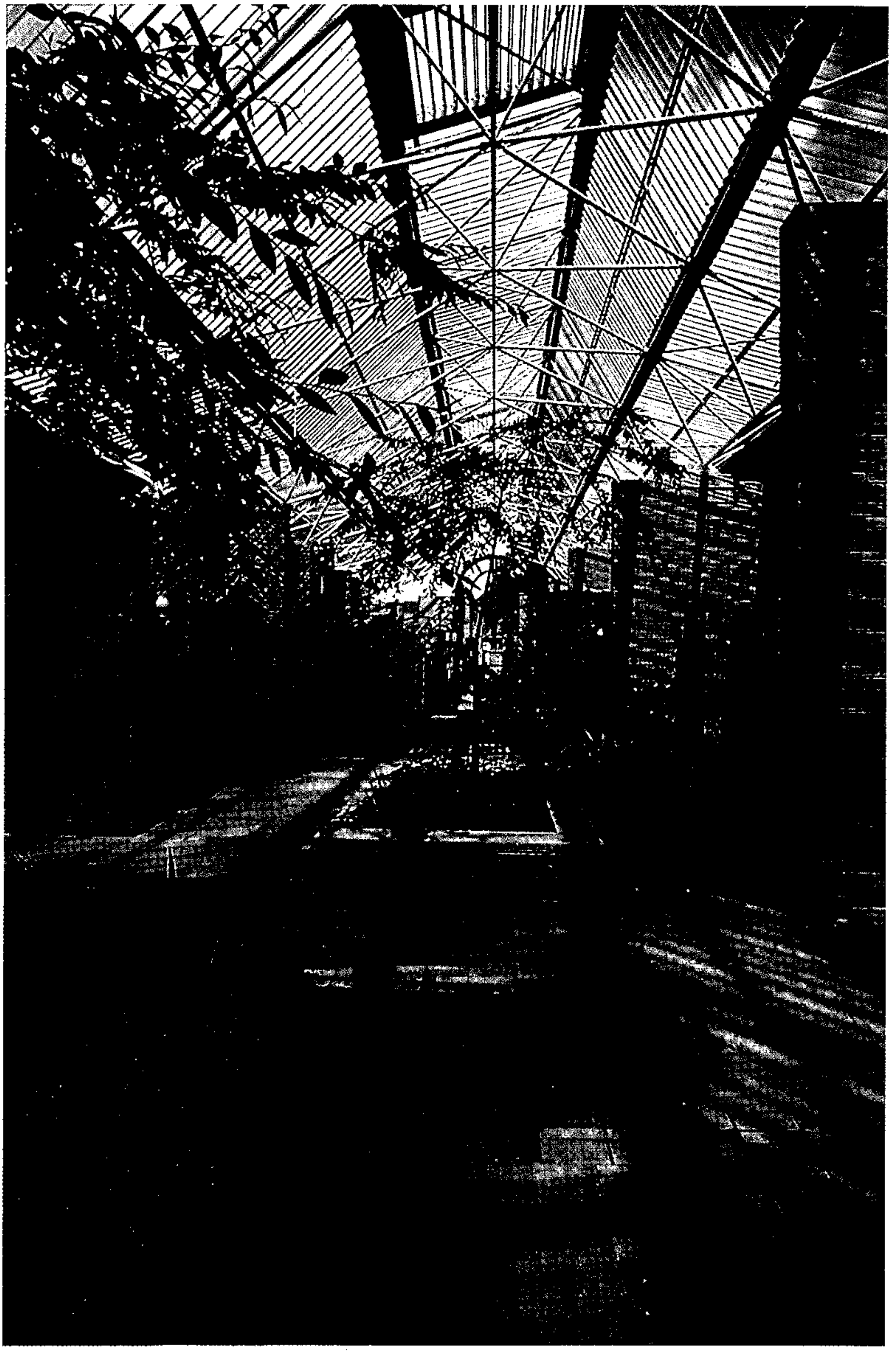
(UK) UNITED KINGDOM

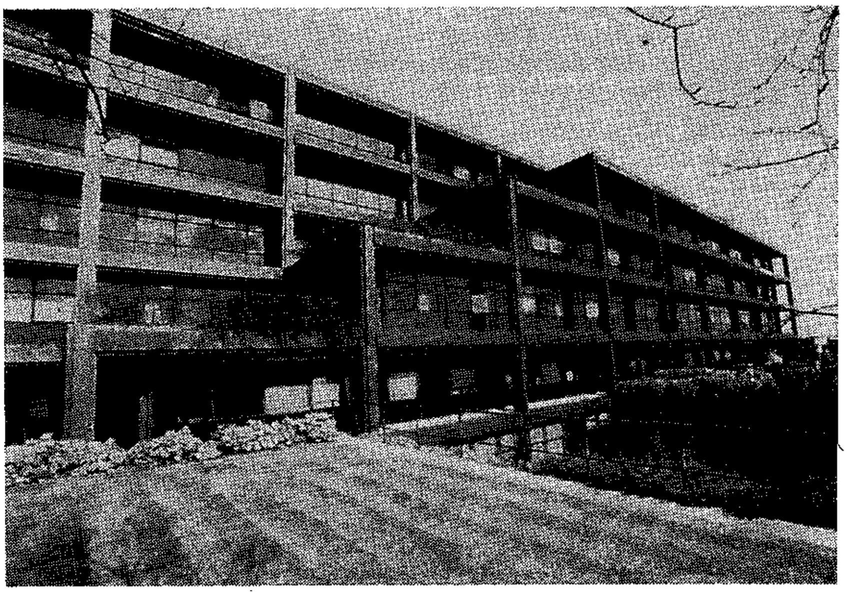
BCS No.	Building Title
38	GATEWAY 2
39	JEL HEADQUARTERS
40	LOOE SCHOOL
41	SSWC HEAD OFFICE
42	YSTRADGYNLAIS
43	NETLEY SCHOOL
44	JOHN DARLING MALL
45	CAER LLAN BERM HOUSE



JOHN DARLING MALL

UK

GATEWAY 2



Building type:
Office

Passive features:
Solar Heating:
Direct
Atrium
Daylighting:
Direct and Indirect
Solar Control:
External shading

Occupancy date:
April 1983

Floor area:
Offices
Gross - 14 840m^2
Heated - 14 840m^2

Cost (1984):
£ - 6 697 000
ECU - 4 108 500

Annual delivered fuel:
(1987)
Gas - 4 535 900 MJ
Elec - 5 046 300 MJ
Total - 646 MJ/m^2 (gross)

Client:
Wiggins Teape (UK) PLC

Architects & Engineers:
Arup Associates

Monitoring:
EPA Project - ETSU (Databuild)

SUMMARY

The new headquarters building for Wiggins Teape was completed in 1982. It is one of the first buildings in the UK to use an atrium as a passive solar feature. Construction costs for the naturally ventilated building were significantly less than a similar air conditioned building. Heating costs are comparable with the best low energy buildings in the UK.

As well as assisting to reduce running costs, the atrium has provided the work force with an attractive space that can be used for a wide variety of social activities.

PROJECT DESCRIPTION

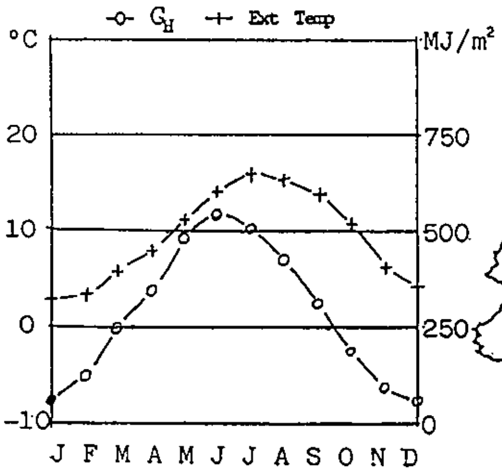
During the early 1980s paper manufacturers Wiggins Teape were forced to reduce the staff at their headquarters from around 800 to 550. Their large, fully air conditioned offices were too large. So they decided to develop new offices on a site next to their existing premises. But instead of air conditioning, the firm's brief called for a naturally ventilated office building.

The designers' solution was to produce 14 m deep offices surrounding a courtyard which was glazed over to form an atrium. The atrium was part of a careful strategy aimed at producing an energy efficient building. It is used as a passive solar element to reduce heating costs, assist natural ventilation and provide daylighting.

SITE AND LOCATION

Basingstoke is a new town about 80 km south west of London. The site is in a business park near the centre of the town. Several large office buildings are near Gateway 2. But the building has an open aspect overlooking a recreation park to the south.

Site data:
Latitude - 51.3° N
Altitude - 91 m



Climate data:
Oct. to Apr. inclusive:
Degree days - 2 747
(base 20)
G_H - 1 121 MJ/m²

Actual sun hours - 616
Actual/theoretical - 0.29

Annual:
Degree days - 3 498
(base 20)
G_H - 3 388 MJ/m²

BUILDING FORM

The overall dimensions of Gateway 2 are 75 x 56.3 m. Normally a building of this size would require air conditioning. But the five floors of office accommodation are restricted to a depth of 14 m and are wrapped around the 45 x 22.5 m atrium. Below the offices are two underground levels of car parking and a computer suite.

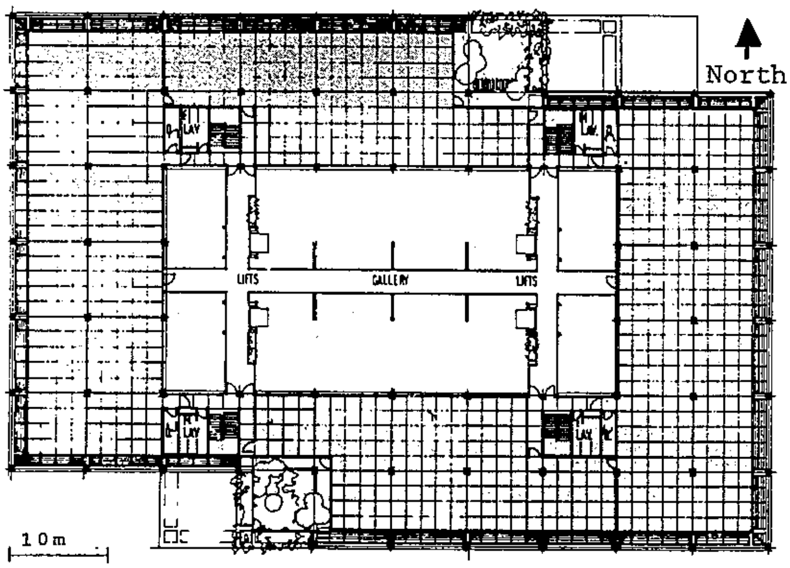
Lifts in the atrium serve galleries leading to the offices. The atrium also contains suspended walkways and staircases which further assist the circulation around the building.

Volume: (m³)
Gross - 39 200
Atrium - 15 600

Dimensions:
Ceiling height - 2.8 m
Perimeter - 262 m

Surface areas: (m²)

Ground floor	- 3 700
Opaque roof	- 3 300
Atrium glazing	- 670
Atrium opaque	- 365
Opaque walls	- 2 325
Windows	- 2 317



TYPICAL FLOOR PLAN

U-values: (W/m^{2}K)
Floor - 0.19
Roof - 0.14
Opaque walls - 0.20
Windows - 6.80
Atrium glass - 3.00
Atrium to offices:
Glazing - 4.0
Opaque walls - 2.0

Installed capacity:
Space heating and hot water - 171 W/m^2

Design conditions:
Internal temperature: 21°C
Lighting (offices): 500lux

BUILDING CONSTRUCTION

Preglazed curtain walling is used to infill the concrete framed structure. The walls are insulated with 150 mm of mineral fibre and the windows are single glazed. The roof to the offices also incorporates 150 mm of insulation. 140 mm of insulation is used to insulate the concrete floor slab over the car park. The roof to the atrium is double glazed while the partitions between it and the offices are single glazed.

BUILDING SERVICES

Space heating - three gas fired modular boilers feed a LPHW distribution system serving perimeter radiators. Each boiler has 12 individually controllable modules each rated at 50 kW. Five main heating circuits feed variable temperature water to different areas of the building. These five zones are then sub-divided to serve, in all, 20 areas each of which is controlled by its own thermostat and two-way valve. Further control is achieved by thermostatic valves on each radiator. A building automation system is used to give optimum start/stop and temperature control for each of the 20 sub- zones.

Heat recovery - heat recovered from the computer suite air conditioning is used to supplement the hot water supply and the heating in the atrium.

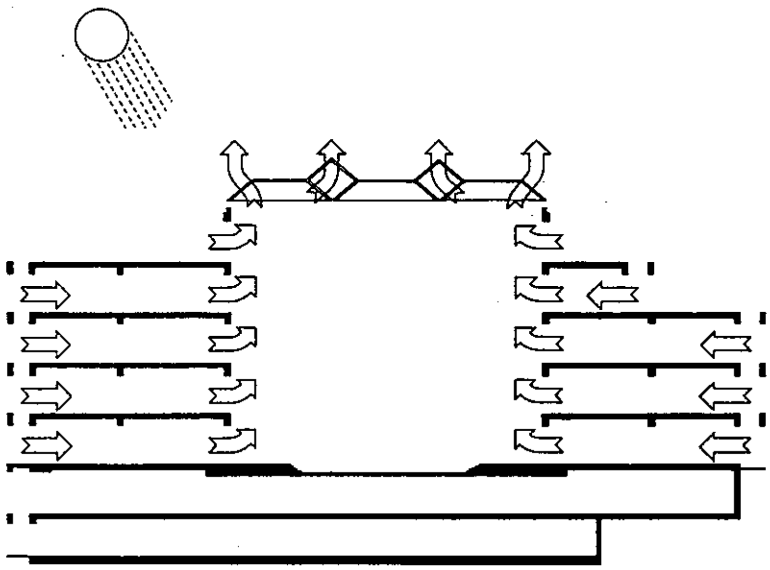
Lighting - fluorescent luminaires are recessed in v-shaped troughs in the office ceilings. These are individually controlled by local pull cord switches. An automatic override system switches lights off at predetermined times throughout the day (8.15, 10.30, 12.30 and 20.30). If the occupants feel that there is not enough light after switch-off, they are able to switch their own light back on again.

PASSIVE SYSTEMS

A major objective of the design was to rely on natural ventilation to control summertime temperatures. The atrium plays an important role in achieving this objective.

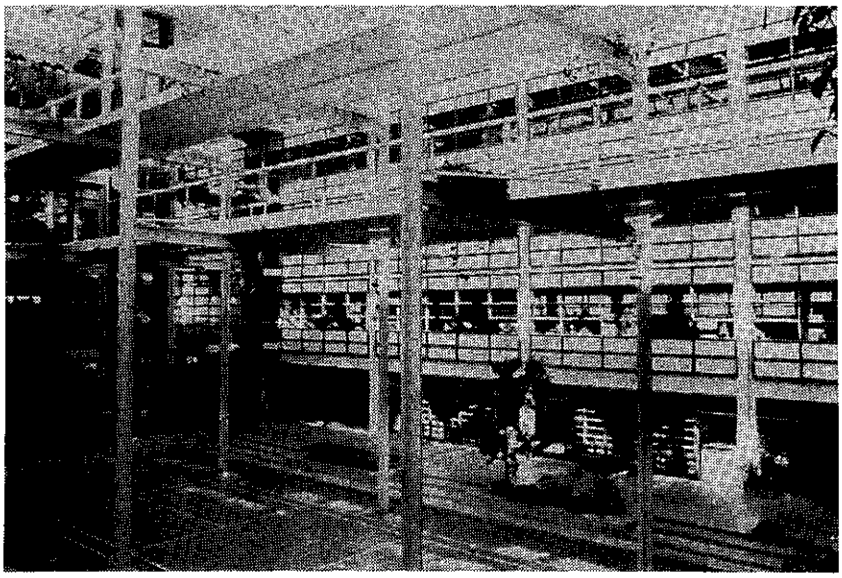
Solar gains create warm temperatures in the atrium. The double glazed roof lights can be opened and the stack effect induces air movement through the building via the perimeter windows. In this way the offices receive cross ventilation. The system has worked well except where internal partitions restrict the airflow. In some of these areas the staff have had to resort to the use of small electric fans to increase air movement.

Overheating is further controlled by the use of louvered external sun screens and the exposed concrete structure. The atrium also helps to ensure that the offices receive good daylight which helps to reduce the heat gains from the electric lights.



ATRIUM USED TO ASSIST NATURAL VENTILATION

In winter the atrium acts as a buffer to the offices. Solar gains warm the space which reduces heat losses from the offices. A low temperature underfloor heating system tempers the environment at ground floor level. This ensures that the heat is directed at the occupants and not at empty space. The underfloor heating can be fed from rejected heat from the computer suite air conditioning.



VIEW OF THE ATRIUM

Atrium dimensions:

Area	-	1 012 m^2
Volume	-	15 500 m^3
Glass area	-	670 m^2
Opaque area	-	365 m^2

Atrium U-values: (W/m^2K)

Ext glazing	-	3.0
Ext opaque	-	0.28
Int glazing	-	4.0
Int opaque	-	2.0

BUILDING COSTS

Building costs ('82):
£ - 451 /m²
ECU - 277 /m²

Typical cost ('82): (/m²)
Non a/c - £444
Gateway 1 (a/c) - £715

In setting a very simple developers brief, the client was looking for a low budget building. The total cost was £8.7 million but this reduces to £6.7m when fitting out, car parking and external works are deducted. The total gross office area is 14 840 m². This gives an overall cost the offices of £451 /m² which compares with typical office costs of around £444 /m² at 1982 prices.

The equivalent cost for the fully air conditioned Gateway 1 was £715 /m² which shows the advantage of opting for a naturally ventilated solution. Not only were there savings on expensive capital plant but also floor to ceiling heights were reduced because of the absence of ductwork. Further the cost of the atrium roof, steelwork and glass lifts was more than offset by the savings over a traditional lightwell.

ENERGY PERFORMANCE

Annual fuel use: (MJ/m²)
Delivered(1987) - 722
Primary (1987) - 1 724

Typical office buildings:
Existing - 900
'Best' new - 660
'Low energy' - 500

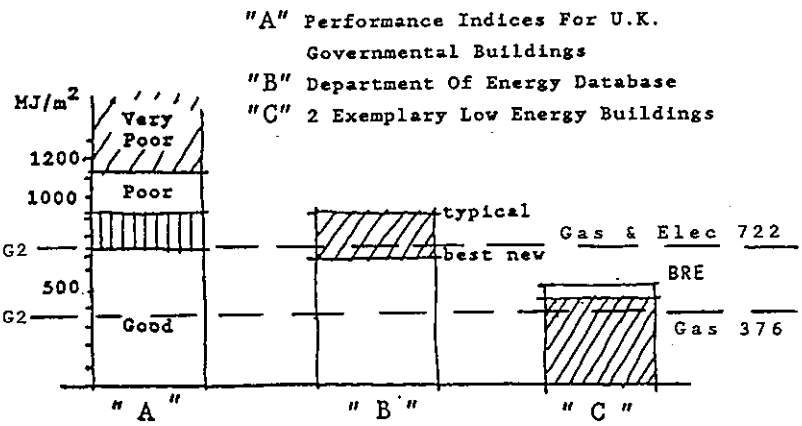
Fuel costs: (1987) (/GJ)
Gas - 3.4
Elect (average) - 10.3

Based on utility meter readings for January to December 1987, the total energy use at Gateway 2 is as follows.

FUEL TYPE	FUNCTION	DELIVERED FUEL (MJ) Total	/m²
Gas	Htg and hot water	4 535 900	376
Elec	Light & power	5 046 300	346
Total	All	9 582 200	722

These figures exclude the electricity used in the computer suite which totalled another 9 270 000 MJ.

The gas consumption compares very favourably with the best low energy office buildings in the UK. Electricity usage appears to be higher than might be expected. This is probably due to the use of some specialised equipment with a high power consumption. It is hoped that this will be investigated in the forthcoming Energy Performance Assessment (EPA).



HUMAN FACTORS

The atrium is not only a key factor in the energy performance of the building, it also provides a space with a great social potential. The growing appreciation of the building is demonstrated by the fact that some managers who originally opted to have their offices on the outside of the building have since moved so that they overlook the atrium.

Design occupancy:
No. 550

22 m^2 office space/person
26 m^2 including the atrium

The atrium has become a focus for a wide range of uses. Staff dinner dances, the company rose show and a snooker tournament have all been staged in the space.

The main difference for the office workers who came from the fully air conditioned and sealed Gateway 1 building, is in their ability to have control over their immediate environment. In their new offices they enjoy opening windows and switching lights to suit their particular needs.

CONCLUSIONS

The design of Gateway 2 has shown that passive solar techniques, using an atrium, can help to reduce both capital costs as well as running costs. In addition the atrium has provided a space of considerable architectural merit adding a further aesthetic and social dimension to the building.

INFORMATION

Architects Journal: 3 August 1983, Volume 178,No 31, pp 26 - 34. "Air Apparent".

Architects Journal: 14 November 1984, Volume 180, No 46, pp 55 - 66. "Building Study" - Gateway 2.
pp 72 - 73. "Energy Revisits" - Gateway 2.

(From Architectural Press, 9 Queen Anne's Gate, London SW1H 9BY; Tel: 01 222 4333, Telex: 8953505)

The Arup Journal: June 1984, Vol 19, No 2, pp 2 - 9. "Gateway 2". Published by Ove Arup Partnership, 13 Fitzroy Street, London W1P 6BQ. Tel: 01 636 1531; Telex: 295341 OVARPT G.

EPA (Energy Performance Assessments) Project; part of Dept. of Energy R&D Programme on Renewable Energy administered by ETSU; further details from REPO, ETSU, Building 156, AERE Harwell, Oxfordshire OX11 ORA; 0235 834621; Telex: 0235 83135.

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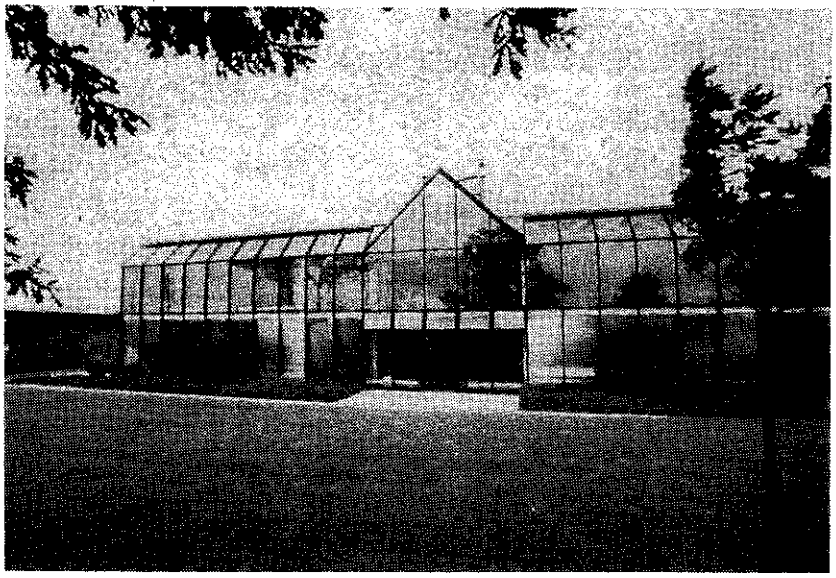
UK

JEL HEADQUARTERS



Building type:
Office and electronic assembly

Passive technology:
Solar heating:
direct and indirect
Daylighting:
direct
Solar control:
shading
Atrium:

Occupancy date:
April 1983

Floor area:
Gross - 2 087m²
Net - 1 889m²

Cost (1986):
£676 606 - ECU 415 035

Annual delivered fuel:
Gas - 646 015 MJ
Elec - 358 920 MJ
Gas and Electricity - 482 MJ/m² gross

Client:
JEL Limited

Architect:
Michaelis, Francis and Le-Roith

Services engineer:
JEL and Architect

Monitoring:
EPA Project - ETSU (Databuild)

SUMMARY

A rapidly growing company, producing Energy Management Systems, required a new building which would attract attention and demonstrate energy efficiency.

To provide for a mixture of activities from research and development to electronic assembly, the building has two storey office space wrapped around a double height workshop.

The southerly elevation is fully glazed to provide direct heat and light gain. South facing roof lights complement the artificial lighting for the workshop. An atrium is used as the plant room.

Solar heat gain is redistributed in the building by a simple forced air heating system. Retractable external blinds limit overheating.

The building performs well by comparison with other similar low energy buildings.

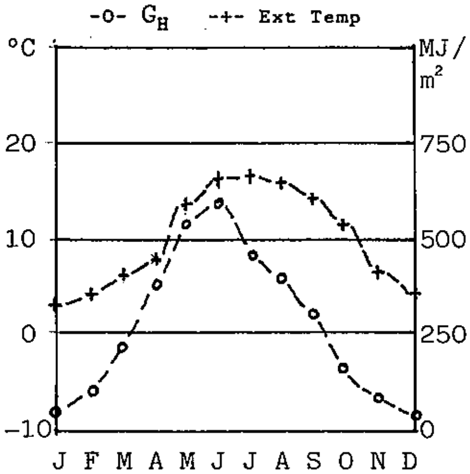
PROJECT DESCRIPTION

JEL design and manufacture hard and software for microprocessor based energy management systems for buildings. In 1982 they commissioned a new HQ to contain a wide range of activities - office, factory, laboratory, training. The building had to symbolize and demonstrate JEL's goal of improved energy efficiency and management.

