

Judith Thomsen, Åshild L. Hauge, Karine Denizou, Sidsel Jerkø,
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User evaluations of energy efficient buildings

The interplay of buildings and users in seven European case studies

ZEB

The Research Centre on Zero Emission Buildings



A world where buildings do not contribute with greenhouse gas emissions

SINTEF Academic Press

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ZEB Project report 1 – 2011

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About ZEB

The presented work was funded by The Research Centre on Zero Emission Buildings (ZEB), Norway (www.zeb.no). ZEB is a national centre dedicated to research, innovation, and implementation within the field of energy efficient Zero Emission Buildings. The Research Council of Norway assigned The Faculty of Architecture and Fine Art at NTNU to host one of eight new national centres for Environment-friendly Energy Research (FME). The duration of ZEB is from 2008-2016.

The main objective of ZEB is to develop competitive products and solutions for existing and new buildings that will promote market penetration of buildings with zero greenhouse gas emissions in relation to their production, operation, and demolition. The centre's research encompasses residential, commercial, and public buildings.

ZEB focuses on five areas that interact and influence each other:

- 1: Advanced materials technologies
- 2: Climate-adapted, low-energy envelope technologies
- 3: Energy supply systems and services
- 4: Use, operation, and implementation**
- 5: Concepts and strategies

This report is part of objective 4: Use, operation, and implementation.

Objective

The objective of the evaluations was to improve our understanding of the dynamics between energy efficient buildings and their users. The focus of the case studies has mainly been on the use, operation, indoor environmental comfort, and the social and cultural context of the buildings. Which user actions and attitudes may influence building performance and how are the users' actions and attitudes influenced by the buildings?

Method

Qualitative interviews with users of seven different case study buildings were conducted to capture a variety of opinions on living or working in energy efficient buildings. In each of the case studies, interviews with two to seven users were carried out. A semi-structured interview guide was used to insure a comparability of results. Both occupational and residential buildings were included in this study. To recruit respondents the architects of the building, or a representative for the employees, was contacted. In the housing projects, the residents were interviewed in their homes, and in the occupational buildings, the interviews were done at the work place. In addition to the interviews, site inspections were conducted and written information available about the cases was reviewed. Because of the small number of respondents per case the study is exploratory rather than representative. We still claim that the multi-method approach of interviews, site visits and document study allows for careful generalizations.

Findings

The buildings in our study have been operational for just a short period and most of them are still in an adjustment phase. The findings show that users in all case studies often stressed the positive aspects connected to the newness and the architectural quality of the buildings. The interviews also show that energy efficiency is often regarded as a bonus or side effect that is gladly accepted but not the main criteria for choosing a house. Nonetheless, most residents seemed to appreciate the environmental benefits over time. Several respondents were also more concerned about the

environment now than before they moved into or started to work in an energy efficient building, and they also reported more environmentally friendly behaviour.

In most of the case studies, concerns were expressed about thermal comfort. Informants often experienced the building as too hot in the summer and/or too cold in the winter. This perceived discomfort caused different types of personal actions, which had a potential to interfere with the concept and the calculated energy balance. In order to improve internal conditions, the users in almost every case intervened with the planned use. They found common and known ways to improving their comfort in the buildings without considering how to optimize the new system.

None of the respondents had much prior knowledge of energy efficient buildings before moving in or starting to work in the case study buildings. They did not know what to expect from their new environment, and were unfamiliar with the concepts. Many of the informants complained about a lack of information on systems and insufficient training. The studies also show that the occupants desired to control at least some operational aspects.

Despite intermittent difficulties with thermal comfort, the tolerance for the buildings` performance appeared to be high throughout all the case studies and many respondents were proud of `their` buildings. Energy efficient buildings are not the norm, yet, and these types of buildings are in a position to promote awareness and receive media attention. Public interest appears to be a good opportunity to spread knowledge and experiences on energy efficient building types.

Further research should deal with:

- Information and demonstration processes for better use of energy efficient housing.
- Which aspects of energy-efficient buildings are necessary for users to control individually.
- Robust and flexible systems that can deal with the consequences of user interventions.
- Standards for post-evaluation studies including measurements of indoor environmental qualities, qualitative and quantitative information, users` experiences, and an assessment of the types of technologies and products used in the respective buildings.

Limitations

All in all, it was difficult to get access to the projects we wanted to investigate. Most organizations or users initially contacted were not willing to participate. We are happy that we have managed to get information on these seven buildings.

Also measurements of indoor environment qualities have not been conducted at this stage, except for the case studies at Marienlyst and Løvåshagen, where energy consumption and indoor air temperature measurements were being done while this report was written. A report comparing user evaluations and technical measurements is planned.

Time and economy also defined the limitations of what was possible to achieve within this project. Within the given economical framework, we will publish this report and two articles presenting a more detailed analysis of the findings.

The reports on the cases that follow are by no means complete or perfect. They should be regarded as a starting point for an exploration of the interactions between users and buildings with low energy consumption.

USER EVALUATIONS OF ENERGY EFFICIENT BUILDINGS
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Project	Function	Country	Energy Standard	PV	Data: Type + no. of respondents	Page
Marienlyst	School	Norway	Passive House	no	Interviews Pupils: 3, Employees: 4, Operational staff: 4	7
Marché International	Office building	Switzerland	Zero-energy	yes	Interviews Employees: 4	17
Løvåshagen	Housing	Norway	Low energy + Passive House	yes	Interviews Residents: 5, + Measured energy consumption 2009	29
Dragen	Kindergarten	Denmark	Passive House	no	Interviews Employees: 4, Parents: 2, Architect: 1	43
La Cité de l'environnement	Office building	France	Zero-energy	yes	Interviews Employees: 2, Survey: 28 respondents	61
Les hauts de Feuilley	Housing	France	Passive House	optional	Interviews Residents: 3 families	75
Fjell Barnehage	Kindergarten	Norway	Passive House	no	Interviews Employees: 2	85

The case studies



Summary

Case: Marienlyst lower-secondary school, Drammen, Norway

The first passive house school in Norway

Based on interviews with users

1. Facts

Owner

Marienlyst lower secondary school is owned by Drammen municipality. It is planned for 550 pupils in 8th to 10th grade (the pupils are 13-15 years old).

Location

Marienlyst lower-secondary school,
Schwartsgate 12, 3043 Drammen
Tel. +47 32 04 96 90

Website: <http://www.drammen.kommune.no/no/om-kommunen/virksomheter/skole/marienlyst-skole>



The school is centrally located within the city of Drammen, with bathing facilities, sport centre, a football field, and a volleyball field near by.

Architect

Div.A.arkitekter AS
www.diva.no
Industrigata 54, 0357 Oslo

Picture: Maps 1881

Climate

Average temperature / year: 5,5°C

Total hours of sunshine / year: -

Precipitation mm / year: 749 mm

Wind, average values: 1,4-2,2 m/s

Statistics for Drammen, from the Norwegian Meteorological Institute (www.yr.no).

During December, the “normal average temperature” is $-4,1^{\circ}\text{C}$. But in December 2010, the average temperature was $-13,2^{\circ}\text{C}$ significantly colder than normal, with a minimum of $-23,4^{\circ}\text{C}$.

Project information

The school was completed during the summer of 2010, and began use in September 2010. The 3 storey building has a simple and compact form.

The school was built with ordinary passive house principles, which included super isolation and u-values from $0,05\text{-}0,12\text{ W/m}^2\text{ K}$. Windows, doors and glass areas in vertical facades, have u-values around $0,80\text{ W/m}^2\text{ K}$, while the u-values for the glass area in the roof are higher. Thermal bridges and air leakages have been minimized.

The school has balanced ventilation with a high power efficiency of 84%. Additionally, the ventilation is demand controlled, through CO_2 sensors and temperature measurements in the classrooms. The lighting is also energy efficient, with LED-light in chosen rooms. The lighting is presence-controlled and modulating daylight controlled. On average, the energy use for lighting is planned to be 7 W/m^2 in the uptime, ca. $15,5\text{ KW/m}^2$ per year (Dokka et al., 2010).

Number of work places: Today there are 46 teachers and 440 pupils.

Gross Net Area: 6500 m^2

Building costs: 223 million NOK

Every class has one classroom, a large group room, a small group room, and an auditorium.

Construction

The in situ concrete construction system has supplementary framework walls, and a light-weight wood outer roof construction. Daylight in the inner parts of the building is supplied through a glass roof in the middle of the building. This is also supplemented with ceiling lights (Dokka et al., 2010).

Energy supply and consumption

The building has central heating in all the floors. The heating source for the building is a district heating –system based on a heat pump, which provides heat to several buildings in the area. The system is also linked to the district heating net of Drammen municipality, which is based on bio fuel. The thick insulation layer and the omission of thermal bridges minimize the heat losses of the building. Energy consumption is simulated to be $13,4\text{ kWh/m}^2$ per year.

For cooling and general summer comfort, there is heat absorbing glass and automatic sun-shading in rooms that face south and west. The smoke openings have an automatic aerate function, and the smoke gas ventilator has a regulative function, which releases hot air during the warm season. Additionally, the ventilation system is automated for night cooling. During very hot periods the floor heating system can also be used for cooling. The surplus heat from the school can then be delivered (heat exchanged) to the nearby bathing facilities. Testing will be undertaken to identify whether energy use for cooling is more efficient through the floor heating system, or through the ventilation system/ night cooling (Dokka et al., 2010).

Intentions and goals

In the beginning, the intention was to build a low energy school. Later, it was decided to lift the ambitions and re-project the building to a passive house. The largest changes were the extra insulation, better solutions for thermal bridges, better u-values on windows and glass areas, and better air tightness. According to the architects, the redesigning of the building to passive house standards was relatively unproblematic. The additional costs of raising the ambitions from a low energy solution to a passive house solution, were estimated to be approximately 10 million NOK, 4,5% of the total budget of 223 millions NOK (including tax) (Dokka et al., 2010).

2. Results

Summary

- 😊 Very good
- 😐 Could be better
- 😞 Can be problematic

Name of the project	Marienlyst lower secondary school
Type of building	School
Perceived atmosphere	😊
General comfort	😐/😊
Thermal comfort in winter	😐
Thermal comfort in summer	Not evaluated
Air quality (winter)	😊
Acoustics	😞
Daylight	😊
Artificial lighting	😐/😊
Materials / Colours	😐/😊
Level of control	😐
Solar protection	😞

NB: The evaluation is done in the running-in period!

Interviews with users

- Contact and choice of respondents

The respondents were proposed by the department leader of the school. Seven informants were interviewed in February 2011, seven months after occupying the building. Three of the informants were pupils and were interviewed in a group, and the four others were interviewed one by one: the department leader (man), two teachers (one woman and one man) and a librarian (woman) (also the department leader and the librarian work as teachers in addition to their other assignments, so all adult informants will be referred to as “teachers” in this report).

The department leader had worked at the school for only two months. One of the teachers had worked there only since they moved into the new building, but the two other teachers had worked at the same school for several years, and could compare the new building to the old school building they had worked in before they moved. The pupils had also previously attended the old school.

Environmental profile and users` reflections

- Intentions and goals

The informants, both pupils and teachers, that occupied the old school before they moved to the new one, said that the expectations they had for the new school building had been fulfilled.

Over all, the pupils and the teachers are satisfied with the new building. The pupils are proud of the environmentally friendly building, and proud that they have the first passive house school in Norway. But the teachers say that the fact that it is a passive house is not very important, it is more of a bonus. What makes the building special is that it is new. The teachers are pleased with the location of the school, proud of the state-of-the-art technical equipment in the classrooms, and other room facilities, for example a music room for band practice. In addition, the school has sports fields and bathing facilities nearby. The informants are also proud and pleased with the aesthetics of the building.

- Previous knowledge on energy efficient buildings and interest in the topic

None of the respondents had previous knowledge regarding passive house concepts. The teachers reported that the knowledge they have now has come mostly from the media, but the school arranged an information day for the employees about the energy concepts of the building. This information day gave them more knowledge. The energy concepts of the building are included in teaching lessons when it is natural, but one of the teachers said that he wished the pupils knew much more about the building.

The pupils that were interviewed said that they had never heard about the passive house concept before they received a passive house school building. The pupils have also been enlightened through the media, and have positive associations with the concept. The pupils said that the teachers and the head master have taught them about the passive house concept. The teachers reported that they hoped the pupils of the school would be more interested in the passive house concept, but they appeared to be more engaged in the fact that the school building is new.



- Changes in interest / behaviour

All the teachers point out the fact that *'as teachers'*, they have to be role models, and therefore have to take an interest in environmental friendly behaviour. If not, they would hear about it from the pupils. They all report energy efficient behaviour at home.

The pupils stated that they were also concerned about the environment and that they were proud to have a school building that is environmental friendly. Only one of the teachers said the new school building had made him more aware of energy efficiency. Two of the pupils said that they are more

aware of how their behaviour can contribute to energy efficiency at home, but the last student said that she has always done what she can for the environment, and there was no difference before and after the new school building.

One of the teachers said that he had expected the pupils to treat the building better than they do. He was disappointed that the pupils sometimes destroy details of the interior, or did not clean-up after themselves, or did not sort the garbage. He thought that the behaviour revealed that the students felt a lack of ownership towards the building, and he said that the school was working on a strategy to enhance students' feelings of personal ownership. The teachers wanted the pupils to feel more responsible for the building, and to be more aware that it was new and that they had to work to *keep* it new. They worked this strategy through with groups of pupils that were given responsibility to watch over the school. The operational staff said that the old school building was to a larger extent an object of vandalism, and they thought it was clear that a new and beautiful building prevented targeted vandalism.

All informants said that it would be very difficult to work in an ordinary building after having this experience.

Comfort and indoor climate

- General comfort

The informants are overall satisfied with the new school building. They described the building as nice, and the contrasts were substantial when the old and new buildings were compared. At the same time, one of the teachers reported that the old building had some nostalgic qualities that the new building lacked, and the same teacher said that the new school building was very institutional and sterile. The interior looked especially sterile now before the decoration of the building had started.

The three pupils that were interviewed reported more energy and motivation to work because of the comfort that the new school provides, compared to the old school building. Two of the teachers were also certain that the new school building influenced their work in a positive way.

Both the pupils and teachers were proud of, and happy with, the new school building, but some negative aspects kept coming up during the interviews: The acoustics (noise - from the ventilation system and other people), problems with the sun-shading, and low and varying temperatures during the winter.

- Temperature

One informant said that the temperature during the winter has been okay, but he also said "don't ask me, I'm always hot". Except for him, both pupils and teachers reported that it *can* be cold inside. Some said that it was not a very big problem; they could put on extra clothes. The pupils did not consider it as a problem. But some of the teachers described it as an aspect that made their working day not as pleasant as it could be.

They registered that it was especially cold inside after a weather change, when weather changed from mild to cold. When it was cold outside, it was often cold inside. There were also certain rooms that were colder than other rooms. It was especially cold in the rooms that were in the corners of the building, classrooms and offices on the north side, and in rooms that were seldom used. The operational staff was aware of this, and was working on it. They have reported calibration errors in

the thermostats. The temperature problems could also be explained from difficulties of getting heat into the corners through the water-based floor heating system.

The building always felt colder in the morning than in the afternoons. It got better during the day. But the pupils often sat with their jackets on during the mornings.

Three of the teachers working at the school brought their own heaters to their offices because they thought it would be too cold without them. None of these teachers were among the informants, but one of the teachers that was interviewed had measured the temperature in her office during the winter, and said that it is approximately 17 degrees. She thought that this was too cold. Especially the teachers' offices were cold, and the temperature was most noticeable when people were sitting still.

One of the teachers said that the biggest problem was the temperature varies, between rooms, and between floors. Another one of the teachers thought some small rooms were too hot, especially rooms that were above the technical service room.

The employees were worried about the exam period close to summer, and wondered if the temperature was going to be too hot during warmer periods. Additional interviews will be done in June 2011.

All the informants expected the temperature system to work better next year, and said that they tolerated some discomfort during the beginning. When the informants saw the temperature problems as part of the breaking-in-stage of the building, it seemed like the problem was more acceptable than it would have been if this were the situation in the future. Next year has to be different! The informants said that the evaluation of the building and conclusions that would be made had to wait until next year.

The operational staff reported that the complaints about cold temperatures had nothing to do with the fact that the school building was a passive house. If it had not been a passive house, the temperature would have been even colder in the beginning. All new buildings are problematic in the breaking-in-stage, no matter if they were in passive houses or not. The owners/users were often overly eager to move into the building, and the building was therefore, taken into use too early. The first period would become a period where the operational staff tried to fix everything that was left to finish when the building was taken into use, and complex systems were tried out while the users are in the building. The staff found errors regarding over-pressure/under-pressure etc. They were constantly working to improve the indoor climate, and it was getting better.

- Air quality and ventilation

Most of the informants said that the air quality had been good during the winter, and not very dry. Some of the teachers have experienced bad air quality in the classrooms during a long day, and needed to open the windows to ventilate properly. One of them said it might also be due to the fact that cold air feels cleaner. The pupils also reported using the windows to ventilate from time to time, but they thought that the overall air quality was good.

One of the teachers thought that the air was heavy, and often opened the window to take a breath of fresh air. The air pressure was also very high, and it could be startling when air pressure made a door shut with a bang when another door was opened. The pupils said that the teachers use to make jokes about it, and tell them that there are ghosts in the school.

In some rooms proper air circulation is difficult to achieve, for example in the reception. They had to leave the door open to get better circulation during a long day.

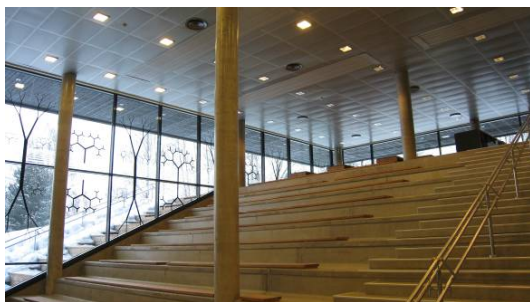
Many of the informants thought the ventilation system functioned well but that it was noisy. This could also be explained by the challenges of a breaking-in stage. The ventilation system has been noisier than intended. The operational staff said there have been errors in the ventilation system that made it noisier than planned, but this has been improved. The old school building did not have any ventilation at all, and it may take some time for the users to become adjusted to the ventilation in the new school building. The operational staff constantly works on improvements to the ventilation system.

Some of the informants have experienced static electricity in the building. Especially in the arts- and crafts hall, where the pupils are afraid to touch the doorknob. The operational staff has reported that it had something to do with the carpet on the floor, and the carpet has now been replaced. The teachers also reported that the floor in the carpenter hall smelled bad.

- Acoustics

In addition to the reported disturbing sounds from the ventilation system (especially in the teachers areas), the acoustics in the hall/cantina area were not very good. This was not due to energy efficiency or any passive house techniques.

The intended design of the cantina was to support the idea of the teachers and pupils as one unit. In addition, the planners wanted to provide a feeling of security among the pupils by making teachers more visible. However, the design of the room in the hallway, three floors high open areas with a tribune for seating, and the cantina on top of the tribune area, makes overcoming acoustic challenges more difficult. Other materials may have minimized the acoustic challenges, but it seems like separating the teacher cantina from the student cantina with a glass wall is the only solution that would optimize an acoustical situation (for the teachers). The teachers report being exhausted after eating their food in the cantina, and say that they really need a silent break during a long school day. The pupils do not report any discomfort or stress due to the acoustical conditions of the canteen, in contrast, they emphasize the need to talk freely to their friends. They do not see the noise as a problem. However, some pupils may be bothered by the noise in the cantina, it may depend on personality.



- Light

Pupils and teachers are satisfied with the daylight access. The group rooms in the middle of the building that gets daylight only through the ceiling windows, are a bit darker than class rooms, but they seem to still function well.



The pupils were amused and annoyed by the energy saving solutions applied to the lighting – the lights turn off if there is not movement, when the pupils sit too still. The teachers are also annoyed by the lighting system, and recommend that the sensor sensitivity is improved, or that it be possible to have individual control (for example during exams). Another possibility is to increase the time limit of the turnoff from 15 to 30 minutes. However, the teachers admitted that too much self-control of the lighting probably would lead to energy dissipation. The facility management has been made aware of this, and has undertaken considerations to solve the problem. The operational staff was open to the adjustment of the sensitivity and time limit for the automatic lighting system, the most important thing was satisfied users. Some of the electric lighting is controlled manually for example, in the corridor of the teachers' offices.

The automatic sun-shading has also been confusing (“living its own life”). The employees have not gotten enough information on how the system is supposed to work, and they did not understand it. One of the teachers mentioned that she is fond of daylight, and wanted to get as much of it as possible, but sometimes the sun-shading went down even when it was not sunny outside. She wondered if it was because the shading was meant to keep the heat inside the building on cold days. Anyway, she did not like teaching in a dark room. The teachers are glad the sun-shading system is silent and “slow” – the sun-shades do not go up and down constantly, but shift at a comfortable tempo.

The operational staff said that the windows are sun reducing, and in the beginning of the planning process they did not think they needed sun-shading in addition to this. However, indoor climate simulations showed that sun-shading would be advantageous in the prevention of overheating during the summer. Unfortunately, the sun-shading has been inaccurately programmed, and issues of glare were not analyzed well enough in the planning phase. The sun-shading problems have been discussed with the users, and as a result, the teachers are now able to control the sun-shading themselves, however not for individual class rooms, but for one façade/ side of the building at a time. The operational staff was worried that more individual control over sun-shading could destroy the mechanisms if the pupils had access to the control panel.

