Passivhausschool at Aufkirchen Germany

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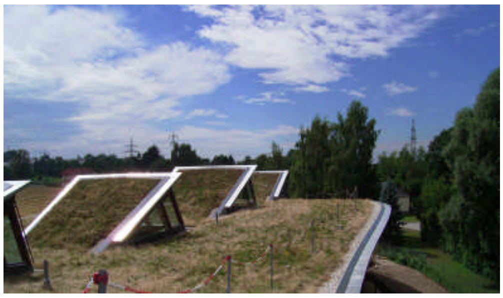
1 Introduction



Sustainability is one of the most important topics for the coming decades. It is desirable to make this matter to an interesting subject for children and youth, because the careful use of resources is an important aspect in the education of the growing up generation. Therefore it will be an ideal situation, if teachers and pupils could learn this in there own school and classrooms.

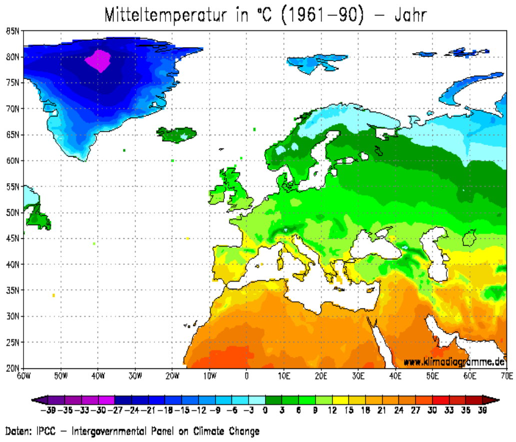
The *Passivhaus* reveals that low energy consumption is possible, and this can be made obvious to the girlsand boys of this school, and they can be trained to use energy economically. That means, the new technology can be understood and learned by the school boys and girls attending this new school.

The construction of a Passivhaus makes it necessary to observe the climate and the building site. These two aspects are very important and must always be considered.

The Montessori school is located in Bavaria near the edge of the alps. This area is the borderline between sea and continental climate. The local climate however is governed by the alps. The temperature averages 7.8 degrees centigrade a year (Oslo has an average temperature of 5.7 degree centigrade).

The building side of the Montessori school Aufkirchen is situated at the edge of an ice-age-moraine on the end of the *Erding Moorland*. Enclosed between the Isar-canal and a small forest, this building is placed at the north side of this small settlement. The location of the school is therefore primarily determined by the landscape and not by the village. Therefore a building with more than two stores was not advisable.

The school is not shadowed by other buildings and plantations are located northern at a greater distance from the school. Planned plantations near the school had to be arranged so that their shadows will not influence the solar profit.



2 Initial Situation

The owner of the new school building is the “Montessori Friendly Society Erding”. This society exists for 10 years. Until the Montessori school moved to the new school building, a building for the elementary school and another for the secondary school was used. Because additional classes had to be installed, it was necessary, either to rent extra classrooms or even a building or to build a new school house. The government of Bavaria therefore urged the Montessori society to build a new building of their own. In this case a monetary engagement of the Bavarian government was determined by law, thus the society decided for a new building. In spite of this situation all regulations for the construction of an official school building had to be observed.

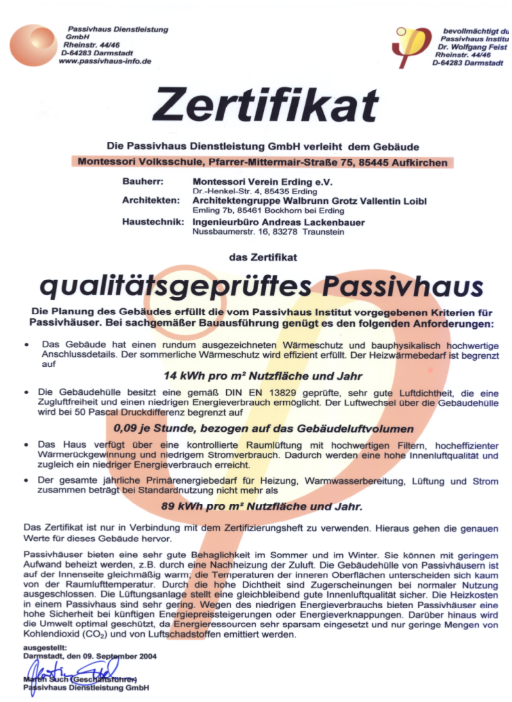
For the Montessori society it was obvious that beside the educational aspects the terms of references concerning the sustainability had to be obeyed.