The building collects solar heat through a 100% glazed south facade and redistributes this, within the simple well insulated box, to other spaces. External and internal shading prevent overheating.

SITE AND LOCATION

The HQ is situated on a small industrial estate, 6 kilometres south of Stockport, a town to the south east of Manchester. The site is flat and windswept and adjacent to suburban housing. Landscaping has been used on the west side to screen the building from the prevailing winds and from adjacent buildings.



Site data:
Latitude - 53.2 N
Altitude - 100 m

Climate data:
Oct. to Apr. inclusive:
Degree Days - 3 415
(base 20)
G_H - 1 022 MJ/m²

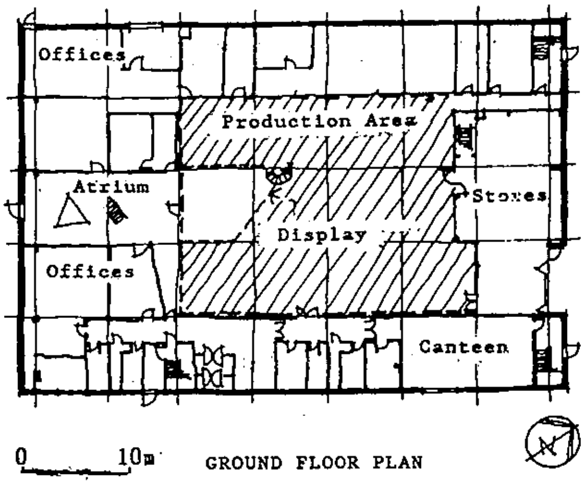
Actual sun hours - 710
Actual/theoretical - 0.26

Annual:
Degree days - 3 935
(base 20)
G_H - 3 408 MJ/m²

BUILDING FORM

It is a 2 storey rectangular building, 45 metres by 30 metres. The centre is a double height production space which is flanked by two storeys of offices and other 'cellular' accommodation. The plan is organised so that management and sales areas are on the south. R&D, training and other support functions are on the east and west perimeters. The centre of the building is devoted to production with stores and access through a north entrance.

The south facade is 100% glazed with offices on either side of a central double height atrium which is, in fact, the plant room. Glazing on other facades is restricted. South facing rooflights are used to provide daylight in the production space.



Volume: (m³)
(all heated)
Gross: 9 800
Nett: 9 000
Atrium: 260

Dimensions: (m)
Plan: 45 x 30
Height: Production - 7

Window data:
Window area is 11% of total external wall area

Rooflight area is 7% of total roof area

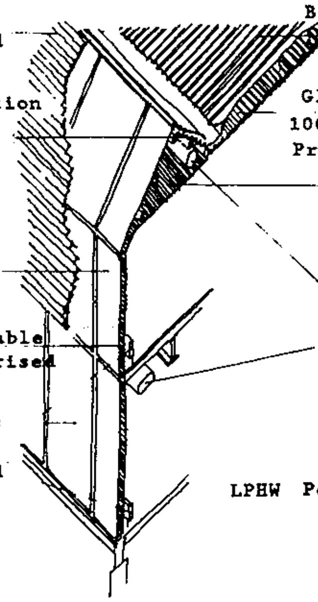
South facade is 100% glazing

U-Values: (W/m² K)
Floor: 0.4
Wall: 0.3
Glazing: 2.9
Roof: 0.2
Overall: 0.4

Envelope heat loss: (kW/ K)
Transmission: 2.0
Infiltration and Ventilation: 1.3

BUILDING CONSTRUCTION

It is a steel framed building supporting a triangular lattice single span roof structure. Brick cladding was used on the north west and east walls. Floors are pre-cast pre-stressed concrete planks. The triangular roofs are finished with PVC coated profile metal sheeting, the low pitched roofs with asbestos sheeting. An insulation quilt of 100mm glass fibre underlies all roofs. All windows are double glazed. The designers have sought high quality joint sealing through careful detailing.



Installed capacity:
Space Heating:
Heated areas - 70W/m²
Internal temp. - 20°C

Lighting:
Production - 9.1 W/m²
Illuminance - 300 lux
Locally - 1000 lux

General - 8.5 W/m²
Illuminance - 300 lux

BUILDING SERVICES

Space heating - the boiler plant serves 3 perimeter zones (south, east and west) with radiators, and a heater battery for supplying warm air to the central production area. Air circulation fans in the production zone prevent air stratification. There is a comprehensive Energy Management System (EMS) for controlling room temperatures, shading and heat redistribution.

Lighting - the glazed south wall and south facing rooflights maximise natural daylighting in the offices and the production area. High efficiency fluorescent lights are used in the offices and high pressure sodium in the production space. The background level is 300 lux with extra task lighting.

Ventilation - provided by roof vents, openable windows and internal louvre windows for cross ventilation. The warm air heating system to the production area can take in external air.

The techniques used to optimise benefits were:-

1. A fully glazed south facing wall providing heat and light to the offices and heat into the central atrium.

2. The atrium houses the boiler plant and the heat from this plus solar gain into the atrium, and heat extracted from the south offices is used to pre-heat the air supply to the warm air heating of the production zone.

3. Mirror finished aluminium motorised blinds (external and internal) prevent summertime over-heating, (under EMS control).

4. Excessive gains are vented by means of the fan and mechanically operated louvres in the gable of the atrium, (under EMS control).

5. The use of south facing roof lights.

BUILDING COSTS

Building cost (1986):
£324/m² gross
ECU 199/m²

Typical cost (1986):
High Technology Factories
£225 - £415/m²
ECU 138 - 254 /m²

The ambiguity of the function reflects in the costs. They fall between those of a factory and an office block. It is more expensive than a traditional factory, but good value for an office. The production area represents just over one fifth of the floor area but one third of the volume.

ENERGY PERFORMANCE

Annual fuel use: (MJ/m²)
JEL (482 gross space)
(532 nett space)

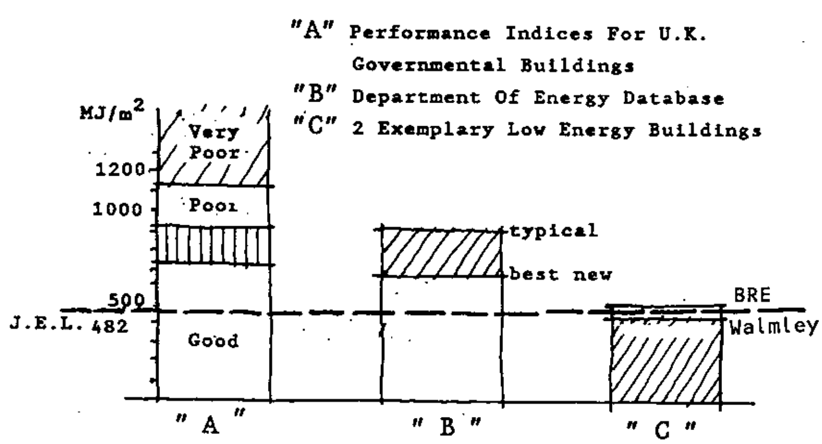
Typical office buildings:

Existing	900
'Best' New	660
'Low Energy'	500

Fuel costs: (1986) (/GJ)

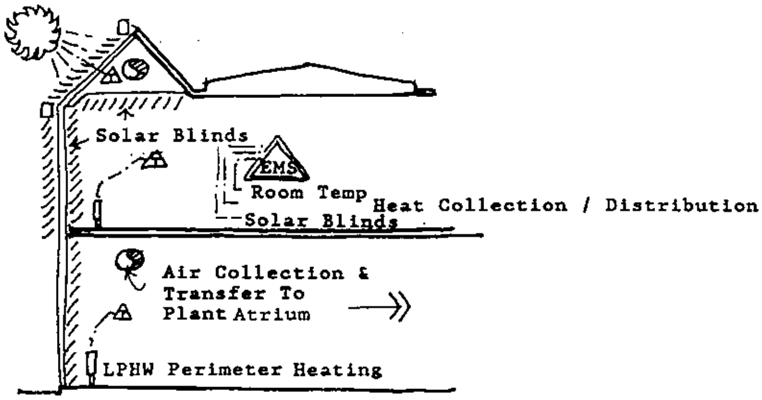
Gas:	£ 3.2
Elect (av.):	£13.9

FUEL TYPE	FUNCTION	DELIVERED FUEL (MJ) TOTAL	PER m² (GROSS)
Gas	Space Heating	646 015	309
Elect	Lighting	49 255	24
Elect	Hot Water	42 527	20
Elect	Other	267 134	128
Gas & Elect	All	1 004 931	482



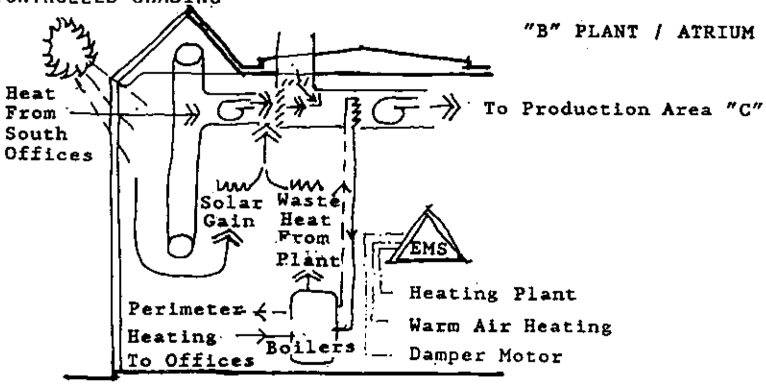
PASSIVE HYBRID SYSTEMS

"A" SOUTH OFFICES



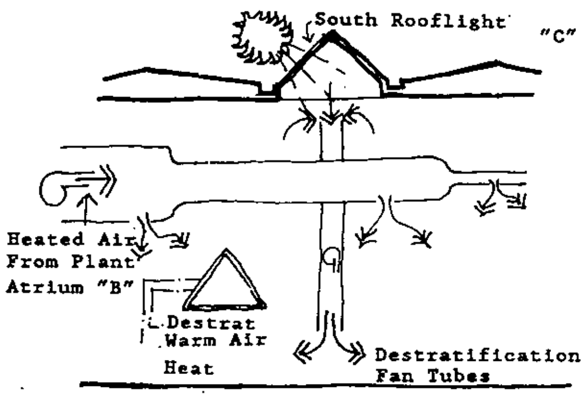
DIRECT HEAT GAIN
DIRECT LIGHTING
CONTROLLED SHADING

"B" PLANT / ATRIUM



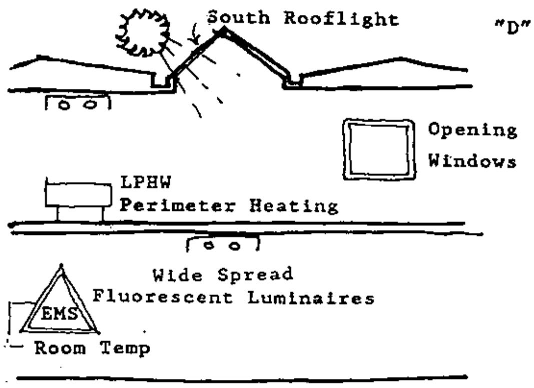
HEAT REDISTRIBUTION

"C" PRODUCTION AREA



DIRECT LIGHTING
HEAT DISTRIBUTION

"D" EAST / WEST
PERIMETER
OFFICES



DIRECT LIGHTING
OCCUPANT CONTROLLED
VENTILATION

Solar facade:
Area:
175m² to office areas
45m² to Atrium

100% glazing:
$U = 2.9 W/m^2 K$

Daylight trans. = 76%
Solar trans. = 73%

Heating and lighting energy use are very low and related to the envelope heat loss suggest a high utilisation of gains. The impact of solar gains is masked by the high use of electricity for laboratory and production facilities. However, the overall fuel use still compares favourably with references.

HUMAN FACTORS

The client wanted a test bed of passive and active low energy design, displaying the company's products. The design is appropriate for its purpose. However, it requires considerable involvement of the occupants in the control of their surroundings. Moreover, the complexity of the energy systems calls for a finely tuned EMS which this client can fully utilise but which might be less suitable elsewhere.

The two tier open plan design provides a sense of involvement through people seeing each other throughout the building. No glare VDU's were used to avoid lighting. There seems to be few comfort complains despite the wide excursions in internal temperatures in parts of the building.

Design occupancy:
60

Functions:
Administration
Computing
Engineering Design
Research and Development
Electronic Assembly
Storage and Distribution

Working hours:
8.25 hours/day
5 days/week
50 weeks p.a.

CONCLUSIONS

The building was intended as a virtuoso display of energy efficiency as a 'shop window' for the company JEL. Form has followed function and the passive measures have deeply influenced the architectural design. The building as a whole has provided energy efficient. On the heating provision this may well be ascribed to the good zone control achieved by the EMS. Energy savings due to passive solar have not yet been determined, but the passive features do serve to produce a pleasant and stimulating environment.

100% south glazing in a low heat loss envelope can function with heat redistribution, shading and extensive EMS control.

INFORMATION

Architects Journal: July 13th 1983, Volume 178, No. 28, pp 40 - 58. "Building Study - JEL HQ Stockport".

Architects Journal: September 14th 1984, Volume 180, No. 45, pp 71 - 77. "Energy Revisits".

(From Architectural Press, 9 Queen Annes Gate, London SWIH 9BY, Tel: 01 222 4333, Telex 8953505.)

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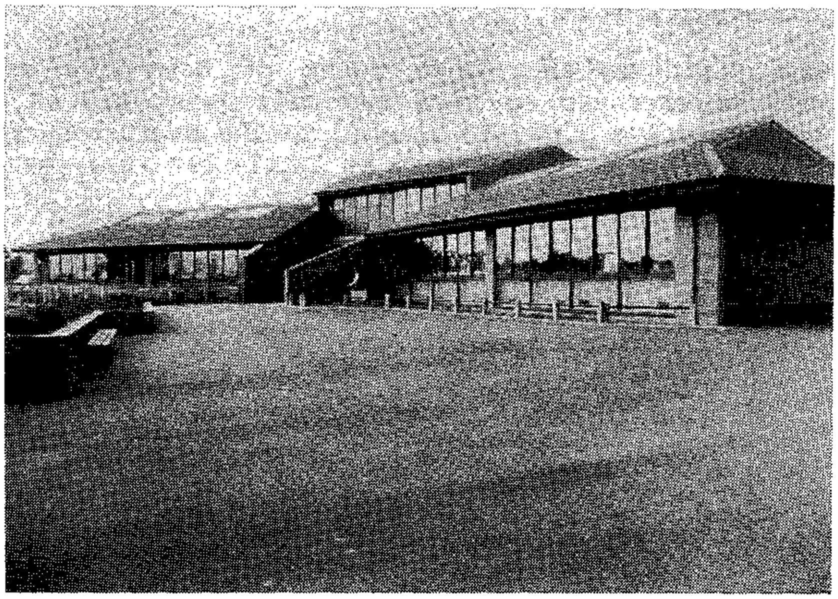
The co-operation of the building's owners, designers and occupants is acknowledged.

UK

LOOE SCHOOL



Building type:
Education

Passive features:
Direct Solar
Indirect Solar
Shading
Direct Daylighting

Occupancy date:
September 1984

Floor area:
Gross - 1 374 m^2
Heated - 1 374 m^2

Cost (1983):
£ - 448 000
ECU - 275 000

Annual delivered fuel:
(85/86)
Gas - 777 400 MJ
Elec - 92 500 MJ
Total - 633 MJ/m^3 gross

Client:
Cornwall County Council, Education Committee

Architect:
Cornwall County Architect's Dept.

Monitoring:
EPA Project - ETSU (Welsh School of Architecture)

SUMMARY

This primary school was commissioned as a replacement for an 18th century building. A main concern was for low maintenance and running costs. The architects incorporated passive solar features whilst using standard materials and construction skills.

The south facing walls of the classrooms are 100% glazed, the lower part of the wall incorporates a low Trombe wall feature to moderate and store the solar gains. The opaque fabric is well insulated, and thermally massive.

The buildings' cost falls comfortably within the normal range for UK primary schools; its' monitored energy use compares favourably with the UK design target and other, more complex, low-energy schools. The building is very well-liked and appreciated by the staff.

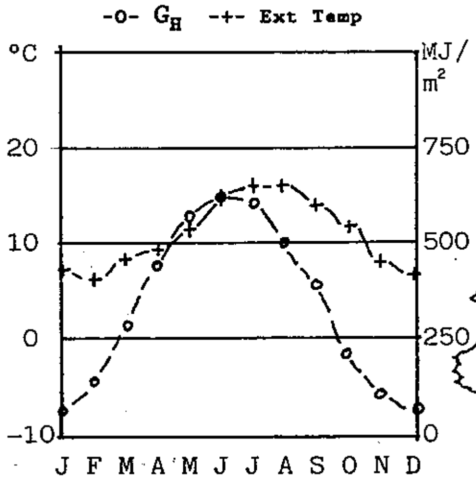
PROJECT DESCRIPTION

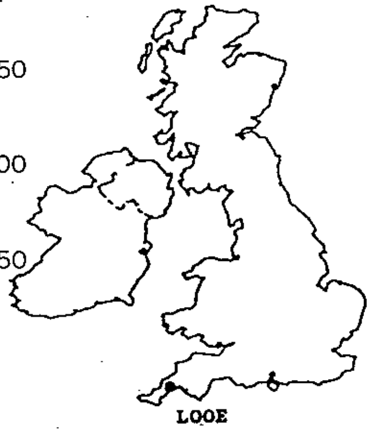
Looe Junior and Infants School is part of a county programme aimed at remodelling or replacing their older stock. The brief (1981) called for a 10 classroom school with normal ancillaries and accommodation. Design began in September 1981.

Building on their previous experience in passive solar designs, and in response to the highly exposed site, the architects choose an approach to minimise maintenance and running costs. Through the use of established techniques and materials, and through "careful design .... and massaging of the plan" significant savings, due to passive solar gains, were thought possible.

SITE AND LOCATION

The site, on the south coast of Cornwall, has extreme exposure to wind and rain. Located on a south sloping plot and bounded to the south-east by a sharp drop seaward, there is little shelter; there is also little site obstruction.



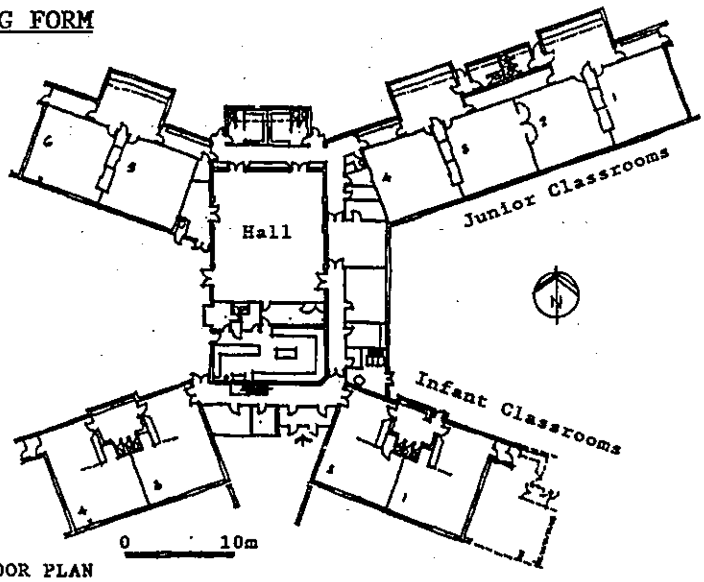


Site data:
Latitude - 50.4 N
Altitude - 100 m

Climate data:
Oct. to Apr. inclusive:
Degree days - 2 590 (base 20)
G_H - 1 400 MJ/m²
Actual sun hours - 1661
Actual/theoretical - 0.31

Annual:
Degree days - 3 480 (base 20)
G_H - 3 980 MJ/m²

BUILDING FORM



GROUND FLOOR PLAN

Volume: (m³)
Gross - 3 600

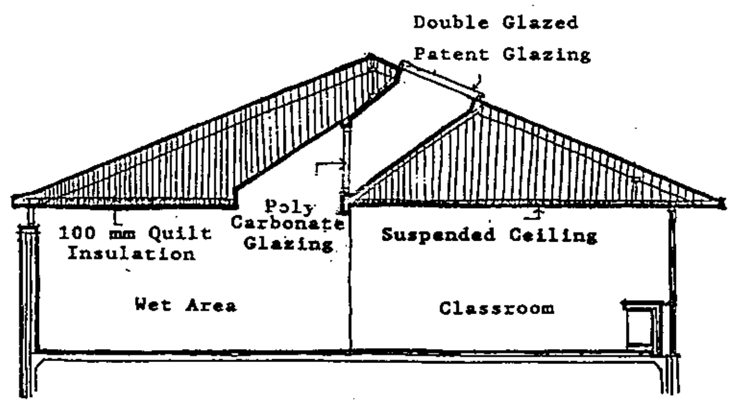
Dimensions:
Ceiling height:
Classroom: 2.4m
Hall: 4.1m
Perimeter: 270m

Surface areas: (m²)
Ground Floor - 1 300
Roof - 1 450
Opaque wall - 659
Total Window - 335

Single storey classrooms extend from a central core, which contains an assembly hall/gymnasium, kitchen, library and staff accommodation. Capacity is 300 pupils. All classrooms are designed to be self contained and self sufficient.

The plan allows each classroom a large glazing area for the acceptance of passive solar heat and daylight. Externally, south facing glazing is extended down to ground level, creating a simple "mini-trombe" wall in conjunction with the heavyweight sills and walls.

North facing glazing is minimal. Heavyweight materials are used throughout to moderate the solar gains. Summertime direct penetration is prevented by projecting eaves and the sill depth. Light-wells inject daylight to the back of the deep classroom areas.



CROSS SECTION THROUGH THE INFANTS CLASSROOM

U-values: (W/m°K)
Opaque walls - 0.38
Opaque roof - 0.35

Envelope heat loss:
(kW/°K)
Transmission - 2.5
Infiltration and Ventilation - 3.0

BUILDING CONSTRUCTION

Construction is traditional; brick and block external walls, tiled pitched roof, solid floor. Standard and familiar materials have been used to reduce maintenance and construction costs. Internal mass has been increased by the use of dense rendered concrete blockwork for internal and external walls. The ceiling has been well sealed and few walls protrude into the loft space, so as to reduce cold bridging. Glazing has been highly biased to the south facade. Windows are normal, double glazed units, set in coated aluminium frames. Glazing has been extended down past the sill level to produce a 100% glazed south elevation.

Installed capacity:
Space heating - 50 W/m^2
Hot water - 35 W/m^2
Lighting - 12 W/m^2

BUILDING SERVICES

Space heating - modular boilers supplying heated water to individually controlled convector emitters in each classroom. There is an adjustable thermostat within each classroom. Boiler plant is controlled by a proprietary optimising system. The hall is operated as a separate zone to allow its use for civic purposes at night. Night setback heating is utilised to reduce the loss of heat from the heavyweight structure.

Design conditions:
Internal temp - 18°C
Illumination - 150 lux
Ventilation - 300m^3/h (in classroom 1) pupil

Lighting - manual switching of fluorescent lighting in each classroom is arranged in rows parallel to the windows. There is no automatic control.

Ventilation - natural ventilation is used throughout, aside from a simple extract system serving the toilets and kitchen.

PASSIVE SYSTEMS

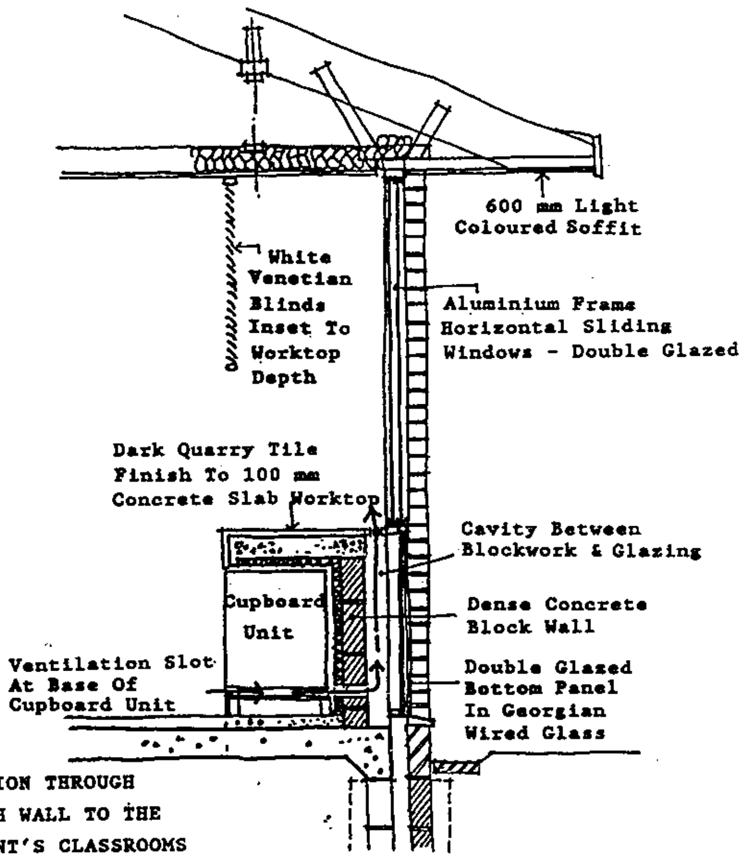
Direct solar heating and daylighting are obtained through a cruciform plan with a 100% glazed south facade and a minimally glazed, heavyweight and highly insulated north facade. Possible disadvantages associated with large areas of glass (over heating, cold draughts, safety) are alleviated by the use of heavyweight construction, shading and the use of trombe wall techniques.