- Use of technique (level of control, information)
 - *Control*

Sun-shading is controlled automatically, but does not work perfectly. The teachers were confused by the sun-shading system, and wish they sometimes could control the system individually. What if the sun-shading is problematic during exam periods? What if they want to get the room dark enough to watch a movie? If the sun-shading system does not work properly within one year, the teachers suggested that they install an individual use sun-shading system on the inside of the windows in the class rooms. But they also said that it would be a shame to do so, because it would interfere with the passive house concept.



There is no individual control of heating or ventilation. Three teachers have brought their own heaters to their office, because they think it is too cold.

The teachers and pupils also sometimes wished they could control the electric lighting.

(See comments from the operational staff above.)

- *Information*

The employees said that they need information on the sun-shading and found the sun-shading system confusing. More information should make the teachers more tolerant towards the system.

The department leader of the school said he was responsible for handling complaints about the indoor climate. However, some of the informants did not know where to go with their complaints pertaining to the indoor environment.

All informants required more information regarding the passive house concept.

The operational staff was worried that information about the building and the operational systems would be too complex, and they thought that their job was to provide a good building so that the users did not have to care or know about how the building works. The operational staff also pointed to the fact that education in environmental friendliness is not their responsibility.

Architecture and aesthetics

- *Energy efficient aesthetics*

None of the informants thought that the school looked like an energy efficient building. They said that it simply looked like a modern building. Most of them described it as a beautiful building. Others described it as just another new office building in concrete and glass.

- *Floor plan organization*

The floor plan organization is good, but there are details that the teachers would like to change.

The student lockers are placed in the back of the ground floor. The students may hide in the area where the lockers are during the breaks, and it is difficult for the teachers to watch over them. Some pupils may be bullied in this area.

There was also a problem with the location of “special rooms” too close to each other. When natural science studies were finished in one room, the glass walls between the rooms made it difficult for the pupils to pay attention to what was happening in their own room. There were also smaller details the teachers wanted to change, for example moving the board to the opposite end of some classrooms.

As already reported, the placing of the teachers’ cantina next to the pupils’ cantina has been problematic, and some of the teachers avoided eating there because the noise level was so high that they would be exhausted after their break spent in the cantina. Some of them missed the old-fashioned teachers’ common room.

One of the teachers also thought that they needed one or two more conference rooms.

The building was described as clear and easy to orientate oneself in, but the informants said that the two floors with classrooms could be difficult for visitors to navigate.

The passive house concept leads to rooms cooling down to a lower temperature when not in use, and due to that they are not used. An example is the teachers' group room, too small for all the teachers, and too cold to use.

- Materials and colours

The teachers and pupils described the building as modern and nice both inside and outside. The pupils thought that the cantina was especially nice. Some of the informants were surprised how nice it looks. Some of the teachers described the building as sterile and cold. However, others used the words "neutral" and "public" to describe the same aspects of the building, so it seems to depend on perspective. The building lacked decoration inside and the walls were white and empty. Decoration has been ordered. The pupils delivered student work for decoration of the school. For the time being, there were no green plants inside the building .

The neighbourhood was originally an industrial area, and not particular nice. But the school building has increased the quality of the area. The informants also said the school building blends well with other buildings in the neighbourhood.

The outdoor areas have been described as nice by the pupils. One of the teachers commented that the "playground" outside the main entrance, that was planned by the youngest pupils, was under utilized by the students.

- Identity / Image

The school and the building process have been positively promoted in the media. The respondents were proud of the school building. Their family and friends were impressed by the school building and school facilities they have. It was however, not the energy aspects of the building that the teachers were most proud of, rather it was the technical equipment and the school facilities. The three pupils that were interviewed emphasized the environmental friendly building when asked what they are proud of.

Summary

The general impression is that the informants like the building, are proud of it, and it fulfilled their expectations as new school.

There are however, some concerns about winter temperatures, noise from the ventilation system and noise from other people due to the design and the materials used. The sun shading is also problematic. The users have been patient because the building is in a breaking-in period, or perhaps because it is supposed to be environmental friendly. Some of them also say that they did not want to complain and they wanted to make the best of it. Therefore, they said that they were satisfied even if not every aspect was perfect. All the informants are sure that the problematic issues will be solved during the breaking-in period.

The teachers have very little control over the operation of the building. But lighting and sun shading are factors they would like to have more control over.

The pupils need more information about the school to take better care of it, and enhance the feeling of ownership towards the building.

References

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All pictures are taken by Anna Svensson, SINTEF Building and Infrastructure

Contact: ashild.hauge@sintef.no



Summary

Case: Marché International Support Office, Kempththal, Switzerland

“The first zero-energy office building of Switzerland”

Based on interviews with users.

1. Facts

(Project description is based on the “Fact Sheet” provided by Marché).

Owner

Marché International is a subsidiary of Mövenpick Company, which specializes in restaurants, bakeries, and diners. The building in Kempththal is the administrative support office of Marché International.

Location

Marché Restaurants Schweiz AG, Alte Poststrasse 2,
CH-8310 Kempththal, Tel. +41 (0)52 355 55 50, Fax. +41 (0)52 355 55 59
Website: www.marche-international.com



The location (A) is adjacent to the Marché motorway restaurant at Kempththal, which provides a connection between Marché’s administration with their everyday practice.

Architect

Beat Kämpfen, Büro für Architektur,
Regensdorferstrasse 15, CH-8049 Zürich
www.kaempfen.com

Picture: Google maps

Climate

Average temperature / year: 8.5 °C
Total hours of sunshine / year: 1482 h
Precipitation mm / year: 1086 mm
(Numbers for Zürich, MeteoSchweiz, www.meteoschweiz.admin.ch)

Project information

The building was completed in 2007, only 12 months after the start of the planning and construction.

The building is a simple 3-storey construction with flexible, open-plan offices. The basic plan can be divided into smaller areas if necessary and is the same for all three stories. The offices face south, while other functions including the cafeteria face north and north-west.



The interior is dominated by wood surfaces and Cemcolour flooring, usually only used as wall cladding. www.eternit.ch/en/products-and-solutions/interiors-and-fire-proof/cemcolour-cemspan/

The staircases are made of recycled concrete with an exposed concrete surface. On each floor there is a 12m² greenery wall which should balance humidity.

The southern façade has large windows while the northern façade has a closed character with only small windows.

The Swiss beech wood office furniture is locally produced and especially designed for the building.

Number of work places: 50

Gross Net Area (Netto-Geschoßfläche): 1,267 m²

Building costs: 3.25 MIO CHF

Building volume: 5`757m³



Construction



The building is constructed with prefabricated wood elements, which were delivered to the site and contributed to the short construction time. The exterior walls are 45 cm thick and consist of a load-bearing wood construction only 3.5 cm thick (Blockholzplatten), giving space for an insulation layer of 32 cm. 80 % of the insulation is made of recycled glass. The wood construction is solely built of local pinewood (Nadelholz) without any chemical preservation applied. The technical installations are located in the attic as the building has no basement.

Energy supply and consumption

The concept is passive-solar, which should require only little external energy supply. The glazed, long, south facing, facade's intention is to optimize the use of solar irradiation. During summer, continuous balconies and sun shading protect the building from

glare and overheating. Half of the southern facade is glazed with opaque GLASSXcrystal elements that, in wintertime, store and give off delayed heat into the room. A prismatic glass has been incorporated that allows solar radiation to pass through only when the angle of radiation is low. A layer of salt crystals store heat irradiated by the sun, and releases this as required into the interior space.

The thick insulation layer and the omission of thermal bridges minimize the heat losses of the building. A geothermal heat pump and ventilation with heat recovery (Erdsonden Wärmepumpe + Lüftungsanlage mit Wärmerückgewinnung) are installed to cover the heating demand. The energy consumption for heating, ventilation and warm water are estimated to be ten times lower than that of a conventional building. As the first zero-energy office building in Switzerland, the construction has been certified by Minergie-P Eco, currently Switzerland's most stringent standard (www.minergie.ch/basics.html).

The roof with an inclination of 12° to the south is completely covered with photovoltaic panels. The annual production of the photovoltaic roof is estimated to be 40,000 kWh, which is estimated to cover the energy demand for the building's technical installations and office uses. The system is linked to the electricity grid of the Elektrizitätswerk Zürich, delivering surplus energy to the grid in summer and receiving energy during the winter.

Intentions and goals

Marché International's intention was to reflect the company's strategies of "naturalness" and "environmental-friendliness" in the building. The working environment should be of high quality and simultaneously use as little energy as possible.

When designing the building the most important keywords were: sustainability, ecological balance, energy consumption, functionality, quality of work place, and design. All building materials can be separated and recycled in case the building should be demolished. All materials were evaluated with regard to environmental and health criteria. A Life Cycle Analysis (method Eco-Indicator) has shown that during its lifetime, including building process, use, and demolition, the energy consumed is, in the course of its entire life cycle, about one third of the energy required by a standard Swiss building.

Awards, media, certificates, etc:

- Certified Minergie-P Eco
- Swiss Solar Energy Award in 2007

2. Results

Summary

- 😊 Very good
- 😐 Could be better
- 😞 Problematic

Name of the project	Marché Kempththal
Type of building	Office building
Perceived atmosphere	😊
General comfort	😊
Thermal comfort in winter	😊
Thermal comfort in summer	😐
Air quality (winter)	😞
Acoustics	😐
Daylight	😊
Artificial lighting	😐 / 😞
Materials / Colours	😊
Level of control	😐
Solar protection	😊

Interviews with users

- Contact and choice of respondents

Contact information was found on the website of Marché International and the respondents were proposed by Marché. Four employees were willing to be interviewed; 2 male and 2 female, between the ages of 35 and 60. Two of them were also involved with the building process from the company's side. Three of the four interviewees have worked in Marché's old office building before moving to the new building. All three of them have worked for Marché for more than 5 years. The fourth respondent was a relatively new employee.

Environmental profile and users' reflections

- Intentions and goals

One respondent related the company's restaurant strategy to the building concept. The strategy includes fresh food, local product carefully treated and produced, flexible organization, energy efficiency, and speed. The intention was to reflect these keywords not only in their restaurants, but also in the new administrative building.

It was also important that the new office building should belong to "them" – the administration. If they would have rented a building and adapted it to their needs, the costs would not have been much lower, and they would have not been free to choose a concept that reflects the company's marketing strategy.

The respondents also state that the company's interest in environmental issues is also present in their daily practices. One interviewee said that there is a focus on saving paper and on re-use, as well as, on switching off electronic items when they are not in use.

In terms of energy consumption, the goal was to achieve a zero-energy balance. One respondent believes however, that the energy balance after the first few years shows that the actual

consumption is slightly above zero, though he does not have the exact numbers. He thinks that the deviation is not very high, so “we do not have to return the Minergie-P eco certificate.” He explains the discrepancy between the result and the goal come through a “lack of discipline of the employees” when it comes to ventilating and the use of shading (also see section on temperature).

- Previous knowledge on energy efficient buildings and interest in the topic

None of the respondents had previous special knowledge about energy efficient buildings. One of them had read about passive houses in the paper, but then forgot about it until introduced to the Marché concept. The respondent involved in the building process did not have experience with the Swiss Minergie Concept either, but the architect introduced them both to the idea.

When asked whether they were interested in environmental issues, one respondent answered, that it is a good idea to “do something” and that we cannot proceed in the future as we are used to. Therefore, the building is considered as “a good thing.” When the interviewees were asked about other people’s reactions, one employee said that within the corporation group of Mövenpick, they were considered as exotic and their goals were not taken seriously in the beginning. This perspective changed, however, when the building was finished. Another respondent says that her friends thought that the concept was either good or funny. Some wondered whether she would now be cold at work during the winter. She is a little sceptical herself, since she has not yet worked there during the wintertime.

- Changes in interest / behaviour

During the planning process, all the employees quickly decided to strongly support the idea (“Feuer und Flamme”). One woman said that becoming the first zero-energy building in Switzerland was something that everybody wanted and felt proud of.

All respondents stated that due to the Marché, they have become more aware of energy efficiency in buildings, independent of whether they were directly involved in the building process or not. One respondent said that she has moved houses privately and that they were concerned with moving into a house that at least fulfilled Minergie Standard. She thought that because of Marché, she now knows more about the possibilities of how one can live smarter and in a more sustainable way.

One respondent working with the construction of the company’s restaurants in different countries stated that his interest in the topic has also grown. He is now aware of the concept of passive house and zero-energy balance, but unfortunately, he does not have enough influence in all of their international construction projects to pursue similar goals. However, he tries to add environmental friendly solutions if possible, even if only on a “small scale”, such as reducing energy use for e.g. ventilation and lighting. When working in such a building one wants to introduce these advantages other places as well, he says.

Another respondent believes that the project has raised his awareness of energy consumption in general. He sometimes reminds other employees to switch off the copy machine over night, but he has experienced that this can be difficult for people to remember, because not everybody is as interested in saving energy. He also said that when he had to change the heating system in his own private house, he invested in a geothermal heat pump instead of repairing the existing gas heating system, despite higher costs. He would not have taken this step without the positive experiences he has had in his work place.

The respondents all believe that it would be a step back if they had to move back to their old office. One even thinks that this would be a “no-go”.

Comfort and indoor climate

- General comfort

One respondent described the office building as very homey. She feels good in the building and thinks that this may be due to the materials used, especially the wood. The natural materials and the amount of daylight are characteristics that she links to comfort. This perspective is also supported by another respondent who stated that she “feels at home” and that it is “always nice and warm.” Staying longer at work, if necessary, is not a problem for her because she perceives the general level of comfort as high. Previously, she worked in an office building that she described as “grey-in-grey”, making her wonder every day about how long she could stand to continue working there.

Another respondent was convinced that it is a good working environment for the employees, he added that the spirit of the Marché team has improved considerably since they moved to the new building. Moreover, the feeling of working in a healthy environment where natural building materials are used also contributes to general comfort. One person also commented that it is nice to have a garden and greenery outside.

One respondent said that good lighting and positioning of the workstations and tables were important aspects of a comfortable work environment.

Despite everybody being very positive in general, there are two aspects that sometimes cause discomfort. Dry air during winter was a primary discomfort for some users, as was high indoor temperatures during warm summer days.

- Temperature

One respondent explained that the room temperature is set by the central ventilation station (Lüftungszentrale). The inlet temperature of the air is 25 °C and will decrease to 18 - 19 °C during its dispersion, temperatures above that shall be regulated by floor heating. Different areas of the floor heating system can be regulated by thermostats, which are accessible to the employees. He also added that fresh air from underneath the building is channelled to the ventilation system and distributed into the rooms. In summer, this system should function as a natural cooling system.

It is however, difficult to get rid of heat once it has come inside. One respondent believed that this is often due to employees forgetting to lower the blinds on hot days or not opening the window early in the morning when the air is still cooler outside. He believed that if the existing measures such as the cool air storage underneath the building or shading, would be used reasonably, the temperature could be contained at a moderate level, even during warm summer days.

Another interviewee said that despite having experienced some hot summer days in the office, she could not imagine moving back to a building with air conditioning. She added that they have to be stricter with opening and closing of the windows, otherwise they “sometimes, suffer in the afternoon.” She added that temperature is not an issue in winter.

There are also discussions between the employees pertaining to comfortable indoor temperature. One respondent stated that there are those who like to open the windows all the time, which included him, and those that would say “I am freezing, close the window!” The same discussion was also reported when it came to the use of the floor-heating thermostat during the winter, but the respondent added that these are minor problems. Even if there are some summer days where they have measured 26-27 °C, he thought that this is still not too bad. He heard about other non air-conditioned buildings where the temperature was above 30 °C during the same period. But he added again, that the behaviour of the employees is a key to the high indoor temperatures

experienced in summer, and that they could do better. People's typical reaction was: "oh, it is warm; I have to open the window." The respondent concludes that there is a need for "education" in order to change behaviour.

Preferred indoor temperatures that the respondents identified were between 20 – 23 °C.

- Air quality and ventilation

Two respondents reported that the air is very dry during the winter, which is uncomfortable for the eyes and when someone has a cold. They mention that the greenery walls that are planted on each storey for the purpose of regulating air humidity do not work as planned. One of the respondents said that a colleague regularly measures air humidity, and they know that it is a problem. She thought that the wood probably absorbs much of the air humidity. They were looking for a solution to achieve better results.

When asked whether they open the windows in order to ventilate, everybody answered that they did so as a part of temperature regulation. One respondent said that they did not have air conditioning and therefore the users were responsible to ventilate in a well-thought-out way. Another respondent explained how the ventilation should be in summer. He said that one should open the windows in the early morning to circulate cooler air, then close them and lower the blinds later in the day. But he also added that nobody did it that way: "Employees leave the windows open, the heat comes in, and then they open the windows on the opposite side of the building to create a draft."

When asked whether the ventilation system is not able to keep the temperature at a comfortable level without opening the windows, the response was that it certainly should be able to, but that this fact does not help if people open the windows in the afternoon on a warm summer day. He added that "there are people you can tell a hundred times."

However, another respondent said that if there are 10 people in the meeting room for 2 hours, the ventilation system does not cope well. He thought that this is a compromise in this type of building, when compared to conventional buildings with air condition. (Under dimensioned ventilation system? J.T.)

When it was remarked that opening windows all the time should not be required with sufficiently dimensioned ventilation, the respondent stated that he has never heard of that rule. He thought that when building Minergie standards, it should not be implied that one cannot open a window anymore, as this would be against human nature. Opening windows, getting fresh air, and experiencing the environment is what people want to do. Restrictions with regard to ventilation through the opening of windows would, in his opinion, prevent the idea of the passive house concept spreading.

- Acoustics

One respondent stated that the acoustic values when measured were good. However, another respondent thought that the acoustics are not optimal. He describes a conflict they had with material choices. They wanted natural materials and they did not want to add sound-absorbing carpets or typical partition walls, which he found awful. The sound absorbing synthetic boards they have put under the ceiling are, in his opinion, on the edge of what the concept of naturalness could tolerate. But adding these was not sufficient for acoustics, so they also integrated sound-absorbing elements in the furniture that was designed for the building.

Other respondents found it sometimes noisy. One interviewee does not feel disturbed, but admits that others may. He points out that it is important to have separate rooms where people can be undisturbed. He also adds that this is obviously not a problem of the passive house concept but of open-plan offices. Even if he sometimes could imagine having a quieter environment, he thinks that the open floor plan building is planned well and spacious enough.

None of the respondents reported disturbing sounds from the ventilation system.

- Light

It was pointed out by all respondents that the daylight situation is very good. The big windows are an advantage and the blinds can be used in case of glare. All employees can control the blinds individually. The big windows can however, be a challenge for the passive house concept as solar irradiation heats up the room. One respondent said that they wanted to have a lot of natural light and the demands of the glazing were high, as well as, the costs. They tried therefore, to reduce costs other places, e.g. by not having an elevator (there is space to integrate one if necessary, J.T.).

Motion sensors are also used to control lighting in the building. One employee was critical towards the control of the artificial lighting. He thought it was too restrictively used in order to save energy. Especially in the winter, when it gets dark earlier, this results in dark traffic zones. When using only the desk lamps it can be hard for the eyes to adjust to the contrasts (light desk, otherwise dark office). He thought that there should be basic artificial lighting when needed, this would provide greater comfort, but would use more energy (Conflict between energy use and comfort?).

- Use of technique (level of control, information)

- *Control*

Sun-shading is controlled automatically but the user can control it individually as well, at their respective workspaces. Thus, they are able to adapt the light / sun situation to their individual needs. One respondent explains that the automatic control function is still necessary. If a work place is not in use, the blinds have to be lowered; otherwise it will get too warm. He also adds that some people need help because they do not remember to close the blinds.

When it comes to heating and ventilation individual control is restricted. Only the floor heating has a simple low-high panel for regulating the temperature in different areas. Some respondents used the panel, but one respondent did not even know that this option exists. In general, the technical installations are minimally visible in the open office building. One woman said that she sometimes sees when a colleague checks humidity or CO₂ content. She thought that these could be adjusted but only by a responsible person. What they thought should be individually controlled are the blinds and the windows.

- *Information*

The employees said that they had received information on how to use the office when they moved in. It was for instance explained how to control the sun-shading, how the photovoltaic roof worked, and what the green walls were for. One respondent said that they have had some new employees since they moved in and that he planned to propose a new information round. Another interviewee added that this information should be repeated after some time, because some employees may have forgotten basic rules.

Architecture and aesthetics

- Energy efficient aesthetics

None of the respondents thought that the office looked like an energy efficient building, one said that she would have thought it was a modern building. If one could spot the photovoltaic cells on the roof, then it would be easier to link it to energy efficiency. Another respondent reported that visitors often think it is a hotel, because of the small windows on the north facade. Two respondents thought that the materials are different from other office buildings and may be linked to energy efficiency. Most other office buildings are glass and concrete buildings that according to their opinion would not fit in with the company's strategy of naturalness.

One interviewee added that visitors are most often architects or engineers. Visitors are often impressed by the building because the concept has been accomplished consistently.

- Floor plan organization

Moving to an open-plan office has been evaluated positively by all respondents. One said that the atmosphere is much better than it was in the previous office, even if "one sometimes can feel a little disturbed in an open-plan office."

One respondent also thought that the organization of the building reflects the energy efficient concept to a certain degree. He thought that reducing unnecessary spaces and reducing energy use was reflected in a precisely planned building. "All spaces have a meaning and there is no superficial infrastructure." He added that this result required a close cooperation with the architect who had to understand the company's and employees' needs.

Another respondent stated that "we have everything we need and nothing we do not need." He thought that this shows because there are no boxes from moving left in any corners, which would be a typical sign of poorly planned spaces. Another employee said that despite having less floor area than in the old office, she finds it more comfortable to work here, as the organization is better.