In this case it was necessary to find architects and planners, who were able and motivated to realize this project.

Soon a Passivhaus construction was accepted as a guideline for this new building. The society decided therefore to observe the Passivhausstandard also because of the useful cost-benefit calculation. The team of planners had on the one hand their own experience with the Passivhausstandard, on the other hand the given planning tools “PHPP”

(**P**assiv **H**aus **P**rojekterungs **P**aket) which plaid an important role in the decision for a Passivhaus. (This tool was developed by the Passivhausinstitut in Darmstadt, Germany).

Additional support was given by the Passivhausinstitut, after the project was certified. Already at the beginning important decisions had to be made in coordination with the Passivhausinstitut, which were relevant for the design and its execution. The planning tool PHPP was the main thread that governed all decisions on the design and its execution in compliance with the energetic concept. For the planning, the PHPP includes special information which should be observed, thus the architect had to make decisions in respect to the planning, of details and their execution already at an early date.



Passivhaus Dienstleistung GmbH
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bevollmächtigt du
Passivhaus Institu
Dr. Wolfgang Feist
Rheinstr. 44/46
D-64283 Darmstadt

Zertifikat

Die Passivhaus Dienstleistung GmbH verleiht dem Gebäude

Montessori Volksschule, Pfarrer-Mittermair-Straße 75, 85445 Aufkirchen

Bauherr: **Montessori Verein Erding e.V.**
Dr.-Henkel-Str. 4, 85435 Erding

Architekten: **Architektengruppe Walbrunn Grotz Vallentin Loibl**
Emling 7b, 85461 Bockhorn bei Erding

Haustechnik: **Ingenieurbüro Andreas Lackenbauer**
Nussbaumerstr. 16, 83278 Traunstein

das Zertifikat

qualitätsgeprüftes Passivhaus

Die Planung des Gebäudes erfüllt die vom Passivhaus Institut vorgegebenen Kriterien für Passivhäuser. Bei sachgemäßer Bauausführung genügt es den folgenden Anforderungen:

- Das Gebäude hat einen rundum ausgezeichneten Wärmeschutz und bauphysikalisch hochwertige Anschlussdetails. Der sommerliche Wärmeschutz wird effizient erfüllt. Der Heizwärmebedarf ist begrenzt auf

14 kWh pro m² Nutzfläche und Jahr

- Die Gebäudehülle besitzt eine gemäß DIN EN 13829 geprüfte, sehr gute Luftdichtheit, die eine Zugluftfreiheit und einen niedrigen Energieverbrauch ermöglicht. Der Luftwechsel über die Gebäudehülle wird bei 50 Pascal Druckdifferenz begrenzt auf

0,09 je Stunde, bezogen auf das Gebäudeluftvolumen

- Das Haus verfügt über eine kontrollierte Raumlüftung mit hochwertigen Filtern, hocheffizienter Wärmerückgewinnung und niedrigem Stromverbrauch. Dadurch werden eine hohe Innenluftqualität und zugleich ein niedriger Energieverbrauch erreicht.
- Der gesamte jährliche Primärenergiebedarf für Heizung, Warmwasserbereitung, Lüftung und Strom zusammen beträgt bei Standardnutzung nicht mehr als

89 kWh pro m² Nutzfläche und Jahr.

Das Zertifikat ist nur in Verbindung mit dem Zertifizierungsheft zu verwenden. Hieraus gehen die genauen Werte für dieses Gebäude hervor.

Passivhäuser bieten eine sehr gute Behaglichkeit im Sommer und im Winter. Sie können mit geringem Aufwand beheizt werden, z.B. durch eine Nachheizung der Zuluft. Die Gebäudehülle von Passivhäusern ist auf der Innenseite gleichmäßig warm; die Temperaturen der inneren Oberflächen unterscheiden sich kaum von der Raumlufttemperatur. Durch die hohe Dichtheit sind Zugerscheinungen bei normaler Nutzung ausgeschlossen. Die Lüftungsanlage stellt eine gleichbleibend gute Innenluftqualität sicher. Die Heizkosten in einem Passivhaus sind sehr gering. Wegen des niedrigen Energieverbrauchs bieten Passivhäuser eine hohe Sicherheit bei künftigen Energiepreissteigerungen oder Energieverknappungen. Darüber hinaus wird die Umwelt optimal geschützt, da Energieressourcen sehr sparsam eingesetzt und nur geringe Mengen von Kohlendioxid (CO_2) und von Luftschadstoffen emittiert werden.