Beneath the windows in the classrooms, is a wide concrete shelf, faced with quarry tiles. This tops a dense blockwork wall set back 150mm from the glazing. Acting as a short trombe wall it sets up a circulation to supplement the conventional convector emitters, without a reduction in plan area, view or light.

Overheating and glare are reduced by 0.6m projecting eaves and the 0.8m shelf of the sill, giving the protection from April through September. Venetian blinds are supplied to reduce glare from the low winter sun.

Double glazing units have been used to reduce cold air currents and cold surfaces, and so increase occupant comfort levels.

Daylighting is introduced to toilets and service areas at the back of classrooms (up to 8m deep) by light wells.



SECTION THROUGH SOUTH WALL TO THE INFANT'S CLASSROOMS

Glazing:
South facing (including rooflights): 295m^2
North Facing: 25m^2

South facing classroom facade is 100% glazed from exterior, 60% as viewed from interior, i.e. 40% is trombe wall.

Building cost ('84): (/m²)
£326 - ECU 200

Typical cost ('84): (/m²)
Primary Schools
£264 to £396

Annual fuel use: (MJ/m^2)
Delivered 85/86 - 633
Primary 85/86 - 862

Other primary schools:
(primary energy)
Typical UK - 1 300
UK target - 1 050
'low energy' - 500

BUILDING COSTS

The building is entirely new build. The accepted tender costs compare well with the UK norm for primary school costs. This indicates that the passive solar elements have not added significantly to the total costs.

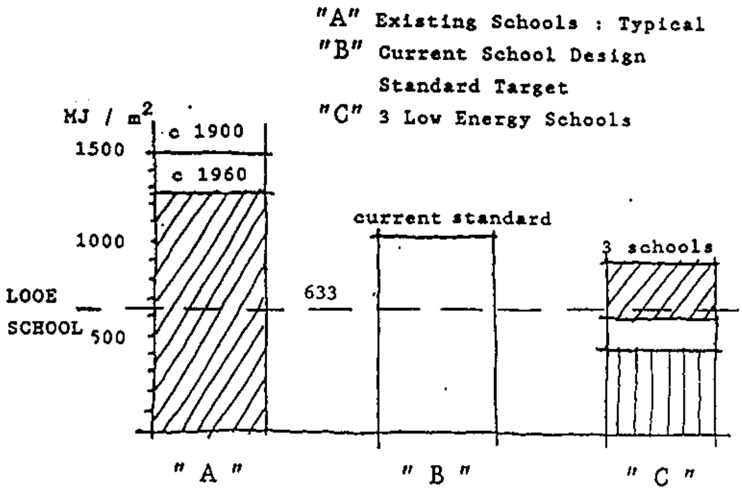
ENERGY PERFORMANCE

Based on utility meter records for April 1985 to April 1986, the total energy use of the school appears as:-

FUEL TYPE	FUNCTION	DELIVERED FUEL (MJ) TOTAL	/m²
Gas	All	777 400	566
Elec	Light and Power	65 500	48
Elec	Cooking	27 000	20
Elec	All	92 500	67
Gas & Elec	All	869 900	633

These figures compare very favourably with available reference fuel use databases for UK primary schools, indicating that the building is energy efficient.

This school is the subject of the EPA assessment programme, which will allow further breakdown of the energy use patterns, and will also investigate the trombe wall area. Completion is expected in 1988.



HUMAN FACTORS

Based on extensive interviews and time-series questionnaires, the building is highly appreciated by the teaching staff. Thermal comfort is reported as good with few adverse internal conditions at any time in the year. Some teachers thought classroom daylighting could be better, although the extensive views afforded by the south facade glazing brought high satisfaction. Required occupant control actions are few and misuse should have little effect on the building's energy performance.

The staffs' principle criticism concerned air quality and the lack of fine control of ventilation; the large openings of the sliding windows produce either very high or low ventilation rates.

Most occupants liked the building's passive solar features and the overall appearance. Some teachers believe that the quiet, naturally responsive environment has had a calming effect on pupils.

Design occupancy:
300 pupils aged 5 to 11 and 12 staff

4.6m^2 /pupil

School hours: 09.00 to 15.30 hours

Occupant's ratings:
Classroom conditions- (mean of 9 staff)
1 very bad; 5 very good

Appearance	- 4.8
Safety	- 4.8
Visual contact	- 4.8
Noise control	- 4.8
Winter comfort	- 4.6
Teaching Layout	- 4.5
Daylighting	- 3.2
Air Quality	- 3.0

A well liked and appreciated building which is also energy efficient.

CONCLUSIONS

A primary school building which is well liked by the teachers has incorporated what might be called 'low tech' passive solar features at little, or no extra overall cost, and is a moderately low energy user.

The use of heavyweight construction and the trombe wall arrangement has allowed a 100% glazed south facade, without the disadvantages usually associated with such a large amount of glass.

INFORMATION

Building, Issue 19 Volume 250, 9 May 1986, pp 43-50; "Building Dossier - Looe School". Building (Publishers) Limited, 1-3 Pemberton Row, Fleet Street, London EC4P 4HL; 01 353 2300; Telex BUILDA G25212.

Brick Bulletin, 4/85, pp 10-11; "School building in Cornwall". The Brick Development Association, Woodside House, Winkfield, Windsor, Berkshire, SL4 2DX, 0334 885651.

Design Note 17 (1981): "Guidelines for Environmental design and Fuel Conservation in Educational Buildings". Dept. of Education and Science, Architects and Buildings Branch, UK.

EPA (Energy Performance Assessments) Project; part of DoE Energy R&D Programme on Renewable Energy, administered by ETSU, further details from REPO, ETSU, Building 156, AERE Harwell, Oxfordshire OX11 ORA, 0235 834621, Telex: 0235 83135.

Report prepared by:
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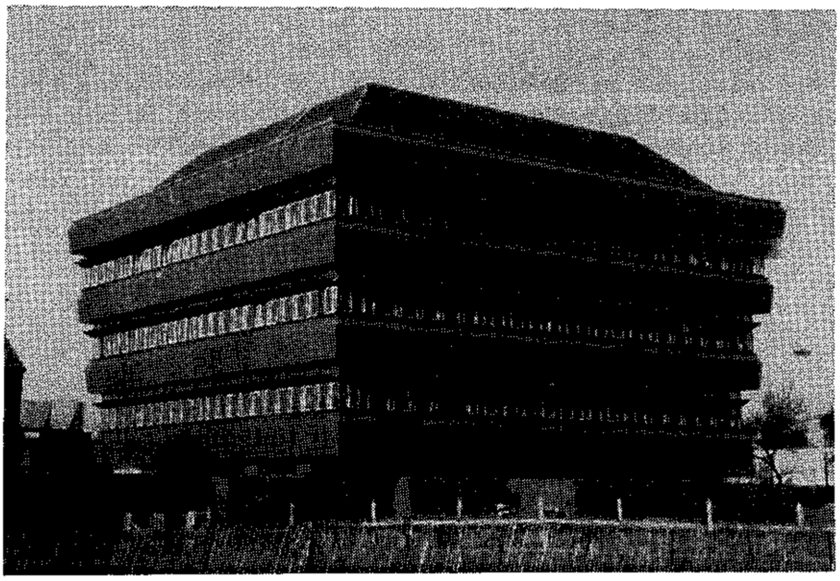
The authors would like to acknowledge and thank the headmaster and staff of Looe Junior and Infants School, and the Cornwall County Architects Department for their help and participation in this study.

UK

S S W C HEAD OFFICE



Building type:
Office

Passive features:
Solar Heating:
Direct
Daylighting:
Direct and Indirect
Solar Control:
Shading

Occupancy date:
April 1985

Floor area:
Gross - 3 833m²
Heated - 3 208m²

Cost (1985):
£ 1 790 000
ECU 1 098 000

Annual delivered fuel:
Gas - 1 771 000 MJ
Elect - 743 000 MJ

Gas & Elect:
- 656 MJ/m² gross

Client:
South Staffordshire Water Company

Architect:
Harry Bloomer Partnership

Energy consultant:
Databuild

Services Engineer:
King Cathery Ptnrship

Monitoring:
EPA Project - ETSU (Databuild)

SUMMARY

The new HQ of the South Staffordshire Water Company centralised previously scattered accommodation. The client required: a low energy use building, a high degree of occupant control of the environment, daylighting and natural ventilation.

The compact form contributed to the resolution of environmental and energy conflicts through passive systems.

7 - 8m deep perimeter offices have 70% windows in facades with external and internal light shelves and shades. The construction is highly insulated. The space heating and lighting combine manual and automatic control.

Client and user reactions are favourable. Heating and lighting energy use are low. The building's cost compares favourably with peers, suggesting that the energy saving systems are effective.

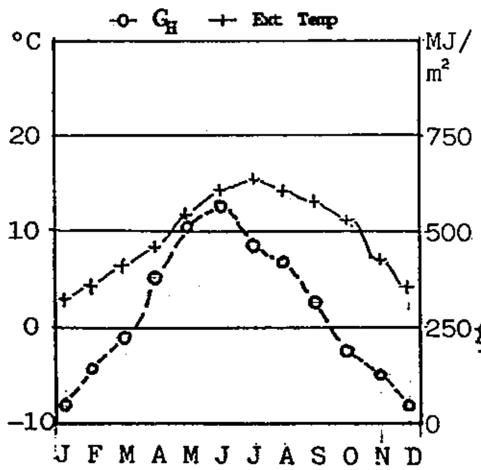
PROJECT DESCRIPTION

The South Staffs. Water Company is a private undertaking, serving 1 600 Km² with a population of 1.25 million. This building is part of a rationalization of previously scattered premises all completed to a 7 year payback criteria.

The brief (1982) called for low energy use with high levels of daylight and natural ventilation. The basic philosophy was to maximise daylighting within a low heat loss envelope. Shading and natural ventilation were used to avoid summer overheating. The design is also intended to have a low maintenance cost. In recognition of the complex goals the design team included an energy consultant.

SITE AND LOCATION

The site is an industrial area of scattered 1 or 2 level buildings to the north of Walsall which lies about 15 km to the north west of Birmingham.



Site data:
Latitude - 52.6N
Altitude - 162 m

Climate data:
Oct. to Apr. inclusive:
Degree days - 2 452
(base 20)
G_H - 1 140 MJ/m²

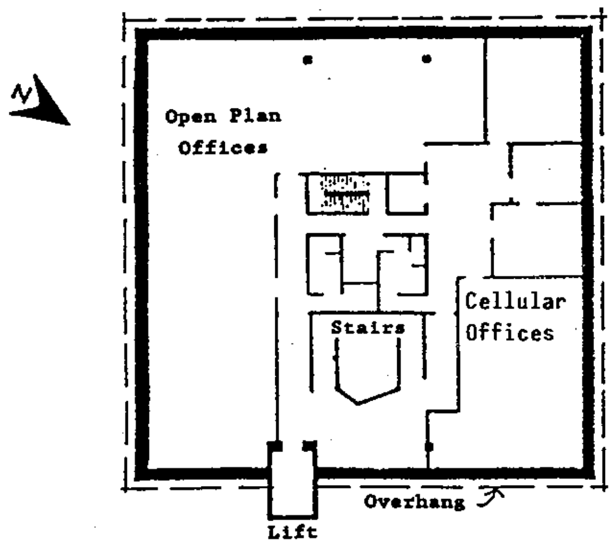
Actual sun hours - 508
Actual/theoretical - 0.24

Annual:
Degree days - 4 094
(base 20)
G_H - 3 463 MJ/m²

BUILDING FORM

The square plan comprises a four storey office block plus an attic. A mezzanine level is provided between ground and first floor. Services and toilets are within a 8m square core. The ground floor adjoins an existing building, the attic is a buffer zone used for storage.

The compact plan is naturally vented in the perimeter offices. The energy and environmental conflicts inherent in a high glass area design are resolved through overhanging storeys, external and internal shelves with reflective sills, resulting in shade at the window wall and increased daylight at the rear of the offices.



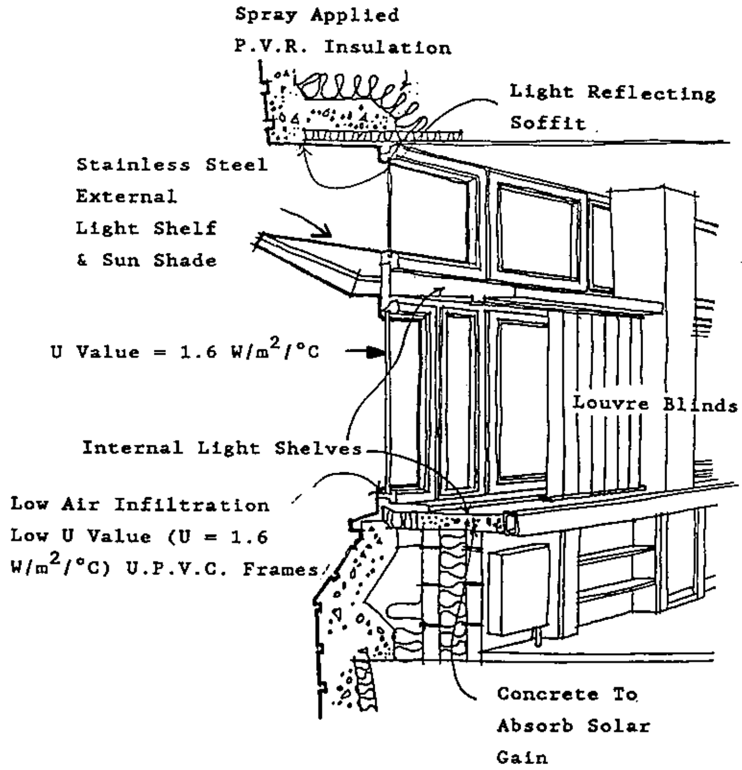
TYPICAL FLOOR PLAN

Volume: (m³)
Gross 14 265
Heated: 12 390
Attic Buffer: 1 875

Dimensions:
Floor to ceiling height of 3m

Surface areas: (m²)
Ground Floor - 870
Roof - 870
Wall (excl. windows) - 650
Windows - 860

Window data:
Glass area is 54% of facade viewed from inside.



U-values: (W/m² °K)

Floor	0.35
Wall	0.20
Window:	
Glass & Frames:	1.60

Envelope heat loss:
(kW/°K)

Transmission	- 2.1
Infiltration and Ventilation	- 3.0

BUILDING CONSTRUCTION

The structure is concrete frame with RC cladding panels and a facing brick finish. Bad ground conditions required a complex sub structure with 128 piles and extensive groundworks.

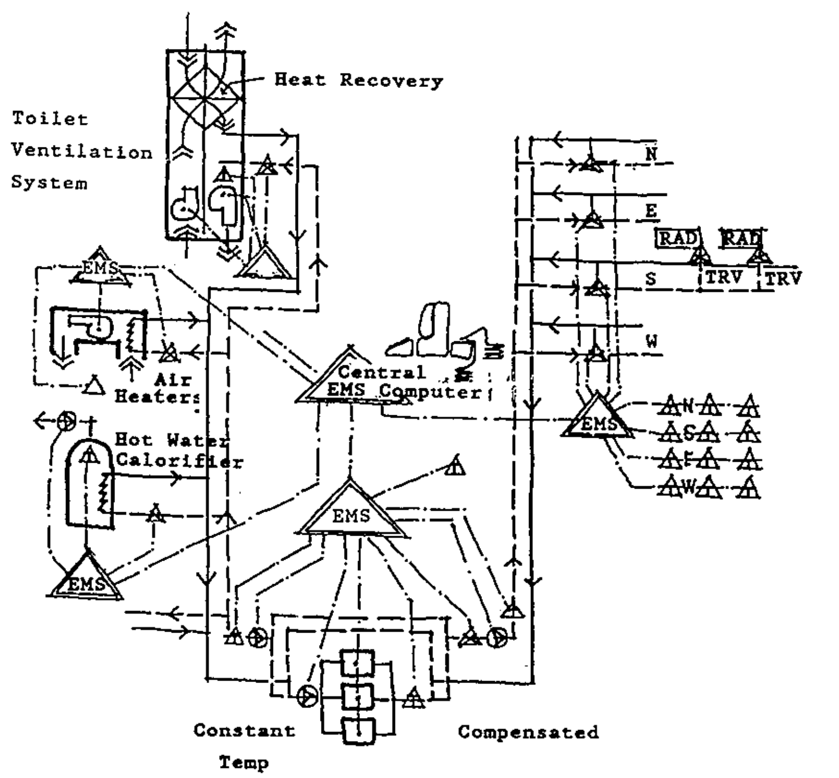
The ground floor incorporates 75mm polystyrene, the walls include 100mm ureaformaledehyde and insulating blocks, the overhangs included spray on insulation (150mm polyisocyanurate) against cold bridges, the pitched roof is insulated in the attic floor with 100mm polystyrene. Windows are low emissivity, argon filled double glazing in UPVC frames of low U value and negligible air permeability.

BUILDING SERVICES

Space heating - central modular boilers supply LPHW to constant and variable temperature systems. The boiler plant is sequenced, optimised and compensated. Room temperatures are controlled by thermostats to 16 zones and radiator valves. (All through an EMS- Energy Management System.)

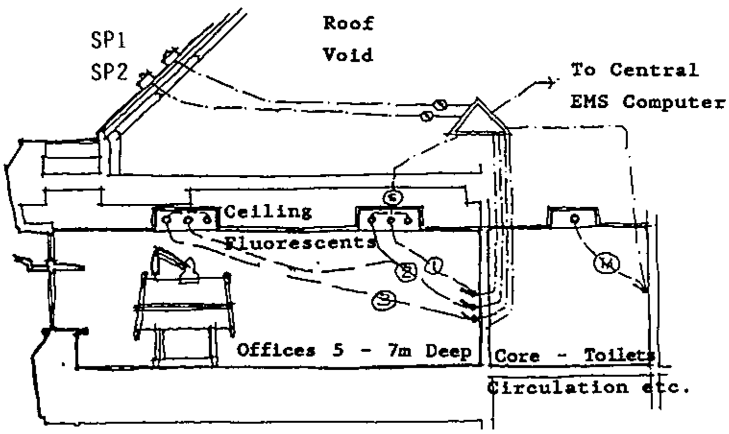
Lighting - roof mounted photo electric cells provide information to an EMS to enable the appropriate manual switching of light banks in relation to available natural light.

Ventilation - Air conditioning serves only the computer suite. Mechanical ventilation and heat recovery serve the toilets in the core.



Installed capacity:
Space heating:
Heated areas - 50W/m²

Design conditions:
Internal temperature:
20°C



Installed capacity:
Lighting (offices):
Ceiling - 10W/m²
Task Lighting-16W/desk

Design conditions:
Lighting (offices)
350 lux
Lighting (circulation)
250 lux

ELECTRIC LIGHTING STATUS.

External Light	Group 1	Group 2	Group 3
High – SP 2	ON	NOT AVAILABLE	NOT AVAILABLE
SP 2 – SP 1	ON	AVAILABLE	
SP 1 – Low	ON	AVAILABLE	AVAILABLE

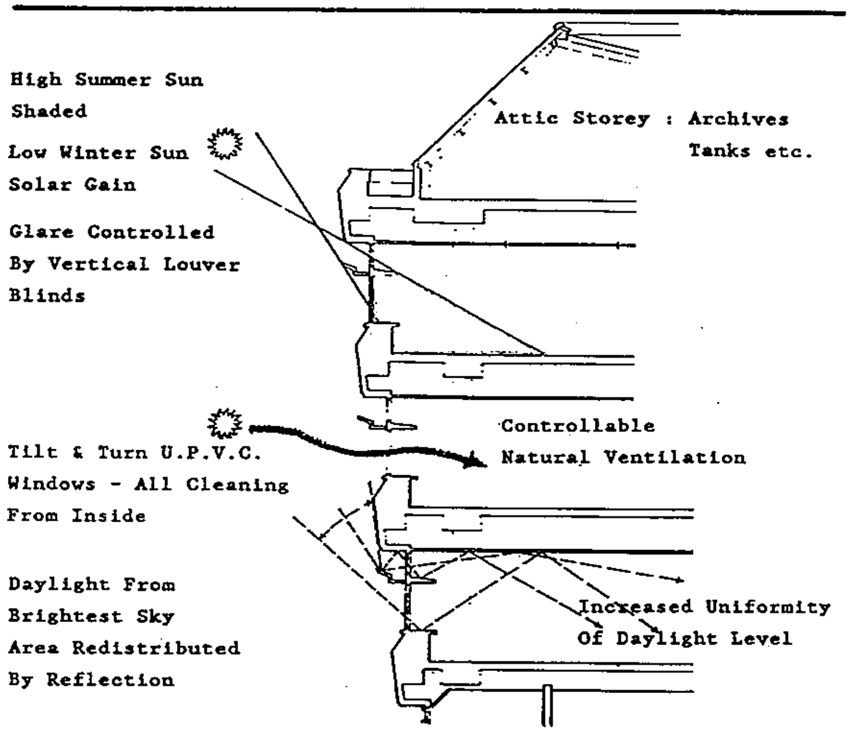
①②③ Lighting Control Groups
Ⓜ Fully Manual Control
Ⓢ Safety Light
Light Switch

PASSIVE SYSTEMS

Maximising daylight led to large windows, conflicting with high seasonal heat gains and losses. To optimise heat and light savings good control was essential.

Glazing properties:
Double glazed, low emissivity, argon filled (12mm)
U = 1.6W/m²°K
Daylight trans = 60%
Solar trans = 59%
or if reversed = 69%

Light shelves:
External - Specular
Internal - (high) white
Internal - (low) beige



The techniques used to optimise benefits were:

- Low emissivity glazing in high performance frames (glass & frame, U =1.6 W/m²/K).
- Combined light shelves and external shades at high level to redistribute light.
- Internal sill at low level of high mass to absorb solar gain.
- Opaque elements insulated to 0.3W/m²/°C.

Building cost (1985):
£467/m² gross
ECU - 287/m² gross

Typical cost (1985):
Medium height and quality
£420 - £500/m²

BUILDING COST

The building is principally new but includes some refurbishment in the link with the existing building. The cost compares well with typical costs for similar offices and suggests that the passive systems have been cost effective. Shelves average 2.6% of total cost.

Annual fuel use: (MJ/m²)
SSWC: 656 (gross space)
784 (heated space)

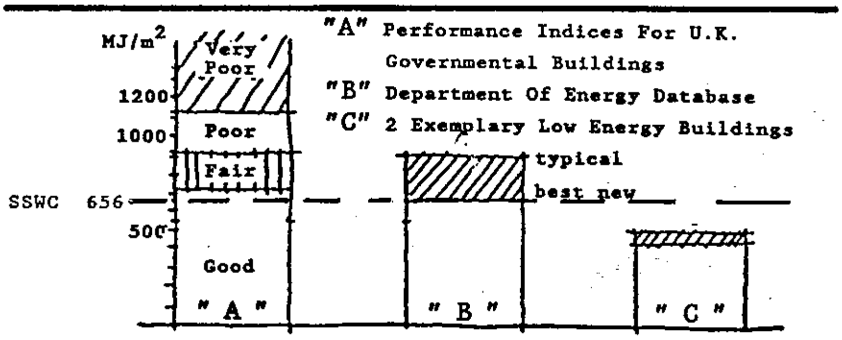
Typical office buildings:
Existing - 900
'Best' New - 660
'Low Energy' - 500

Fuel costs: (1986) (/GJ)
Gas - £ 3.2
Elect (Average) - £ 13.9

ENERGY PERFORMANCE

FUEL TYPE	FUNCTION	DELIVERED FUEL TOTAL	(MJ) /m²
Gas	Space Heating ...	1 074 000	280
Gas	H.W. & Other	696 000	181
Gas	All	1 770 000	461
Elect	Lighting	158 000	41
Elect	Other	585 000	153
Elect	All	743 000	194
Gas & Elect	All	2 513 000	656

These figures exclude all air conditioning and heat and electricity used by the computer suite in the ground floor. Space heating use is very low with a short heating season Oct-April suggesting good utilization of solar gains. Lighting use could be reduced further by improvements to the control software. 'Other' energy use is high due to lifts, microcomputers, plant operation mode, etc



HUMAN FACTORS

The client was aware of the importance of a responsible public image in an emerging recession and explicitly called for a low energy building with a comfortable working environment for staff.