- Material and colours

The use of wood is perceived positively by all respondents. One stated that she finds the wood material fascinating; she associates warmth and a positive atmosphere with it. Glass and concrete buildings were described as "sterile or top-modern office buildings". One interviewee thought that this would not be the type of building that represented a sustainable attitude.

Another respondent was fond of the recycled concrete used in the staircase. She said that this is the first thing she shows to visitors. She thought that it is positive that the material has been re-used and found a new form.

The special GLASSXcrystal windows were understood as being important for the energy balance. One respondent remarked that one can observe that change of the heat storage material (salt hydrate) from solid to liquid.

Also the colours are perceived as positive elements in the office. One employee stated that the good atmosphere may also be a result of the colours. Another respondent thought that the warm and harmonic colours radiated calmness. The red colour of the concrete in the staircase was chosen and painted by the employees.

The materials used were also associated with a healthy indoor climate and one respondent appreciated working in a healthy place.

The building's outdoor area is certified as a natural environment. In order to receive a certificate, different demands had to be fulfilled, e.g. infiltration of water into soil resulted in the installation of a gravel parking lot.

- Identity / Image

The respondents are proud of working in that building and they link it strongly to the company's profile. All supported the idea to become the first zero energy building in Switzerland. One respondent says that she liked to tell visitors about the zero-energy balance. Another thought that the proof that everyone identifies with the building is shown in that all the employees, except one, moved from the old building to the new building even if the distance from Zürich increased considerably.

The old building they worked in is described as a patch-work building, with cellular offices each revealing different worlds. One respondent said that the new building does not give them as much room to add a personal identity to their work places, but she thinks that this does not matter so much, because this building is more open and friendly.

The fact that other departments of the company did not take their intentions and goals seriously from the beginning, gave them an extra push. "We have proven it to them", one respondent said. Since the completion of the building they have heard a couple of envious comments and statements from corporation partners who would like to have a comparable office building.

Summary

The general comfort is perceived as high and the overall picture of the building that the interviewees conveyed was very positive. They all enjoy working there and feel good in the building, pointing out the good atmosphere and the pleasant materials used. There is also a high degree of identification with the concept.

Natural daylight was perceived as an important element of comfort. Glare was not named as a problem and blinds can be lowered down in the case of sunshine on screens.

There were however, some concerns with dry air in winter and high temperatures during warm summer days. They had not found a solution to adjust the air humidity to a comfortable level, after realizing that the greenery walls do not work as planned.

In terms of high temperatures in summer, the users' behaviour was named as a crucial factor influencing indoor temperature. People did not close the blinds when needed, or left the windows open when it was hot outside, trying to create a draft.

Information on how to use the building was given when moving in, but it seems that this should be repeated once in a while. Despite being informed, employees did not do "the right thing" all of the time (e.g. "some people you can tell a hundred times to close the blinds"). This indicates that people's behaviour is a difficult factor to influence and to calculate for.

The interviews also reveal that additional ventilation through opening windows is very common. It does not seem to be regarded as critical behaviour in regard to the energy balance, especially during winter. How much the employee's behaviour (opening the windows to ventilate) actually off-sets the calculated energy balance, cannot be said, as there are no measurements available. This should be

further investigated. It was also discussed whether a greater emphasis on the fact that one should not open the windows in passive houses would prevent the concept from spreading further.

Also, the ventilation capacity in the meeting rooms does not seem to be sufficient sometime. Users' stated that the system does not cope with 10 people meeting over 2 hours, at which time the air quality is perceived as bad. Could it be under dimensioned? This should be checked.

Even if behaviour does not always optimize the system, the respondents' statements indicate that the concept raised awareness of environmental issues among the users. Previous knowledge on energy efficient buildings among the employees was limited and the planning process of the office building has clearly increased their level of knowledge.

There was also a high degree of identification with the concept. This may be because all employees were informed on the intentions and goals pertaining to the building, thereby creating a common spirit (e.g. everyone was suddenly keen on becoming the first zero energy office building in CH). Their positive experience with the building and its environmental goals seems also to have led to greater consciousness on choices in employees' private life (e.g. geothermal heat pump instead of gas heating; choice of Minenergie flat instead of conventional flat).

Taking the perspective that behavioural change is necessary to achieve a reduction in emissions, this indicates that good examples and demonstration projects can contribute to creating awareness, and may also contribute to facilitating behavioural changes over time.

Even though a zero-energy building, judged by its architectural character, it was just perceived as a modern building. No architectural elements were associated with energy efficient buildings except for the photovoltaic cells on the roof, which are not apparent from the street view.

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All pictures are taken by Judith Thomsen

Contact: judith.thomsen@sintef.no



Summary

Case: Løvåshagen housing cooperative, Bergen, Norway

Based on interviews with the architects; ABO Plan og Arkitektur, and residents.

“The first Norwegian passive house project on a bigger scale.”

Fig. 1: Løvåshagen.

Photo: Rigmor Sletnes, ABO Plan & Arkitektur AS

Løvåshagen is realized through a strong collaboration between the builder, the architect, the research institute SINTEF Building and Infrastructure, and the Norwegian State Housing Bank. Flag-shipped by ENOVA and the Norwegian State Housing Bank as an ideal example to be followed that showcases the current “best practices” in energy efficient architecture within Norway today.

1. Facts

Project description is based on information given by the Architects; ABO Plan & Arkitektur AS, Arkitektur N, The Norwegian review of Architecture 09(06) and NAL Eco box database.

Builder

ByBo is a company that is developing, building and selling flats in the Bergen region. They “focus on future oriented housing solutions that benefit the environment and residential surroundings in total.” ByBo is a partner in the ZEB project. (ByBo 2011)

Website: <http://www.bybo.no/>

Architect

ABO Plan & Arkitektur AS, Hamnevegen 53, Postboks 291, 5203 Os, Norway

Website: www.abo-ark.no

Location

Løvåshagen, Løvåsbakken 31 -37, Bergen



Fig. 2: Air photo from Løvåshagen web-site.

Løvåshagen is situated in Fyllingsdalen, close to popular recreation areas, and 6 km away from Bergen city centre. Public transport by bus is good with frequent connections. The road system goes through a lot of tunnels, so it is not possible to walk or bike to the city, though the distance is not too far.

In Løvåshagen, the residents are close to facilities like schools, kindergartens, post office, shopping centre and public transport.

Climate

The site is sheltered and the local climate is therefore not especially challenging.

Average temperature / year: 7,6 °C (one of the highest in Norway)

Total hours of sunshine / year: 1186 h

Precipitation mm / year: 2250 mm

(Numbers for “St.nr. 50540 Bergen-Florida”, The Norwegian Meteorological Institute)

Project information

Period of regulation: Approximately 2004-2006

Design and projecting: 2006 until starting constructing; autumn 2007

Building period: Autumn 2007 until end of 2009

The first feasibility sketch was made in 2004. Detailed projecting was then finished except for the balconies. The architects had a close follow-up during the construction work. The first residents moved in during the spring and summer of 2009.

The building was fully completed with all certifications in the beginning of 2010.



Fig. 3 and 4: The passive house with balconies, oriels and living rooms facing west (left picture) and entrances to the common outdoor space. (right picture) Solar collectors on the roofs facing south. Photo: Knut Egil Wang

Architectural form and Energy Design concept

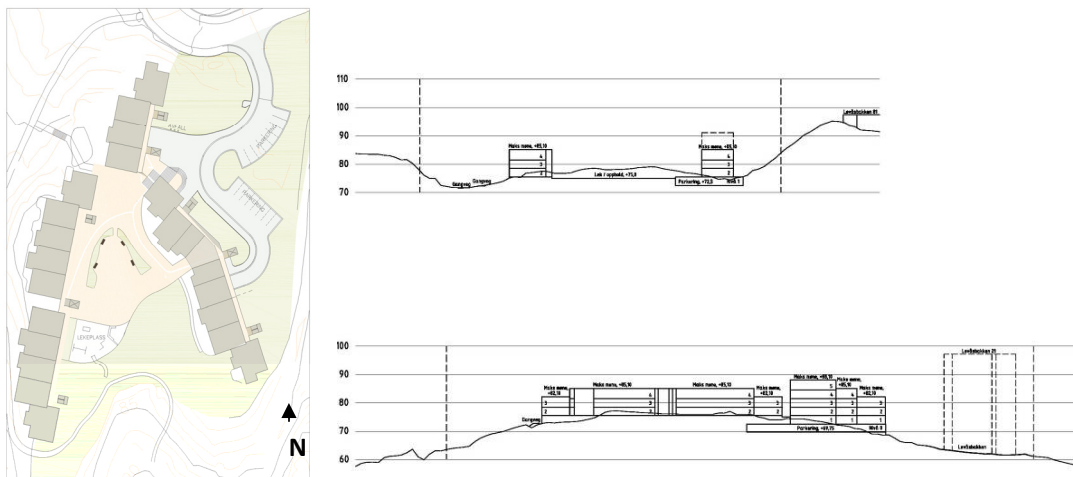


Fig. 5 and 6:
Site plan and section Løvåshagen. Illustrations ABO Plan & Arkitektur AS

Løvåshagen is built with a simple and sober-minded approach to energy efficiency in housing. The sustainability mindset that this project is based on, has also been a leading star for the adaptation to both site and nature. The buildings are placed to screen against the rain and cold winds from the north-east and it shapes protect and shelter outdoor areas facing south. The shapes of the housing blocks are simple and compact to avoid thermal bridges (fig. 16). To avoid the need for heating in common spaces such as common entries, steps and doorways, these elements are placed on outdoor galleries. Galleries, oriels and balconies have been a part of the desired architectural idiom and aesthetic tools to produce variation despite rather equally flat layouts, and are planned with attention to detailing to avoid air leakage.



Fig. 7 and 8: Photo: Knut Egil Wang



The main objective has been to combine architectural qualities, a usable, thriving and friendly residential area with energy efficiency.

It was seen as important in the design process to avoid “a box-design”.

The choice of colours was a part of a conscious and strong wish to create a piece of “happy” and lively architecture (personal communication with the architects at ABO Jan Haaland and Rigmor Sletnes 2010).

Architectural qualities were focused on just as much as energy efficiency: *“It has been important for us to prove that energy efficient architecture should not be attended with straight lines and boring boxes.”*

(Quote architects)

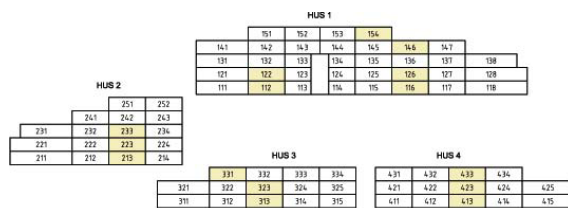


Fig. 9 and 10: Typical 3-room flat, 80,3 m.
 From the prospect on the ByBo website.



Fig. 11: Photo: Solvår Wågø

The residential area at Løvåshagen consists of 80 flats. 52 flats have low energy standard and 28 have passive house standard. Average flat size is 80 m². Sizes vary from 50 m² – 95 m² in 3, 4 and 5 room flats. The density is about 50 housing units pr. hectare (10.000 m²).

The residents share a common outdoor area and playground which is very popular. In addition, each flat has its own balcony or an outdoor space on the ground floor to the west. Entrance to the flats occurs through a common outdoor gallery which also may serve as a second outdoor space facing the opposite direction.



Fig. 12: View from the living rooms in the passive house flats Fig. 13: Private balconies.

Fig. 14: The residents may control ventilation on three levels in addition to an “on” and “off” button by the doorway. Below the control panel the electricity meter is placed.

All photos: Solvår Wågø



Fig. 15: Kitchen and entrance area in one of the flats. Photo: Solvår Wågø

Kitchen and living room, and in the smallest flats also the entrance areas, are designed as open space. The living room has big windows facing woodlands and there is greenery outside (the passive house flats) and the common outdoor space of the low energy flats. Windows from bedrooms face the common outdoor space via the common entrance gallery. Interior walls and ceilings are covered with plaster. For the floor parquet was used. The only heating device in the flats is a single radiator in the entrance. (See fig. 15). The bathrooms have floor-heating with heat from the thermal collector on the roof.

Construction

Løvåshagen consists of 4 residential buildings, from 3–5 storeys high. The two westernmost buildings are built as “passive houses” to achieve the German passive house criteria according to PHI (Passive House Institute in Darmstadt, Germany)¹ and two are “low energy standard”. The load-bearing structure is concrete. The load-carrying partition walls between the flats are also concrete. The roof and external walls are a light-weight timber construction. The balconies are a steel construction. There has been a specific focus on making the building envelope as dense as possible to avoid thermal bridges.

Energy Supply and consumption

Intentional energy consumption:

The heat source is solar collectors and electricity in addition to a mechanically balanced ventilation system with heat recovery (83 % efficiency). Net energy use in the passive houses is calculated to 91 kWh/m²/year where 74kWh/m²/year is energy supplied. The rest (17 kWh/kvm/year) is from solar heat. In the houses with low energy standard energy net use in total is calculated to 101 kWh/m²/year.

When Løvåshagen was built, there were no Norwegian standards for passive houses. Løvåshagen was therefore built after the standards from Germany. The ambition of ByBo AS and Enova is that Løvåshagen will become the first project to be certified and receive a Norwegian energy label according to Norwegian rules.

Measured energy consumption:

The measure was done by BKK (the energy suppliers in Bergen) in 2009 (BKK 2010).

The measure of total energy used showed a large variation from 30–173 kWh/m²/year in the passive houses. In four passive house flats the use was below 60 kWh/m²/year. Interviews were given in two passive house flats where the energy use was 150 and 173 kWh/m²/year. Most used 70–80 and 100–110 kWh/m²/year, both variations in use and use in general, were approximately the same in the passive and the low-energy standard flats where the highest consumption measured was 203 kWh/m²/year. Based on this, average use in passive houses might be approximately 90 kWh/m²/year. Assuming that these measurements contained source errors like uninhabited flats or simply errors in the measurements, real consumption is hard to estimate. Interviews with both BKK and the builder ByBo will be carried out with the goal to clarify these findings.

Intentions and goals

Løvåshagen is planned to house people with different living situations and be attractive for a wide variety of residents. Affordable solutions have, in addition to universal design and energy efficiency, been a premise of the project.

To make it easy for the residents to save energy, there is a button in each flat to turn “on” or “off”, dependent on if their leaving the flat or coming home. The button controls the heat and ventilation system. Beyond this, the residents do not have to be conscious of the fact that they live in an energy efficient house.

¹ PHI criteria: heating energy use ≤ 15kWh/m²/year and total primary energy use ≤ 120 kWh/m²/year

The housing project Løvåshagen has three focus areas:

- Energy
- Universal design
- Design for the future

(ABO Plan og Arkitektur as 2009)

Awards, media, certificates, etc:

- Bergen city development prize 2008.
- VVS (heating, ventilation and sanitation) –prize in 2008.
- Nominated for “Byggeskikk-prisen” (Norway’s most important architectural award) in 2009.

2. Results

Interviews with users

- Contact and choice of respondents

A list was provided by the developer ByBo with contact information for all the residents, what flat they live in and for how long they had been living at Løvåshagen. The chairman of Løvåshagen housing cooperation assisted in handing out an inquiry to identify respondents who were willing to be interviewed. A main goal behind this kind of “strategic recruitment” is to get in touch with interested residents, willing to share their experiences. This form of recruitment might also tell something about residents’ attachment to their homes. They might be very satisfied or very dissatisfied. The residents that really want to participate in the investigation might be more dedicated to energy efficiency and sustainability matters than others, or they might be very critical of the whole concept.

Almost immediately, positive answers from two respondents were received, in addition to the chairman and a person responsible for residential environment in the housing cooperation. The chairman also suggested a couple of other residents to interview. During the spring of 2010 monitored energy accounts for 2009 were available. The numbers show a large variation between flats regarding electricity-consumption, which was an opportunity to interview residents based on different electricity-consumption to better understand the reasons for the discrepancies, and how the residents themselves perceived their electricity-use. During a warm summer-day in the beginning of June 2010, the first 5 interviews were accomplished.

The following information is based on the transcription of these first five interviews.
(Residents_at_Løvåshagen 2010)

Environmental profile and users` reflections

- Intentions and goals

The residents at Løvåshagen are a mix of families with small children, adults without kids or young adults that have moved out of family homes, seniors and pensioners. The interviewed respondents represent all 5 categories and come from all kinds of earlier housing experiences and have all kinds of reasons for wanting to live there. Some come from one-family houses in the suburbs or in the neighbourhood. Some have lived in old and colder houses in the city centre. They all express a need for a bigger or smaller flat dependent on their present living situation, and that they were attracted to Løvåshagen because of the site, the promised lower energy bills, the easy access to services and the close proximity to the city centre.

One respondent expressed that she perceived the architecture as future oriented and that she was very much aware of the future-oriented design and the focus on energy efficient architecture when she decided to buy a flat at Løvåshagen. Other respondents expressed that environmental matters were considered in combination with the area and price. One of the respondents did not know anything at all about the energy efficient focus before they bought the passive house flat. The size of the flat and its universal design were more important to them.

Common for all, was that they enjoy living in a new and fashionable housing area, without importunate rehabilitation work, without traffic noise and dust, but rather a nice and silent environment, pleasant outdoor facilities and friendly neighbours. They were also happy with the comfortable indoor temperature during winter though they all express that it got far too hot during summer.

None of them claimed that they were especially dedicated to environmental issues. When asked about this, they seemed a bit shy, and replied: "I am not one to talk big about being very engaged in environmental issues..."

Nevertheless, three out of five respondents expressed that living at Løvåshagen had made them more conscious and interested in environmentally related issues. Most expressed that the energy-bill is far more important to them than the feeling of being environmentally friendly. One resident said that being conscious of the fact that he was living in Norway's first passive house development was not of importance; "it's just like spices with dinner!" but he does not believe that living here has any effect on the global environment either: "If all the houses in Norway were built like this, it would make sense, but then everybody would have to make a change. Living in a house that is wasting or saving energy is only a mean to my economy!" Still, he considered that it has a significance to save nature from power plants ruining the landscape.

- Previous knowledge on energy efficient buildings and interest in the topic

None of the respondents had previous special knowledge on energy efficient buildings.

One of the respondents asks for a renewable energy source; ground heat. He found it very strange that ground heat, which he perceives to be the most stable heat source, was not utilized at Løvåshagen, when solar collectors, with a considerably reduced efficiency during winter (due to snow), were used: "I find it very strange; they've made a lot of energy efficient efforts here; we have walls that are half a kilometre thick, and during the summer we're about to peg out due to the high indoor temperature, we have heat collectors on the roof, but no ground heat...?... I find that very strange..."

All interviewees expressed that they found it rather "cool" to live here due to the positive publicity, visitors and curiosity among friends and colleagues. "It feels great to be in the forefront!" Most of them did not know much about their own consumption; they knew what they paid and they claimed that they used "very little", "almost nothing" etc. and referred to the meter that "almost never turns red", "only on Christmas eve when everything is turned on...". All informants except one, expressed contentment with the reduced energy-bills that they claimed are much lower, but they were not content with the fact that they were not able to control their own energy consumption in detail (day by day or room by room). In the beginning this was possible on the energy supplier BKK's website. Since construction works on the site this information service has been out of function. Most of the informants say that their energy bills have been about halved. The informants that were not content have one of the highest measured consumptions and they were quite frustrated about the fact that they paid approximately the same as they did in their big one-family house with three kids living at

home, as they do now; living alone in a passive house. They also said that other residents have had the same experience: “Huh... low-energy.. When the bill comes it’s not that low-energy at all.... It is not as economical as expected; up to 85% it was said... but according to the bill; it is approximately as high as when we were living in a one-family house.”

Most of the informants seem to be much more concerned about how their energy efficient home influences their wallet, than how it influences their environment and the global climate. In daily life, they tried to save energy when it was convenient, and they expressed frustration about the fact that they were not able to control where the energy goes. They call for a possibility to influence their own energy-consumption; “All we have is a big button... and then a bill comes every other month... that’s all. It is extremely bad! Regarding the “on” and “off” button, four out of five respondents did not use it. Some have even dismantled it. They claimed that it is too close to the lighting button, and therefore often it was switched off by mistake. Some also called it the “lazy-man’s” button; ideal for those who e.g. do not take the trouble to switching off the lights in each room when leaving. In addition, they prefer to rule each apparatus manually instead. Some even expressed that it was more convenient to leave the TV and lap-tops on when leaving the flat.

Out of five respondents, only one still stuck to using “the button”. She has also brought up the possibility of creating a car-share system and charging stations for electric cars within the housing cooperative. She is the only one that pointed out the environmentally friendly aspect of living at Løvåshagen as more important than the economy of savings.

- Changes in interest / behaviour

Some claimed that they had always been aware of “environmentally friendly living” in terms of “switching off the lights and saving electricity”. All of them said that their most important contribution in daily life was to sort their waste and switch off the lights and heat. Regarding transport, they chose what was most convenient, the bus, if that turned out to be convenient, and airplanes for longer distances. Habits according to weekend- and leisure time travel had not changed for any of them except for one couple in their forties who no longer lived in a one-family house. To be able to spend more of their spare time at the cottage, was one of the main reasons for them to move to Løvåshagen.

None of the respondents perceived themselves especially dedicated to environmental issues, but three out of five expressed that living at Løvåshagen had made them more conscious and interested in environmentally-related issues. “By living here I get it under my skin in a different way. It is more practical than just reading about it in the newspapers.”

All of them expressed that they were proud to live here and find the publicity and all the people visiting Løvåshagen, due to its energy efficient focus, very cheerful. Everyone expressed that energy savings are positive, and would also call for energy saving efforts in their next house.