ausgestellt:
Darmstadt, den 09. September 2004

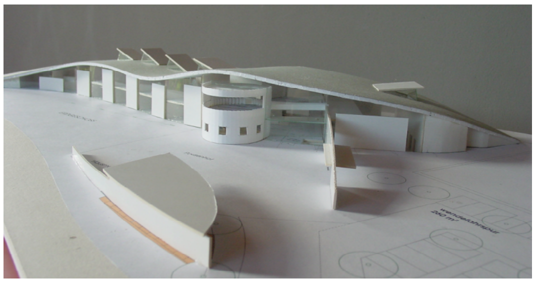
Martin Such (Geschäftsführer)
Passivhaus Dienstleistung GmbH

3 Design

The “Montessori Friendly Society Erding” exists for 10 years and is the private holder of an elementary and a secondary school with the possibility for the pupils to obtain a secondary school certificate. The elementary and the secondary school where placed in two different buildings.

The new building made it possible to accommodate both schools under one roof.

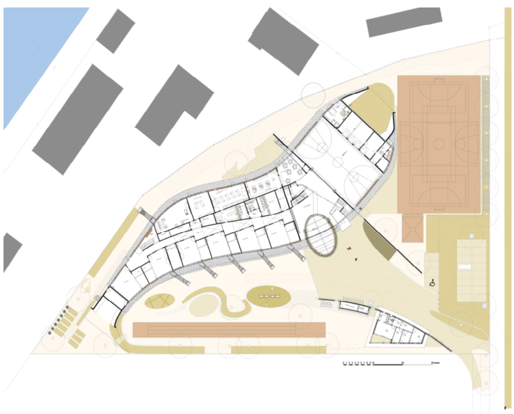
Thus the educational concept to mix the pupils of different ages became reality. This is an important part of the Montessori educational concept. To create a living space for the children was the aim while planning the Montessori school at Aufkirchen. The design shows a two floor building with a curved grass covered roof and a well formed ground plan. The brightness in the cheerful building is the reason for the children to like this school and to use it even in their leisure time. The market roof is harmonically integrated into the landscape, the different heights of the rooms flow due to the curvature steeples into each other. The building has only two facades, because of the roof that reaches to the ground. The south east part opens to the entry and the break area. The north west part shows to the open landscape.



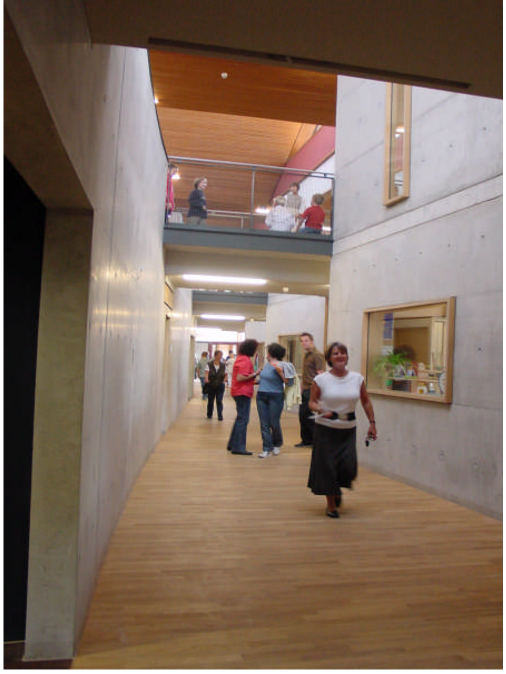
The entry is marked by a facade with a rotunda and a leading wall.

Behind the entry you can see the assembly hall which reaches to the roof. The adjacent dining area can also be used as cafeteria for the pupils. By means of a mobile dividing wall the assembly hall can be enlarged into a gymnasium and a round multifunctional room. In case of large events it is possible to install a mobile grand stand in the assembly hall.

Directly to the assembly hall there is the classroom area. It includes in the ground floor the six secondary school classrooms with the special classrooms and in the first floor the four elementary classrooms with their special rooms and the administration area. The many skylights in the roof and the steerages create a transparent room inspiration. The building corresponds inside and outside with many details and guidelines of



the Montessori education concept, with which the architects where confronted while sitting in the classrooms in order to get an idea of Montessori education.