The Architect used specialist energy advice to remove the difficulties associated with large areas of glazing.

The environment appears to be well liked by the occupants. Temperatures are stable during the working day in all seasons. Daylight appears uniform in the offices. The shelves give pleasing deep penetration of sun beams. There have been occasional incidences of glare from low angle sun through the high level windows.

The energy management staff are not content with the lighting control software and the high fuel use for functions other than space heating and lighting.

Design occupancy:
No. 160

Functions:
Senior management
Administrative
Accounting
Engineering
Computing, etc.

$14 m^2$ office space/person

Working hours:
07.00 to 21.00 hours
Flexible working times

CONCLUSIONS

By use of passive systems and careful balancing of energy and environmental strategies, the design team have produced a design with highly utilised solar and daylight gains within a low heat loss envelope. The passive features work well and reliably. Initial monitoring suggests that plant control items could be fine tuned for further energy savings. The building demonstrates the benefits of an integrated design team working closely with a well informed client.

A low heat loss envelope can utilise daylight and solar gain.

INFORMATION

Building Services: The CIBSE Journal, December 1986 Volume 8 No. 12, pp 15-26. "Building Services Award for Energy Use in Buildings 1986". Building Services Publications Limited, Builder House, 1/3 Pemberton Row, Red Lion Court, Fleet Street, London EC4P 4HL, 01 533 2300, telex 25212 Builda G.

Energy Performance Assessments (EPA) Project, Part of DoEnergy R&D Programme on Renewable Energy, administered by ETSU; further details from REPO, ETSU, Building 156, AERE Harwell, Oxfordshire OX11 ORA, tel: (0235) 834621, telex: 83185.

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Telex: 334535 BM TECH G

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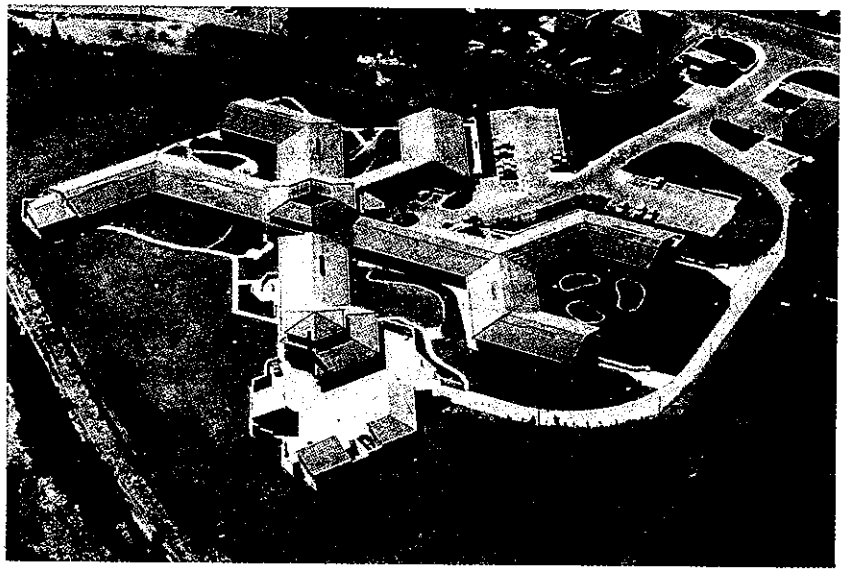
YSTRADGYNLAIS



Building type:
Health

Passive features:
Direct Solar
Daylighting:
Direct and Indirect

Occupancy date:
March 1986

Floor area:
Gross - 4 568 m^2
Heated - 4 135 m^2

Cost (1984):
£ - 1 820 885
ECU - 1 117 107

Annual delivered fuel:
(87/88)
Gas - 6 928 000 MJ
Elec - 1 481 000 MJ
Total - 1 827 MJ/m^2 (gross)

Client:
Powys Health Authority

Architect:
Welsh Health Common Services Authority

Monitoring:
EPA Project - ETSU (Welsh School of Architecture)

SUMMARY

Ystradgynlais Community Hospital is a 4 500m^2 new-build hospital serving a community of 16 000 people in south west Wales.

A site microclimate study resulted in much emphasis being placed on shelter and landform. In addition to extensive earth mounding and tree planting, the building has been dug into the site on the north side. Simple passive solar techniques have been used to create sunny day areas and provide well daylit interiors.

PROJECT DESCRIPTION

The project represents a move to reinforce the provision of small community-based hospitals in rural parts of Wales. Ystradgynlais Community Hospital contains a 38 bed Elderly Persons' ward, a 14 bed General Practitioners' ward, a 20 place Day Hospital, an Outpatients department and a small Casualty facility. The hospital is on a 3.2 hectare site and serves a community of 16 000 people.

When designing the building the Architects paid particular attention to the local climate and the landform. Landscaping has been used to shelter the building from the prevailing winds. The orientation and planning of the internal spaces attempts to utilise passive solar techniques to ensure good daylighting and sun penetration into day spaces.

SITE AND LOCATION

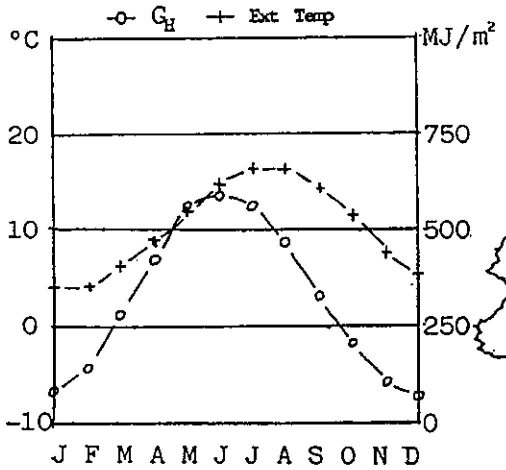
The site is on the edge of the town of Ystradgynlais which is 25 km north east of Swansea in South Wales. The town is in an area of wooded hills and valleys. The site is in a valley on the banks of the river Tawe.

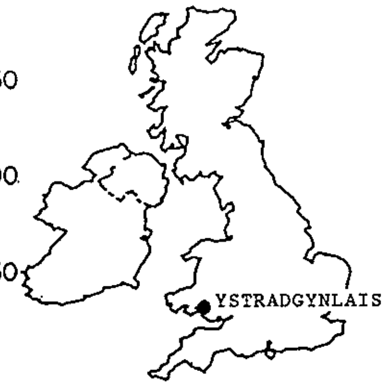
Site data:
Latitude - 51.8° N
Altitude - 100 m

Climate data:
Oct. to Apr. inclusive:
Degree days - 2 846
(base 20)
G_H - 1 284 MJ/m²

Actual sun hours - 619
Actual/theoretical - 0.29

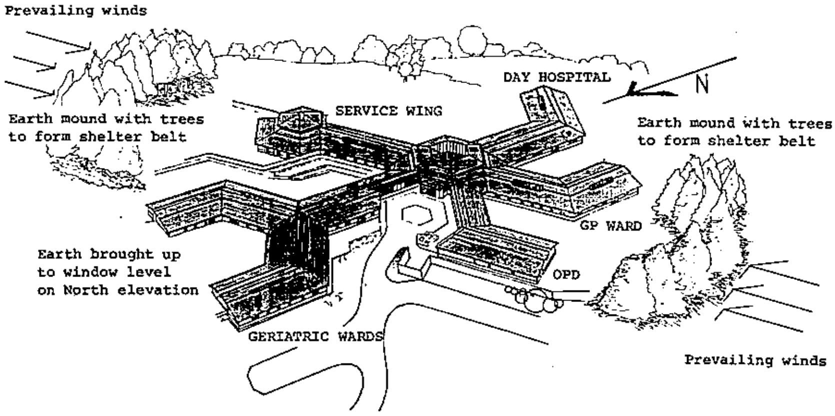
Annual:
Degree days - 3 763
(base 20)
G_H - 3 766 MJ/m²





Local experience of the site conditions and a micro-climate study indicated that the site is very exposed to winds from the SW and NE which are channelled along the river valley. Excavated sub-soil has been used to create mounds at each end of the site. These have been planted with trees and will eventually provide shelter from the prevailing winds.

The site falls towards the south and the building has been set into the slope. Earth covers the north elevations upto window sill level. This reduces heat losses and gives added protection from the wind.



Volume: (m^3)
Gross - 13 110
Heated - 11 790

Dimensions:
Ceiling height - 2.7 m

Main Building
Surface areas: (m^2)

Ground floor	3 825
Opaque roof	3 800
Roof glazing	80
Opaque wall	1 380
Windows	550

U-values: (W/m^2K)

Floor	0.45
Roof	0.31
Walls	0.60
Glazing	5.60

Envelope heat loss:
(kW/K)

Transmission	7.2
Infiltration	3.1

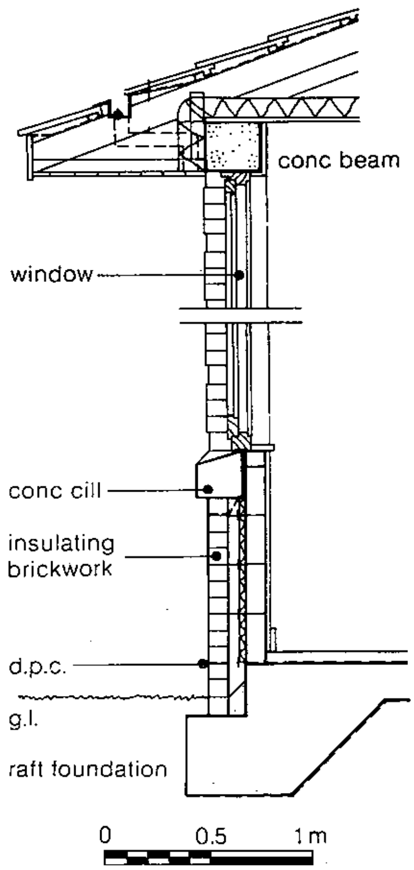
BUILDING FORM

The single storey building has been planned so that the various departments radiate from a central "hub". This has reduced circulation space and allows each area direct access to the main entrance.

Generally the internal layout gives day rooms a southerly aspect while store rooms and toilets are confined to the north sides. Large windows are used on the south elevations, with small windows lighting the ancillary accommodation. Central corridors are lit by rooflights.

BUILDING CONSTRUCTION

The construction is traditional using a masonry wall construction and a pitched tiled roof. The roof incorporates 100 mm of glass fibre quilt at ceiling level and has a U-value of 0.31 W/m^2K. The walls are only insulated to current Building Regulation standards ($U = 0.6\ W/m^2K$) with 25 mm of polystyrene fixed in the cavity of the brick/block wall. The concrete floor is uninsulated and the windows and rooflights are single glazed.



Section

BUILDING SERVICES

Space heating - The boiler house is situated at the end of the service wing. It contains five lightweight gas fired modular boilers, each rated at 97 kW. A constant temperature heating circuit is routed, at high level, round the central "hub". The departments, which radiate from this "hub", are each treated as one or two heating zones. The zones are fed from the constant temperature circuit but mixing valves are used to deliver water at a temperature which matches the load on the zone at any given time. The variable temperature circuits feed radiators which are fitted with thermostatic radiator valves. Optimum start control has been used for the day hospital and outpatients department.

Installed capacity:
Space heating
and hot water - 120 W/m²

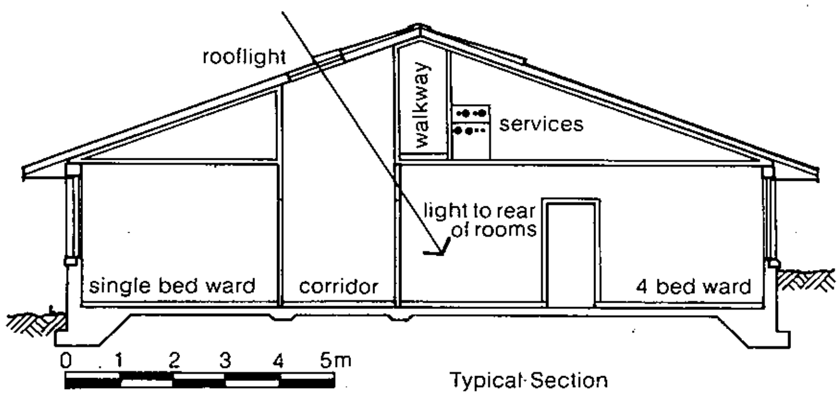
Hot Water Supply - hot water storage calorifiers are situated in the boiler house. A secondary circuit is used to feed draw off points around the hospital. A plate heat exchanger is used to reduce the temperature of the hot water circulated for patient use.

Lighting - much use has been made of compact fluorescent light fittings which retain a domestic appearance without the high running costs associated with tungsten lamps.

Ventilation - most of the ventilation is by local extract systems which incorporate time switches to prevent them being left on for more than half an hour.

PASSIVE SYSTEMS

Many of the major rooms, such as dayrooms, occupational therapy and staff dining areas have been designed with a southerly aspect and large windows. At one stage during the design, the dayrooms opened onto conservatories but as the design progressed these sunspaces became highly glazed rooms within the day areas.



Typical Section

Each of the wings are 13 m wide which allows most areas to receive natural light. Daylight at the back of the larger rooms is enhanced by borrowed light from the rooflights above the corridors.

An 800 mm overhang at the eaves shades the windows in summer. Overheating is further reduced by good natural ventilation and the use of heavyweight block for the internal partitions.

BUILDING COSTS

Building costs ('84):
£ - 400 /m^2
ECU - 245 /m^2

Typical cost ('84): (/m^2)
Hospitals: £384 - £642
Nursing homes: £468

At £400/m^2, the cost compares well with that of similar size general hospitals. But community hospitals are intrinsically less expensive than general hospitals. Services costs at Ystradgynlais were 22% of the total. Whereas for a general hospital, building services are likely to represent 50% of the total. So perhaps a better comparison is with costs for nursing homes and short stay medical homes. The mean cost of these buildings is £ 468/m^2. Thus the cost of Ystradgynlais is well within acceptable limits.

ENERGY PERFORMANCE

Annual fuel use: (MJ/m^2)
Delivered (87/88) - 1 827
Primary (87/88) - 2 807

Other Hospitals:
Best Practice < 1 600

Good 1 600 - 2 000

Average 2 000 - 2 500

Based on utility meter readings for March 1987 to February 1988, the total energy use at the hospital is as follows.

FUEL TYPE	FUNCTION	DELIVERED FUEL (MJ) Total	/m^2
Gas	Heating Hot Water Cooking	6 928 000	1 516
Elec	Light & power	1 418 000	311
Total	All	8 346 000	1 827

It is difficult to obtain comparisons with these figures because this is a relatively rare type of new hospital. Energy performance indicators for the hospital stock in England and Wales suggest that consumption at Ystradgynlais should total less than 2 000 MJ/m^2.

The designers report that there is scope for improving the energy performance at the hospital by better management procedures. It is hoped that the Energy Performance Assessment, which is due to start in autumn 1988 will highlight any areas where further savings can be made.

HUMAN FACTORS

The design of community hospitals in Wales is a direct result of studies into accessibility and social and financial costs for hospital patients and visitors in rural areas. The hospital provides an integrated community and hospital nursing service for many patient groups. Community and hospital nursing staff are often interchanged and, in some instances, retain responsibility for patient care both at home and in hospital.

Good standards of daylighting are a feature of this hospital. Research has indicated that daylight is beneficial to patient recuperation in hospital. It is hoped that this aspect will be examined more closely in the EPA project.

Design occupancy:
Elderly ward - 38 beds
General Pract'r - 14 beds
Day Hospital - 20 place
+ Outpatients
+ Casualty

CONCLUSIONS

Ystradgynlais uses landscaping, building form and simple passive solar techniques in an attempt to reduce energy consumption. It is an interesting example of the use of energy saving techniques which add little or nothing to the capital cost of the building. Unfortunately energy consumption is not as low as might be hoped for in a new low energy building. The extended plan form and the relatively poor insulation levels probably account for part of this reduced performance. It is hoped that the EPA monitoring will highlight any other shortcomings.

INFORMATION

BUILDING, 25 July 1986, pp 31 - 38 "Building Dossier - Ystradgynlais Community Hospital". Building (Publisher), 1 - 3 Pemberton Row, Fleet Street, London EC4P 4HL; 01 353 2300; Telex: BUILDA G25212.

BRITISH STANDARDS INSTITUTION, "Energy Design Guide". November 1985, pp 23 - 25; "Case Study 5: Ystradgynlais Community Hospital. British Standards Institution, 2 Park Street, London W1A 2BS; 01 629 9000; Telex 266933.

John Willoughby, "Energy Conscious Design for Health Care Buildings". Published by: The Institute of Advanced Architectural Studies, University of York, The King's Manor, York YO1 2EP; 0904 643915.

EPA (Energy Performance Assessments) Project; part of Dept. of Energy R&D Programme on Renewable Energy administered by ETSU; further details from REPO, ETSU, Building 156, AERE Harwell, Oxfordshire OX11 0RA; 0235 834621; Telex: 0235 83135.

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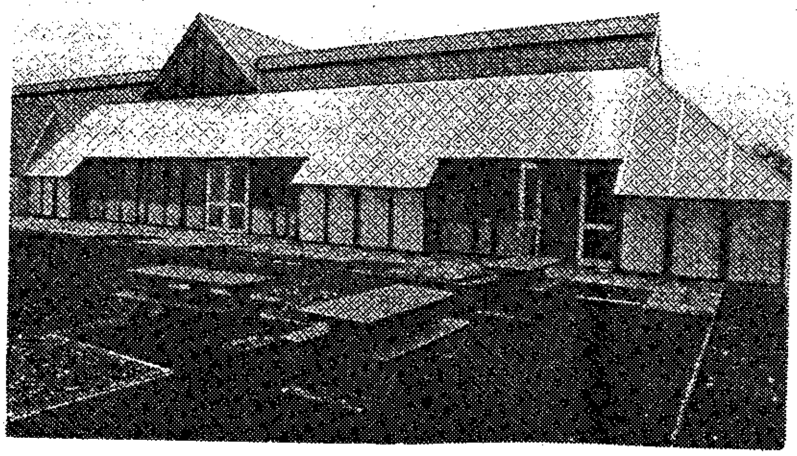
NETLEY SCHOOL



Building type:
Infants School

Passive features:
Solar Heating:
Indirect
Ventilation pre-heating
Daylighting:
Direct & Indirect
Solar Control:
Shading
Stack & Ridge Ventilation

Occupancy date:
September 1984

Floor area:
Gross - 1035m^2
Heated - 835m^2

Cost (1984):
£ - 396 718
ECU - 243 345

Annual delivered fuel:
Gas - 287 500 MJ
Elec - 67 600 MJ

Client:
Hampshire County Council

Architect:
Dennis Goodwin
Hampshire County Council

Energy consultant:
Nick Baker
Martin Centre,
Univ Cambridge

Services engineer:
Fuller & Partners

Monitoring:
Chris Martin
Energy Monitoring Company

SUMMARY

This infants school was seen by the client, to be a test bed for ideas developed to utilise passive solar energy as a complimentary strategy to conventional conservation measures.

The main feature of the school is a long unheated conservatory serving both as an access route to the classrooms, and as a solar collector. Solar energy is utilised to pre-heat the ventilation air which is conveyed into the heated classrooms via the warm-air heating system.

Although no extra building costs were incurred, energy savings of almost 50% compared with the norm for Hampshire, have now been attained. However, experience showed that commissioning and trouble shooting were of vital importance.

PROJECT DESCRIPTION

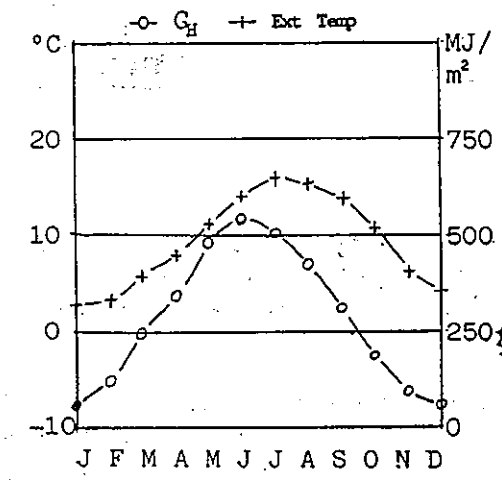
The scheme originated with a study carried out in 1981 for the clients, Hampshire County Council, by The Martin Centre, University of Cambridge, funded by the Science and Engineering Research Council. The study developed the idea of solar ventilation pre-heating as an alternative to direct gain systems, which earlier studies at the Martin Centre had been shown to be likely to suffer thermal comfort problems.

The direction of development was in line with Hampshire's response to the post-war system built schools, that is an environmentally 'selective' approach as distinct from a more heavily serviced 'exclusive' approach being pursued by other educational authorities in the UK.

In an initial design study the Martin Centre worked closely with the Architect to produce a design for a school at Locksheath, which due to falling pupil numbers, was never built.

However, the principles were then transferred to this infants school at Netley Abbot. Since the design incorporated a number of innovative features, it was the intention of the client to carry out fairly detailed monitoring, both of the energy systems and the response of the occupants.

SITE AND LOCATION



Site data:
Latitude - 50.8N
Altitude - 30m

Climate data:
Oct. to Apr. inclusive:
Degree days - 2 747
(base 20)
G_H - 1 121 MJ/m²

Actual sun hours - 616
Actual/Theoretical - 0.29

Annual:
Degree days - 3 498
(base 20)
G_H - 3 388 MJ/m²

The site is located in SE England within one mile to the NE of the Solent, a major coastal waterway. Apart from being within the influence of coastal breezes, which in this case augment the prevailing south-westerlies, the site has no other climatic peculiarities.

The school is sited on the edge of a residential area, exposed to open fields to the north and two storey houses at low density to the south.

BUILDING FORM

The very characteristic section has been generated by the relationship between conservatory and the teaching areas, and the use of the pitched roof which provides space for a mezzanine plant area, and increased height to enhance buoyancy-induced (stack-effect) ventilation.

The plan is also dominated by the conservatory. Simulation studies showed that, typical of buildings occupied for a short day, there was a slight advantage to be gained in a south-easterly orientation.

There is also a small unheated top lit atrium.

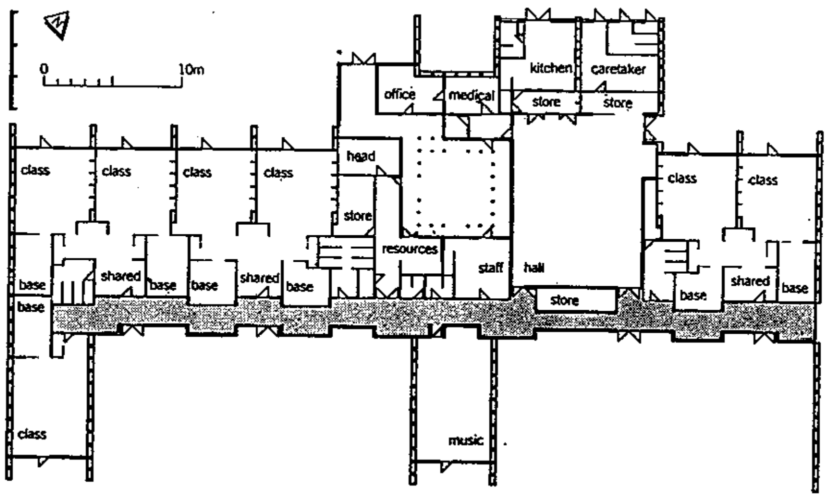
Volume: (m^3)
Gross - 3092
Heated - 2256
Conservatory - 586
Atrium/Entrance - 250

Dimensions: (m)
Floor to ceiling height:
Classrooms - 4.2 max
- 1.4 min
Hall - 7.1 max
- 2.3 min
Overall Average - 2.7

Surface areas: (m^2)
Wall to Conservatory:
single glazing - 140
mezzanine floor - 135
brickwork - 90
South Walls:
single glazing - 8
polycarbonate - 7
stud framing - 15
North Walls:
single glazing - 36
polycarbonate - 32
stud framing - 68
Atrium:
single glazing - 35
stud framing - 53
polycarbonate - 88
Roof - 1180
Floor - 835

U-values: (W/m^2K)
Single Glazing - 5.6
Polycarbonate - 2.8
Brickwork - 0.4
Stud Framing - 0.4
Floor - 0.4

Designed conditions:
Internal temperature:
14 - 24°C
Illumination: 200 lux
Ventilation:
10 - 30 m^3/person/hr



BUILDING CONSTRUCTION

The most dominant element is the roof and its timber frame which also supports the conservatory. Asbestos equivalent cement slates cover 100mm of fibre glass quilt, followed by a vapour barrier then a further 50mm of fibre glass. The acoustic absorbing soffit is then formed by white woven glass cloth, held by timber battens at 100mm centres.