Comfort and indoor climate

- General comfort

All interviewees explained their perception of comfort at Løvåshagen with terms such as openness, airiness, good daylight conditions, a comfortable indoor climate; “the possibility to walk barefoot indoors during winter.”, and conveniences in the meaning of easy access to the city centre, shops and service facilities in the neighbourhood. Some also pointed out easy access by lift to the P-garage. The way of sorting their waste was commented on in the sense that residents found it easy and convenient and it helped them to keep the common areas clean and tidy.

One respondent also pointed out the housing environment with the common outdoor area; the Italian “patio”, and all the possibilities for recreation and possibilities to make treks up to the mountains, as an aspect of comfort. He also pointed out that a friendly neighbourhood is an important part of a comfortable life.

When asking if they eventually missed to have a fireplace; some expressed that they did not need it for heating, but for cosiness, and some have considered bringing in a gas fireplace.

One respondent answer the question like this: “Of course! In winter it would be very cosy with an open fire, but I assume it would get far too hot.” She also reflected upon the pollution and the fact that it after all is a renewable energy source too. Others said that they enjoy the smell from wood fireplace when they are at the cottage, but that they do not think about it ordinarily.

All of the respondents living on the topmost floors with extra floor to ceiling height pointed this out as a quality that offered a feeling of airiness. They were all content with the daylight conditions and temperature during winter; “it is SO pleasant!” but all of them claimed that it gets too hot during the summer; “we’re about to peg out, you see...” All interviewees had their balcony doors and windows open during the summer; not only to air, but to get the smell of flowers and greenery and the sounds from the woods: “...birds’ twittering and everything that there is out there. Its not only air, you see...” After staying inside during the winter they perceived it as comfortable “to let the nature in” when spring comes.

The wish to be “true to the manual” has resulted in different efforts that influenced the feelings of comfort in homes: One of the interviewees who is more dedicated to sustainable matters, has not hung up any lamps or pictures yet, after almost 2 years of habitation, because she was afraid of making holes in the walls. She said: “We were told to be careful, and I am afraid of puncturing the whole residential building...” She expressed this as the only negative thing she could say about living here, in addition to the overheating in summer.

All interviewees described the housing as very comfortable, but too hot during the summer. In the beginning they kept to the manual were they were told not to open the windows; “the house was a closed system, and we would then ruin the balance, God knows which balance..., if we opened the windows. After a while, around spring, we started to open windows...”

- Temperature

There are two heating devices in the flats; the floor heating in the bath-rooms and a small radiator in the hall, which is open to the living room. The balanced mechanical ventilation system has a rotating heat exchanger which reuses the heat in the used air. This system does not have a cooling element, which means that when using the ventilation during summer the heat in the used air is just reused. In other words; this system was not meant for cooling, as this was not expected to be necessary in a Norwegian climate. It is up to each resident to order sun shading devices.

The temperature in each flat is regulated by the residents. Concerning a perceived comfortable indoor-temperature, some said 20-21 °C, others up to 23 °C. One informant said that she ordinarily liked to have it a bit cooler, but due to the baby, she has to have a higher indoor temperature.

As referred to earlier, all respondents said that it gets far too hot during summer. Some claimed that it gets up to 40°C; “cruel” and “killing” are words they used about the overheating.

The only ones who thought about, and when doing the interview, ordered installation of sun shading devices, are those who perceived their electricity-bill as far too high and according to the numbers from BKK, have an extraordinarily high consumption of electricity. They said:

“If it does not get better (in the meaning of: if the temperature does not goes down) we will have to install a fast and efficient fan!”

- Air quality and ventilation

The respondents were very satisfied with the air quality. One respondent compared it with how it was when she was living in the city centre: “Black dust everywhere.” and stated that her respiratory problems have improved after moving to Løvåshagen.

Both temperature and ventilation levels are regulated by the residents in each flat. When asked if it is possible to switch off the ventilation system during summer, in order to air naturally (since they air naturally in addition to use the vent anyway), the respondents claimed that it is neither possible nor smart, due to moisture problems that would appear in the dense building volume. They said that they eventually would have to switch off the fuse for the ventilation device. The level of regulation for the ventilation is 1-3. Most of them regulated ventilation, heating and all other devices manually instead of using the “on” and “off” button meant to be turned off when leaving the flat and on when coming home. Most of them said that the ventilation level normally stays at level 2. Some said to me that when leaving the flat and during the night they put it on level 1. When a lot of people were gathered in the flat, they used level 3. None of them suggested this operation was complicated. They seemed to appreciate the freedom of being able to control this system on their own and according to their needs in regards to how many people there were in the flat.

- Acoustics

The acoustic indoor environment is by the respondents perceived as very good between flats and resistant to traffic sounds. They all said that it was very quiet, and they related this to a high degree of insulation. “When sitting outside or when opening the doors and windows we might hear the neighbours... Inside here we don’t hear anything. It is completely silent.”

One respondent expressed that he was not satisfied with the soundproofing between rooms inside the flat.

Regarding the sound of the ventilation system, most respondents said they were aware of it and wondered; “what is this sound?” right after they had moved in, but after awhile they got used to it and now they didn’t notice it anymore. One respondent said that guests told him that the sound helped them fall asleep. Another respondent said that his 15 year old daughter who lives at his place now and then, complained about the sound of the ventilation. Her father put it this way: “It is a habit. Once you gets used to it you don’t hear anything. If you start to listen; everything is making noise.”

One respondent said that the ventilation system makes a little bit more noise when put on level 3, but she claimed that the noise was drowned out by the sounds of people talking and laughter when a lot of people were in the flat.

- Light

It was pointed out by all respondents that the day light situation is very good. The big windows in the living room are an advantage. Only one interviewee mentioned that the window in the bathroom was a little small.

As presented in regard to the “temperature” issue, the big windows are a challenge for the passive house concept as solar irradiation heats up the rooms. Sun shading devices are necessary to solve this problem, yet, none of the respondents have installed any.

Use of technique (level of control, information)

○ *Control*

The respondents expressed that they would appreciate a higher degree of control of their own energy consumption, and claimed that this would make them more aware of which devices, in which rooms or what times of the day that they could actively reduce their use. This was in correspondence with the fact that “the button” was not used by all.

○ *Information*

The informants had different perceptions of to what degree the information level was sufficient. Some thought that this was very easy, some thought that the information was given in a very short time, and that they were left with a manual in order to operate a system that was different than what they used in earlier housing, though some claimed that they were familiar with “heat-exchangers and such...” In households where the interviews have been carried out with both partners, the women often say that “maybe we do not operate the system correctly” or “ it is my husband who operates that...” while the men said: “Its not complicated. If you have a little technical insight it’s easy.” The men also tended to be very eager to show the heat exchanging system in the bathroom: “This is very special! Everyone talks about solar cells and solar collectors, but few actually own one.”

Architecture and aesthetics

• Energy efficient aesthetics

All interviewees responded very positive to the architectural aesthetics. One of them said that “it is really, really nice! This is not a block of flats like you see elsewhere; like the ones that seemed to be rolled out and chopped up in appropriate parts. Grey, sad and similar. This looks fun, something special, something else... and I like that! On pictures I thought it looked a bit “yuppie”, but when I came here for the first time I was positively surprised. It is a very lucky combination between colour, form, materials and how it fits into the environment and the landscape.” He perceived the oriels (“the piers”) as “very funny”. He honoured the architects and reflected on whether this was just done by chance, by cleverness or in a combination, and he concluded: “This must be a combination of luck and cleverness! This cannot be accidental! Bold!”

Questioning if the architecture reflects that the buildings are environmentally friendly, one of the other respondents answered: “It reflects that it is modern, and then maybe it implies its` energy efficiency, at least.” Others expressed that they liked the modern and future oriented image; “it is cool with architecture that express modernity; that not has to be old style.”

Other respondents didn’t have a reflection about the architecture as an expression of sustainability or environmentally friendliness; “the only things must be the solar collectors and the thick walls...” One respondent pointed out the solar collectors as an environmentally friendly feature, but she also said that she does not see them.

• Floor plan organization

All the respondents expressed that they all in all are very content with the floor-plan. The size of the flat and the organization were in general perceived as in accordance to their needs.

The respondents expressed that they appreciated having such a roomy entry. One of the families interviewed has children with special physical needs, and this family found both the outdoor area and the flat very usable for their needs, except from the entry/ the hall that they would have liked even bigger and more spacious. One respondent said that she would not like to have the bedrooms facing the living room in her next home. Another respondent said that the storage capacity was a bit too small. The two couples that had moved out of one-family houses said that they were a bit

unaccustomed to live in an open floor plan, and found it difficult to adjust to doing different things in the same open space, but they assumed that they would get used to it after awhile. One of the couples has furnished the flat with a mobile kitchen-island to divide the space between the kitchen and the living area.

- Material and colours

Some of the respondents expressed that they had been a bit sceptical towards the wallboards, and that they would have liked more use of wood. Another point that was commented on by more of the respondents was the glass used on the balconies banister. They perceive it as very beautiful, but did not like the transparency, which was an obstacle to privacy on the balcony. "It is like sitting on the same balcony as the neighbour..." They in turn called for a frosted or coloured solution that offered a better shielding.

One of the respondents was critical of some of the architectural choices and also the craftsmanship indoors regarding details like no moulding between ceiling and walls, unusual window mouldings, and the solutions around the entrance door and common outdoor steps. He found these solutions very vulnerable to constructional movements and outdoor; climatic strains. "It's nice, I can see that, but it is not functional... Architects are all the same... never focusing on functionality..." His wife did to a certain degree agree with the vulnerability regarding the interior detailing, but she accounts for it differently; "it is very strange for us to live in a flat after having a big one-family house. My husband has too little to do, and is not used to live like this yet. Regarding our house move, I was more sceptical than him, but now it has changed... I feel happy!" and she said the same as some of the other respondents: "The choice of colours are exquisite!"

They all celebrated the choice of colours and how it fit into the landscape, with the greenery and the woods, and they gave a very beautiful and colourful impression of how it is to come home on a cold winters eve, when it is dark outside; "The colours are glowing! It is so beautiful!"

- Identity

The informants said there was a good neighbourhood spirit and friendship among neighbours in the very dense neighbourhood. They told of women who had a nice chat in the open galleries and parents with kids who met in the sandbox, while enjoying the common outdoor area. It was also said that there are people who do not bother because they are "just living here for a while" or people who just invest money but do not contribute socially and people who always like to complain or get annoyed by children's play and laughter, dogs, rubbish, etc.

All of them expressed that they live in very nice cooperative housing, that gets a lot of visitors and they expressed that it was fun being a part of this. One respondent said: "What is written about Løvåshagen in the media is very nice; and that's great because they seldom write anything positive about residential environments in the newspapers."

By asking the respondents: Do you feel proud living here? – some answer immediately "yes!", while others hesitates and did not agree that the word expressed their feelings, but they were obviously flattered by the fact that others think Løvåshagen is an interesting future oriented residential environment.

Summary

The low deposit has made it possible for both families in the establishment phase, the elderly and people with special physical needs to move in and feel comfortable at Løvåshagen. This goal has not failed! One respondent even pointed out that she was not sceptical of the low energy aspect but of

the low deposit aspect. However, she perceived the endorsement by the Norwegian State Housing Bank as a hallmark, "...then it could not be a small and speculative project..." and decided to buy.

Some of the informants thought that living in the first passive house in Norway; stated as an ideal to follow by Enova and The Norwegian State Housing Bank, and all the publicity Løvåshagen has achieved due to that, has linked them as inhabitants together in a positive way. They felt proud and cheerful about this fact, but they are nevertheless not keeping the more negative aspects to themselves, and are more than willing to share this information too. One of them expressed it like this: "Of course; it would be nice if you could report that this is quite fantastic and people do not use electricity, but that is not exactly the truth... though we live quite ordinarily and don't do anything extreme." They express that they want to understand why their bills are not what they expected them to be, and that they in general were very content with living at Løvåshagen.

In general the interviewed residents were satisfied with heating, ventilation, day lighting and usability issues, but overheating during summer was an outspoken, big problem.

Concerning changes in lifestyle it did not seem that this had happened at Løvåshagen, yet. In general the respondents tended to be more conscious about how they might influence their own energy consumption in relation to their own wallet, but the consciousness seemed to be limited by what they comprehend as convenient. In addition, some expressed that they did not believe in any global effect by living in energy efficient housing, and each and every ones contribution in saving the climate by making a change in own lifestyle. Even if not always behaving in a most optimised way, the respondents' statements indicate anyway that the concept raised awareness for environmental issues among the residents.

Their statements verify that physical environments matter. They enjoyed the architecture and the common facilities that supported a feeling of unity within the residential cooperative. They linked the beauty of the environment and the beauty of the architecture to sustainability and future oriented issues. They got annoyed when the possibility to control their own energy use was out of order for months before it was removed, and they were eager to find out why some energy consumption bills were so much higher than the neighbours'. It's quite obvious that a good working system and nice architecture will benefit the energy efficient household concept and sustainable issues in general.

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Contact: solvar.wago@ntnu.no



Photo: C.F.Møller

Summary

Case:
Dragen Children's House, Odense, Denmark

Based on interviews with users and the architect

1. Facts

Project description is based on the "Fact Sheet" provided by Odense Municipality, and by an interview with the architect. Published information has also been provided by the architect.

The construction is a certified passive house with energy-class: "PHI-Standard Darmstadt", one of the first in Denmark. Almost all components are eco-labelled "Nordic Swan".

Owner

Dragen Children's House is a public kindergarten, owned by Odense Municipality in Odense, Denmark. Odense Municipality is the client, headed within the section for Facilities management in cooperation with the Schools and Kindergartens department.

Location

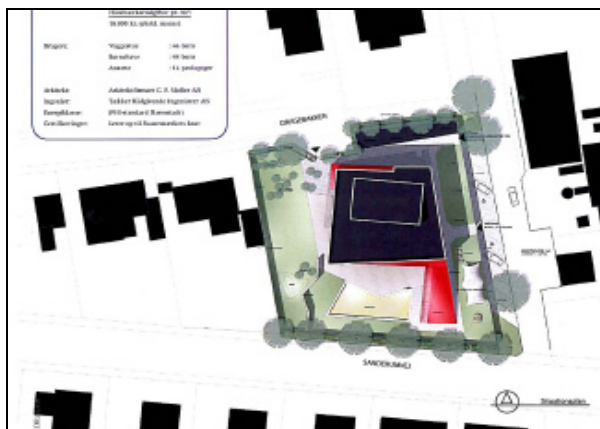
On the island Fyn, in the South-West region of Odense city, "Sanderum, Dragebakken".

Address: Sanderumvej 81-83, 5250 Odense SV, Denmark.

Tel: +45 637 55 085 (the kindergarten office)

+45 2459 7646 (head of the kindergarten's cell phone: Susanne Laila Christensen)

E-mail: such@odense.dk



Located close to a relatively busy medium sized road.

The buildings close to Dragen to the East are a part of the local "district heating plant".

Picture: Odense Municipality

The site is rather narrow, and residential neighbourhoods are relatively close to the children's playground. Noise has been a challenge from both the road traffic and the playground; the neighbours have also found the playground noisy.

Architect

Responsible Architect: C. F. Møller Architects, situated in Århus, Denmark. The company also has offices in Copenhagen, Aalborg, Oslo, Stockholm and London.

The responsible contact person from the Århus office: Architect Mette Nymann Nielsen.

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Climate

Average temperature / year: ca. 8 °C

Total hours of sunshine / year: -

Precipitation mm / year: < 600 mm

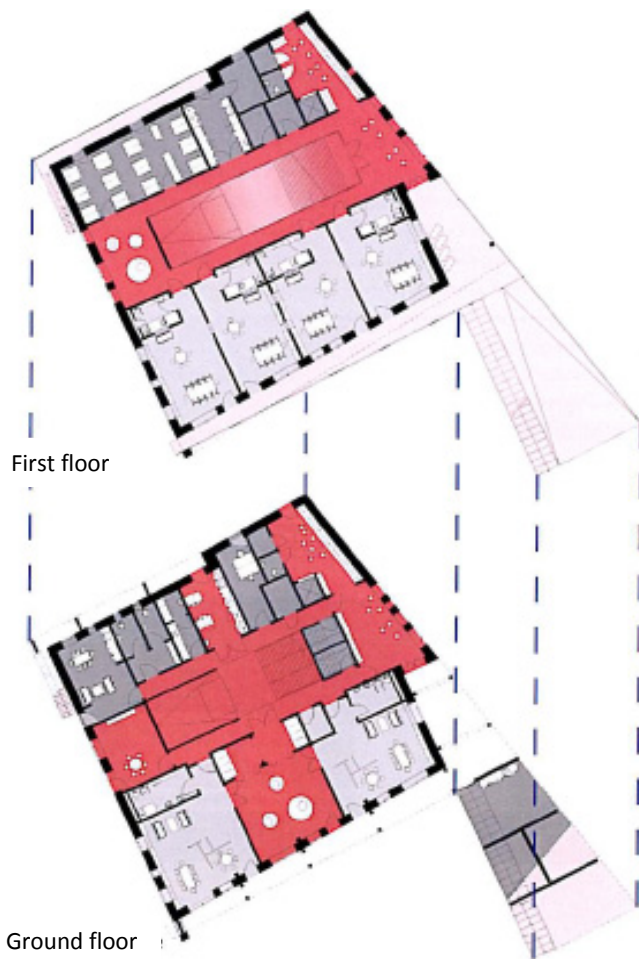
Numbers for Odense, www.snl.no/Danmark. Numbers are based on national averages from the period between 1961-90. Differences between summer and winter are small, and as a "plant geographical zone", this region is categorized as "Middle European forest climate". February is the coldest month, with a minimum temperature of -3°C.

The micro-climate of the site is not particularly challenging, and the site is sheltered from wind by tall trees across the southern road. In the planning process, these trees were also a part of the energy design premise: the theory was that the trees would protect against sunshine during the summer period, and allow low sunshine to come through the windows in winter time.

Project information

Dragen Children's House was built in 2008-2009, and completed in the summer of 2009. The architectural concept is a simple, geometric shape consisting of two levels, with the children's areas located on the south side. Offices, kitchens and secondary functions are located on the north end. The two levels are linked by staircases and ramps, and the central hall is a gallery, open on both levels.





First floor:
Small children's section (0-3 years) located on the south end. Kitchen, sleeping rooms, storage space etc. are located on the north end. In the middle of the building, there is a central hall with the main stair, a large open space and daylight from a clear storey of window.

Ground floor:
Two sections for older children (3+ years) are located on the south end. The offices and staff accommodations are located on the north end.

The concept of two floors derives from the need for outdoor space to facilitate a playground on the narrow lot selected, and from the necessity to have a compact building as a part of the energy solution. In Denmark, two storey kindergartens are usual.

Approximately 40% of the glass areas are windows and doors facing south. These are shielded against sunshine by a balcony in the second floor, and on the first floor by an overhanging roof. The balcony is also the fire escape. The north façade has a closed character with only small windows.

The three most important issues in the design – beyond the passive house concept – were 1) to develop the children's motor skills, 2) respecting the neighbours, and 3) creating a design that includes indoor and outdoor activities. The Children's House is designed for 44 children aged 0-3 years and 44 children aged 3+ years, and 14 adult employees.

Gross area: 1.050 m² (= 11,9 m² BTA/child), where 414m² is defined as "indoor play space"
Building costs: 27,5 MIO DKK in 2009 (excl. VAT).

According to web-based information from the Odense Municipality, they are proud of the play space: "The total area is 414 m² of play space for the 88 children, which is far more than the minimum standards of 268 m². This will reduce the risk of spreading illness, and generally make room for more activities", and they state that "there is far more space available than in traditional kindergartens".

Accordingly, the play space is approximately 4.70 m²/child, which is more than 50 % larger than the minimum standard (according to provided information: 3.0 m²/child). The spatial area was decided in consensus by the architect and the users.

Construction

The external walls are built of pre-fabricated wooden, insulated wall segments of a low weight, which have a low CO₂-emission over their total life span. The wooden parts used in the project have FSC-certification and thus are produced in an environmentally friendly way.

The wooden elements also contribute to a positive and healthy indoor climate. The generously glazed facades provide a lot of daylight to the play spaces. Most other materials used were selected from “Nordic Swan” eco-labelled products.



Figure: The central hall with the common play space.

In addition, a focus on the indoor quality resulted in artistic acoustic installations, designed for the children: “trees” made of 78% recycled textile materials.

Photo: C. F. Møller

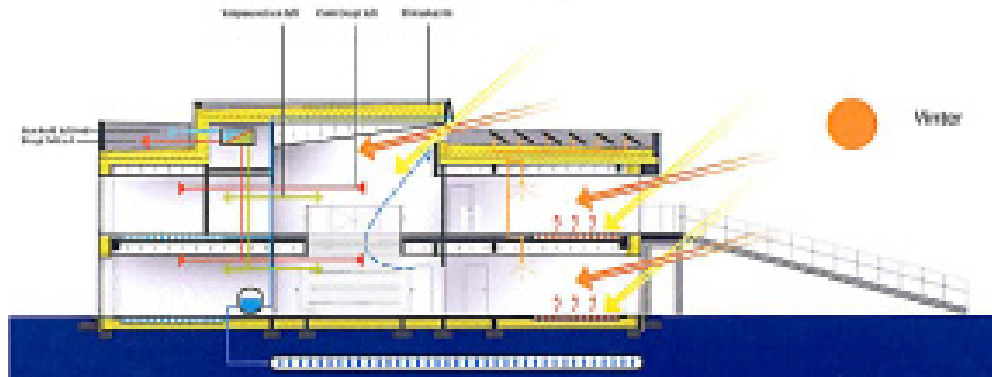
Materials used:

- Façades: Concrete plaster and fibre concrete elements
- Windows: Wood and 3 layers of glass, U = 0,74 (fixed elements) and U = 0,85 (movable)
- Inner walls: concrete and wooden elements
- Floors: Ash tree and rubber floors
- Ceilings: Acoustic materials and plasterboards
- Furniture: Wood, painted white

The construction period was kept as short as possible. They tried to have short travel distances for the building materials to reach the site (locally supplied if available), and there was a strong focus on a dry and clean construction site.