4 Building Expenses

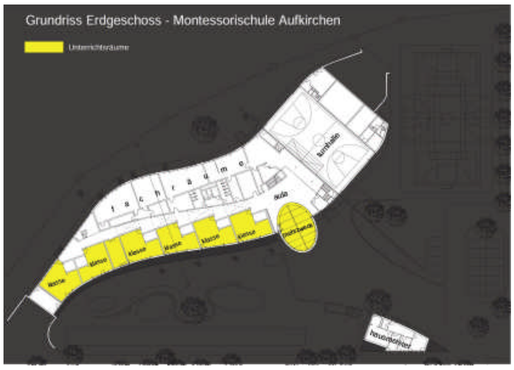
In spite of the ambitious design of this building, it was necessary to observe economy rules. Therefore we had to observe the budget that was pretended by the government. The costs of construction amount to 5.4 million € (about 44 million Norwegian crowns).In this frame the energy saving measures in form of an ecological rated construction are enclosed.

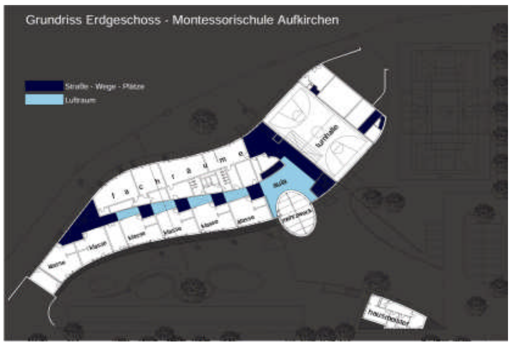
The Montessori Friendly Society was able to realize this project, because the Bavarian government supported it. The raising funds amounted 80% of the costs. The rest of 20% had to be raised by the Montessori society.
Because the society was only able to pay 20% of the costs, therefore the budget was limited to the encouragement of the government. The ecological rated construction had therefore to be realized to the costs of a normal - a conventional - building. Additional costs had to be compensated by saving expenses.

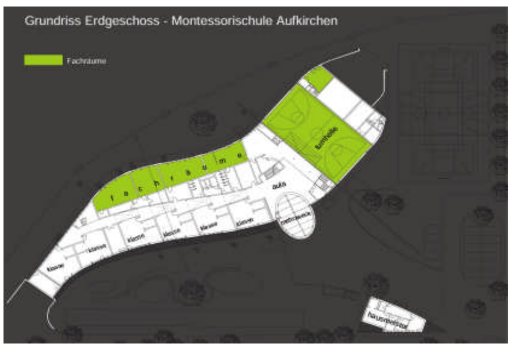
5 Energy Concept

The Montessori elementary and secondary school in Aufkirchen is the first certified Passivhaus school that was realized as a new building. The compact shell is heat insulated by means of ecological rated glazing and windows. The controlled ventilation with heat regeneration supports the building with fresh air.

5.1 Zoning and Compactness as Aspects of Passivhaus Standards





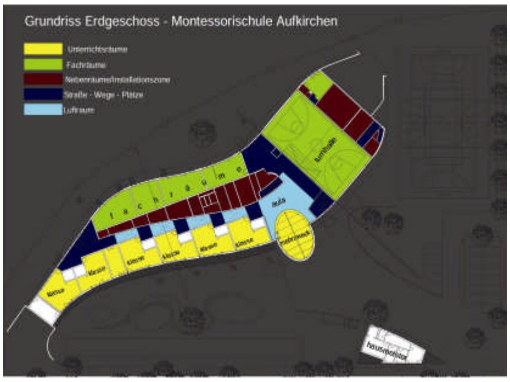


Large buildings can only be energy and cost efficiently be realized, if they are planned as a compact structural shell. More than two stores were not indefensible, because the building site is located at the edge of a small settlement. The building was designed with two facades only. The disadvantage, which resulted out of this concept, was an illumination problem that was solved by roof glazing and skylights. By means of skylighs and the underneath air flooded area a light flooded zone comes up. Thus quality improvement of the building is attained and the school becomes a place of reflection.

A consequent zoning was required. The structural shell therefore had to be built in north-south direction, in order to gain maximum solar energy for the main rooms. Not so important rooms are situated in the north part of the school. By a distance of about 20 to 28 meters the following zoning was designated:

- south part: class rooms, multifunctional area and assembly hall.
- centre: other not so important rooms, store rooms, staircases and corridors - circulation floor spaces.
- north part: special training rooms and administration rooms.