The conservatory roof is twin-wall clear acrylic coated polycarbonate, with vertical single glazing of laminated glass.

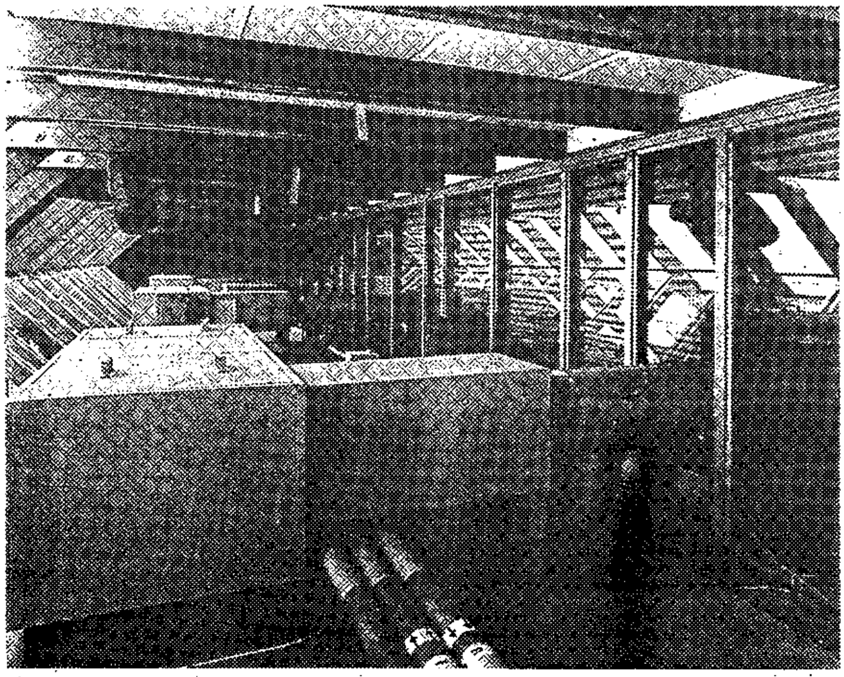
External walls are partly lightweight gable walls, and partly white calcium silicate brick diaphragm walls. The former are clad in asbestos equivalent cement sheet, lined in pinboard. Both contain 75mm of polystyrene insulation.

BUILDING SERVICES

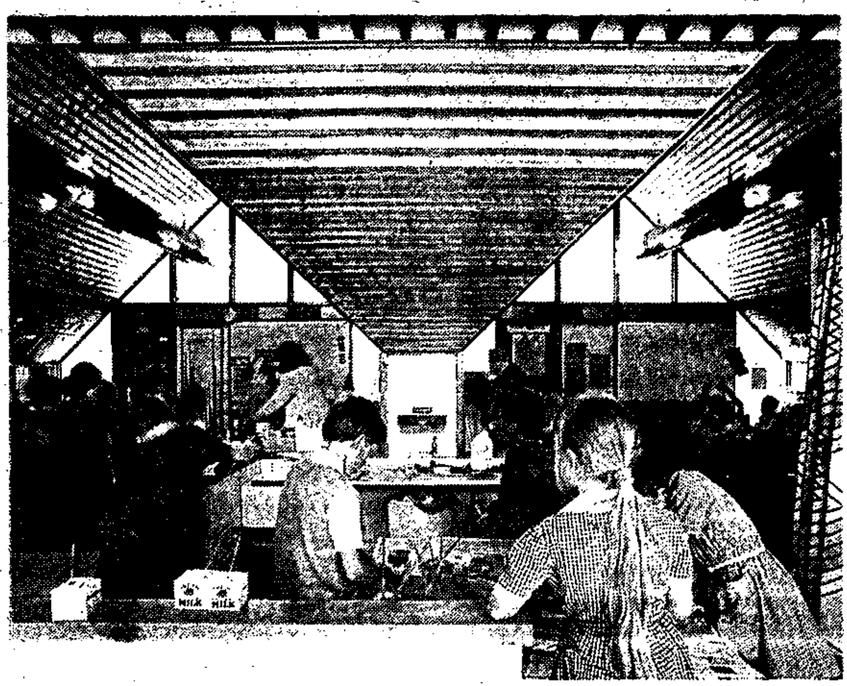
Each teaching area has an air heater battery located on the mezzanine floor. Warm air is delivered to each teaching area via a rectangular duct within an outer circular duct suspended below the ceiling, the duct also supporting the low energy fluorescent lighting. The return air is extracted between the ducts from classes, 'home base' and shared 'wet' areas beneath the mezzanine. The main hall and the music room is heated in a similar way.

Fresh air can be drawn into the heater battery from the conservatory. Whether the system is on recirculation or fresh air, is controlled manually from a button in the classroom, via an electric damper in the air handling unit.

The mechanical heating/ventilation only operates in the winter, apart from mechanical extract in the toilets. The building is designed to be naturally ventilated outside of the heating season.



Service gallery, with air handling unit and duct, which passes through a glass screen into an adjoining classroom.



View into a classroom from the conservatory entrance. Note, the low energy lighting is atatched to the warm air ducts and is on even during bright days.

PASSIVE SYSTEMS

The most important feature is the use of the conservatory for the provision of pre-heated ventilation air. The use of this strategy was prompted by the following consideration.

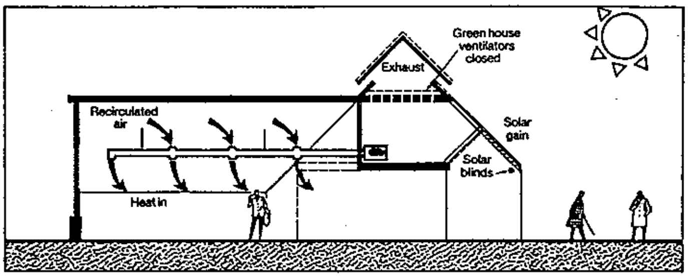
As the standards of thermal insulation increase, the proportion of heat loss associates with ventilation heat loss becomes greater. Schools are subject to a minimum ventilation requirement of 30 cubic metres per child per hour, and although this is rarely met in full, due to the high occupancy density the ventilation demand is considerable.

Building heat loss: (KW/°K)

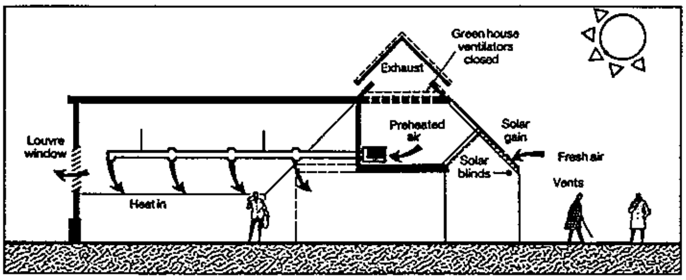
Fabric Losses	-	2.6
Infiltration & Ventilation	-	1.9

Bearing in mind that the utilisation of solar energy is a function of the heating load, it seems logical to associate the ventilation heat load directly with the solar gains. This carries the further advantage, characteristic of solar ventilation pre-heat, that there is no low threshold - any temperature increment to the ambient air will reduce the ventilation heating demand. This contrasts with other passive systems.

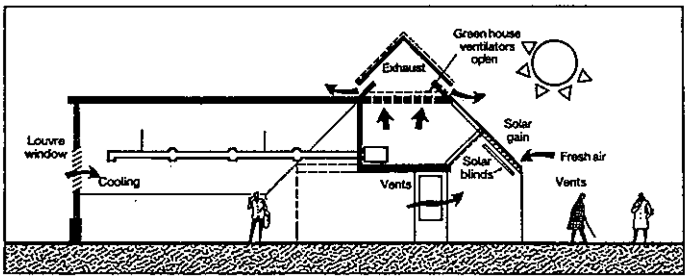
A further consideration was the difficulty of maintaining thermal and visual comfort conditions suitable for a teaching area, with a direct gain system.



Winter : air is preheated in the conservatory and atrium and fed to room heaters.



Spring/Autumn : options for shading and ventilation, or preheating air for heaters.



Summer : cooling using through ventilation and stack effect.

Other passive features are concerned with avoidance of overheating in summer. Automatic vents connect the conservatory with a continuous roof vent. Air enters through grilles in the north gable walls and is drawn through the teaching areas by stack effect or wind-induced suction at the ridge. Internal white roller blinds are also provided in the conservatory.

COSTS

Building cost (1984):
£ - 360 /m^2
ECU - 221 /m^2

Comparative costs for Hampshire Schools are shown in table 1 and it can be seen that Netley compares favourably with other schools in the area. No special provision was made for extra costs and this was understood during the development of the design.

The heating system did turn out to cost more than normal. This was disappointing as the original concept of the local air heater unit was partly to reduce cost over more conventional systems. Much of the cost went into the high standard of engineering (in particular silencing) and in the complex but conventional control systems.

ENERGY PERFORMANCE

The first occupied heating season showed up problems in both building systems and monitoring. By the second season monitoring problems had been sorted out but a new crop of system faults showed up. Energy performance for both these periods was far worse than expected.

By the third season 86-87, all of these problems seem to have been solved. The figures are given below.

FUEL TYPE	FUNCTION	DELIVERED FUEL TOTAL	MJ $/m^2$
Gas	Space Heating	223 344	267
	Water Heating	32 765	39
Elec	Pumps and Fans Lighting Water Htg. in Toilets Misc. Power	67 626	81
TOTAL		323 735	387

The solar performance of the building was assessed by the regression plot shown. It shows that the effective solar aperture of the building was $56m^2$ +/- $5m^2$. This is close to the theoretical maximum, indicating high solar utilisation. The intercept gives the building Ua value of 2050 +/- 200 W/K. This figure has progressively decreased as the occupants have developed improved understanding of the building and reduced "irrational" ventilation.

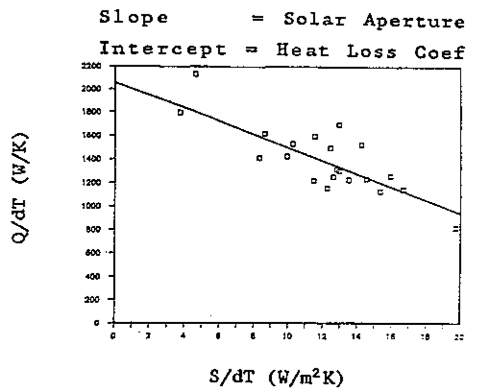


Table I Building costs of Hampshire schools

School	*Building cost (£/m²)*
Hulbert Middle School	363·74
Four Lanes Primary School	352·83
Bosmere Middle School	344·07
Burnham Copse Infants' School	415·62
Netley Infants' School	363·66

Annual fuel use ('86/'87):
Delivered - 370 MJ/m^2
Primary - 560 MJ/m^2

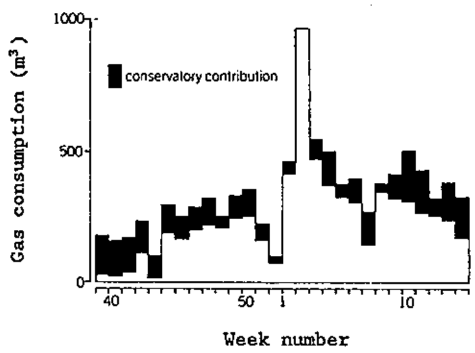
Design standards:
Delivered MJ/m^2
from CIBS part 4
< 700 = good
< 800 = satisfactory
<1000 = fair
<1200 = poor
>1200 = v. poor

Fuel costs (1986):
(£/GJ)
Gas - 3.2
Elec (avg) - 13.9

Solar Aperture: 56 m^2
Heat loss coef: 2050 W/K

By subtracting calculated fabric losses from total, the ventilation loss could be estimated. From measured ambient and conservatory temperatures the contribution of the conservatory could be calculated as shown below. The overall annual contribution is 28% of useful heat.

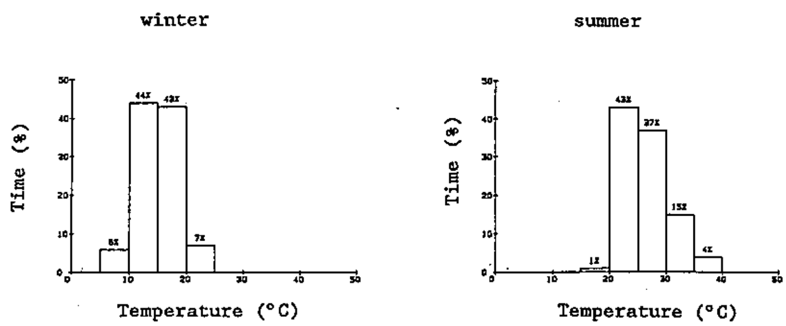
Percentage conservatory contributions



The habitability of the conservatory was assessed and is indicated below. Winter temperatures (Nov. 6 to Jan. 6 1986) for the period 8am to 6pm are shown below indicating an average temperature of around 15°C. Summer conditions show some indication of overheating with 15% of hours above 30°C.

Conservatory temperature distribution

computed from data recorded between 8am and 6pm



HUMAN FACTORS

Occupancy:
245 pupils (aged 5 - 11)
8 staff
11 ancillary

3.95m²/person

School hours:
09:00 to 15:30
30 weeks p.a.

Considerable difficulty was encountered initially with the heating system controls. This lead to under and overheating of the teaching areas and some doubts concerning the validity of passive solar technology.

However, the conservatory was well liked, and used so much to supplement the teaching areas that the doors from the teaching areas were left open, adding to the temperature control problems.

The fresh air mode is selected by a large green button next to the "warmer - cooler" thermostat adjuster and the light switches.

Pressing the button switches the damper to 100% fresh, but reverts back to recirculation after a time delay of about 30 mins. However, unfortunately the functioning of this control was not properly explained, and remained a mystery to some of the teachers. For example, some did not use them at all, relying upon opening windows, defeating the ventilation pre-heat. Others used them in summer, drawing in warm air from the conservatory!

The history of poor thermal control often lead to teachers setting the thermostat to maximum, and very high classroom temperatures were recorded.

However, with the solving of engineering problems with the control system, recent evidence shows that the occupants are now much more sympathetic to the building, and generally described their experience of the building positively.

CONCLUSIONS

After three years of occupation it is now evident that the principle of ventilation pre-heating by indirect solar gain is sound. The fuel bill for Netley is roughly one half of comparable recent schools in Hampshire, and this was attained at zero extra costs.

Hybrid technologies enhanced performance but only after careful commissioning.

The use of the unheated conservatory for circulation and certain activities has also proved satisfactory.

However, as the primary energy figures indicate more attention should have been paid to reducing electrical loads, both by better fan and pump controls, and by better use of daylighting.

On the negative side, experience showed that system control design and commissioning was initially unsatisfactory. This was partly due to insufficient dialogue between energy consultant, engineer and architect.

Related to these early problems, and perhaps aggravated by further lack of explanation, occupants were dissatisfied with conditions during the first two years of occupation.

INFORMATION

"The influence of thermal comfort and user control on the design of a passive school building". Nick Baker, Energy and Buildings, Vol 5. (1982).

"Walking on sunshine - Netley Infants School", Mark Bowman, Building Services, April 1986,

"Energetic Design - Netley Infants School" Dean Hawkes, Architects Journal, 22nd June 1988.

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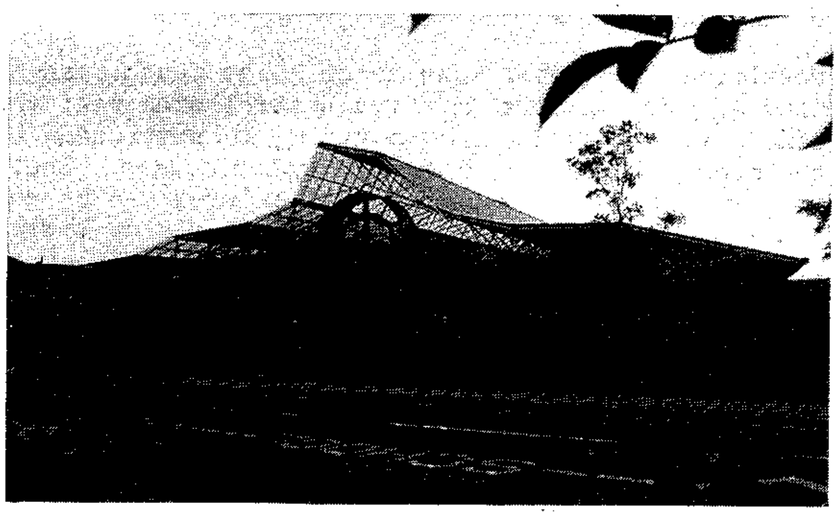
UK

JOHN DARLING MALL



Building type:
Hostel/Domestic

Passive features:
Solar Heating:
Indirect
Daylighting:
Direct and Indirect

Occupancy date:
June 1985

Floor area:
2 335 m²
(gross - including the street)

Cost (1984):
£ - 805 134
ECU - 493 497

Annual delivered fuel:
(1987/8)
Gas - 2 553 302 MJ
Elec - 325 332 MJ
Total - 1 233 MJ/m² (gross)

Client:
Hampshire County Council
Social Services Dept.
Raglan Housing Ass'n

Architects & Engineers:
Hampshire County Architect

Monitoring:
EPA Project - ETSU
(UWIST)

SUMMARY

The John Darling Mall at Eastleigh provides hostel accommodation and flats for physically handicapped young people in Hampshire. Energy consumption in the complex is below the norm for this type of building. It was built at less than the cost of similar developments despite having two separate roof structures. An additional transparent plastic roof covers a traditional flat roof to create a covered street through the centre of the development.

The external pvc roof acts to create a more favourable microclimate around the building and also helps to provide good daylight penetration into internal rooms in the middle of the complex. Ventilation of these internal rooms into the covered street has been achieved without problems. The need for the covered street to remain unheated and the occupants desire to have a controlled and heated environment is a conflict that needs addressing in many passive solar buildings.

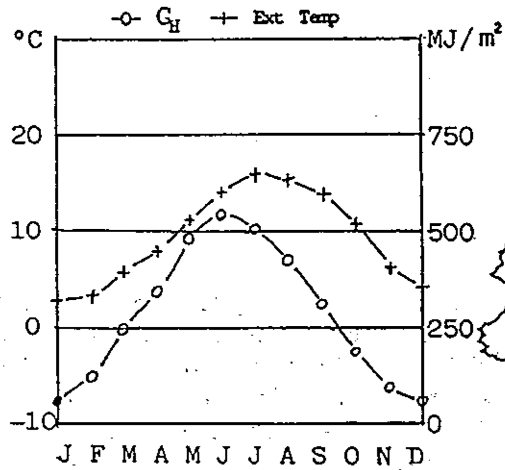
PROJECT DESCRIPTION

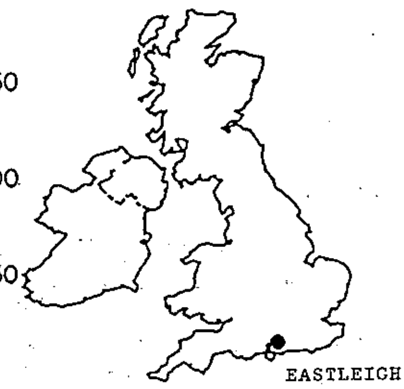
The development gives accommodation for upto 36 young people with physical handicaps. There is a hostel with 24 bedsits and six 1 to 2 person flats. In the hostel, the bedsits are in groups of five or six clustered around shared bathrooms, dining, cooking and common room facilities. The scheme is primarily intended for young people who are able to go out to work but need support in the home environment.

The project is the third in a series of schemes by Hampshire County Architects which have developed the use of covered streets. These are essentially external spaces which are protected from wind and rain by transparent roofs. As well as providing low cost covered external space, the streets collect solar gains and helps to reduce heat losses from the building fabric.

SITE AND LOCATION

Eastleigh is a small town about 80 km south west of London. The site is in a residential area near the centre of the town. The building is surrounded by two storey detached and semi-detached houses. There is a considerable amount of shelter provided by new and existing trees. Close to the building hedges protect the facades as well as providing privacy to the gardens.





Site data:
Latitude - 51.3° N
Altitude - 35 m

Climate data:
Oct. to Apr. inclusive:
Degree days - 2 747
(base 20)
G_H - 1 121 MJ/m²

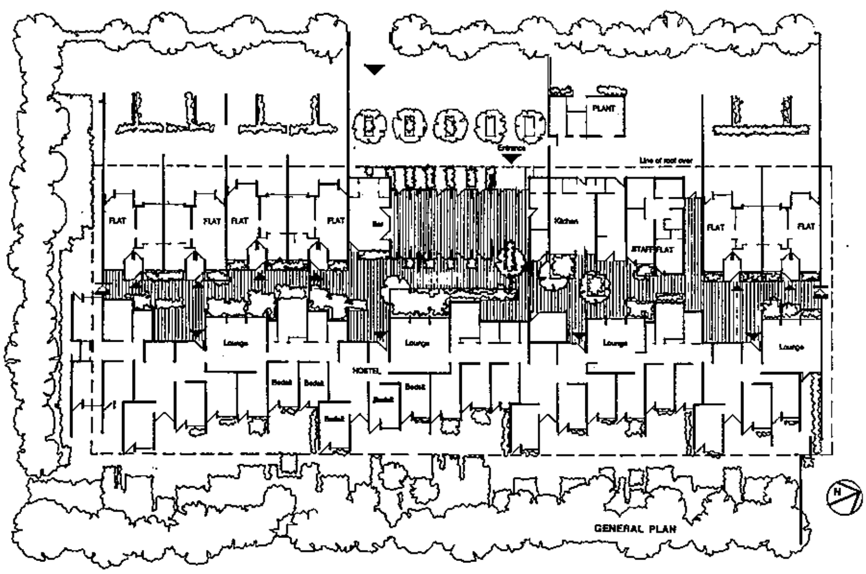
Actual sun hours - 616
Actual/theoretical - 0.29

Annual:
Degree days - 3 498
(base 20)
G_H - 3 388 MJ/m²

BUILDING FORM

The building is approximately 90 m long by 26 m wide and is orientated with N-S along the long axis. A band of hostel accommodation 10 - 14 m wide is situated on the east side; while the six flats, communal areas and service areas are on the west facade. These two blocks of accommodation are housed in separate buildings and a transparent plastic roof covers them both thereby creating a covered street between the single storey blocks.

Access to the accommodation is from the covered street with entrances to and from the gardens on the outside of the building.



Dimensions:
Overall approx - 90 x 26m

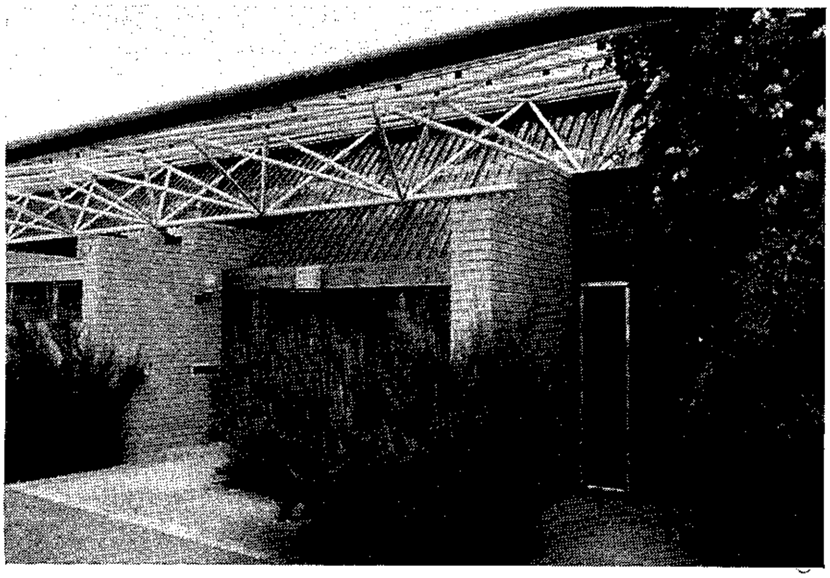
Volume: (m³)
Gross - 10 500
Heated - 4 400
Covered Street - 5 400

Areas: (m²)
Gross - 2 335
Heated - 1 535
Street - 750

U-values: (W/m^2K)
Floor - 0.20
Roof - 0.33
Opaque walls - 0.60
Windows - 5.7/3.0
Street glass - 5.7

BUILDING CONSTRUCTION

The building is of single storey load-bearing construction. The cavity walls include a 25 mm thick layer of expanded polystyrene which is fixed to the inside face of the cavity. The flat roof contains 100 mm of insulation. The inner roof is finished with three layers of felt so that it does not rely on the outer plastic roof for rain protection. The windows are generally single glazed with some twin wall polycarbonate sheeting in the clerestorey windows to the central accommodation. The floor is uninsulated.



Installed capacity:
(W/m^2)
Space heating - 341
Hot water - 24

Design conditions:
Internal temperature: 21°C

BUILDING SERVICES

Space heating - two 262 kW gas fired cast iron sectional boilers feed a LPHW heating circuit in a floor duct around the building. This constant temperature circuit feeds radiators each fitted with a thermostatic valve. The heating is on 24 hours a day but has recently been fitted with controls to give 6K night set-back. There is no zone control.