Energy supply and consumption

The building is a certified passive house according to the “PHI-standard Darmstadt”.



Measures used are:

- Compact shape. The shape of the building minimizes the heat loss through facades and the flat roof.
- The external walls are made of prefabricated wooden wall segments with very thick insulation (approx. 40 cm), and inner walls and floors of mostly concrete, to obtain accumulation of heat/cooling through the constructions, and thus reduce the need for cooling systems.
- Orientation. The building has large windows facing south with small and narrow windows facing north – to let the sun’s heat come in from the south, and minimize heat loss from the north.
- Dense construction. Attention to the high performance of wind barriers and moisture barriers, and to technical solutions that omit thermal bridges – to reduce heat loss and infiltration.
- Solar shading. Overhangs for solar shading of windows in the south façade: approx. 1.3 m roof overhang shades the top floor, and a balcony of the same size shades the ground floor.
- Ground-coupled heat pump. The heat pump with 400m pipes delivers energy for the water for space heating. The heat pump provides 35 °C, and has a COP (**coefficient of performance**) of 3,9.
- Solar heating through solar collectors. 13 m² solar collectors contribute approx. 5.300 kWh/year to the domestic hot water supply.
- Electricity from solar cells (photovoltaic). Approx. 250 m² solar cells on the roof contribute approx. 9.430 kWh/year to the electricity supply.
- Ventilation system with rotary heat recovery unit, provides a dry temperature ratio of 81%.
- Electricity for fan power is 1,65 KJ/m³ (while the requirement given in the Building Regulation is not more than 2,5 KJ/ m³).
- District heating is a supplement to the solar heating of domestic hot water (especially in winter when solar collectors do not cover demand).

Intentions and goals

Odense Municipality’s intention was primarily to establish a kindergarten in which the architecture contributed to their ambitious goals for education: the architecture should contribute to creativity and inspire within the play spaces and the playground.

The building should also contribute to the holistic approach of sustainability, by combining educational goals with measures for a sustainable building: the building should have a passive house standard, focus on life cycle costs and environmentally-friendly materials, the understanding of these values should be visible to all the children.



Photo: C. F. Møller

Awards, media, certificates, etc:

Certificates etc.:

“PHI-standard Darmstadt”

“Nordic Swan” eco-label

Awards:

The Odense Municipality has honoured C. F. Møller Architects for the design of the building.

The award ceremony has praised “Dragen” primarily because of the architectural qualities. But it was also acknowledged for the acoustic installations (designed by artist Lene Barnkop Kaas).

2. Results

Summary

- 😊 Very good
- 😐 Could be better
- 😞 Can be problematic

Name of the project	Dragen Children's House
Type of building	Kindergarten
Perceived atmosphere	😊
General comfort	😊
Thermal comfort in winter	😊 / 😐
Thermal comfort in summer	😊 / 😐
Air quality (winter)	😞
Acoustics	😊
Daylight	😊
Artificial lighting	😐 / 😞
Materials / Colours	😊
Level of control	😐
Solar protection	😐

Interviews with users

- Contact and choice of respondents

Contact information was found on the website of "archinnovations.com" (an online architecture magazine), and further information through direct contact with C. F. Møller Architects.

The respondents were proposed by the Head of the kindergarten at "Dragen Children's House". The building was completed the summer of 2009, so none of the respondents have experience in the building for longer than little over a year – one of the parents only 3 months.

6 respondents were interviewed, and in addition the responsible architect was interviewed.

All of the respondents are females, and relatively young (25-35 years old). They were:

- a) The Head of the kindergarten (woman, 35 years). She also followed the planning process.
- b) 3 employees (all women: 25-35 years); all preschool teachers; two work with 0-3-year old children, one works with 3+ years old.
- c) 2 parents – (both women: 25-30 years), and both parents of 0-3-year old daughters.

Environmental profile and users' reflections

- Intentions and goals

Initially, none of the respondents were especially interested in the passive house concept; they were interested because it was new, nice and the educational concept was new.

None of the three employees or the Head of Dragen applied for job at the kindergarten because it was a passive house or had focused on the environmental qualities. Two of the three employees did

not even know about this. They all applied for jobs because the building was new: they primarily wanted to work with a new and creative educational concept in a building with nice aesthetics.

The parents also applied primarily because the building was new. However, they also knew it was a passive house; one of them regarded this as a pro – the other thought this might imply greater comfort regarding space and a healthy indoor climate.

- Previous knowledge on energy efficient buildings and interest in topic

Respondents' interest

None of the three employees (or the Head) knew much about passive houses before they applied for the jobs at Dragen. Two of them had been interested in environmental issues and energy consumption in their private houses, but not much.

The Head was involved in the planning process and had to take decisions alone. She became gradually more interested in the design concept and in the health aspects – even though the educational topics related to floor plan design were still of greater interest to her.

Of the two parents, one of them was familiar with the passive house concept while the other was not. And none of them were really interested in energy consumption and/or environmental issues – but they thought that, “it could not be harmful”. However, both parents were interested in health, ecological food, and other types of environmental issues / attitudes in general – especially making the children interested in environmental issues.



Focus and information related to energy consumption

In the entrance hall there were screens displaying two types of information:

- The upper part of the screen is dedicated to information about the activities at Dragen: pictures and written information of what they have done during the day, information of what they plan to do next day, a summary of events, messages to parents, etc.
- The lower part of the screen (at “reading height” for the children) shows information about energy consumption and other aspects related to the passive house concept and other “sustainable elements” of the house.

Photo: S. Jerkø

At the first meeting of the season, the Head of Dragen distributed a booklet about the passive house concept and the information displayed on the energy-screen. Nonetheless, the general impression is that there was little focus on energy consumption at Dragen – even if one of the parents said that the staff told them information about energy-related issues at all the meetings.

Of all the six respondents, only one of the teachers actually looked regularly at the screen showing energy-related information. She was one of the two employees who reported that she had been interested in energy consumption in her private house as well.

None of the others were interested in watching the energy-screen (the lower screen in the hall), and they also said that they did not understand the information on the screen. One of the employees would like to know more about what the screen displays. Both parents followed with interest the upper part of the screen, with information about the children's activities.

The Head did not monitor the energy consumption regularly except when someone tells her that the screen shows a deviation from the norm.

Interest from family, friends and others

The families of two employees were interested in the passive house concept, and asked for information regularly – one of them had a father with a special interest in machines and the monitoring equipment. The rest of the informants reported little interest from their private associations. The staff did not believe the parents of the children were very interested.

A lot of interest has been shown to the passive house in local newspapers and other public media. In this respect, the energy concept was focused on. Most of this focus was positive. However, one of the teachers said that she would rather have the reporters write about "their" new and special education concepts – which was more important to her than the passive house concept.

The staff also said that during the planning process there had been some protests from neighbours when the selection of the site had been made– the construction site was seen as "too narrow for 88 children and too close to their houses", and neighbours were concerned about noise and traffic. Discussions about design concepts to avoid these conflicts received much more attention in the neighbourhood than energy consumption – and journalists took a greater interest in this potential conflict.

- Changes in interest and behaviour

The changes in interest and behaviour have been minor. The Head of Dragen became more conscious and interested during the planning period, and has since then become more interested in the topic – but to a relatively modest degree. Two of the three employees have not changed their views or behaviour – but the third has been slightly more interested (from not interested at all), and she also would now "defend the concept" if anyone criticized it.

One of the parents said that she had not changed, but the other reported that she was slightly more interested in energy consumption.

Most of the respondents reported that the public interest was positive regarding the kindergarten, and that they were proud to work at this place or have their child attend. But if they should change job (or kindergarten for their child), the passive house concept, the energy consumption or the environmental profile would not be important for their next choice of kindergarten. The profile of the education and the general aesthetic impression would still be more important.

Comfort and indoor climate

- General comfort

When asked their opinion regarding the general comfort of the building, almost all reported that they thought the comfort was good or very good. But when asked what they meant by "good comfort", definitions could be quite different:

- Good indoor climate
- Better indoor climate now than in the first period
- Good ergonomics in furniture and work-related installations
- Good acoustic regulation
- New building, and beautiful design, colours and use of daylight
- User-friendly building in all aspects (universal design, including elevator)

Despite a generally positive attitude towards comfort, two aspects were not answered with the same level of consensus: temperature and air quality.

- Temperature

When the building was new, they had a number of problems with temperature – now this has been regulated better and there are fewer complaints. But still, they have a few problems.

In general, they did not know what the indoor temperature in the building was. They had the possibility to regulate the temperature by turning a knob on the wall, but this knob did not have any marks telling the actual temperature in °C – the only possibility was “to the right = warmer” or “to the left = cooler”. But as the Kindergarten Head informed, the concept of temperature regulation was in fact not so simple: several rooms did not have floor heating, and in these rooms it had been necessary to install additional heating via electric ovens (standing in the middle of the rooms; unpractical). In addition, there had been significant difference in temperatures between the rooms, which was also difficult to address. They thought the temperature differences caused some health problems in the first period. But they did not know what they would regard as an optimal indoor temperature either: one guessed “twenty-and-something”, another 18-19 °C (and she also said that she often felt cold, and put clothes on both herself and the children, especially in winter time).

Most often the staff did not touch the temperature-regulation knob at all; they regulated personal temperature by taking clothes off/on – both for the children and themselves. But the parents thought that the employees made too much fuss about the clothes on/off.

Most of the respondents were content – except for the person who was freezing, they said that it could be too warm in the play spaces (on the south) in summer time, and sometimes too cold in the rooms on the north side (sleeping room for the children, and offices for the staff).

- Air quality and ventilation

In general, interviewees first said that the air quality was good, and one of the parents even commented that the air was “surprisingly fresh and nice” when they picked up the children in the afternoon.

But all the employees reported that they had to open doors and windows as often as possible to avoid the feeling of stale air, even if they had been told not to do so. The Head of the Kindergarten told us that it was also necessary to get rid of ‘pooh’ smell etc., and that the system could not handle these “bad smells” fast enough.

All the employees reported that the air was too dry, especially during the winter. One of them had to drink a lot of water to avoid headaches, and another had problems with her eyes etc. and had to use eye-drops.

- Acoustics



Figures: All the respondents describe the acoustics as very good or excellent. In the play spaces, there are acoustic elements placed in the shelves or similar places close to the ceilings. These elements are also made of textiles similar to the “trees”. Their positions can be adjusted for acoustic effects (angles, numbers etc.) and to change the colour combinations.

Photos: S. Jerkø

- Light

The artificial lighting was commented on by all the respondents except for one of the parents. It was considered too sharp, especially in the central hall, and also during the morning when they would like a “soft start” to the day with the children. They wanted the possibility to dim the lighting.



Figures: All the respondents were very pleased with the natural daylight in the play spaces, but they thought that it could be too light and too hot during summer periods; they wanted blinds. The architect had calculated the balcony and roof overhang to provide sufficient shading, which it obviously did not. The rooms / offices to the north façade were also regarded as too dark.

Photos: S. Jerkø



Photos showing the balcony and the roof overhang which should serve as solar shading integrated in the façade.



Photos: S. Jerkø

- Use of technology (level of control, information)
 - *Control*

The concept for facility management was that as much as possible shall be controlled automatically, and the users of the building are only allowed to adjust the temperature.

The employees are partly content with the systems where everything is controlled automatically. But they add that they have had problems with the automatic systems for opening windows. It did not work the way it should – but they didn't report this; they think it was a better solution just to open the windows as much as possible. The sensors for the artificial lighting also failed from time to time.



Photo: S. Jerkø

There are two large technical rooms, but to everyone, except the Head of Drogen, this is just “two closed and locked doors”.

The Head inspects the rooms 1-2 times a week, and is instructed to look at the positions of the needles. In case of deviation from the normal position, she calls the FM administration in Odense Municipality. The Head is content with this routine, even if she thinks that she spends more time on FM here than in a normal building.

○ *Information*

The employees said that they received general information when they started to work there and as long as they are not allowed to control the systems themselves, they think that they do not need constant information. For especially interested people, they can follow information given by the “screen for energy consumption” in the entrance hall, to follow the “performance”.

Architecture and aesthetics

• Energy efficient aesthetics

None of the respondents thinks that the house looks like an energy efficient building.



Photos: S. Jerkø

The interviews took place in the room with the windows shown in the photo to the left.

The photo to the right shows the windows in the play space rooms with 40 cm insulation.

They could not point out any specific elements that showed that there was anything special with the building. When they were told that 40 cm of insulation was unique for passive houses, they said that they had not noticed this and they would not have thought that this building had thick walls. Having brought this to their attention, one of the employees insisted that the walls were “not thicker than usual”.

However, most of the respondents thought that the building was “environmentally-friendly”, but the meaning they attached to environmental friendliness differed between people. One pointed out the extended use of wooden materials in interior, furniture and toys as an important factor, one referred to the natural light and general “friendliness”, one noted the interior volumes and space, and another said that it was just a “general impression” without any specific reason.

The others were not aware of that the building was “energy-efficient” or “environmentally-friendly” and they did not consider this important. They also pointed out that the technical solutions and equipment were hidden – it was on the roof, down in the ground, behind locked doors etc., and that they would need to have better knowledge of what they should look for.

• Floor plan organization

The respondents regarded the floor plan organization as good; with clear and functional organization. However, they had some additional comments (positive and negative):



Photos: S. Jerkø

The thick walls were turned into to play spaces in several ways.

- Between the rooms (in interior walls), they had several “crawl openings” with different sizes and shapes, and these were very popular among the children (see photo to the left).
- They also had some (one or two) similar openings in the external walls – smaller and with longer “crawling lengths”.
- The windows came down to the floor when possible, and the children could then use this space for activities. They even played in window sills when they where higher up on the walls. (See photo to the right).

The architect and the Head of Dragen had visited some passive houses in Germany during the planning process, and had seen passive houses with thick walls, but there the position of the glass was closer to the inside. They really wanted the thickness to benefit as a play space.



Dragen also had several rooms reserved for the children’s’ special activities:

- Room for motor skills
- Room for design activities
- Stage / performance

The room for motor skill development was especially popular.

Photo: S. Jerkø

Almost all of the respondents had negative comments about the main staircase in the central hall and / or the stage.

- The stage was impractical because of the slope, the under utilized space and it is considered too big for the room.
- The main staircase was considered too big and it took too much space in the room, making the play space less functional.



Photos: S. Jerkø

- The main staircase was too dangerous for the children. They had tied a pink ribbon in the middle of the staircase, to indicate to the children how high up they were allowed to crawl, and the children were obedient. Still, the employees used too much time and energy on looking after children in the staircase.
- For safety reason, they also had to close the top of the staircase with railings (in glass).



The organization of the floor plan was based on having the youngest children (0-3 years) on the first floor, while the older children (3+ years) and the specialized playrooms were on the ground floor. The solution with the smaller children (0-3 years) on the upper floor was regarded as impractical at first – both of employees and parents. They had to take the prams into the elevator to get up to their sections, even if some of the children were sleeping outdoors in their prams. And/or they had to carry/lift the small children up the staircases or use the elevator during the day, which they thought of as heavy and impractical. But now, they regard this as a habit.

The architect commented that the building *had to have two floors*, and that some functions had to be placed on the first floor. And the older children would better utilize the ground floor, because of the outdoor access.



The photo shows prams in a shielded balcony on the first floor.

Photo: S. Jerkø

- Material and colours

The use of wood is perceived positively by all the respondents. Some of them also regard the use of wood as a key indicator to users and visitors that “this building is environmental friendly” and “healthy”.

The respondents also reviewed the other materials in the building positively– except for one of the employees, who thought that the materials used in some places appeared “too cheap”, and she wondered if the cost of all the passive house equipment had been too expensive, so they saved money on other materials. Both the architect and the Head denied this; the economy of the construction was considered good.

The architect had more comments regarding the materials. The requirement of using only materials with the “Nordic Swan” eco-label was more difficult than expected, especially when the architect also had design ambitions on the materials. The choice of products in the market was also too limited, and “the producers are a bit behind”. The greatest challenge was to find suitable windows, but at last they managed to find a small, local producer able to fulfil the requirements.

- Identity / Image

The interviewees are proud of the building – but mainly because it is “nice and new”, and because they appreciate the architecture and the educational concept. The passive house-concept is only regarded as a “bonus value”, but makes them feel “proud”.

Summary

General attitudes

The general comfort was perceived as high and the overall picture of the building that the interviewees convey was very positive. They felt well in the building, pointed out the good atmosphere, the beauty of the daylight in the interior, and the pleasing materials used.

The interviewees were not particularly interested in passive houses before they came to Dragen. They were in general not interested in paying attention to the energy consumption, and this experience has not changed their attitudes very much, except for smaller changes reported by some. They would ‘*maybe*’ give these aspects a bit more attention in daily life. Still, they were proud of the building. Their main concern was the profile and quality of the activities and the new educational concept.

Indoor climate

The acoustics was considered excellent, they were very pleased with the materials used and with the natural daylight – even if this could be too much on the southern side and too little on the northern. Unfortunately, the artificial lighting was considered too sharp, and they wanted the possibility to dim it.

The temperature could also be a challenge. During the summer, the play spaces facing south were too hot, and during the winter, the offices to the north were too cold. All year there were temperature differences between the rooms, resulting in a lack of comfort and probably effected health. They had the possibility to regulate the temperature by turning a knob, but they did not. Their solutions to the temperature challenges were: a) adding extra heating with electricity, and b) taking clothes on/off, which was regarded as impractical with children.

The parents perceived the air quality as good when they picked up their children in the afternoon, but this was not because the system was working well. The employees were instructed to not open the windows, but they did so as much as possible – both for lowering the temperature and for getting rid of odours. They regarded ventilation through windows as natural and necessary. In addition, the air quality was perceived as too dry during the winter period, which caused problems such as dry eyes.

They were content with the generous floor space allotted per child, and with the huge indoor volumes. The users of the building thought this was a part of getting better indoor climate – but according to the architect, it was a product of the space programming for the kindergarten.

References

Fact booklet, by Odense Municipality
<http://www.archinnovations.com/featured-projects/academic/18/>



Summary

Case:
La cité de l'environnement, Saint-Priest, France

Based on interviews and surveys among users.

"The first zero-energy office building in France where all energy use (including electrical appliances) is compensated!"

1. Facts

The project description is based on information provided by the architectural company *Atelier Thierry Roche et associés* (91 Bis av République 69160 Tassin-la-Demi-Lune) and the consulting engineering company *ENERTECH*.

Owner

La cité de l'environnement is owned by Pole SOLERE. Founding members are: MCP Promotion, developer and initiator of the project with Atelier Thierry ROCHE et Associés. Atelier LD: Town Planning, Landscape, Environmental Technology Bastide Bondoux : consultants for thermal engineering in housing. There are associated members too, all of them consultants on environmental questions.

Address

355 allée Jacques Monod, FR-69800 Saint-Priest, France

Location



The office building is located in Saint-Priest (45° 41' 50" N, 4° 56' 41" E), a suburb southeast of Lyon. Lyon is situated in east-central France in the Rhône-Alpes region, 470 km from Paris. The building is part of the technological park of Saint-Priest and mainly surrounded with office buildings and green park areas. All sides of the building are exposed to the exterior (no adjacent construction).

Figure 1: Overview (Photo: Atelier Thierry Roche et associés)

Climate

External air temperature for heat loss calculation: -11°C

Total hours of sunshine / year: 1937,4 h

Precipitation mm / year: 887,3 mm

All figures are regionally normal for the period between 1971-2000 for the meteorological station of Bron (45°43'N, 4°57'E, 7 km from Lyon, altitude 200m). Source: <http://www.lameteo.org/lyon.html>

Year of construction

The idea of building “La cité de l’environnement” was initiated in 2005. The construction was completed in October 2009.

Project information

La cité de l’environnement is the first centre of excellence dedicated to energy efficient housing in France. It brings together urban planners, architects, consultants and developers who are recognized for their knowledge of environmental quality in urban planning. It has the ambition to be the first “positive energy” building in France.

The cité de l’environnement is a five storey building, with three office storeys and two underground storeys for parking and technical rooms. The building consists of two rectangular parallel wings with a central atrium. Gateways link the wings. It has a south-west/north-east orientation. The wings are only 12 m wide which gives good conditions for daylight use.

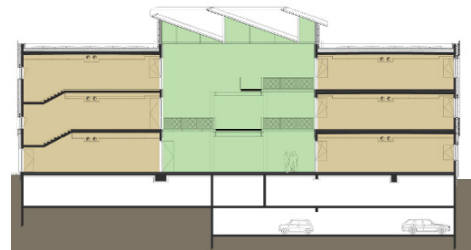
Number of work places: 130 for the moment (2010, part of the building has not moved in yet). It can house up to 225 persons.

Area: 3 400 m² offices, 600 m² atrium, 1 600m² parking, 7 000m² building plot

Building costs: 9 915 000 € exclusive of tax / VAT not included



Ground floor



Section through the atrium

The atrium is very important to the architectural concept, as a place for meeting and gathering. It is not heated. In order to warm the atrium the walls of the adjacent buildings are less insulated towards the atrium than towards the outside environment. Skylights provide natural ventilation. Lighting at night is LED, during the day it is only lit by daylight.