All classrooms have a direct exit to the school garden, also the first floor has a direct exit via staircase. These outside staircases are at the same time part of the fire prevention concept. The staircases are situated, so that no shawdowing is placed. The same situation is given in the upper floor, where special rooms for drawing and music instruction and the lounge are located. To increase the compactness the gymnasium is situated at the long side of the assembly hall. The connection to the assembly hall allows large mutual events, school festivals and other performances. All these elements are means to support the Montessori education concept.



5.2 Coordination between Load Bearing Construction and the Outside Shell

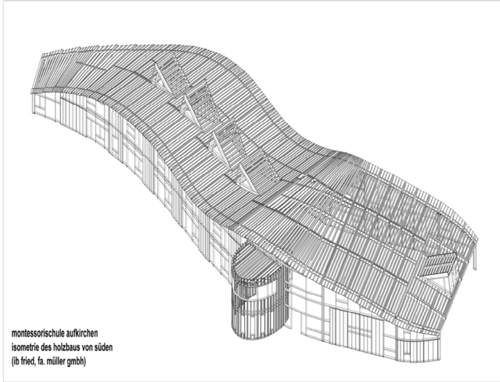
The decision concerning the load-bearing construction was made in favor of a house built in a solid manner. The requirements for noise insulation and fire protection where also easier and cheaper to solve in case of a solid building. It is also an advantage for the climate within the building and the energy concept, if you have a large storage mass.

The basement is constructed in waterproof concrete and all inner walls and ceilings are made of fair-faced concrete, thus the building appears dematerialized. With regard to maintenance costs this is an inexpensive solution.

The facing of the building was planed to be made as a wooden construction, because with wood heat protection is inexpensive. On the other hand, the prefabrication is usual, safes time and reduces costs. However an exact planning is necessary to achieve air-tightness and to avoid thermal bridges.

As far as possible wood should not only be used to build the facades, it is also useful for the interior construction. The combination of ferroconcrete and wood creates a homelike atmosphere.

Because of the mixed construction the advantages of concrete and wood are used in the best way. The basic construction of the building is formed by the inner walls. Most of them carry the construction together with the outside walls, which are wood made. By intention we abandoned from a subsidiary construction, in order to built a roof with a large span length enabling an effective construction. The spacing between the roof grids are dammed with cellulose. The static height creates space, which is necessary to reach the requirements of heat protection for a Passivhaus. Because the horizontal areas of the construction shell required the most space, it was possible to achieve an inexpensive heat protection.

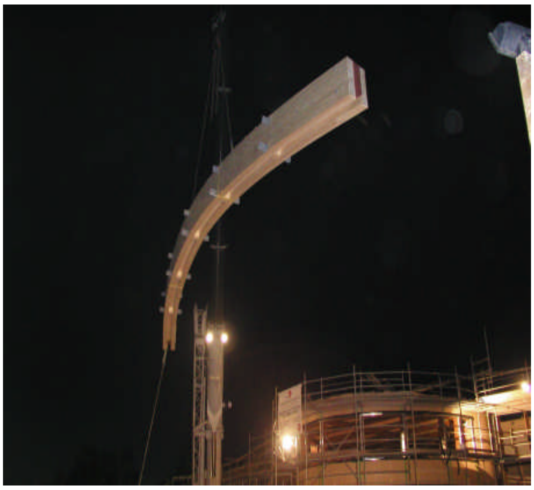


5.3 Requirements for the Components of the Buildings Shell

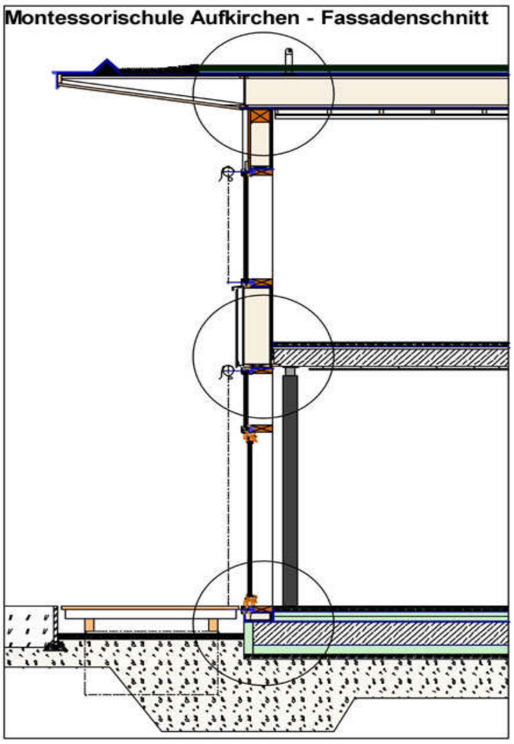
The heat protection is mainly determined by the construction of the roof and the ground floor.