Hot water - is supplied by an idependent 37 kW water heater which incorporates 270 litres of water storage. A pumped secondary circuit distributes the hot water around the building.

Ventilation - the building is naturally ventilated with only a small amount of mechanical ventilation in the kitchen and laundry. The extract from these rooms is into the covered street.

Lighting - compact fluorescent lamps are used in the street and in some of the communal areas while tungsten lamps are used in the flats and hostels.

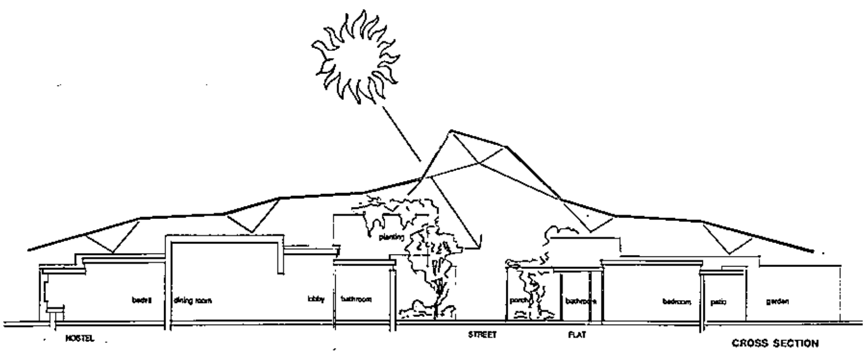
There is a central laundry and kitchen facility.

PASSIVE SYSTEMS

The building is generally well daylit. The varying room heights allow plenty of opportunities for clerestory windows which increase daylight penetration into the inner rooms.

The way the buildings have been arranged on the site does not give much scope for utilising direct solar gains. However the transparent roof covering should act as a useful passive solar feature. Solar gains should ensure that the street and the area above the flat roofs is always a little warmer than outside. Heat losses from the interiors should thereby be reduced. The heavyweight brick walls and floors used for the street provide some thermal storage.

The heavyweight materials should also help to control summertime temperatures. The gable ends of the transparent roof are open. This, together with the fire vents in the apex of the roof, helps to ensure high ventilation rates in summer. Pneumatic actuators can be used to open the fire vents; detectors will close them in the event of rain.



CROSS SECTION

<u>Street dimensions</u>:

Area	-	750 m^2
Volume	-	5 400 m^3

<u>Street U-values</u>: (W/m^2K)

Glazed roof	-	5.7
Ext walls	-	0.57
Walls to living accommodation	-	0.57
Glass to living accommodation	-	5.7/3.0

BUILDING COSTS

Building costs ('82):
£ - 345 /m²
ECU - 212 /m²

Typical cost ('82): (£/m²)
Bungalows - 264 - 340
Hostels - 378 - 506
Homes for the physically handicapped - 400 - 438

At £345 per m² the total cost of John Darling Mall compares well with costs for other similar buildings. The cost is just above that for bungalows and well below that for hostels or homes for the physically handicapped. Services costs for the building were 23% of the total.

ENERGY PERFORMANCE

Based on utility meter readings for April 1987 to March 1988, the total energy use at John Darling Mall is as follows.

FUEL TYPE	FUNCTION	DELIVERED FUEL Total	(MJ) /m²
Gas	Htg hot water & cooking	2 553 302	1 663
Elec	Light & power	325 332	142
Total	All	2 878 634	1 805

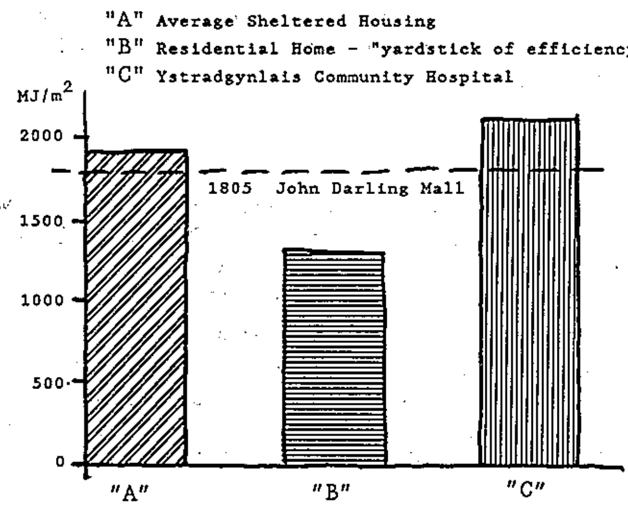
Annual fuel use: (MJ/m²)
Delivered ('87/8) - 1 805
Primary ('87/8) - 2 321

Typical existing buildings:
Residential homes - 1 470
Sheltered housing - 1 920

Fuel costs: (1987) (/GJ)
Gas - 3.5
Electr (average) - 14.5

The electricity consumption is slightly above typical domestic levels. This is to be expected and probably reflects the higher densities and items as the laundry and battery charging for electric wheel chairs.

The gas usage compares well with typical consumption figures for this type of building. However these comparative figures include old as well as new buildings. Gas is used in the central kitchen and laundry as well as for space and hot water heating. However, the high usage is probably more a function of poor insulation levels, high infiltration and an oversized and poorly controlled heating plant. It is hoped that the forthcoming Energy Performance Assessment (EPA) will highlight any areas where improvements can be made.



HUMAN FACTORS

A clear objective for the design was to avoid an "institutional feel" to the building. The entrance area and the brightly daylit street are significant factors in achieving this objective. The planting, which grows vigourously under the pvc roof, adds to the non-institutional feeling. Originally the flats and the hostel were considered as separate developments. But they were brought together under one roof and linked by the covered street. This gives both groups access to the communal facilities around the entrance.

Having provided the covered external space, there seems to be a conflict between the energy-saving need for it to remain an unheated "external" space and the occupants desire to use it as an internal space. The occupants seem to find it cold in winter - particularly in the unheated communal area next to the bar.

Design occupancy:
24 bed hostel
6 No 1/2 bed flats

CONCLUSIONS

The glazed street at John Darling Mall is a good example of a simple passive solar technique which helps to reduce energy costs by creating a more favourable microclimate around the building. It is a tribute to the design team that the passive solar feature was able to be included in a building of such relatively modest cost.

The building is one of considerable architectural merit. The glazed street adds to the building in a number of dimensions - aesthetically, socially and functionally. The conflict between its function as an unheated covered external space and the occupants desire for improved thermal comfort is one which needs addressing in many passive solar buildings.

There is no doubt that the roof plays a part in reducing energy costs. However, the fuel bills would have been even lower if the design approach had also considered some of the more basic energy conservation techniques such as draughtstripping, insulation and boiler controls.

INFORMATION

Architectural Review. June 1986, Volume CLXXIX,No 1072, pp 58 - 61. "Hampshire Symbol". Published by Architectural Press, 9 Queen Anne's Gate, London SW1H 9BY. Tel: 01 222 4333, Telex: 8953505
EPA (Energy Performance Assessments) Project; part of Dept. of Energy R&D Programme on Renewable Energy administered by ETSU; further details from REPO, ETSU, Building 156, AERE Harwell, Oxfordshire OX11 0RA; 0235 834621; Telex: 0235 83135.

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UK

Building Type:
Residential

Passive Features:
Indirect Solar

Occupancy date:
October 1987

Floor area:
Gross - 363 m^2

Cost (1987):
£ - 120 000
ECU - 73 600

Annual delivered fuel:
(est.)

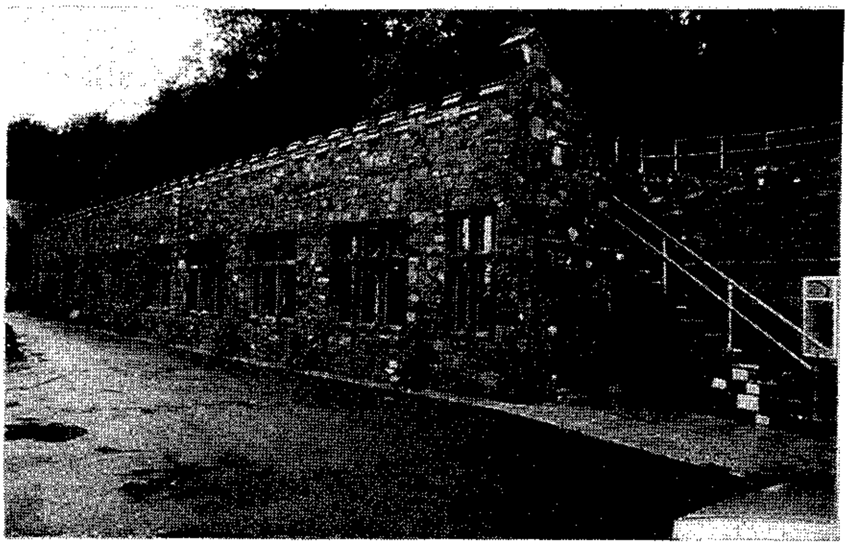
Elec - 21 000 MJ

Total - 57 MJ/m^2 gross

Client:
Caer Llan Field Studies Centre

Designer:
P. Carpenter,
Caer Llan Field Studies Centre

CAER LLAN BERM HOUSE



SUMMARY

The Caer Llan Berm House is an extension to an 18th century house, now used as a field studies centre, in Gwent, Wales. It provides bedroom accommodation for up to 29 people, and has been designed and built with very low maintenance and energy costs in mind.

Apart from the south facing facade, little surface area is exposed to the elements; the structure is built into a bank and backfilled with earth. Very heavyweight materials are used throughout, and the structure is very highly insulated, as well as completely waterproofed. Solar gains are used to pre-heat ventilation air. The building is heated solely through solar, occupancy, and incidental gains; no heating system has been provided.

The building's cost is comparable to residential and domestic building in the UK, though the fabric costs are proportionally much higher. Much of this increase in costs must be attributed to the high quality materials and construction techniques used to ensure low maintenance and long life.

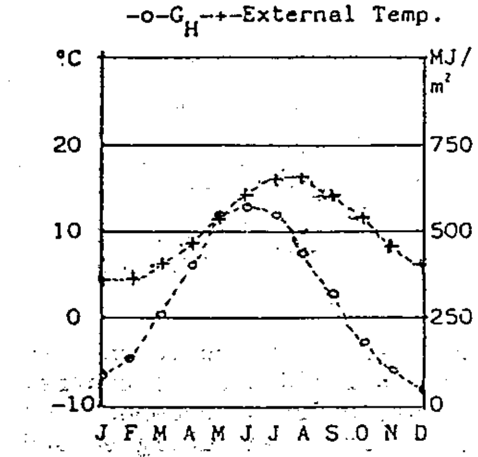
PROJECT DESCRIPTION

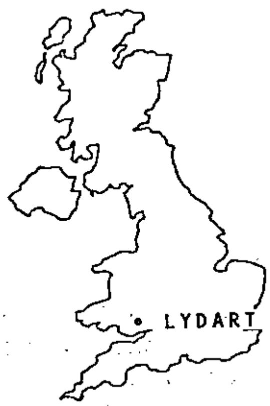
Caer Llan Field Studies Centre offers accommodation and facilities for school study groups, and for tourism, in the heart of a designated "Area of Outstanding Beauty" in South Wales. In response to a need for extra bedroom units, and as a result of a visit to America, where the centre's warden was greatly impressed by earth sheltered buildings there, design began in 1979 for a simple, low energy, low maintenance extension. Work began in earnest in 1986, and the extension was in use for the autumn of 1987.

The key aims of the design were to be; long life, low maintenance costs, no energy costs, and no environmental impact. The resulting building is essentially a labour of love, largely self-designed and self-built.

SITE AND LOCATION

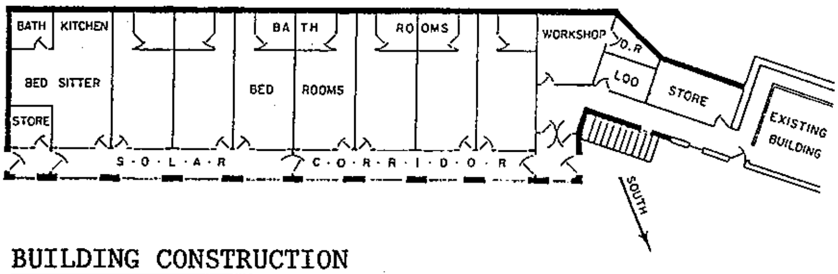
The centre is located on a steep, south-southwest facing slope overlooking the Vale of Usk. The topology of the site required considerable excavation for any proposed building work; the decision to cut the extension into the slope and backfill after completion was therefore not untoward.





BUILDING FORM

The single story linear form provides seven bedrooms (for up to 4 persons each) for use as bed and breakfast accommodation. Each bedroom has bath and toilet facilities; there are no kitchen facilities. There is also one permanently occupied bed-sitter apartment; this has full domestic facilities. The plan is designed to be modular and could be extended laterally. The living spaces are completely buried, and communicate with the outside only through the "solar corridor". This provides sheltered access, and a buffer for solar gains.



BUILDING CONSTRUCTION

The construction is robust, very heavyweight and highly insulated. Much attention has been paid to ensuring that the loads of the earth fill can be safely met, and that the structure is completely waterproof. The floor is a reinforced concrete raft laid directly on bedrock. The roof consists of rows of pre-stressed concrete beams grouted with 100mm of dense concrete, and topped with 1.5m soil. The back and side walls are massive to help protect against both vertical and horizontal loads from the earth covering; they must also be completely waterproof and maintenance free. Facing brick is used for internal walls, which are all load bearing. The external facade is faced with local

Site data:
Latitude - 51.8 N
Altitude - 220 m

Climatic data:
Oct to Apr inclusive:

Degree Days - 2 846
(base 20)
G_H MJ/m^2 - 1 280

Actual sun hours - 620
Actual/Theoretical 0.28

Annual:
Degree days - 3 760
(base 20)
G_H - 3 766 MJ/m^2

Volume:
Gross - 909 m^3

Dimensions:
Ceiling height - 2.4m
Exposed perimeter- 40m
Room floor area- 27m^2
Room depth - 7.7 m
Corridor width - 1.5 m

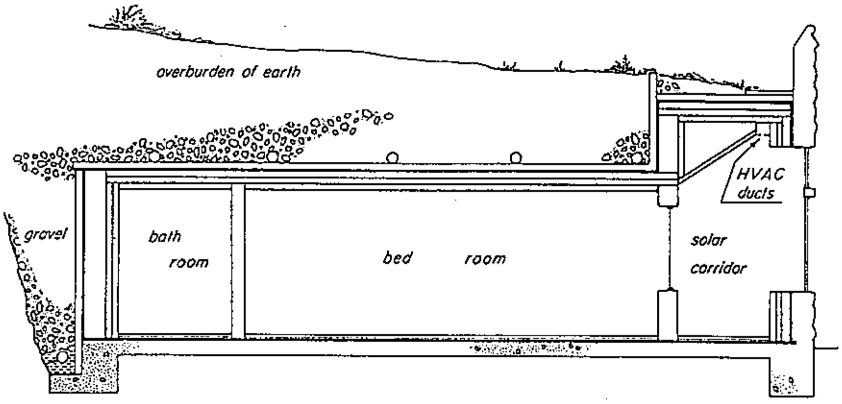
Surface areas: (m^2)
Ground floor - 360
Roof - 400
Back/side wall- 90
Front wall - 140
Window - 37

Constructions:
(exterior to interior)

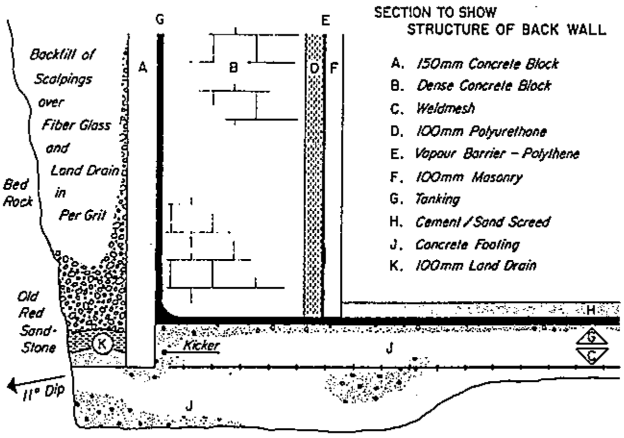
Back wall:
150mm concrete block
waterproof membrane
660mm concrete block
100mm expanded polyurethane
vapour barrier
100mm facing brick

Front wall:
225mm stone work
waterproof membrane
225mm concrete block
100mm expanded polyurethane
100mm facing brick

Roof strength:
25 kN/m^2



stone, and the aluminium frame double glazed windows are set in artificial stone surrounds to further match the extension to its surroundings. Kappafloat glass has been chosen for its enhanced thermal performance. In keeping with the principle of low maintenance, no paint, plaster, paper, putty etc. have been used and the amount of wood in the structure is kept to a minimum. The entire structure, including the front wall, is enclosed in a water proof membrane; 5mm APP modified bitumen felt. Apart from the floor, all are insulated with 100mm polyurethane foam. Fire resistant materials have been used throughout. The designer expects a lifetime of several centuries from this structure.



U-values: ($W/m^2 °K$)
Floor and
Back Wall - 0.19
Roof - 0.20
Front wall - 0.26
Glazing - 2.0

Envelope Heat Loss:
(kW/°K)
Fabric - .25
Ventilation - .15

SERVICES

The installed services are extremely simple. There are no heating services provided in the extension. Hot water is provided from the main building; each bedroom contains bath and toilet facilities. Domestic scale small power and lighting circuits are provided. As the majority of the structure is essentially air-tight, there are no natural ventilation routes, mechanical ventilation is essential. This is provided by a balanced system producing a nominal 0.5 acr, boosted to 3 acr under occupant control. Fresh air is drawn through the solar corridor where it can be preheated, while the extract ducting is contained within the supply duct so that it acts as a rudimentary heat exchanger, to reclaim heat from the waste air.

Installed capacity:
Space heating- 0 W/m^2
Lighting - 8 W/m^2

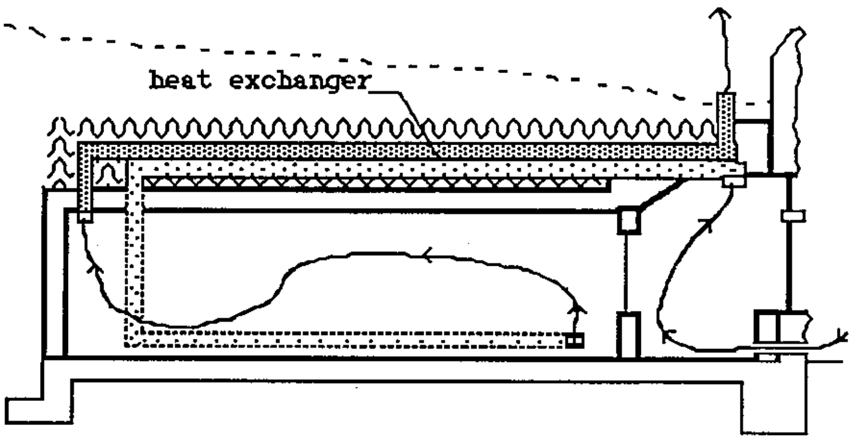
Design conditions:
Internal temp - 20°C
Ventilation - 450 m^2/h

PASSIVE SYSTEMS

While some direct solar gains to the bedrooms may be expected, the primary strategy is to heat the corridor through solar gains. This space then acts both as a thermal buffer to the living areas, and as a source of preheated fresh air. The ventilation system draws outside air through the corridor before it is ducted to the rooms. The internal surface of the corridor is finished in dark coloured facing brick, to enhance the absorption of solar gains. As the rooms are partitioned from the corridor, there is no need for curtaining on the external windows, and there is therefore little clutter to reduce solar gains.

Glazing data:
South facing - 27 m^2 (100%)

Estimated solar contribution:
average jan day: 12%
average apr day: 66%
average oct day: 57%



Heat exchanger area:
16.5 m^2

In summer, high sun angles will eliminate direct gains to the bedrooms, whilst the corridor will generally be protected by extra ventilation promoted through external doors being left open. Should the corridor temperature rise too high for comfort, there is a secondary extract system which channels the unwanted hot air through a piping network in the earth fill above the roof, hopefully storing some of the energy for later use.

The placing of the insulation near the inner leaf helps to keep the interior responsive; the rooms warm quickly as they are occupied. The earth banking provides a near constant temperature sink, approximately 10°C throughout the year. This helps to prevent the rooms from becoming cold and also provides protection for water services, should they not be occupied for long periods.

BUILDING COSTS

Assessing costs for this building is difficult as much work was done voluntarily, and some materials were available free of charge. The total cost was £120 000 (1987). Allowing for uncertainty in the construction costs, this is comparable to average UK costs for residential buildings. While considerable savings have been made on services and finishings, these have been largely offset by the extra costs incurred through the high strength, quality and durability of the constructions used.

Building cost:('87)
£330 - ECU200 /m^2

Typical costs:('87 UK)
Hotels - £496/m^2
Communal Housing - £432/m^2
Communal Housing (rehab) - £352/m^2

ENERGY PERFORMANCE

The extension has been in use for a full season; the bed-sitter has been permanently occupied, while the occupancy rate for the bedroom has been approximately 20-25%. Since the external windows have been installed, there has been no auxiliary heating used in the extension (although fan heaters were to be made available on request). The internal temperatures have stabilised, with little drift, to around 20 C throughout the year.

Annual fuel use:
(estimated)

Delivered- 57 MJ/m^2
Primary -212 MJ/m^2

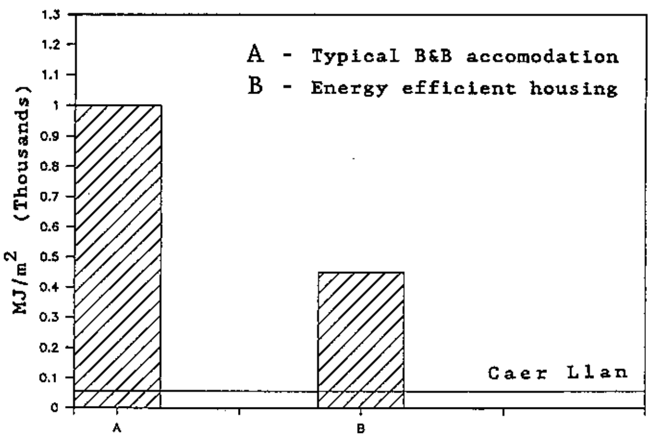
Average UK fuel use:
Bed and Breakfast Accomodation
(heat and light only)
1000 MJ/m^2

UK Targets:

Energy Efficient Housing - 450 MJ/m^2

The energy use of the extension has not been metered separately from the main building. A reasonable estimate of electric use can be made from the known services and the occupancy rate. The ventilation is provided from two 240 watt fans; these are assumed to be on full 24 hours a day. Each bedroom is assumed to be in use 8 hours a day for 30% of the year; when in use a maximum of 250 watts is assumed for lighting and television use. This provides as an estimate:-

FUEL TYPE	FUNCTION	est. DELIVERED FUEL (MJ) Total	/m2
Elec	Ventilation	15 000	41
Elec	Light and Power	6 000	16
Elec	All	21 000	57



In practice the ventilation fans are not always run at full speed, particularly when the rooms are not occupied, and occupants would not necessarily use all available lighting for 8 hours a day. Thus this should represent an upper limit on the energy use of the extension.

Even allowing for considerable uncertainty in these figures they compare extremely well against typical UK energy use in the residential or domestic sectors. A survey of UK Bed and Breakfast accommodation in 1981 suggests a typical energy use for heat and light of 49 GJ/bedroom or approximately 1000 MJ/m2.

HUMAN FACTORS

Visitors reactions to the extension have been very favourable. There have been no complaints of under-heating, or of claustrophobic feelings. With only one 'window' to each room, sealed and in actuality leading only to the corridor, the latter may have been a considerable problem. Somewhat austere in appearance, the rooms are however comparable in feel to typical 'motel' type accommodation and far better than the usual student/institutional bedroom. Due to the very heavy materials used, noise insulation for instance, is very high.

Occupancy:
29 adults maximum

Target occupancy rate:
30%

Retrospectively the owner regrets the choice of 0.5 acr as the basic ventilation rate; a room with four adults becomes stuffy quickly and fogging of the window can occur. The owner now recommends that the boost extract fan is used continuously when a room is full.

Due to the waterproofing of the structure, the building will take many years to dry out completely. Given the expected lifespan, the owner does not consider this to be significant. Currently the internal humidity is high (70% at 21 °C), but not unduly uncomfortable.

The owner is highly satisfied with his extension. It is worth noting, however, that due to the lack of central heating and of openable windows, he is finding it difficult to have it listed in tourist accommodation guides.