Figures: Natural ventilation of the atrium in summer: sliding doors at entrance level are open during the night (there is a security feature). The air goes through the skylight and refreshes the atrium.

Intentions and goals

The members of the SOLERE Cluster wanted to build a demonstration project which could match their own professional practices. One of their objectives was to showcase innovative environmental solutions to municipalities, developers/builders and building owners, so they can be able to implement environmental qualities in the different phases of their own projects. The intention from the start has been to incite synergies and facilitate cooperation in order to design and produce new ambitious building projects. The architectural concept has been thoroughly designed to achieve the energy objectives of the building. The building had to produce more energy than it uses. Not only should it have exemplary energy performances but it should be a building where the employees' health and social needs are in focus as well. A doctor in medicine was involved in the choice of materials and surfaces (medieco) to achieve the best potential air quality. It was important to create a pleasant and comfortable workplace in order to encourage interaction between firms. The aesthetic aspect was thus an important matter too. That is why the atrium is an important element, which provides users the opportunity for informal meetings.



Figure: The Technology Park, designed with advanced environmental standards, accommodates approximately 90 high-tech companies. It was developed by the SERL, a public company in charge of the commercialization of the land and committed to sustainable development. The landscaping is an important part of the development and has been given great attention. It is developed on 140 hectares and includes retention ponds for rain water, landscaped areas, public transport (tramway).

Construction



Figure: Vertical timber cladding in combination with glazing and sanded surfaces.

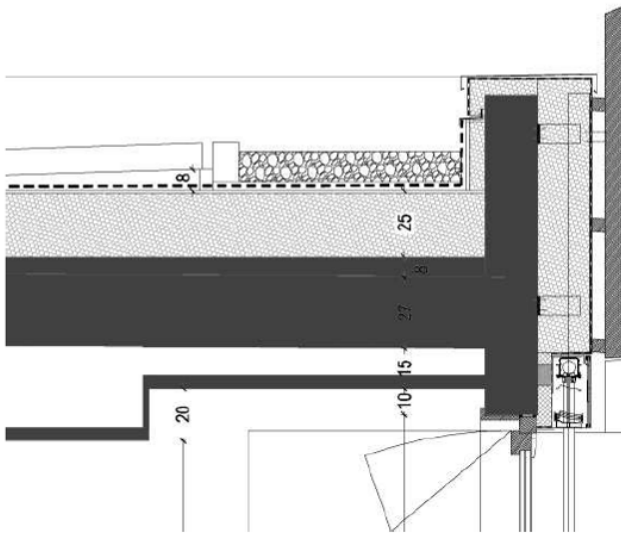


Figure: External insulation is used to avoid thermal bridges.

Table 1: Insulation level of the building

Building's part	U-value	Construction
Floor	0.24 [W/m ² K]	140 mm rock wool insulation
External walls, offices	0.19 [W/m ² K]	Concrete wall, 200 mm EPS (external insulation)
Internal walls facing atrium	0.39 [W/m ² K]	Lightweight walls, 40 mm glass wool insulation
Roof, offices	0.10 [W/m ² K]	240 mm PUR insulation + 40 mm perlite
Roof, atrium	0.17 [W/m ² K]	180 mm glass wool insulation
Windows, offices	0.90 [W/m ² K]	3-layers glazing, wood/aluminum frame
Glazed surfaces, atrium	2.6 [W/m ² K]	

Look at annex 1 for more details.



The atrium can be used as a place of meeting and conviviality.



Lack of heating leads to another use of the atrium than intended during the winter.

Energy supply and consumption

The net energy demand for the whole building has been estimated at 41 kW/m²·yr during the planning stage. The building has been designed as a zero-energy building, which means that the total energy demand of the building (lighting and electrical appliances included) has to be compensated for by the production of electricity from the photovoltaic roofs.

The annual production of energy from the photovoltaic roofs was estimated at 140 000 kWh during the design stage. The production started in July 2010. The production by the end of November approached 55 000 kWh. We can estimate a production for the second half year of 2010 to reach approx. 60 000kWh. Supposing a higher production in spring than in autumn, the annual estimation seems possible to reach. The system is linked to the electricity grid of EDF (Electricité de France). In order to achieve architectural integration two different types of photovoltaic modules are in use:

- 153 m² semi-transparent type (mono crystalline)
- 1250 m² polycrystalline type

(Which represents 0,40 m² of PV/ heated m².) There is floor heating in the offices.



Figure: There is no central heating in the kitchenette, but a little radiator. The ventilation is mechanical and the heat produced is not recovered.

2. Results

Interviews with users

- Contact and choice of respondents

The feed-back from users of the building has been collected in two interviews and a survey submitted to 30 other users who were working in different areas in the building in order to represent different experiences of use. The survey had 28 respondents, which corresponds to a response rate of 93%. In addition, a meeting was held on the site with the architect and there were informal dialogues with a few other users.

Environmental profile and users' reflections

- Intentions and goals

One goal is to avoid any unnecessary energy use. Individual behaviour should be questioned. How can the employees change their way of doing things to improve their energy use?

"Positive energy is possible to achieve, but if the behaviour is "bad" as to say not energy conscious you will not reach the goal" says the architect. In order to reduce water use the 10 urinals are water free (dry urinals). That will save 131 000 litres of water per urinal per year. In order to reduce the energy use the employees use laptops instead of traditional computers and there is a common server located in the basement. There is also only cold water in the restrooms. The employees are encouraged to socialize with their colleagues. In order to avoid individual coffee machines there are high quality coffee machines in every kitchenette. A landscape architect has designed dry grassland and a kitchen garden. This is managed by the employees of the cluster.

- Previous knowledge on energy efficient buildings and interest in topic

They were used to conventional heating and air condition solutions. One of the interviewees would like to live in a passive house, she dreams of the quality of daylight and the acoustics, as if in a cocoon.

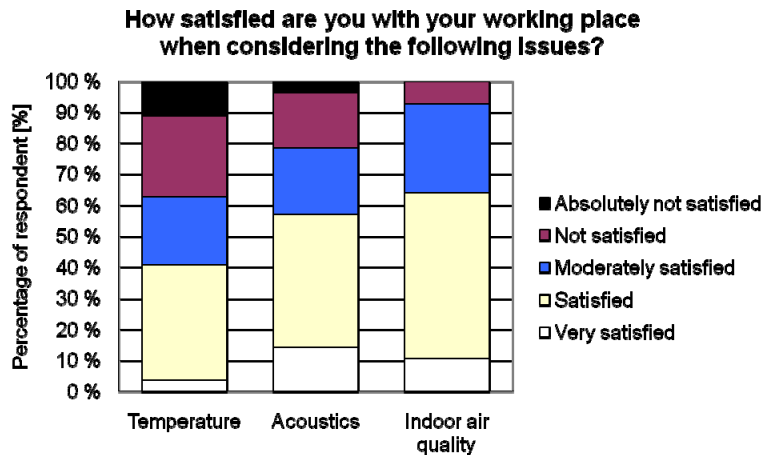
- Changes in interest / behaviour

They feel they are changing their habits. They have become much more aware of the use of artificial lighting. The last one who leaves in the evening switches off the light at the central panel which is near the entrance. When it was very hot last summer, they got used to ventilating with the windows during the evenings – that was a matter of survival. The informants can manage without hot water in the restrooms during the summer, but it is difficult during the winter especially if the indoor temperature is perceived to be too cold. The interviewees said that people wash their hands with hot water in the kitchen. Changes have also occurred in transportation behaviour; some now use the tramway rather than a car.

Comfort and indoor climate

- General comfort

When asked about the general comfort, it appears that the temperature was the major issue of complaint, with almost 40% not satisfied or absolutely not satisfied. Noise was the second issue of complaint. The indoor air quality was a minor issue of complaint, with only 10% respondents not satisfied. Many complaints can be attributed to working in an open space and not to the passive house concept. In an open plan solution: *"You have to make some agreements and accept compromises to manage"*.

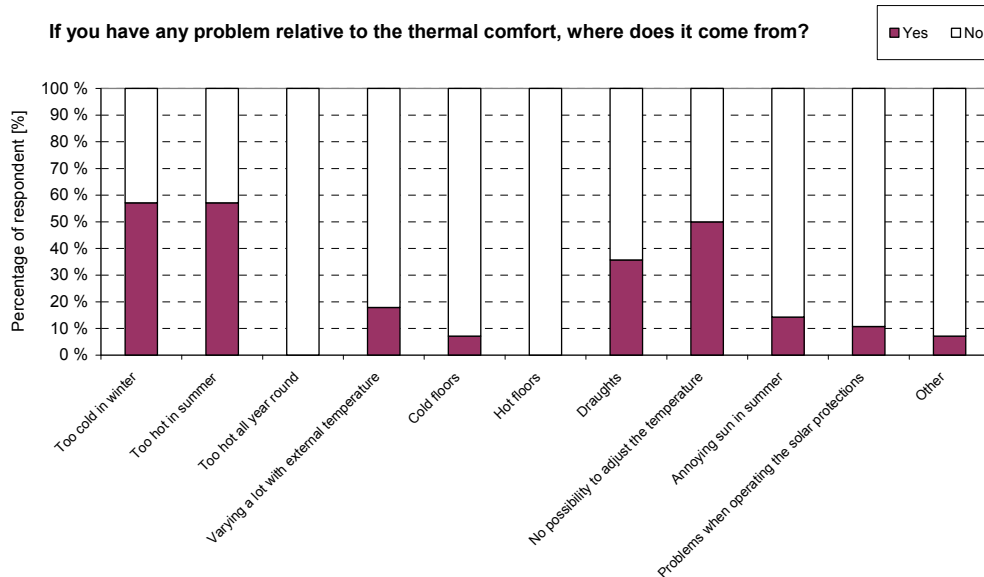


- Thermal comfort

Relevant problems experienced with temperature conditions included:

- Too cold in winter, 57 %
- Too hot in summer, 57 %
- No possibility to adjust the temperature, 50 %
- Drafts, 36 %

A major challenge has been dealing with the thermal comfort during the summer. The heat pump (which also provides cooling) was defect last summer, leading to high indoor temperatures. The temperature reached 30° in the offices facing south. The users opened the windows (tilt-opening) during the night, and they closed the blinds during the day but this was insufficient. The temperature was acceptable during the spring but during the winter it was too cold, particularly to the north (17°). One interviewee said she does not mind it being cold, but she has a low tolerance for the high summertime temperatures.

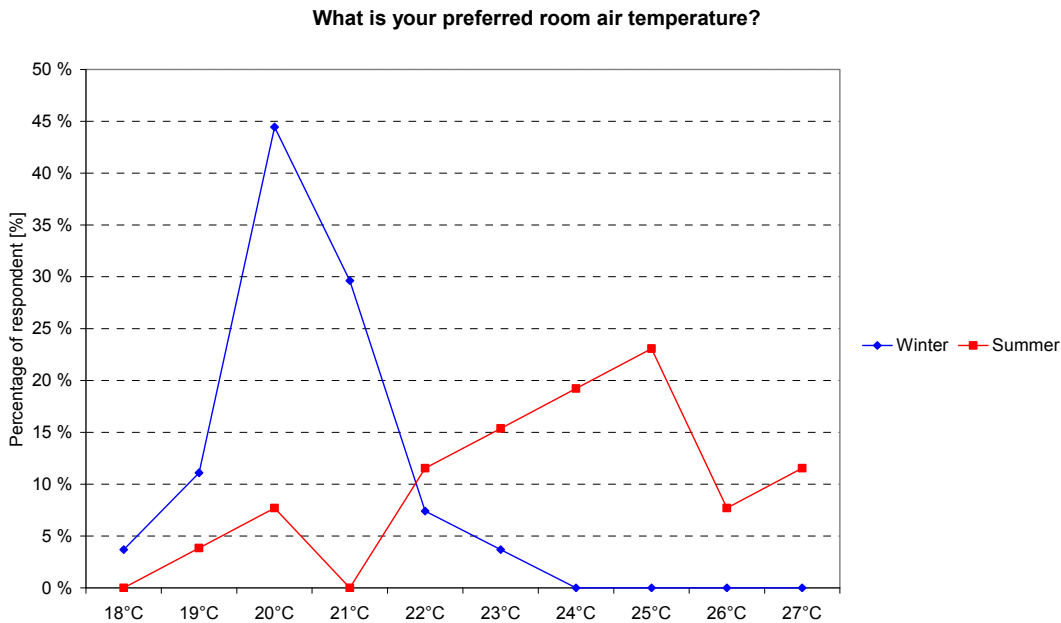


- Preferred room air temperature

French law requires to maintain a minimum temperature of 19°C during the winter and a maximum temperature of 26°C during the summer (art. 131-20 du Code de la Construction et de l’Habitation). The architect is aware that at least half of the employees perceived a heating set point temperature

of 19° as too cold. He estimates that 50 % are not able to work effectively at that temperature. He considers that 20° gives a much better comfort, without consuming much more energy. As he put it, "it would consume 15 % more energy but 15 % of "not much" isn't much". What is important in his point of view is to compensate for the increase of energy use by minimizing heat gains that is to say by adopting energy conscious behaviour.

The survey confirms that thermal comfort is an individual preference. The survey shows a temperature difference of 8° between the lowest preferred room air temperature in summer (19°C) and the highest one (27°C). A majority of respondents would like to have a room temperature around 23-25°C in summer. Room air temperature peaks have been measured up to 30°C on sunny days during July 2010. Such a temperature is perceived as uncomfortable.



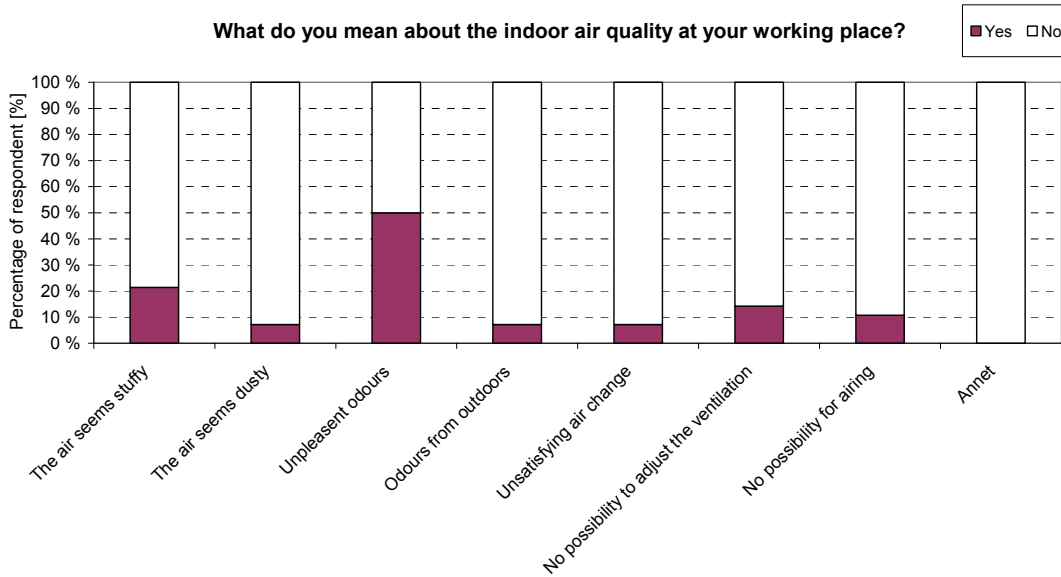
For winter conditions, the lowest preferred room air temperature was 18°C and the highest 24°C. A majority of respondents requested a temperature of 20°C or 21°C in winter. The set point temperature for heating is 19°C wintertime. It seems 1°C too low in order to satisfy a large part of users. The operative temperature results from the room air temperature and the temperature on all surfaces. In this building the surface temperatures should be higher than in a traditional building (the glazing temperature is higher thanks to the 3-layers glazing compared to a poorer glazing quality, the floor temperature is higher thanks to the heating floor system). The resulting operative temperature should then be higher than the room air temperature measured 1.5 m above the floor (emplacement of the temperature sensor). The survey shows that the temperature feels uncomfortable in wintertime.

- Air quality and ventilation

Relevant problems experienced with air quality conditions were:

- Unpleasant odours, 50 %
- Stuffy air, 21 %
- No possibility to influence ventilation, 14 %

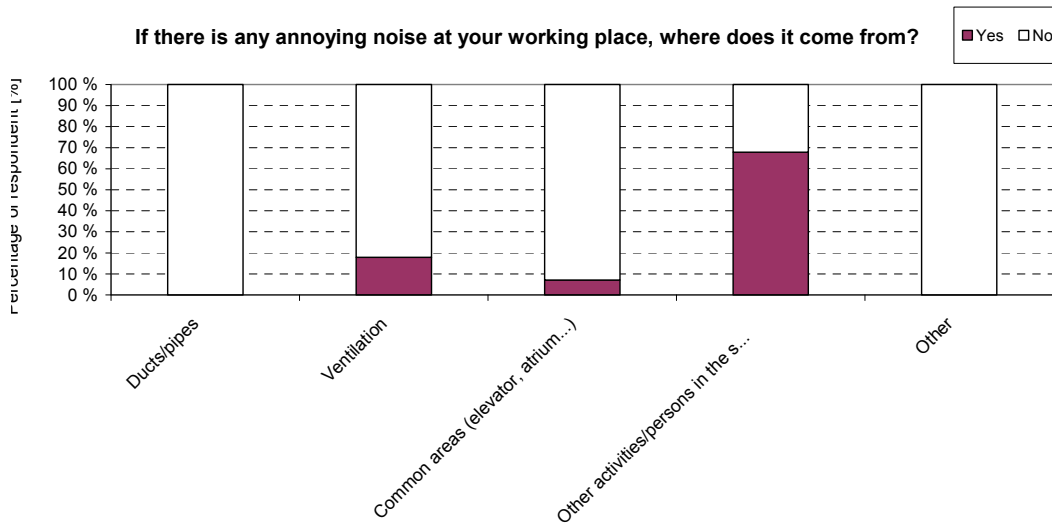
Unpleasant odours were registered in the restrooms and in the small canteens. It is supposed that the relatively high percentage of employees who react negatively to odours indicates that more locations are affected.



- Acoustics

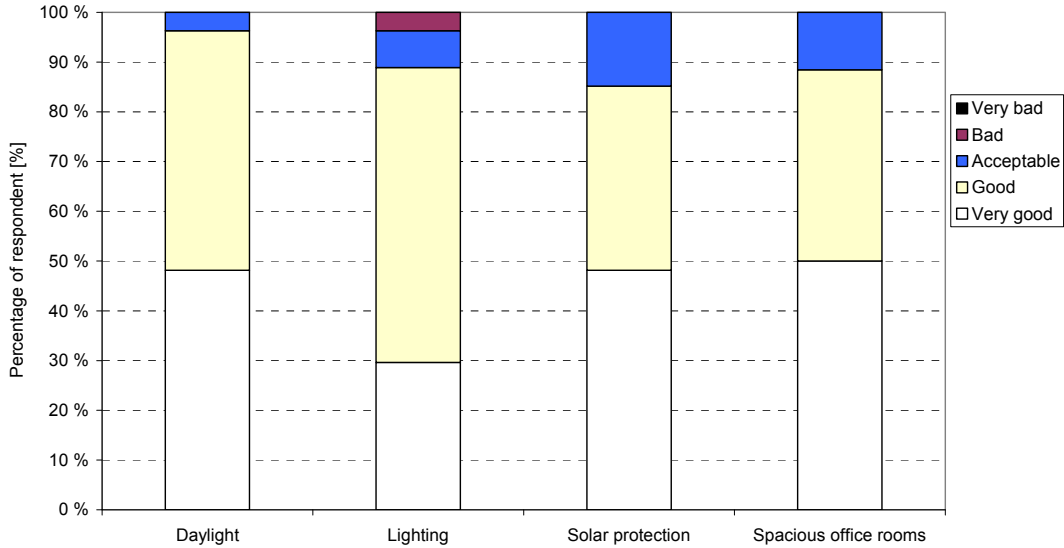
Relevant problems experienced with noise conditions were:

- Other activities/persons in the same room 68%
- Ventilation 18%



- Light

How do you judge the quality of the following criteria?



- Use of technique (level of control, information)

- *Control*

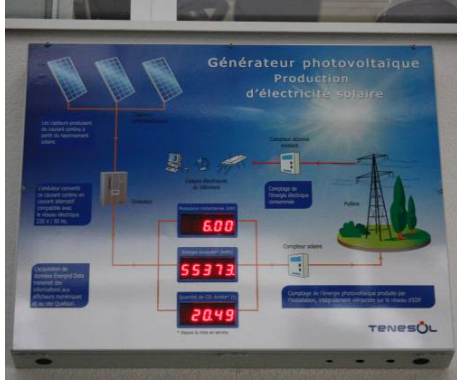
The employees can not control the temperature. Some of them thought of bringing their own radiators during the last winter. They did bring extra sweaters. In the summer some of them brought individual cooling units and took showers to cool down.

They can activate the blinds manually during the daytime. In the evening all the blinds are lowered automatically.



To control the light above their working station the employees use a mobile switch. Some of them have pasted their personal switch on a wall not to loose it.