All windows and the glass facades are triple fold. The high costs of the glazing results from the standards of safety for school buildings.

But also the shade was taken into consideration. An exact research on the trees and houses in the vicinity of the school was made to obtain data for calculating the solar profit. All windows fulfill the requirements of a Passivhaus because they have a dammed frame in order to avoid dew on the inner site. Therefore the thermal comfort is adhered to in all window areas.



A perfect air-tightness is a prerequisite for a Passivhaus. Moreover for a wooden construction a quality check is necessary to avoid convection damages. For the Montessori-School we made an air-tightness check with an excellent result of 0,09. This result is even for a Passivhaus an excellent value, because this school is a large volume building. On the other hand this excellent result also depends on a consequent planning of the details, as well as on the professional construction management.



According to the *Passivhaus Planning Tools* (PHPP) a heat demand of 14 kWh/m²a is given. Because of the type of building – the Montessori-School is a large construction - thermal bridges could not in any case be avoided.

The reason: At the point where the ferroconcrete walls touch the base plate heat bridges come into being, this must be calculated. In case of the windows it is possible to avoid heat bridges by damming the frames.

The effort to avoid heat bridges however, should be rationalized because the cost-benefit calculation must be taken into consideration.

5.4 Summary

The energetic concept is strict orientated on the criteria for a *Passivhaus*. The execution however requires concessions. In case of the Montessori School even more concessions could be made to keep the Passivhaus standard. Thus it was even not necessary to dam the window frames.

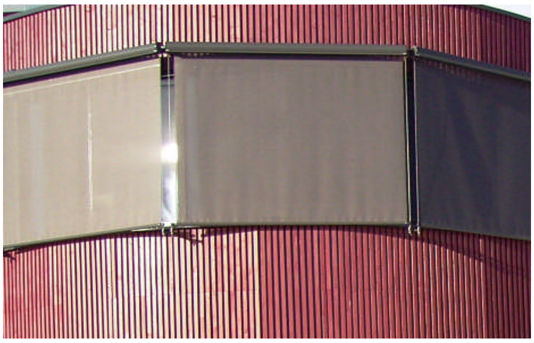
Several heat bridges could not be avoided in all zones. On the one hand heat bridges can in the case of ferroconcrete not always be avoided especially at the ground and ceiling points, on the other hand a good design of a building requires sometimes compromises. It must be pointed out that it is possible to observe the principles of design for Passivhäuser even in the case of large buildings as the Montessori-School. Nevertheless it must always be checked, whether there are other arguments to abstain from executing *Passivhausstandard* for instant physical reasons or cosiness and thermal comfort.

A strict obedience to the construction plan and a good construction management makes cost savings possible. Nevertheless an exact calculation and a continuous check of the development of costs is always necessary.

Coordination of the Housing Technology

A controlled ventilation as a *Passivhausstandard* is especially for a school building important and must already be taken into consideration while planning the building. This is because a large amount of air pipes are involved. All central situated rooms are included in the housing technology concept. The horizontal pathway of the pipes lies invisible above the lower ceiling in the centre of the building. The use of secondary rooms for storerooms have a suspended ceiling. All rooms which need ventilation are situated in the central area.

All automatically controlled components as there are the entrance door and the means of sun protection are to reconcile with other users in respect to the Passivhaus standards. A motivated facility manager is very important in order to take care of the technical devices of the Passivhaus. In case of the multifunctional entry door unnecessary lost of energy could only be avoided with the assistance of the facility manager.



6 Housing Technology Concept

This part of the presentation was compiled by Mister Andreas Lackenbauer, the housing technology planer of the school.