CONCLUSIONS

A motel-like bedroom extension incorporating simple earth sheltering and passive solar techniques, provides a low energy, low maintenance building requiring zero auxiliary heating, with an acceptable internal environment. Savings made in the capital costs of installed services are offset by high construction costs for the fabric however. Apart from the added complexity of a mechanical ventilation system, there is no reason not to expect the structure to remain viable for at least as long as the house to which it is attached (200 years +) with little effort or cost.

A successful "zero-energy" building extension.

INFORMATION

Data used in preparing this report has been supplied by the Caer Llan Field Studies Centre. Further information is available in their pamphlet; "Caer Llan Berm House". P. Carpenter, 1988, Caer Llan Field Studies Centre, Lydart, Monmouth, Gwent.

BUILDING TODAY, 18 August 1988, vol 196 no 5769, pp 19-21; "Breaking New Ground in Buried Houses". International Thomson Business Publishing Ltd, 100 Avenue Road London, NW3 3TP.

Report Prepared by:
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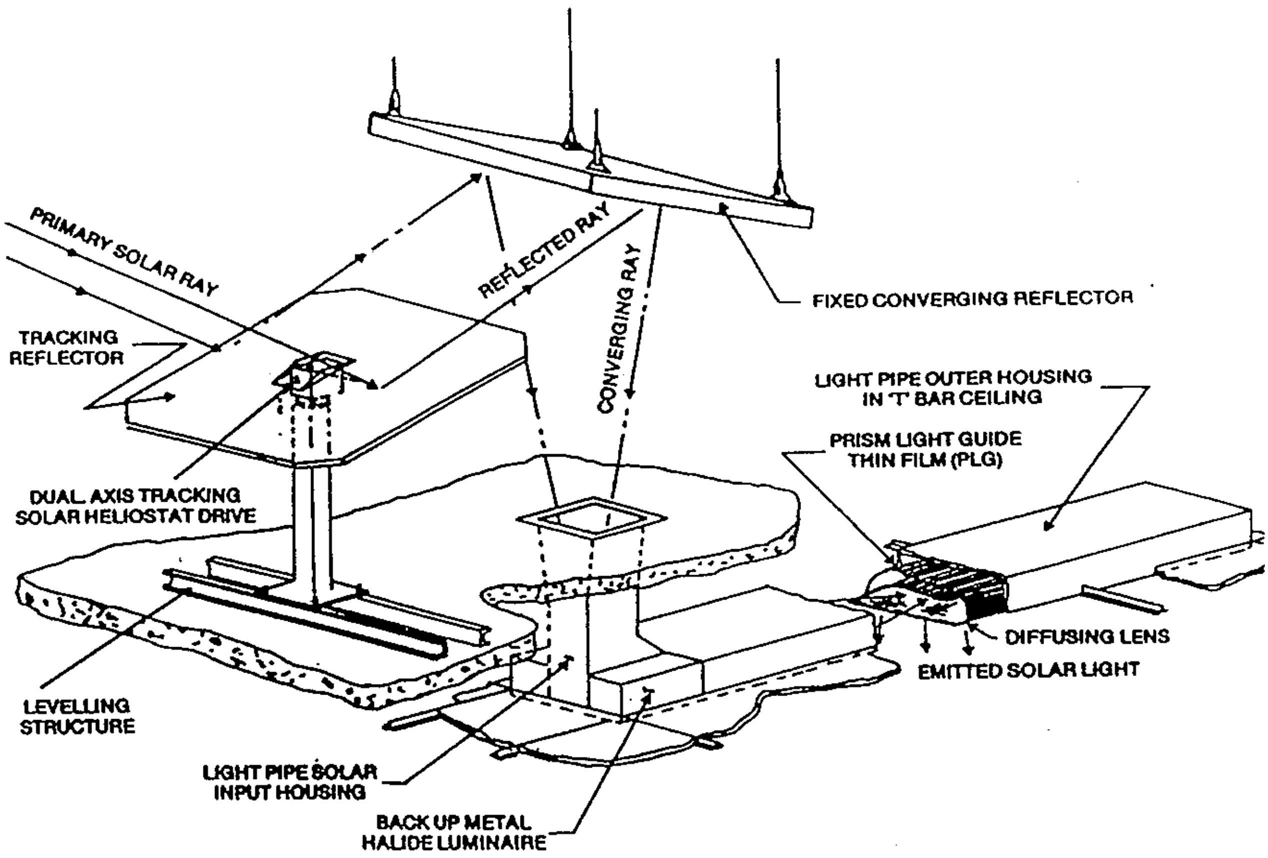
The cooperation of Peter Carpenter in preparing this report is acknowledged and appreciated.

SPECIAL CASE STUDIES

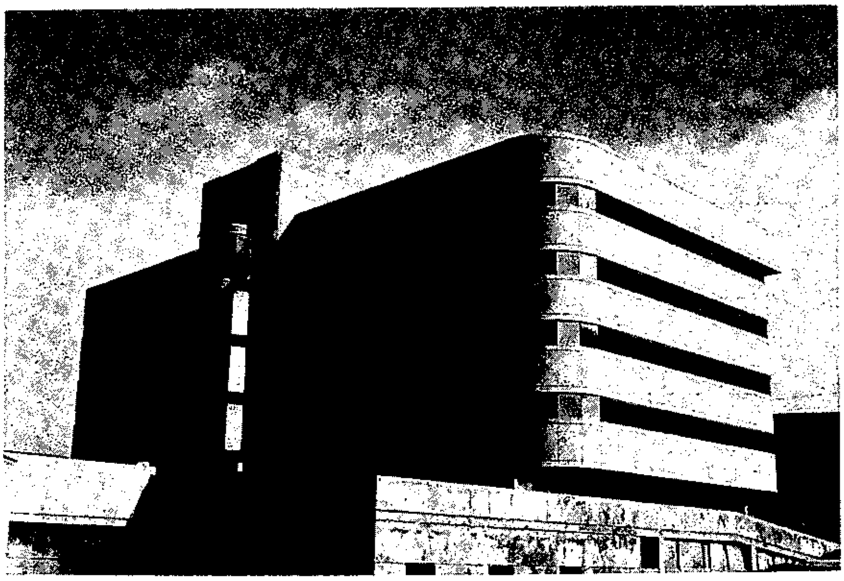
BCS No.	Building Title
46	VICTORIA PARK PLACE
47	SOLAR LABORATORY
48	INSTITUTE BUILDING 'ENTE'

A typical solar Light Pipe installation



CDN

VICTORIA PARK PLACE



Building type:
Office

Passive feature:
Indirect Daylighting

Date of occupation:
February 1986

Floor area:
2,000 m^2
Pipe light: central 200 m^2 of 5th floor (top)

Capital cost of H/LP:
$ 2 00 000 Cdn.

Annual delivered fuel:
For H/LP back-up:
66 960 MJ (electric)
= 335 MJ/m^2

Client:
Energy, Mines and Resources (EMR) of Canada and Konvey Construction Co.

Design teams:
TIR Systems Limited:
L. Whitehead, President
J. Scott, Chief Engineer
B. York, Photometrics Engineer,
B. Lee, Electronics Engineer

Monitoring agents:
Victoria Park Place Investments Limited

SUMMARY

This installation is the world's first Solar Light concentration and distribution system through use of patented light guide technology.

Capture of sunlight on the roof of the building, transition via a 0.74m^2 total aperture area, and even distribution over a core office area was demonstrated.

Features include computer control of heliostat heads for sun location, plus operation of auxiliary luminaires to feed LIGHTPIPE™ guides in times of lower solar light input.

Uniform light distribution at a nominal level of 753 lux has been produced by this distribution system.

Full information on the building is not available but it is included as a case study because of interest in the LIGHTPIPE™ system.

PROJECT DESCRIPTION

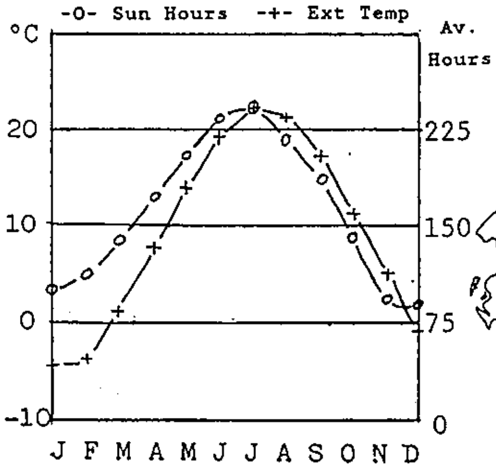
The project was conceived jointly be TIR, Konvey and EMR.

The driving motivation of all parties was to demonstrate an environmentally sound, renewable energy source for daylighting, without conventional glazing approaches. The approach taken is the application of leading edge technology. The ultimate goal is to make this a mass produced, cost effective alternative to conventional lighting.

Monitoring consists primarily of observing light levels and checking for continual system operation, that is, sun-tracking of heliostats.

SITE AND LOCATION

The building is situated north of Toronto, Ontario in the suburb of Willowdale.



Site data:
Latitude: 45°N
Altitude: 300 m

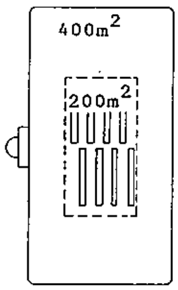
Sunlight data:
Actual bright sunshine hours = 960
Actual/possible = 0.33

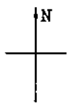
Actual hazy sunshine hours (half power) = 840
Actual/possible = 0.29

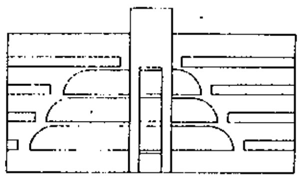
Solar light active
Actual/possible = 0.62

BUILDING FORM

Five storey building with windows on exterior walls of all storeys. Indirect daylighting of core area on the top floor, covered by an opaque ceiling.







SCALE 1 : 200. 0 5m

5th floor area:
400 m^2

Core area with LP light:
$200m^2$

Ceiling height:
2.7m

Transition from roof:
1m

BUILDING CONSTRUCTION

Not applicable.

U-values:
Not available

Envelope heat loss:
Not available

BUILDING SERVICES

The Heliostat/LIGHTPIPE™ System delivers virtually no heat to the inside of the building, since it is a far better light transport than thermal energy transport system.

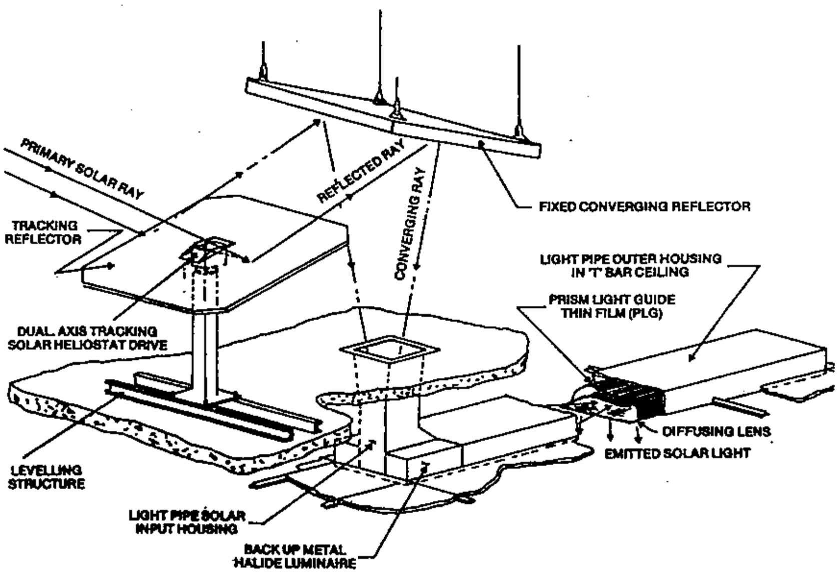
Mechanical ventilation is required in the Heliostat Solarium area, which must be kept relatively dust free, yet cool enough to prevent motors from seizing up. Superior moving parts are under investigation.

Converging mirrors (8):
Area: 1.3m^2
Shape: circular
Height: 2m above heliostats

Heliostat mirrors (8):
Area: 2.2m^2
Shape: Rectangular
Height: 1m pedestal

Space of sub systems:
1.2m between heliostats

A typical solar Light Pipe installation



COSTS

See summary section.

ENERGY PERFORMANCE

Lighting capacity in core offices:
753 lux at workplace
10.00am - 4.00pm on sunny days in April and September

Auxiliary levels:
400 or 800 W metal halide:
538 lux maintained

Auxiliary light sources:
2 x 400 W metal halide HID sources, collimated.

Annual fuel use:
335 MJ/m^2

Occupancy:
12 - 15 persons.
16 m^2/person (approx.)

Light effects:
No glare
Good colour.

The Heliostat/LIGHTPIPE™ System control currently draws 2600 kW hours/annum (300 W continuous) mainly due to stepper motor load. This can be mostly eliminated by use of brakes. A solar battery can drive the system (not currently installed, but recently tested).

The auxiliary lighting for this space is provided by two 400W high intensity discharge (HID) sources, which also feed into the light guides, near the roof solar transition. With one source off on hazy days and both off on sunny days, this represents a saving of 9.6 MW hours per annum.

HUMAN FACTORS

The effect of cloud passing across the system is noticeable to persons who are not near windows, via dimming. This is referred to as a "pleasant, natural" effect by occupants.

Slow start of the metal halide (MH) sources gives gradual change in light; when an electric source is shut down, change is abrupt. Frequent transitions are prevented by a computerised time lag.

The MH colour temperature is very near that of solar, although it does not contain full spectral components.

CONCLUSION

The unknowns have been eliminated through this first system installation, including:

a) Sun prediction geometry - many sun tracking systems fail to "lock-on" to the light source. The TIR algorithm has been determining sun position accurately for two years.

b) Reliability - the computer control and heliostat head motors have operated without fail for over two years, suggesting redundant components are not needed.

c) Efficiency - The overall light transport ability has been demonstrated to fall in the range predicted, namely 25-30% of input light flux. This is critical in determining heliostat and other mirror sizes for new system designs.

d) Cost - The primary challenge remains cost reduction of components. Hotter climates may be faster able to make this system economically viable, due to higher sunlight input and reduced cooling needs in building interiors.

Features:
* Reliable system
* Predictable light output
* Good light distribution and illuminance levels achieved
* Needs cost reduction

INFORMATION

References:

"A Demonstration of Large Scale Core Daylighting by Means of a Light Pipe".

Presented at 1986 International Daylighting Conference, 4 - 7 November 1986, Long Beach, California.

Paper #143
L.A. Whitehead, J.E. Scott, B. Lee, B. York, TIR Systems Limited.

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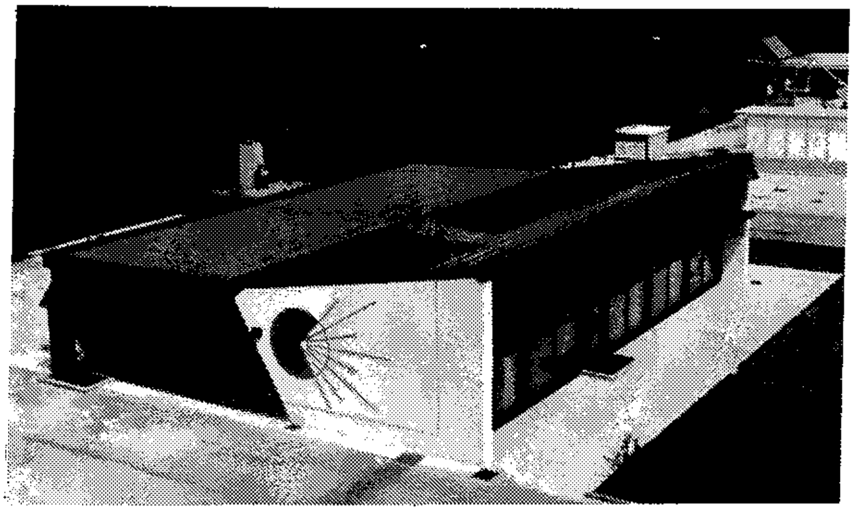
CEC SOLAR LABORATORY



Building type:
Office

Passive features:
Solar heating
Direct gain with
heat pump.

Daylighting:
Direct

Solar control:
Shading

Occupancy date:
December 1986

Floor area:
Total: 260 m^2,
of which:

Sun space 90 m^2
Heated surface 210 m^2

Building cost:
ECU 208 000

Annual fuel use:
Elec 0.11 GJ/m^2

Design & monitoring:

D. van Hattem
and
R. Colombo

SUMMARY

The Solar Laboratory in Ispra has a passive solar heating system using a heat pump and a long term heat store. The passive system consists of a sunspace with low thermal inertia, attached to an exsisting building.
The aim of the project is to study the control of a direct gain system and the possibility of storing the heat of such a system over longer periods of time.
The first operational results of the building show that considerable energy savings are possible, while maintaining a good indoor climate.

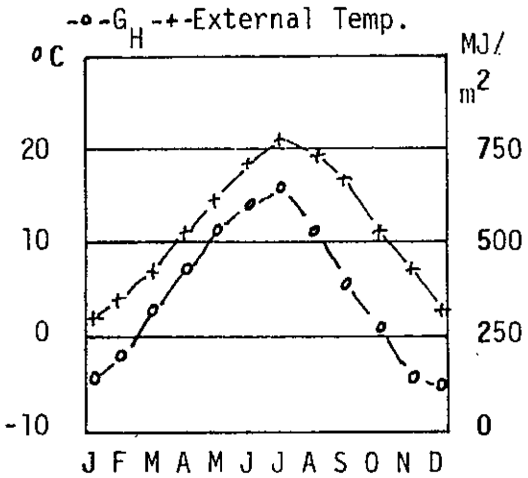
PROJECT DESCRIPTION

The Solar Laboratory is a project in the "Non Nuclear Energies" Programme of the Joint Research Centre of the Commission of the European Communities, at Ispra.

The aim of the project is to study the control of a direct gain passive solar system, while integrating it with long term heat storage and a heat pump. This control concerns mainly the storage and re-use of the excess heat from the direct gain passive system. The importance of this, is related to the fact that passive storage techniques tend to release the heat during the night, when it is not needed. Also, given the relatively limited amount of time that heating is required in most commercial buildings (roughly 40 % of the time), light weight constructions will benefit more from intermittent heating schemes.
The project involves the modification of an existing building by the addition of a light weight sunspace.
The design and the operation of the sunspace is intended for use in commercial buildings (no heating required during the night).

SITE AND LOCATION

The project is located at Ispra, about 60 km N.W from Milan, in a region between the Alps and the Po valley. The climate is characterized by stable, sunny winters and warm, humid summers. Large amounts of precipitation are common in the fall and spring.
The building is sheltered on the North side and is almost shadow free on the South side.



BUILDING FORM

The single story building is rectangular and it consists of two parts: main building and sun space. The main building is of heavy construction. It was built in 1976 for the study of active solar heating and cooling systems. For this reason, the South facing wall has an inclination of 60°. In this inclined wall there is a direct gain system of about 15 m^2. These windows also ensure day lighting for the Northern part of the building. The glazing on the North, East and West sides is minimal.
The sunspace is designed for a maximum heat gain during the winter and minimum gain during the summer. It differs from sun spaces in Northern latitudes in that there is no horizontal glazing, since it is very difficult to shade such glazing during the summer time. For the same reason East and West glazings have been avoided.
In the building there is a meeting room, a hall and an machine room. The sun space is used as library and exhibition room.

Site data
Latitude 45° 48' N
Longitude 8° 37' E
Altitude 257 m

Climate data:
Oct6. to April (inc):
Degree days 2 857
(base 20°C)
G_H 1 661 MJ/m^2
Actual sun hours 945
Actual/theoretical 0.46

Annual:
Degree days 3 094
(base 20°C)
G_H 4 354 MJ/m^2

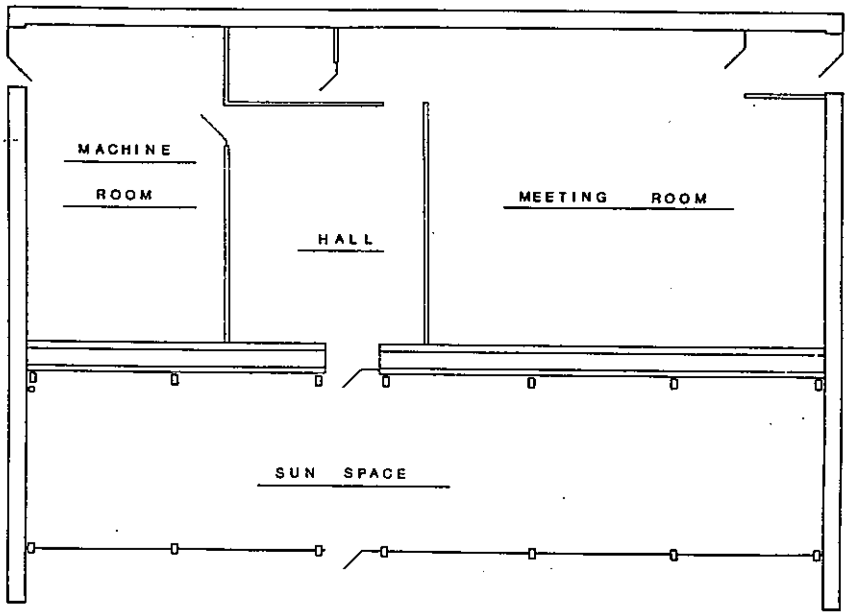
Volume:
Gross 865 m^3
Heated:
main bldg. 380 "
Sun space 320 "

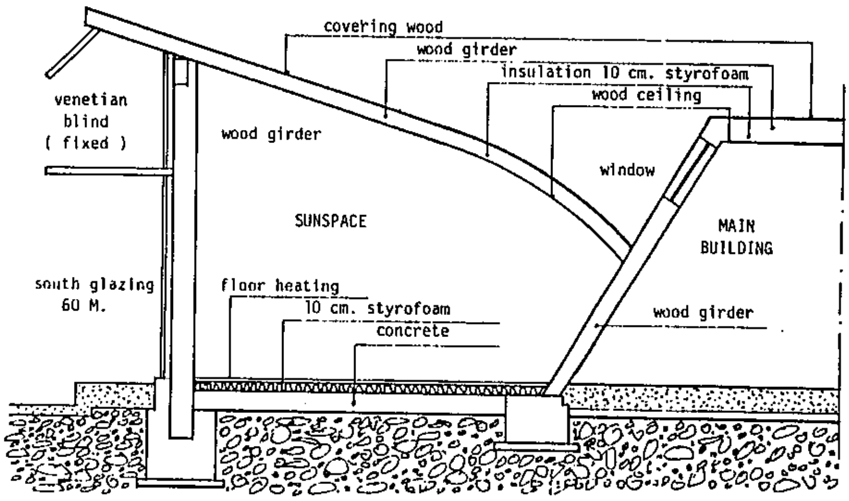
not heated:
Machine room 165 "

Dimensions:
Floor to ceiling height:
sun space 3.4 m
(average)
other rooms 3.1 m

Surface areas:
Total floor area 260 m^2
Sun space 90 m^2

Window data:
Sunspace:
Glass area is 90 % of South facade
Main bldg.:
18 % of South facade
15 % of North facade





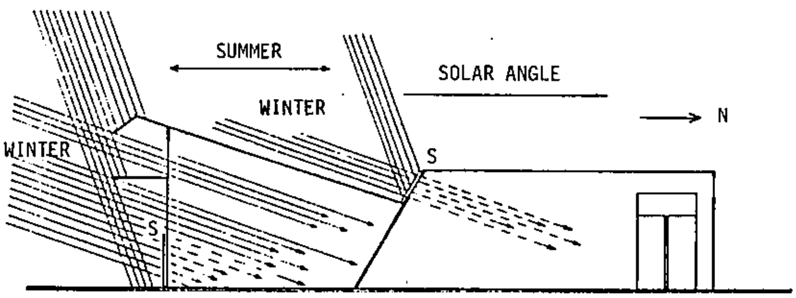
BUILDING CONSTRUCTION

U-Values:		
Floor	.222	(W/m^{2}K)
Roof	.251	"
Wall	.245	"
Window	1.6	"

Main Building: The North, East and West walls are made of two layers of brick with 12 cm of insulation in between. The roof and South wall are made of wooden girders, with 10 cm of insulation in between and covered by boards. The floor consist of a concrete layer in which heating pipes are incorporated. Under this there is an insulation layer of 10 cm. The South facing windows are shaded with movable louvres.

Sunspace: The composition of the walls and roof of the sunspace is similar to that of the main building. The thermal inertia has been kept as low as possible. The South facade is completely glazed with low emissivity double glazing. Fixed shading devices are mounted on the South facade. The roof of the sunspace is designed to leave a row of south facing clerestory windows in the main building. It is inclined to allow them to receive winter sunshine.