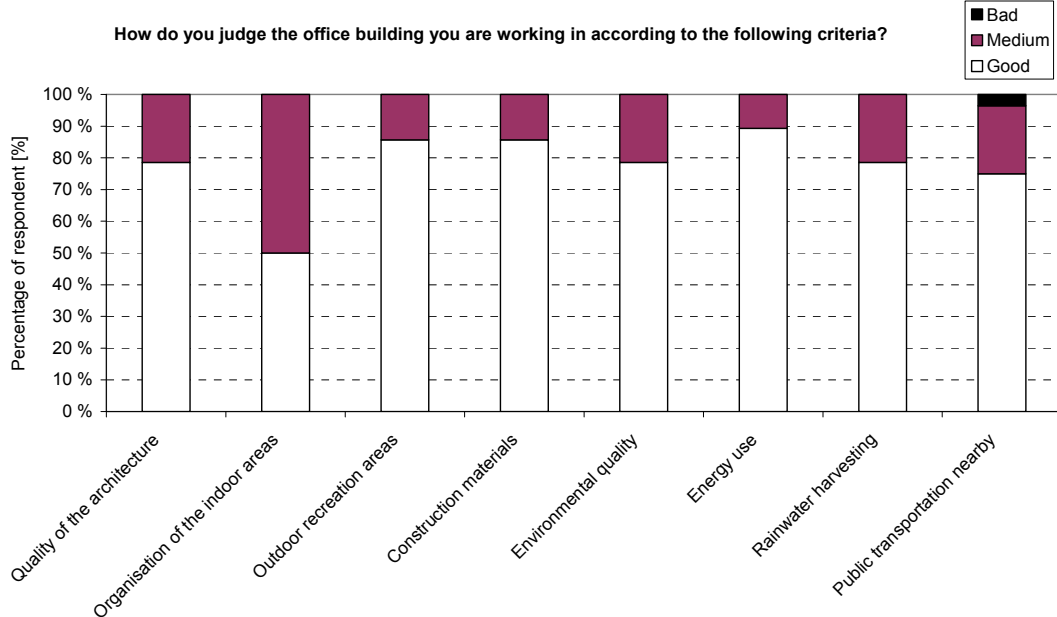
○ Information



A display in the atrium gives explanations about the photovoltaic system and shows the amount of energy produced since the building was occupied. Feedback regarding energy production for the users can help raise awareness about daily life in the building, including energy saving measures.

The developer provided some information before they moved in.

Architecture and aesthetics



- Energy efficient aesthetics

One interviewee stated that there was no difference from a traditional office building when it came to thermal comfort and acoustics. Even the windows did not have any special design. In this building he thought that the spatial organization was an added-value (the atrium with space for lunch and coffee breaks). The interviewees were particularly satisfied with the daylight, and the view towards the forest. They liked the atrium and the sloping roof.

- Floor plan organization

The atrium is perceived and used in different ways according to the season. Because it is not heated occupants do not use it very much during the winter. People were more likely to hurry through it than to gather with their colleagues.



- Identity

Are you proud to work at "La Cité de l'Environnement"? (27 respondents)

	YES	NO
Respondents	24	3
Percentage	89%	11%

Summary

The designers have chosen a global approach to influence both physical and social parameters which are important to energy use. There were some problems after the building was occupied. Many employees were not yet satisfied with the indoor climate and temperature. One important aspect of this problem was not being able to personally control the temperature.

The following-up of the buildings` performance will be crucial. The maintenance can be problematic. When the heat pump was defective last summer, the person in charge was sick. The Cité had not employed a technical manager yet. However, three volunteers working at the Cité have now the responsibility to check if there are any dysfunctions. The energy consultant was contracted to follow up the installations over a 2 years period. One of the suppliers has been engaged to do the maintenance.

In some aspects, the project was demanding for the employees, and required a good social climate in each firm and between the firms. The owner states that he wants to take into account the well-being of all the employees. Partnering with them in order to succeed with the energy goals is a necessary strategy since the behaviour of the employees will influence the potential success of attaining the energy goals.

Table 2: Information on the building's envelope and technical installations

Criteria	Information	Comments
Windows area / Floor area [%]	< 20%	
Air tightness n_{50}	n.a.	Not measured
Solar shading type	Swivelling venetian blinds	Manually controlled daytime Automatically controlled night time
Lighting		
Lighting type	LED	
Installed power	6 W/m ²	Controlled by presence sensor
Power use when non occupied	0 W/m ²	
Office automation		
Power use for stand-by functions	On/off button for each zone	The button permit to avoid energy use by stand-by functions at night/week-end
Ventilation		
Airflow daytime (07 am – 07 pm)	25 m ³ /pers	100% fresh air
Airflow daytime (07 am – 07 pm)	0,8 m ³ /h·m ²	Based on 110 occupants and 3 400 m ²
Airflow night time (07 pm – 07 am)	0 m ³ /h·m ²	
Airflow weekend (00 am – 12 pm)	0 m ³ /h·m ²	
Heat recovery mode	rotary wheel	
Heat recovery efficiency	80%	Test value for nominal conditions
SFP, Specific Fan Power	n.a.	[kW/(m ³ /s)]
Heating battery	Yes	
Supply temperature, winter	21°C	
Cooling battery	-	
Supply temperature, summer	-	
Ventilation system, atrium	Natural ventilation	
Ventilation system, mini-kitchen	Exhaust air	Overflow from the atrium
Room heating		
Room heating system, office	Hydronic radiant floor heating system	
Supply/return water temperature	-	
Installed capacity	30 W/m ²	87.000/3.400 = 25,6 W/m ²
Room heating system, atrium	No heating	
Room heating system, mini-kitchen	Electrical stove	
Energy supply by ground source heat pump		
Heat pump capacity	87 kW	
Collector area	1.700m ²	
Energy production		
Photovoltaic roof area	1.400m ²	

References

<http://www.atelierthierryroche.fr>

<http://www.plan-batiment.legrenelle-environnement.fr/index.php/actualites-du-plan/derniers-projets-ajoutes/83-construction-dun-immeuble-de-bureau-a-energie-positive-a-saint-priest>

Contact: karine.denizou@sintef.no



Summary

Case: Les Hauts de Feuilly, Saint-Priest, France

Based on interviews with the developer, the architect, residents in 3 houses and an on-site inspection.

1. Facts

This project description is based on information provided by the architects *Atelier Thierry Roche et associés*, the developer MPC and information from various websites.

Architect

Atelier Thierry Roche et associés, 91 Bis av République 69160 Tassin-la-Demi-Lune

Address

Saint-Priest, France

Location



The development is located in Saint-Priest (45° 41' 50" N, 4° 56' 41" E), southeast of Lyon. Lyon is situated in central-eastern France in the Rhône-Alpes region, 470 km from Paris.

Saint-Priest is located next to four highways, 9 bus lines, a railway station and a new tramway.

Climate

External air temperature for heat loss calculation: -11°C

Average temperature / year: 11,9 °

Total hours of sunshine / year: 1937,4 h

Precipitation mm / year: 887,3 mm

All figures are national averages for the period between 1971-2000 from the meteorological station of Bron (45°43'N, 4°57'E, 7 km from Lyon, altitude 200m). Source: <http://www.lameteo.org/lyon.html>

Intentions and goals



The municipality has for the past twenty years worked to preserve the environmental quality of urban developments. A Green Plan was agreed on in 1990. Actions like the preservation of the Feuilly forest as a connection from St-Priest to Lyon and the construction of a new tramway are examples of the Municipality's concern for the environment.

Project information

The Hauts de Feuilly scheme consists of 3 different types of housing laid out over 13 hectares (townhouses, houses with atrium and small blocks of flats), which are all constructed with environmental concerns in mind. Five different developers have been involved, the MCP group being the latest to build.

31 townhouses with Passive House quality are, at the time of this article under construction. Construction started simultaneously with the European financial crisis, and the scheme had to be adapted to the market changes. Some of the houses were divided into two independent dwellings. The project has been delayed, and at the time of writing, only 8 of the 31 have been successfully sold to owner occupiers.



Entrance level



First floor. The roof of the garage is covered with vegetation to improve temperature during the summer.

The density is 19 housing units pr. hectare. The plots are from 100 to 700 m² and accommodate two buildings: a compact two storey house and a detached garage with a sheltered outdoor dining area. The gable ends are aligned with the street, the north façade being a party wall. We have visited two types of houses: one has a floor area of 128 m² and the other an area of approximately 150 m². Both originally had 4 bedrooms between 9 and 11 m², while the garage and sheltered outdoor area take up 40 m².

The orientation of the houses was designed to maximize solar gains. 60% of the windows are southern facing. There is only one small window facing north, to provide stairway access to daylight. The garage is detached to optimize solar gains. The architects have taken into account the roof shape

and orientation in order to reduce mutual shading of buildings and to ensure that each installed photovoltaic system operates under acceptable conditions. Trellised vines between the house and the garage provide cooling in the backyard during summer months. Motorized Venetian blinds have been used for solar shading. There is one remote control per storey and it is possible to command all the blinds on the same floor simultaneously.

As an option it is also possible to install a swimming pool with natural filtration and/or a wine cellar. The latter comes as a prefabricated pod which can be installed underneath the garage. Several measures have also been taken to save water. These have included water saving taps, toilets and showers. Recovered rainwater is stored in a cistern under the terrace. This water can be used to fill the pool, wash the car or water the lawn. Volatile organic compounds are reduced to a minimum in interior coatings, paintings, floorings and insulation. All materials have been selected in collaboration with a doctor of medicine that has specialized in environmental questions and the prevention of health risks in buildings materials.

Construction costs: 270000 € exclusive of tax / VAT not included for the largest house.
(Sold for 3350 €/m² inclusive of tax)

Construction



Most of the external timber cladding is put in place on site after the industrially produced components have been assembled.



All components are assembled inside a factory. This industrialization should allow building without humidity. Unfortunately, the elements are stored outside in bad weather on the site.

To reduce construction costs MPC has chosen an industrialized method, with prefabricated wooden elements produced in France by Ossabois (<http://5d.ossabois.fr/index.php>). The houses were assembled within 8 days. Laundries and bathrooms were delivered as prefabricated units. From an environmentally friendly perspective it was important to use wood (Douglas pine) both as a construction material and as facing for external walls, despite the fact that there is no tradition for this in French housing. The wood comes from sustainably managed forests in France.

The insulation of external walls is increased to 250 mm in total, which is less than in Passive Houses in Norway and more than usual in France. The wooden windows and doors were delivered from Austria (<http://www.internorm.com/64.html>). Air tightness has been measured three times during the building process.

Table 1: Insulation level of the building

Building's part	U-value	Construction
Floor	0.1 [W/m ² K]	280 mm polystyrene insulation (Knauf)
External walls	0.19 [W/m ² K]	wooden wall, 50+150+50 mm glasswool (Isover)

Roof	0.11	[W/m ² K]	400 mm glasswool
Windows	0.80	[W/m ² K]	3-layers glazing, wood/aluminium frame



View from the yard towards the street. The wine trellis.

Energy supply and consumption

Heat recovery ventilation

The houses are ventilated by an air handling unit (AHU) of type Aldes T-Zen 3000. The AHU is built with a heat recovery exchanger and a heat pump for the extracted air. The ventilation, heating and cooling demands are satisfied by double-flow ventilation. The central control unit is installed in a cupboard with sliding doors in the laundry or in the wardrobe. The unit does not have a heating coil, heaters are decentralised and located in boxes installed in the ceiling. This allows the temperature to be controlled by thermostats in each room.

The houses are equipped with a solar thermal system. A collection area of 5 m² provides domestic hot water to a 300 litres tank with electric boost. As an option the houses can be equipped with a photovoltaic (PV) system (10 m²). The electricity produced is then sold to ERDF (the distribution network operator). Administrative procedures for the connection of the PV system to the grid are the developers' responsibility. The house owner has to establish a contract with the operator and send invoices for the electricity that is produced.

Low energy lighting controlled by a presence sensor was part of the original design, but was at the end sold only as an optional extra. All electrical appliances are chosen by the owner of the house. Washing machines and dishwashers can be connected to hot water to minimize electrical use for water heating.

The net energy demand for one house has been estimated to be approximately 70 kW/m²/yr during the planning stage. The primary energy demand have been estimated to be 98 kWh/m²/yr. CSTB keeps track of the energy consumption but systematic energy consumption measures are not yet analysed. Enertech (the energy consultant for this project) has followed up the air quality and energy consumption in one of the houses while other families will get a home automation module (Dom-box) as an option for monitoring own energy consumption.

Awards, media, certificates, etc:

- BBC Effinergie label assigned to houses that meet the requirements for the label Low Consumption Building (BBC 2005 - Bâtiment de basse consommation énergétique), which puts constraints on air tightness transmission of external construction. <http://www.concept-bio.eu/label-bbc-bbc-effinergie.php>
- Prix Grenelle BBC 2010 for detached houses (Maison individuelle groupée)
- 2e prize detached houses, Salon Maison Bois Angers 2009

2. Results

Interviews with users

- Contact and choice of respondents

The feedback from users has been collected by means of on-site inspections and interviews. We have interviewed 3 families who have lived there the longest. The architect participated in two of our interviews because she was interested in how the residents experienced the houses that she designed. She did not follow up on the houses during the construction phase, and she had not seen them in use before the interview.

The first residents among the families had moved in during the summer 2009. They have two small children. The second family moved in during the summer 2010, with two teenagers and the third household is a couple without children. They moved in during July 2010.

Environmental profile and users' reflections

- Intentions and goals

One of the goals of the developer has been to make energy-efficient housing that is also affordable. It has been expensive to build Passive Houses on an individual basis, these houses are more expensive than conventional housing. Two of the three interviewees had not intended to live in an energy-efficient house of any type, but they found the totality of the development attractive. They appreciated the well maintained neighbourhood, without disturbing noises and close to many facilities. One of them summed it up as follows: "It matched our desires: a natural swimming pool, a wine cellar, a small garden with very little maintenance"- they left an old flat in the centre of Lyon, where they felt they were getting sick because of the moisture and mould.

- Previous knowledge of energy efficient buildings and interest in the topic

One of our informants had a special interest in energy and environment and she had recently completed a 20-day course in "Qualité Environnementale des Bâtiments" (environmental quality for buildings) or QEB, under the management of the association of architects in Lyon. She was the only one of our informants who specifically wanted to live in a Passive House. None of the interviewees had any previous experience with energy efficient buildings, but they are however, aware of climate changes, and happy to be given the opportunity to contribute a little. Informant 2 said she is not an ecology freak (pas "écolo-écolo"), yet she does not use led lightning and she is not very good at sorting out garbage.

- Changes in interest and behaviour

This informant was, however, aware that they had slowly changed their habits after they moved in. Her sons use plenty of water in the shower, but she tries to reduce her own consumption. The family has two scooters and two conventional cars, one of them a Smart® (A vehicle concept that has low CO₂emission) while, the children use the tramway. Next time she intends to buy an electric vehicle.

Another informant tells us that he had not changed his habits of showering, but pointed out that he now uses a water saving showerhead. He was proud of having sorted garbage for a long time already. He said he could never move back to a traditional house.

One of the informants has stopped using candles and incense because the latter produces formaldehyde and the former produces soot and CO₂. Another does not understand why it is still possible to build new housing with traditional methods. This informant had never heard of Passive House before she moved in 6 months ago.



The residents had by now two cars or more. Several used the garage for storage and the space between the garage door and the roadway to park the cars. It is possible to catch a glimpse of the photovoltaic panels on the roof.

She missed the stove she had in her previous house, not because of the usability but for aesthetical reasons. Their friends were biased before seeing their new house but, the first time they visited they were very surprised by the air quality and indoor temperature, especially when they had to take off sweaters.

Comfort and indoor climate

- General comfort

When asked about general comfort, all the informants appeared to be very satisfied. The indoor air quality was experienced as very high. Two of them described the feeling as “living in a cocoon”. They saw this as a positive feature, which made them feel well protected. One of them related this feeling to a combination of the even air quality and the acoustics: no noise penetrates from the outside. The green plants thrived and it was even possible to sit next to the window without feeling any draft. Noise was an issue in only one family. They compared the noise of the compressor to a helicopter. Another informant, who was used to a louder noise from the boiler in her previous home, did not have any problem with the sound of the compressor.

- Thermal comfort

The sales information promised that the inside temperature would be 8° lower than the outside temperature in the summer. One of the informants was very satisfied with the summer temperature; without any feeling of air conditioning, the temperature inside stayed as low as 26° even when it rose to 32° outside. Another family experienced temperatures up to 40° the first week after they moved in. The refreshing function was at that time not in use, yet this function should not be necessary in a “real” Passive House. The concept and the users’ behaviour should answer this need, for instance by an appropriate use of blinds.

The preferred room air temperature appeared to be higher than the temperature used for the calculation. In winter the informants chose 21° and 22° in the living room and 18° in the bedrooms. During the summer they accepted temperatures of 25° or 26° in all rooms, bedrooms included.



A towel drier in the bathroom is seldom in use, but they miss the comfort of using warm towels.



The family miss their old stove. The arrangement around the television has in a way taken the stove's place.

- Air quality and ventilation

They have been surprised not to experience unpleasant odours, especially in connection with cooking, as the kitchen and living room share the same space.

It is not possible to adjust the airflow, only the temperature and the “surventilation” (Time limited booster function in kitchen). The kitchen extractor is not connected to the ventilation system; it has active coal and grease filter.

All homes have a central vacuum system and the informants were very happy with it. Thanks to the balanced ventilation, one of the informants told us that there was no need to open the windows for ventilation. The MD who participated in the project nevertheless recommended ventilating through the windows for at least 15 minutes every day. One interviewee said that they did not have the windows open during the night anymore. They let in fresh air for a few minutes every morning instead.

- Acoustics

The corrugated sheet cladding and especially the roofing generate a lot of noise when it rains. The metal shutters are noisy when it is windy and the families with children are not very happy with the sound transmission between the storeys and between bedrooms. Although, one of the informants qualified: *“But that is our own noise, we can stop it!”*

- Daylight

The residents were delighted when it comes to daylight quantity, especially on the ground level. There are floods of sunshine in the bedrooms. They perceived the window in the north facade, which is the only one facing the neighbours' yard, as a problem and have tried to cover it. They would prefer non-transparent glazing.

The metal blinds have been easy to use, and everyone used them, not only for sun protection but also as a security feature, particularly during the night or when they were at work. The only concerns were a defect blind in one house and a narrow strip of daylight that came in through the gap between the blinds and the window frame – enough to wake up the youngest children.

- Use of technical equipment (level of control, information)
 - *Control*

Ventilation user controls were limited too high and low settings. The residents were waiting for their “Dom-box” which would enable them to check on their energy consumption. The control panel in the living room was perceived as easy to understand and user friendly. It had only a few functions. Individual thermostats in the bedrooms for temperature are also appreciated.



The control panels are spread out randomly in very visible locations. There is potential to improve the aesthetic quality.

The central control unit occupies a cupboard in the wardrobe.

The filters were not available on the general market but have to be delivered by a product supplier, the units give off a signal when the filters should be replaced.

○ *Information*

The residents had so far received very little information about the technical installations in their homes. One of them didn't even know that he should change the filters in the air handling unit. He only checks if the photovoltaic system is functioning. He also points out the high quality of the control panels. He was aware that the temperature of the water heater had dropped; he was going to check the manual.

The developer and seller MCP gave the residents some basic information about operating the house but they were discovering new things about the houses daily. He had not yet received an electricity bill. Bills come twice a year, but he was not afraid to receive it.

Architecture and aesthetics

• Energy efficient aesthetics

The informants agreed that these homes hardly differed from traditional housing. There did, however, seem to be some differences once they thought about it: *“There are some preconceived ideas that energy efficient housing is cubes without windows where you freeze in the winter, and are too hot in the summer”*. The residents appreciated having no radiators. Most people do not know what an *energy efficient* house is. One informant said how impressed they were when they saw the houses for the first time, *“Wow! They were so modern”*.

• Floor plan organization

The houses have no entrance hall. The front door leads directly into the living room. None of the interviewees were much concerned about this, but one of them would like to build a small porch roof. He was aware that he had not yet experienced a winter in this house and could change his mind. Anyway, it was perceived as a minor problem, compared to the overall quality of the house. One family had ordered some changes in the organization of the floor plan. They thought the children's bedrooms were too small, and reorganized two bedrooms from three. In addition, they moved the fuse box from the kitchen (a cupboard with easy access for the operator) to a new

position near the front door, where it defines a sort of entrance hall. Another family opted for an extra door from the garage to ease access to the front door.

















- Materials and colours

Before seeing the houses, a couple thought of wooden houses as something very “*écolo*” (ecology freak) and “*soixante-huitard*” (sixty-eightyish). The French often associate timber buildings with barns. Not only are farm buildings quite numerous in this area, but they are also the only buildings for which timber is used. The residents were aware that the municipality set detailed specifications for the materials. There are small touches of colours.

- Identity

One informant reflected about the fact that people had the impression that these houses were expensive, but having built 30 at the same time gave good value for money. However, this part of the Lyon suburbs had not been particularly attractive until now. People associated it with high-rise blocks of flats and social problems. The efforts made by the municipality to improve the environment are now visible. The project had once been compared to a concentration camp, because of the association to barracks. People in the surrounding areas know about the houses, and they are curious in a positive way.

Summary

Name of the project	Hauts de Feuilley	 Very good  Could be better  Can be problematic
Type of building	Housing	
Perceived atmosphere		
General comfort		
Thermal comfort in winter		
Thermal comfort in summer		
Air quality (winter)		
Acoustics	 	
Daylight		
Artificial lighting		
Materials / Colours		
Level of control		
Solar protection		
Information		

The residents we have spoken with were so far very satisfied with their investment. They were particularly satisfied with the plan solutions, the solar installations, the quality of the air and the daylight. It can be mentioned that the architect himself had bought one of the houses. There have of course been some teething problems, but no more than what would happen with traditional housing. Subcontractors and suppliers could be difficult to get during the finishing process.

“*Anybody could live here*”. It is only a question of common sense:

“During the summer: Open the windows when it is cool during the night, and close the blinds during the day. During the winter: Open everything during the day to catch the heat from the sun and close the blinds in the evening to retain the heat. We repeat the gestures we made in the old house. Afterwards we may refine the running of the house, as the choice of bulbs.”