6.1 Ventilation of the School Building

Sufficient ventilation for a classrooms with 30 or more children is compulsory. The reservations against air conditioning can be understood because of the investment costs and the hygienic problems. But the side issues have changed: An efficiently dammed and glazed building enables a better and easier handling of the heating technology as well as an exact planning and more efficient heat protection in summer. Even the ventilation can be optimized in connection with adequate Passivhaus components. Provided an exact planning was made, a better house technology, at the same investment costs and even lower running costs than a conventional technology requires, can be realized. Therefore the costs of the construction of this school - build as a Passivhaus - were not higher than the costs of a conventional school building.

6.2 Ventilation Facility

In the area were the common rooms are located as lounges, classrooms and other rooms, it was the aim to reach a value of not more than 1500 ppm CO^2. The maximum value not allowed to be surpassed amounts to 5000 ppm. With the common window ventilation this value can be fulfilled. The hygienic limit however is surpassed by 70% of the time spend in school.

The continues surpass of the hygienic limits can only be guarantied by technical ventilation. The necessary air-exchange for one person amounts 15 m^3/h.

6.3 Ventilation Engineering

The ventilation facility is not an air conditioning device but only a substitute. Neither air humidity nor room temperature can be regulated with it. The air stream temperature is limited to 16° C. The outside air steam will be reduced from 30 m³h/person to 15 m³h/person.

An additional ventilation by opening the windows is in case of this construction however necessary.

6.4 Total Air Volume

Considering that all classrooms are occupied at the same time, the total air volume of the ventilation facility can be reduced. In the normal case at school the ventilation facility has a capacity of about 6.000 m³h. The maximum capacity however reaches up to about 8000 m³h. Outside the school time and during vacations the amount of air is reduced to about 2000 respectively to about 1000 m³h. In the case that all classrooms are used, the amount of air varies between 100% and 140%.

6.5 Special Rooms

Special facilities for chemical and kitchen ventilation are separated and not combined with the central ventilation.

6.6 Installation of Air Ventilation

All classrooms, special rooms and offices as well as the teachers' room (lounge), the multifunctional room and the gymnasium are supplied with fresh air. The adjustment of the amount of air for each room or zone is done by means of a multipoint switch. All rooms located in the centre of the house as well as the restrooms and the checkroom belong to the exhaust air zone. Surplus air will be exhausted into the upper floor of the assembly hall.

The ventilation centre of the building is located in the basement. Heat recovery is done by a condensation rotor that has a diameter of 1800 mm. The heat gaining amount is about 86% in case of delivery air and 74% in case of exhaust air.

6.7 Heating Energy Concept

Heat production is done by means of a “combined heat and power unit” and with a gas-fuelled “condensing boiler”.

The heating centre together with the ventilation facility is located in the basement. The calculation of the required heat shows a normal need of 75 kW. In this calculation heat recovery is not included. Considering additional energy resources as direct or diffuse solar radiation and internal gain by heat radiation of persons or illumination, the heat output of less than 40 kW can be reached. For the heat production a gas-fuelled “condensing boiler” in use. It is fixed at the wall and it has a capacity of 60 kW thermic.

Additionally a small “combined heat and power unit” with an output of 5,0 kW electric and 12 kW thermic is used. The heat output amounts to 72 kW thermic and this is sufficient to heat the building. The heating output of these facilities are so calculated that at an outside temperature of minus 16 degrees centigrade the used rooms can be heated to 22 degrees centigrade.

This output is however insufficient to heat the building after a considerable cooling. Therefore in a Passivhaus the temperature should never be reduced at night, on weekends or during the vacations.

6.9 Installation of the Radiators

The building is heated by radiators which are installed in classrooms, offices and in the assembly hall. Other parts of the building as the gymnasium, the rotunda, the library, the teachers' lounge and the kitchen are supplied with heat by other heating circles. Rooms - not often used - are not heated. The average temperature is controlled in compliance with the outside temperature. The heating pumps are regulated by closed-loop-speed control and they will be adjusted according to the heat demand.

7 Additional Costs for a *Passivhaus*

The discussion about additional costs for a building constructed as a *Passivhaus* is necessary. Such a discussion is important and forces the architect to reflect the costs in the sense of optimizing the cost-benefit calculation.

In this connection the higher costs for the construction of the building must be compared with the lower costs for maintenance and possible repairs.

An economical calculation will show in most cases the positive result for the *Passivhausstandard.*

The planners play in this case an important role. An inexpensive construction in a *Passivhausstandard* is only possible, if the planner has sufficient experience in the field of planning low energetic houses. Additionally he must be motivated to realize the energetic standard.