Envelope heat loss:
Transmission .20 (kW/K)
Infiltration and ventilation .30 "



S= SHIELD SUMMER ONLY

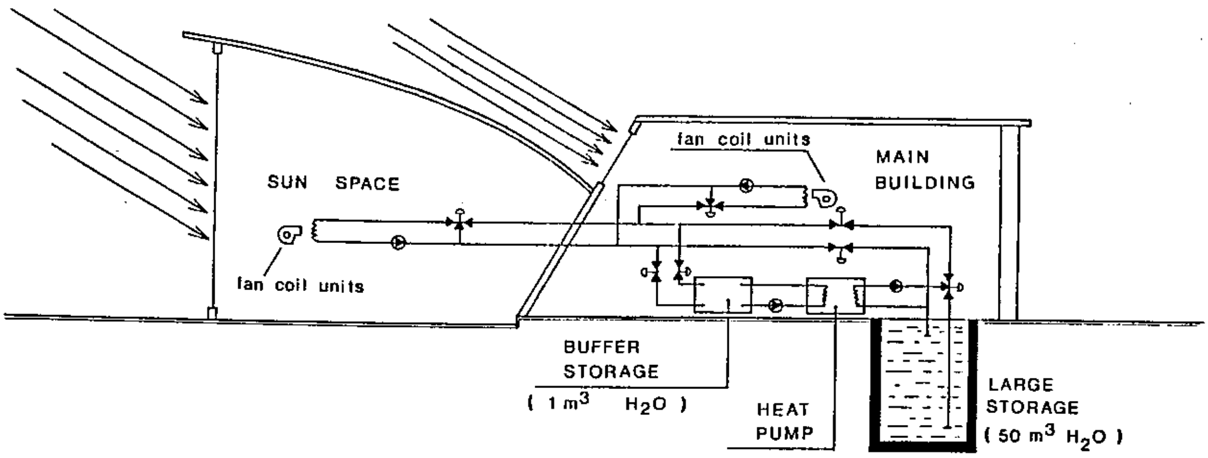
BUILDING SERVICES / PASSIVE SYSTEM

Space heating/cooling: The passive system of the sun space has been deliberately oversized. Over heating ($T_{room} > 22.5$ °C) is avoided by extracting excess heat with fancoil units and storing it in a large heat store beneath the building (see schematic figure). This heat is used with a heat pump to heat the sun space and main building during dull periods.
The sun space is heated during office hours (8.00 to 18.00 hrs.) only.
The main building has a much smaller direct gain system and a large thermal capacity. Overheating therefore occurs only occasionally. Nevertheless also in the main building, fancoil units can cool the rooms and store excess heat in the large heat store. In summer the same system can be used for space cooling.
Ventilation: The main building has a small forced ventilation system which is operated according to need. The sun space has windows which can be opened by the users.
Lighting: Under normal conditions no artificial lighting is necessary in any part of the building. A manually switched fluorescent lighting system is installed throughout the building.

Installed capacity:
Space heating 55 W/m^2

Design conditions:
Internal temp. 20 to 23 °C
Lighting 250 lux

Glazing properties:
Double glazed, low emissivity argon filled (14 mm) U = 1.6 W/m^{2}K
Daylight trans. 60 %
Solar trans. 60 %



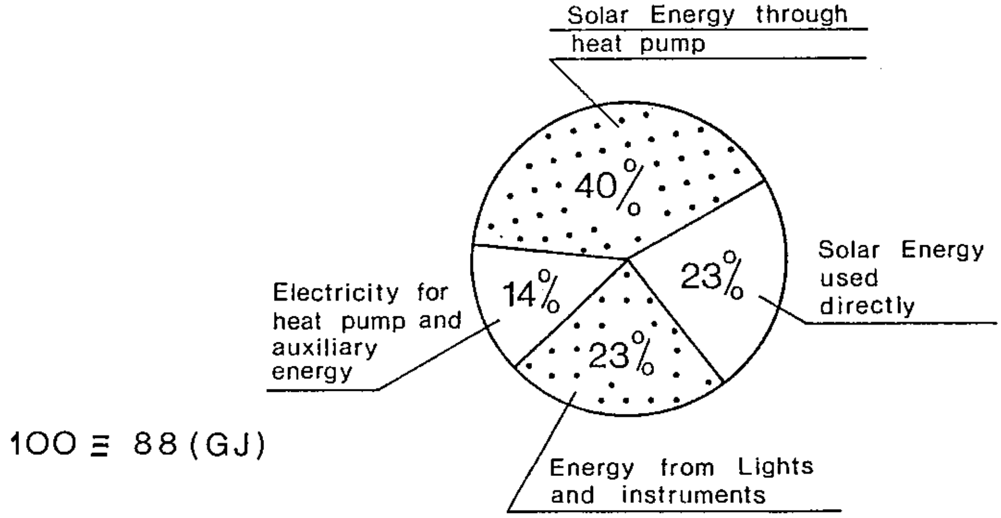
SCHEMATIC VIEW OF THE HEATING SYSTEM OF THE SOLAR LABORATORY AND SUNSPACE

BUILDING COSTS

The building has no particular features which should made its costs very different from the costs of traditional buildings in this region. An economic evalution of the estimated extra costs for the heat storage, heat pump and HVAC equipment, has indicated that a simple pay-back time of around 16 years can be expected under Italian economic conditions (1986). The fact that the same system can also be used for space cooling is a significant economic benefit in this climatic region.

ENERGY PERFORMANCE

The expected energy performance of the building is shown in the pie-chart below. The first experimental results obtained, seem to confirm this prediction. The solar fraction is roughly two thirds of the net space heating load of the building which illustrates the energy saving potential of the system concept.



HUMAN FACTORS

The large window of the sun space give an uninterrupted view of the surroundings , which is much appreciated by the occupants. The temperatures in the building are well controlled even during periods of high insolation. The main problem for human comfort is the noise of fancoil units. Action has been taken to resolve this problem.

Design occupancy:
Variable

Functions:
Research object
Meeting room
Library
Exposition

CONCLUSIONS

- Control of the passive system and the long term storage of excess heat is possible, though not without problems.
- Existing buildings can be "solarized" by the addition of hybrid sunspaces such as this.
- Significant energy savings can be made by manipulating the heat generated in buildings using heat storage systems and heat pumps.
- The human comfort of the system, though already acceptable, could and should be further improved.

Working hours:
8.00 to 18.00 hrs.

INFORMATION

* Van Hattem, D. and R. Colombo, 1986, "Design and analysis of a passive solar heating system with a heatpump and a long term heatstorage for an office building". CIB'86 Conference, Washington.

* Van Hattem, D., R. Colombo and P. Actis-Dato, 1987, "The passive solar heating system of the Solar Laboratory in Ispra". European Conf. on Architecture, Muenchen.

Reports to be ordered from:
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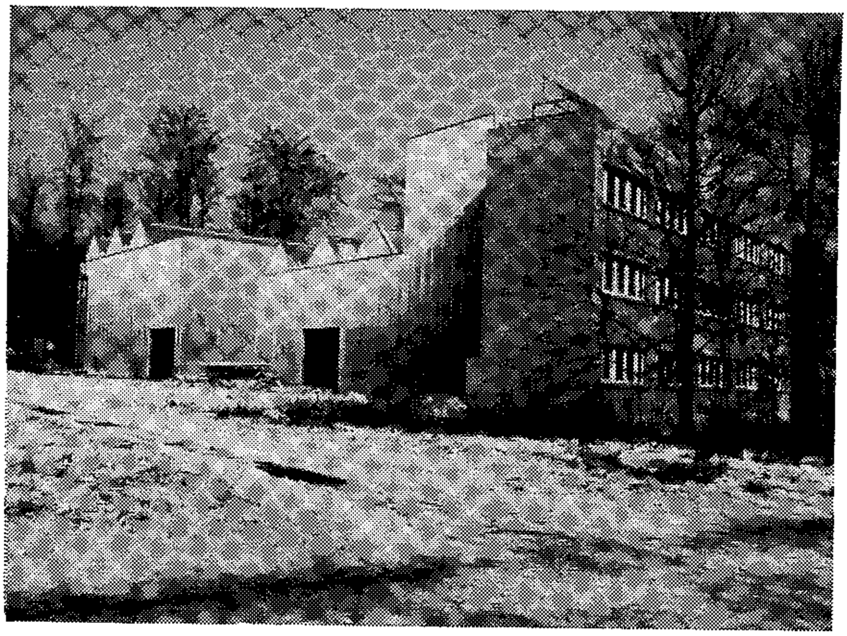
J.R.C.
I-21020 Ispra (VA)
Italy

D

INSTITUTE BUILDING 'ENTE'



South-west view

Building Type:
Office and Laboratory

Passive Feature:
Solar heating:
direct
Daylighting:
direct
Solar control:
manual shading

Occupancy Date: 1984

Floor Area:	m^2
Gross	6 735 (100 %)
Heated	4 850 (72 %)

Cost 1983:	
DM	24.6 Mio
ECU	11.4 Mio

Annual Delivered Fuel:
Heat consumption:
2 152,8 GJ= 319.64 MJ/m^2
Electric consumption:
2 572,5 GJ= 381.96 MJ/m^2
(without heatpump)

Heat & Elect:
4 725,3 GJ = 701.6 MJ/m^2

Client:
University of Stuttgart

Architect:
Universitätsbauamt
Herr Nülle

Energy Consultant:
Planungsunion

Monitoring:
Institut für Thermodynamik und Wärmetechnik

SUMMARY

The institute building 'Energietechnik`of the University of Stuttgart has been designed as an office and laboratory building. It is well insulated and the offices and laboratories are located at the eastern and southern parts of the building, providing large windows. The northern and the western of the building contain very small windows. The shed-type roofs of the two institute-halls are aligned in the east-west-direction, their southern slope serves for mounting unglazed active collectors. In summer the absorbers deliver heat to a seasonal storage of 1000 m^3 volume. During the heating season this storage is discharged by a heatpump to heat the office spaces of the building. More than 60 % of the low heat-demand - caused by passive heat gains and high insulationlevel - has been delivered from the storage.

The occupants appreciate the bright offices and the well daylit corridors.

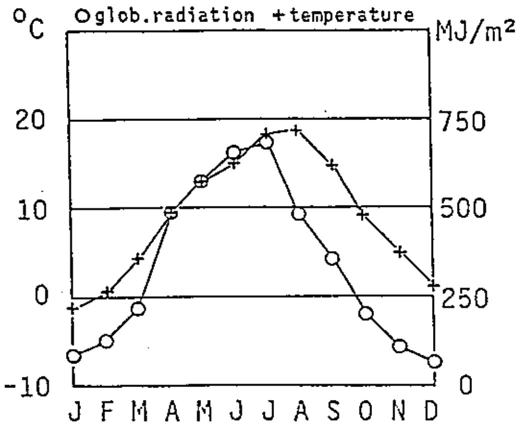
PROJECT DESCRIPTION

The institutes - that occupy the building - are engaged in research work and doing university lectures in the two lecture rooms of the building. The halls serve as an erecting bays and laboratories for large projects.

The apply to the architect describe a low-energy building with well daylight-saving in the working-rooms. The design of the space-heating system was carried out under consideration of a low-temperature heating system.

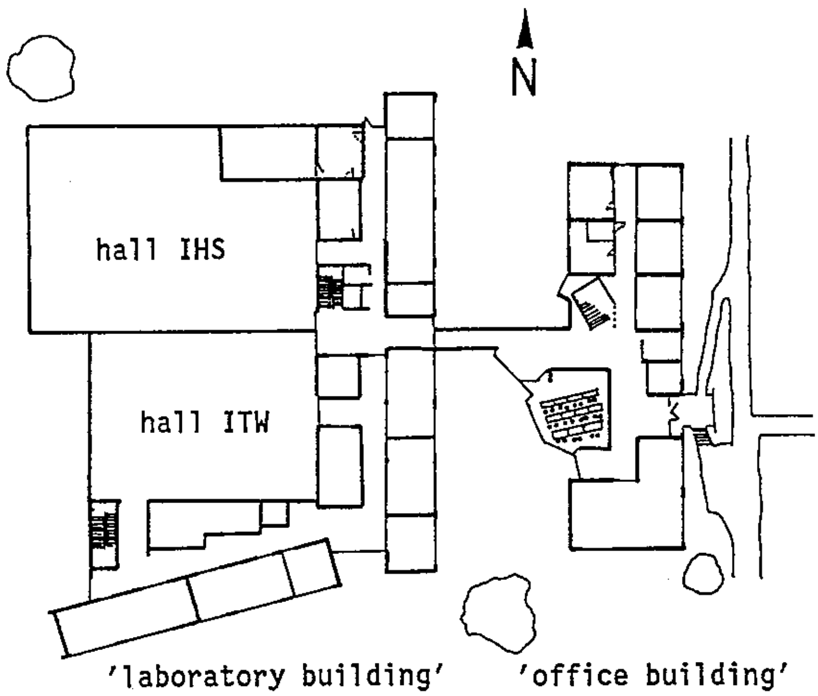
SITE AND LOCATION

The building is located in Stuttgart-Vaihingen in the grounds of the Stuttgart University.



BUILDING FORM

The whole building is divided into two parts: the two storey office-building which is connected by a corridor with the three storey laboratory building. The main orientation of these two building parts is east and south, with the erecting bays as buffers in the north and the west. The social-rooms and the staircases separate the two institutes.



Floor plan of "ENTE"-Building

Site Data:

Latitude	47°47'N
Altitude	460 m

Climate Data:

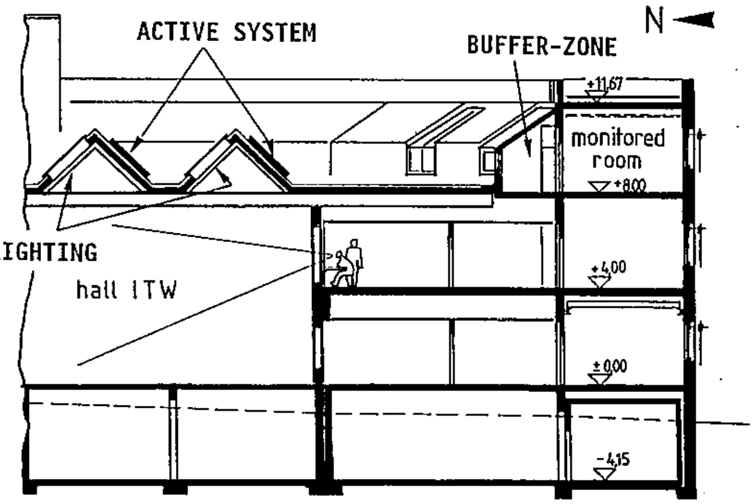
Degree Days:	
October to April:	3 729
Annual:	3 908
Global Radiation:	MJ/m^2
October to April:	1 307
Annual:	4 016
Sun hours:	
Actual:	1 763
Actual/theoretical:	0.40
Average temperatures:	°C
Winter:	6.2
Summer:	17.4
Annual:	9.0

Volume:	m^3
Gross:	33 073
without halls:	19 518
Heated:	25 200
without halls:	11 700
Buffer (corridors, staircases)	5 940

Dimensions:	m
Floor to ceiling height	3.40
Buffer zone (corridor) depth	2.20

Surface Areas:	m^2
Ground floor	2 650
Roof	2 698
Wall (excl. windows)	2 220
Windows	600

Window Data:	%
Glazing factor =glazing/ exterior surface	
East	23.1
South	22.6
North, west	0



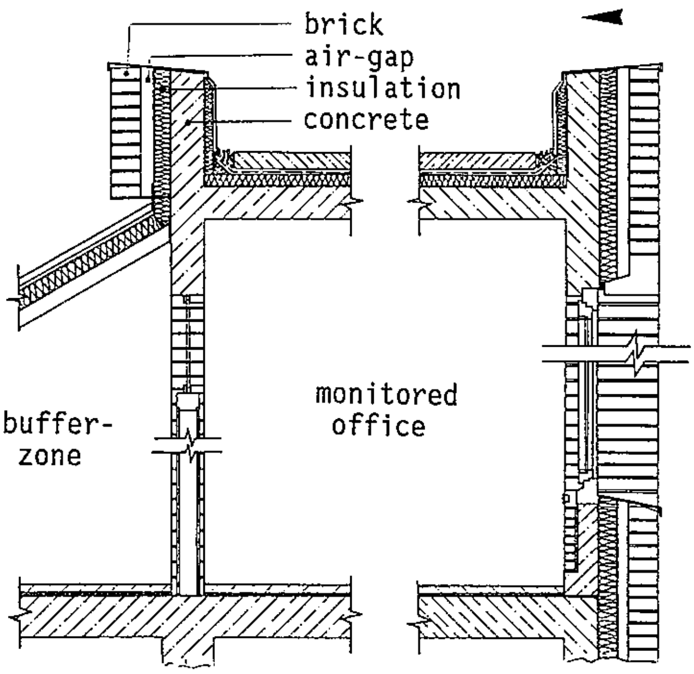
North/South cross-section of the laboratory building

BUILDING CONSTRUCTION

The University building construction is a reinforced skeleton structure with interior and exterior masonry walls. The exteriors walls include rockwool insulation and an air gap of 4 cm. The north and the west facade are covered with aluminium panels. The windows are double glazed and timber framed.

U-values: W/m^2K	
Floor	0.44
Wall	0.34
Roof (average)	0.66
Windows:	
Glass and frames	3.00

Envelope Heat Loss:	kW/K
Transmission: (design)	4.61
Infiltration: (conditions)	0.93
Measured all:	6.57



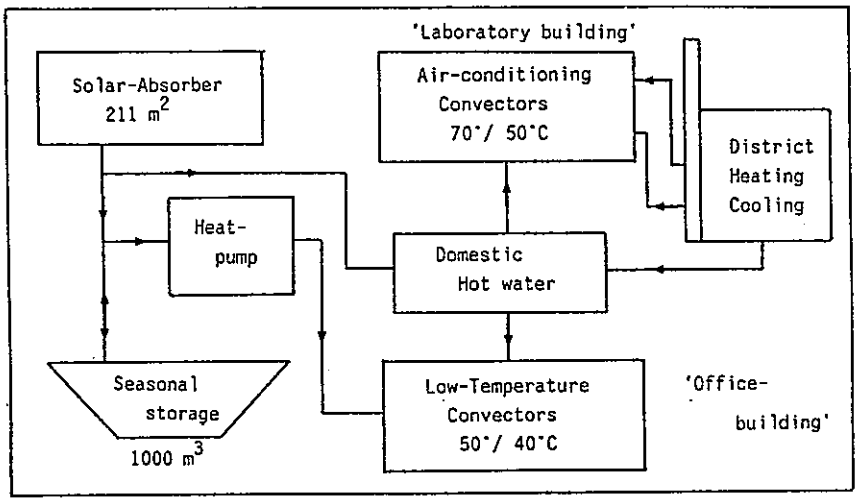
Construction details of a south-faced office

BUILDING SERVICES

Space heating:
The ENTE-building is supplied by the district heating system of the university campus. The part of the building which contains the laboratories is supplied by a conventional heating system 70/50°C. The space heating radiators are dimensioned according to the low temperature heating system in the office-part. A seasonal storage and a heatpump deliver heat to this part. Charged during the summer with the gains of 211 m^2 unglazed collectors, the storage-heatpump system cover 92% of the heat demand. The rooms in the laboratory-building, which are aligned to the south, are provided with air-conditioning, to allow cooling in summer or during an experimental phase. The artifical lighting is switched manually but in the circulation areas - staircases and corridors - time switches are installed.

Installed Capacity:
Space heating:
heated areas 44 W/m^2
Lighting (offices):
ceiling 11.6 W/m^2
task lighting 60 W/desk

Design Conditions:
Internal temperatur:20°C
Lighting (offices)300lux



PASSIVE SYSTEMS

Through large windows the rooms gain maximal daylight but on the other hand they get difficulties through high seasonal heat gains and losses. To avoid overheating in summer it is necessary to close the internal window shading devices manually.

On the north side of the monitored room a corridor acts as a buffer zone to the cold ambient air.

Glazing Properties:
Double glazing
Solar trans. = 85 %

BUILDING COST

Almost 40 % of the building costs are technical equipment of the laboatories.

Building Cost (1983):/m^2	
DM	3 653
ECU	1 699
Reference DM	1 765

Annual Fuel Use:	MJ/m²
Gross space	701.6
Heated space	974.3

Fuel Costs:	DM/GJ
District heating	27.7
Cooling	38.8
Elect.(average)	74.8

ENERGY PERFORMANCE

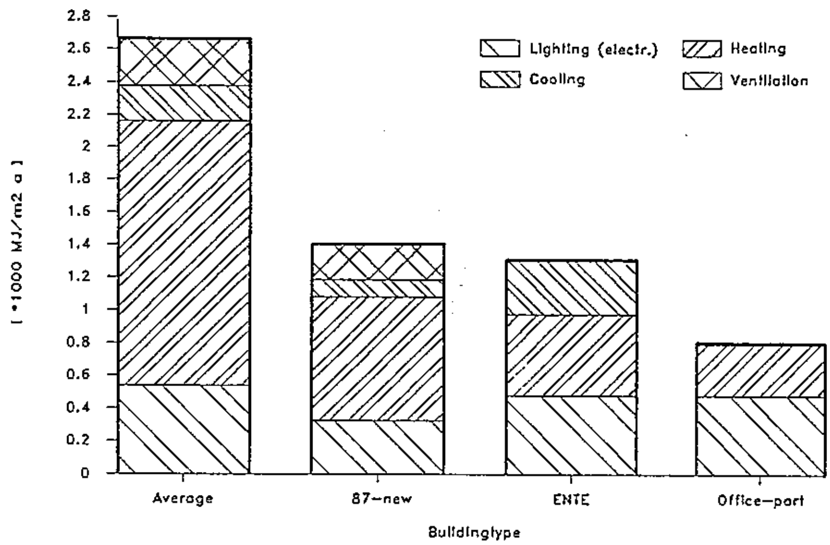
For the whole building:

FUEL TYPE	FUNCTION	GJ	MJ/M²
District heat	space heat	1 613,2	239
District heat	water heat	204,8	30
District heat	all	1 818,0	269
Solar	space heating	216,0	32
Electric	space heating	118,8	18
Electric	lighting, others	2 572,5	382
Electric	all	2 691,3	399
Heat, solar, elect.	all	4 726,3	701

Only for the solar-heated office-part:

FUEL TYPE	FUNCTION	GJ	MJ/m2
District heat	space heat	30,24	20,2
District heat	hot water	35,54	23,7
Disrict heat	all	65,78	43,9
Solar	space heat	216,00	152,64
Electric	space heat	118,8	79,2
All	space heat	365,04	243,6

The comparison of the results of the whole building and the office-part show great differences. The high electric energy consumption in the large experimental halls and in the air conditiond laboratories in the basement of the building cause those differences.



Energy consumption for space heating and global radiation measured during 1985.

HUMAN FACTORS

The aim of the ENTE-building was to get a successful solution to different requirements. The most important issues are the energy saving and the comfortable working environment. The last one influences the work in the offices, laboratories and lecture halls.

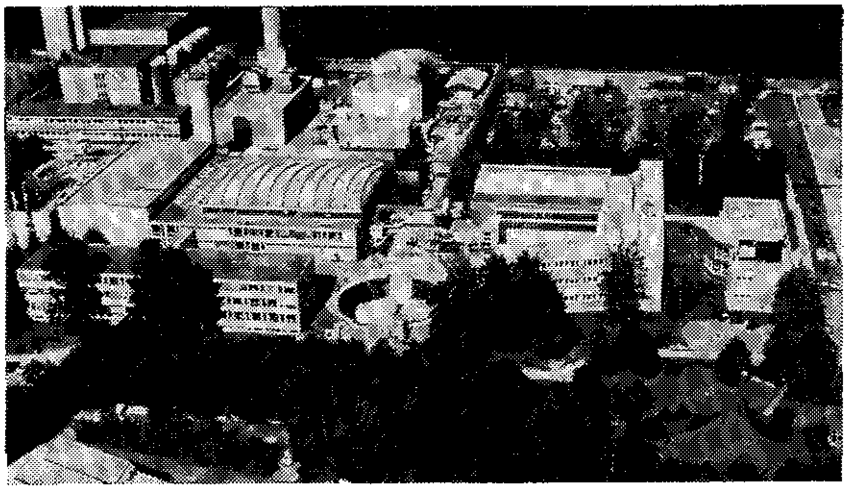
The first two years have shown, that the occupants enjoy their bright offices, which allows working most of the time with daylight alone.

The management of the space heating, which works with an outdoor-temperature control-strategy, shall consider the outdoor humidity too. This size is very important for the amenity at a fixed temperature.

CONCLUSION

The annual fuel consumption was about 30 % lower than the calculated value. It is very difficult to attach this result to the solar gains without monitoring. The space heating system, especially the low temperature part with the seasonal storage and the heatpump works well, but there might be important energy savings by the heating discipline of the occupants.

The monitoring of the energy demands of the whole building, recorded daily, has been started in January 1985 and will be supported by room-monitoring in 1988.



Bird view elevation of total project

INFORMATION

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Herr D. Nülle
Pfaffenwaldring 32
7000 Stuttgart 80
Tel. 0711 685 39 62

Design Occupancy:

Permanent	50
Frequently	30

Function:
Institut office
Laboratories
Computing
Lecture halls

Space/person 12 m^2

Time of Occupancy:
07.00 to 20.00 hours
flexible working times

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