If projects are planned as conventional buildings, they can only at the risk of higher costs be rescheduled as *Passivhauses.* That means, all changes which are necessary to fulfill the *Passivhaus* standard later on, will increase the costs.

The price for the housing technology for a Passivhaus standard is not higher than for a conventional building, because of the efficient ventilation and heating conception. To enable this, the ventilation-profile is to be minimized, to have no lost of useful space and volume. Thereby costs are reduced.

The experience of the house technology planner and the assistance of the *Passivhaus Institut* is the guarantee that this can be achieved.

The outer walls, the base and the standard construction are not more expensive than in case of a conventional building. Air tightness is compulsory for each ecological rated building, but does not result in higher costs. A lower air tightness is caused by an inaccurate planning and performance in construction.

Higher costs for the roof elements are not to be expected. In case of the Montessori-School we did not construct a “secondary construction” and thus a cheaper construction was possible. We increased the height of the roof construction from 356 mm to 406 mm. Thereby damming could be reduced and that resulted in lower costs of about 10 €/m² (about 81 Norwegian crowns/m²), because we need less frames.

The windows for a Passivhaus are expensive, because their frames had to be dammed. The price difference between dammed and not dammed window frames however are important. But only a few windows can be opened.

Glazing for a *Passivhaus* is very expensive . For the Montessori-School at Aufkirchen a triple fold glazing was necessary. The considerable costs in this case are caused by the safety aspects and overhead glazing, because the necessary thickness of the glazing is very expensive. The costs of better isolation requiring an additional plane and an additional filling is not significant. Nevertheless all these measures where necessary for this construction, because for this *Passivhaus* - as a school building - a generous glazing was compulsory for having a good illumination.

The discussion concerning the costs must be observed in connection with placing and offering, because submitted tenders differ considerably sometimes by 20%. The calculation often does not consider the costs caused be the planned details of the construction. The only costs that can be reduced are the costs of that elements of the design which will not be realized.

8 Perspective

The concept of Montessori education aims - beside the normal instruction - also at an ecological education. The young people shall experience this already in their own school. That was the reason for the Montessori society to built a school with a high ecological an energetic standard. Definitely the planed energy consumption of the school was reached:

The amount of heat consumption planed according to Passivhaus planning tool (PHPP) is 49.605 kWh/a. The measured energy consumption was 50.927 kWh/a. The difference of 3% between the planed and the measured need of energy was caused by problems with the entry door. In the first month, while the school was in construction, touching-ups of the entry door had to be made. The door had to be left open during the breaks. Therefore a considerable amount of heat was lost.

With the construction of the first certified *Passivhaus*-school in Germany a high energy standard was realized at a low price. Many aspects of the *Passivhausstandard* are advantageous for schools. Especially the controlled ventilation and the high dammed glazing create the feeling of homelike. If you consider the maintenance and energy costs, the school has to pay, the *Passivhaus* is the better ecological and economical solution in reference to a conventional building. The costs of a *Passivhaus* can be limited, if from the beginning of planning the *Passivhausstandard* is taken into consideration. Attention however must be paid to relevant aspects as compactness of the shell and a consequent zoning. A greater planning effort is of course necessary. The *Passivhausinstitut in Darmstadt* was involved in the planning from the beginning, because this building should be certified. Thus the basis for a coordinated and optimized energetic planning was given.

A school as a *Passivhaus* is a model of success and I hope that I could animate you to follow this idea.

Technical Data:

Owner: Montessori Verein Erding, D-85445 Aufkirchen
Archtetcts: Walbrunn Grotz Vallentin Loibl, D -85461 Bockhorn
Archtiect + Passivhaus Concept: Gernot Vallentin, D-84405 Dorfen
Housing Technology: A. Lackenbauer, D- 83278 Traunstein
Statics: G. Jochum, D- 82239 Alling
Certification: Passivhausinsitut (Dr. Feist), D-64283 Darmstadt

10 Classrooms, 9 Special Rooms, one Gymnasium

Useful areas:	*3.649 m²*
Cubic Contents:	*18.486m³*
Heating Demand:	*13,5 kWh/m²a*
Primary Energy Demand:	*89,0 kWh/m²a*
Airtightness:	*0,09- h*
Total Building Costs:	*5.484.000 €*
Building Costs Cubic Contents:	*289 €/m³*
Building Costs Useful Area:	*1.503 €/m²*

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