One of the other informants agreed, but she added that not everybody will be able to optimize the technical installations in the house. Only one of our informants had enough experience with the house to be really aware of the need to follow up the technology. None of the informants complained about changing the filters, although it was not possible to do without disassembling the panels of the central unit with a screwdriver. The access to the central unit should be made easier with respect to changing the filters. A user manual with instructions, warranties and contact details should be delivered with the house as well. Until now it seems that the residents did not have enough knowledge about the maintenance of the technical installations. They could have some surprises in regards to comfort and air quality if this continues in the same way.

The attractiveness of the area together with the aesthetics of the houses were important factors in informants choices. Two of the informants were sold on the image of the house, and the possibility of getting more than just a home, but a feeling of the “good life” with a pool and a wine cellar, in addition to the modern appearance. The fact that it is energy-efficient is one of several qualities, but would not have been enough on its own. They did not feel that they should have to sacrifice anything to save the planet. They receive more comfort, and pay less for it than they would in a conventional house. They see it as a win-win situation. Even the informant who was concerned by an energy-efficient way of life had chosen to have a pool.

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Bedroom with the blinds down



Wine cellar is an option



Tilt window on the ground floor

Contact: karine.denizou@sintef.no



Summary

Case:
Fjell Kindergarten,
Drammen, Norway

Based on interviews with users,
and information from the
architect and from the FM
administrator

1. Facts

Project description is based on the fact sheets from “FutureBuilt”, NAL/ Ecobox, and from information given by the architect and the owner / FM administrator: Drammen Eiendom KF.

The construction is certified as passive house according to the Norwegian passive house standard NS 3700.

Owner

Fjell Kindergarten is a public kindergarten, owned by Drammen Municipality in Norway. The client role has been adopted by Drammen Municipality, in their section for properties, which is a public, independent company owned by the municipality (KF).

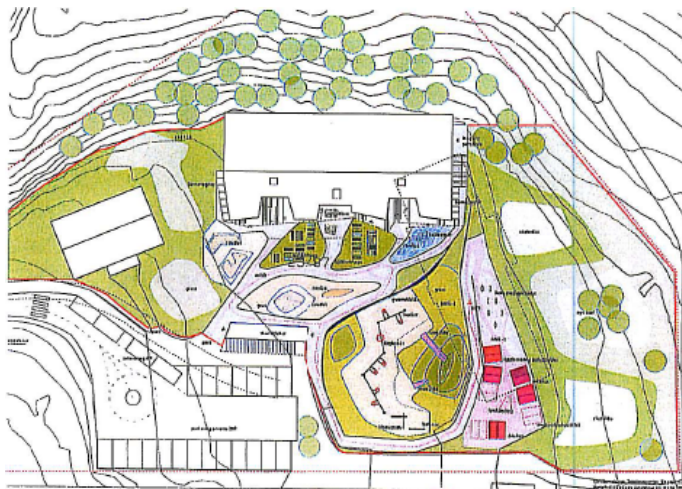
Location

Adress: Fjellsveien 5, NO-3035 Drammen, Norway.

Tel: +47 452 17 311 (the mobile to the head of the kindergarten: Elisabeth Foss Knutsen)

E-mail: elknut@drmk.no (to the head of the kindergarten)

Website not available.



The kindergarten is located on the south side of Drammen city, on top of a hillside with a nice view over the city, facing north.

The close surroundings on the east and south are dominated by flat buildings.

Picture: Code arkitektur AS

Architect

Architect: Code arkitektur AS, Oslo, Norway

Landscape architect: Hindhamar Landskapsarkitekter AS

Climate

Average temperature: In July: 17.1°C, in January: -5,4°C, /year: 5,5°C.

Total hours of sunshine / year: -

Precipitation mm / year: 749 mm.

Wind, average values: 1.4-2,2 m/s max: (January) 10,6 m/s.

Numbers for Drammen (Norwegian Meteorological Institute, www.yr.no).

For December, the average temperature is -4.1°C. But in December 2010, the average temperature was -13.2 °C – significantly colder than normal, with a minimum of -23.4°C.

The local climate is not especially challenging, but the site is high up on the hillside and the site may have a colder microclimate than the city of Drammen.

Project information

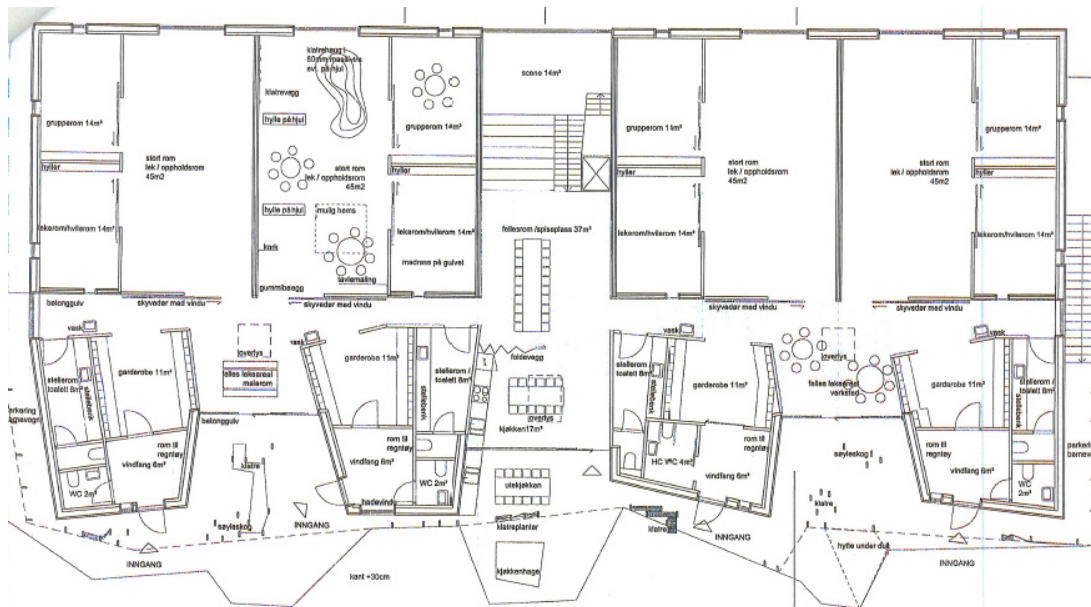
The old Fjell Kindergarten burnt down the 27th of September 2008. The planning and construction period for the new building has been very short, and Fjell Kindergarten was completed in September 2010. The interviews are therefore only based on experiences from the last winter period, which was colder than usual.

For the new kindergarten, Drammen Eiendom KF wanted passive house standard and a focus on environmental qualities. The location of the new kindergarten was moved from the east section to the north section of the site to maximize the outdoor playground area and hours of sunshine.

The architectural concept is a compact construction on two levels: a ground floor and a small basement floor. The floor plan is repetitive and effective. In addition to the environmental goals, the vision has been to create many different types of indoor and outdoor play spaces.

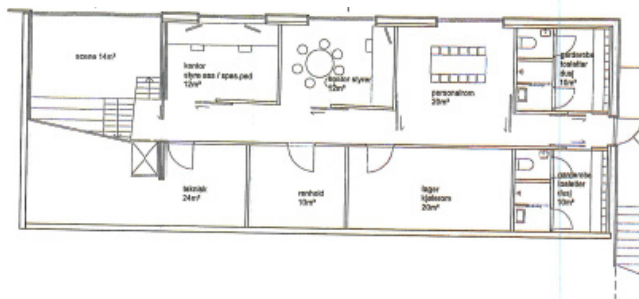
The children's play spaces are located on the ground floor, with windows facing north, while entrances, wardrobes etc., and the common kitchen are facing south. The staff's offices and secondary functions are located in the basement. The staircase from the kitchen area down to the staff's area is designed as a "stage area" to gather everyone together.

Almost all of the main windows are facing north: both from the children's play spaces and from the staff's area. The wardrobes etc. only have small windows, and the kitchen is the only room for activities with windows facing south. There is no sun protection and no curtains.



Ground floor

Basement floor



Fjell Kindergarten is designed for 80 children, organized into two sections for children aged 0-3 year and two sections for children aged 3+ years.

Gross area: 800 m² BTA (= 10,0 m² BTA/child).

Building costs: approx. 28 MIO NOK in 2010 (incl. VAT).

According to information from the architects, the total play space is 410 m² for 80 children, which is more than the minimum standard given of 320 m².

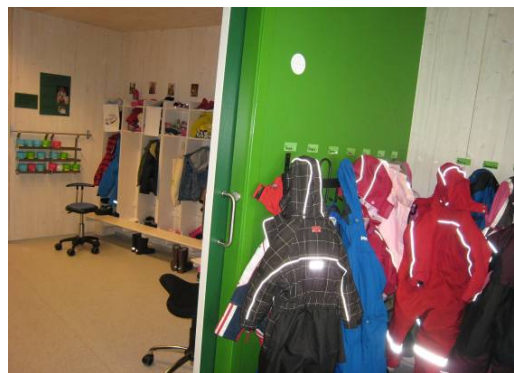
Accordingly, the play space is approximately 5.1 m²/child, while the minimum standard in Norway is 4.0 m²/child.



Above: Two neighbouring sections for indoor play space, with open sliding doors to one of the special play space zones.

Left: Personnel meeting room

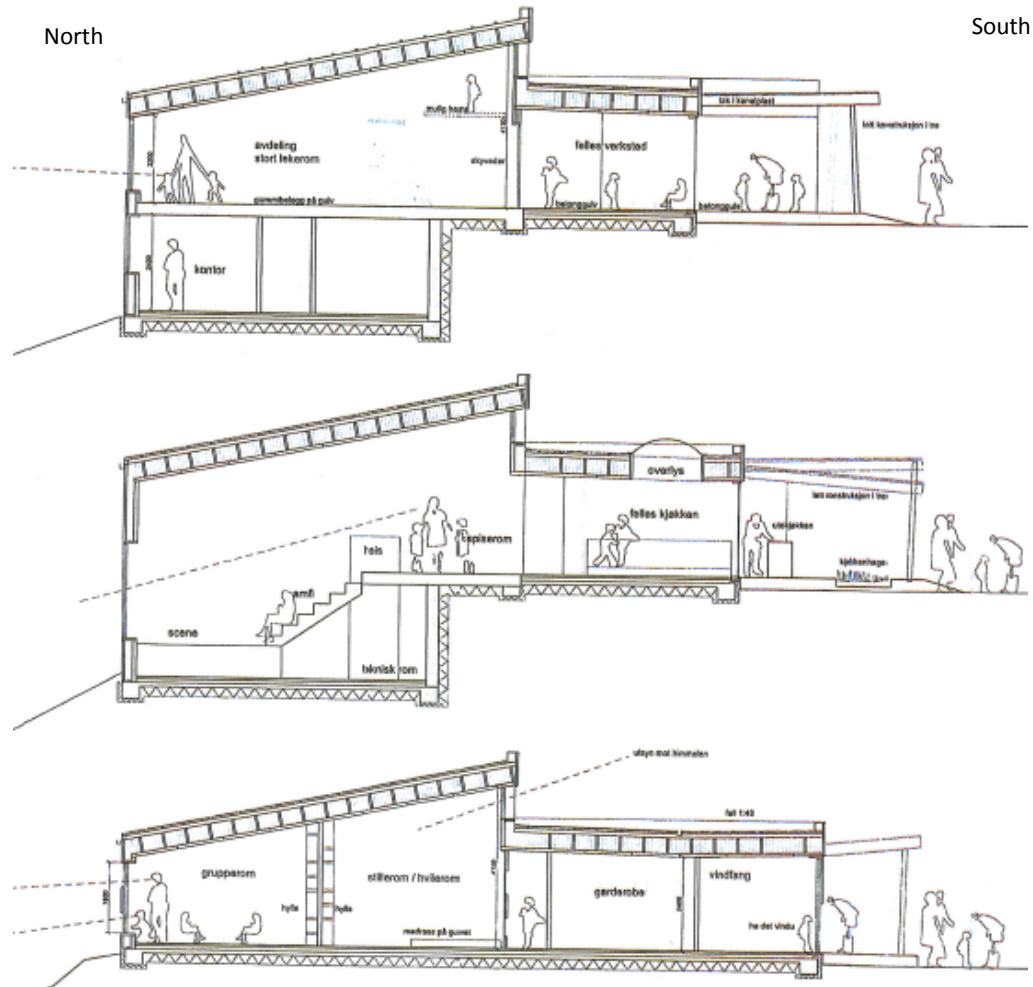
Below: Two different wardrobes, the one to the right is specifically planned for disabled children and wheel chairs.



Construction

The construction is made of massive wood and consists of pre-fabricated sandwich elements made of massive wood with 25 cm insulation in the external walls and 60 cm insulation in the roof elements.

These sandwich elements are the load bearing structure both horizontally and vertically, and they also function as exterior cladding, interior cladding and are exposed in the ceiling. The massive wood should provide a robust surface for rough use.



Materials used:

- Façades: Massive wood.
- Roof: Partially covered by plants.
- Windows: 3 layers of glass.
- Inner walls: Massive wood, painted with diffusion open paint.
- Floors: Rubber.
- Ceilings: Massive wood, painted with diffusion open paint.
- Sections with acoustic materials are used both in ceilings and parts of the inner walls.

The use of exposed wood in ceilings and inner walls is supposed to have a positive effect on the indoor climate, regulating humidity.

Energy supply and consumption

The energy concept consists of the following elements:

- The energy consumption was calculated to be 66 kWh/m²/year.

- The external walls and roof are made of prefabricated massive wood sandwich elements with very thick insulation (approx. 25 cm in walls and 60 cm in roof).
- Few, but large windows mainly facing north. Total glass area is approximately 18% of floor area. This concept is chosen partly to avoid extensive heating in summer due to intense sunshine into the indoor play spaces, and partly because of the situation on site where the outdoor playground were given high priority.
- Solar shading was not considered necessary when the windows face north.
- The central heat is connected both to a ground-coupled heat pump and to an electro boiler. The heat pump collects energy from two “energy wells”, each 200 m deep.



Façades:

- **West** façade (left) displays the principle for the section of the construction.

- **South** façade (below) with entrances, and with few windows.

The massive wood prefabricated elements are displayed in the façades.



- **North** façade, with large windows for the children's indoor play space, for the central hall with stage, and for the staff's workplaces (includes a city view).



- **East** façade, with staff entrance to the basement.

2. Results

Summary

- 😊 Very good
- 😐 Could be better
- 😞 Can be problematic

Name of the project	Fjell Kindergarten
Type of building	Kindergarten
Perceived atmosphere	😊
General comfort	😐
Thermal comfort in winter	😞
Thermal comfort in summer	Not evaluated
Air quality (winter)	😞
Acoustics	😊
Daylight	😊
Artificial lighting	😊
Materials / Colours	😊 / 😐
Level of control	😐
Solar protection	😊

Interviews with users

- Contact and choice of respondents

The respondents were proposed by the Head of the kindergarten. However, due to unexpected incidents among the children the day of, only two people were interviewed: the Head, and one of the employees – the later also functioned as “assistant head”. The results reported below have to be considered as explorative because of the small number of interviews.

The building was completed September 2010, so there are no experiences within the building during the summer months.

Environmental profile

- Intentions and goals

Drammen Municipality (Drammen Eiendom KF) had decided that the new kindergarten should have a passive house standard. But the users of the new building were not interested in a building with passive house standard, because it was thought there would be a risk of delay getting the new building.

The employees were, however, were positively surprised over the municipality’s commitment: In the design competition they accepted “a better project than they could have dreamt of” in spite of higher cost, the passive house concept did not lead to delays in the building process. The municipality could choose between four design concepts and did not choose one of the cheapest (the project cost was estimated to approx. 28 mill. NOK).

- Previous knowledge on energy efficient buildings and interest in topic

Respondents’ interest

The two interviewees were not interested in the environmental issues or the passive house concept, they were focused on the functions.

It was pointed out that the Fjell Kindergarten was an “Environmental Lighthouse” before it burnt down. But to the staff, this only involved pedagogical elements they could use in their work with the children: consciousness about switching off lights when they leave rooms, recycling of waste, energy use seen from a child’s point of view etc.

Both of the respondents were directly involved in the planning process. This involvement had mainly influenced functions and the choice of colours/furniture. However, they were actively involved in locating the new kindergarten at another location on the site, to improve the outdoor playground regarding sunshine.

Interest from family, friends and others

The two respondents did not notice any interest in the environmental issues pertaining to the building from their families or friends – only a few questions were asked. But they asked about the general progression of the new kindergarten. When told more about the passive house concept, they noticed a small increase in interest.

- Changes in interest / behaviour

User involvement did not change the interest in passive houses at first, interest was limited to the building process. The respondents thought this might be because their situation was rather stressful, and they did not have time to bother with other issues.

The three directly involved users (the two respondents and the personnel safety representative) became more interested in the passive house concept step by step during the process. And when the construction period was finished and they had occupied the building, they stated that they were “forced” to be even more interested in the passive house concept because of a huge number of interested visitors. The visitors are architects, municipalities etc., most of them asking about the concept and about their experiences.

Today, the respondents are very proud of the building, and they point out the importance of the user involvement, which contributed to a great feeling of “ownership” of the kindergarten. Due to this, the increased interest for the passive house concept would play a role if they were given the opportunity to choose a housing concept once again. They are also very proud of the architectural qualities and the aesthetics in the new building.

Behaviour

Behaviour related to the use of energy has not changed. Their status as an “Environmental Lighthouse” already in the old kindergarten implied focus on energy saving behaviour and care-taking of resources and nature, and they still focus on that with equal intensity. They also have the same daily routines as before the fire.

As an “Environmental Lighthouse” kindergarten, they focus on saving energy on a small scale, by using as little warm water as possible:

- they have special “locks” on the tap water to reduce the consumption of warm water (combined with safety reasons)
- they instruct everyone to wash garbage in cold water if washing is needed
- they focus on all behaviour related to the use of warm water

The children also separate the garbage themselves.



The system for the separation of the garbage

Comfort and indoor climate

- General comfort

When asked about their opinion on the comfort, they reported that they regarded the comfort as very good when it worked as intended, and that they had had no strong complaints or negative comments regarding the indoor climate. They explained this as a positive reaction to working in a new and nice looking building, contrasted with the intermediate solution when they had to run the kindergarten in a basement of a church.

But they had several problems with both air quality and temperature in December.

- Temperature

In the two respondents' opinions, the problems with the temperature in December might have been caused by some failures in the regulation of the ventilation system, and in addition to especially cold outside temperatures. In January, the outside temperatures differed a lot, but the indoor temperature was rather constant – and at that point the ventilation system had been adjusted. However, now the outdoor temperature was warmer, and the problems were less critical for the time being.

They also had problems with the capacity of the floor heating. The main problem was that the floors were too cold in the sections for small children 0-3 years. They did not know which temperature they should have or which temperature they actually are having, but the floor had been too cold, and they could not get it warmer. To meet this problem, they used warm blankets on the floors where the small children play.

In addition, the temperature sensors were placed too high up on the walls to give relevant information in a kindergarten: approx. 1,5 m above the floors. There might be a difference between the temperature measured by the sensors and the actual temperature where the children were playing. All the children use warm indoor shoes – but they do not put on extra clothes when the temperature drops.

The two respondents noted that there was no notable drop in the temperature close to the windows, and that the temperature did not seem to change with the outdoor temperature.

Since the kindergarten was finished in September, they did not have experiences with summer conditions. But there was a warm period in September, so they have an indication. The kitchen, with windows facing south, was too hot, and sharp sunshine was also regarded as a bit uncomfortable. They did not know yet if this will be a permanent problem during the summer.

They did not notice the same problems with heat/sunshine in the two zones for specialized indoor play activities also facing south. But they pointed out that the small transparent roofs over the closed outdoor area were designed in a different way, and maybe provided better shade.

The rest of the indoor space did not have windows facing south. The entrances have few windows, and in addition there are transparent outdoor roofs.

- Air quality and ventilation

During a cold period in December, the ventilation system stopped several times, and the air quality almost instantly reaching a very poor quality – and they all got headaches. When such problems occur, they phone the FM administrators at Drammen Eiendom KF to receive help. The ventilation system has been out of order several times, and they now regarded the facility managers as almost a “part of their crew”.

Some of the problems are related to a lack of alarm systems. They have no alarms in their rooms for abnormal activities, telling them that the ventilation system is out of order or that the fans have stopped. Normally, they can hear the low and constant buzzing from the air in the ventilation channels, and they theoretically have the possibility of noticing if this sound has stopped. But most of the time, there is noise and activities in the kindergarten. Once somebody gets a headache, they will check the technical installations room and they will check if the ventilation system has stopped.

They do not have measuring instruments to tell if the CO₂-levels in the rooms are too high. They do not have the possibility of opening windows – it is technically not possible. Their only option is to open doors – regardless of the outside temperature.

They have a draft problem with the doors in the kitchen as well. They often use these doors because of the direct contact to the outdoor playground, and the doors should close automatically. But the doors do not close, and there is a constant and intense draft through a little gap in the door, and a buzzing from the air flow can be heard. In their opinion, it seemed like a “contradictory air flow” through the door-gap: both warm air going out and cold air coming in. But perhaps more warm air going out than the opposite. In addition, they found the indoor air to be too dry during the winter. Their eyes felt dry, and they have to use eye-drops. They also notice dry skin, dry lips, and they feel thirsty and drink a lot of water.

- Acoustics

The acoustics are very good. Acoustic elements are also used as decorative elements, and this is highly appreciated. They do not regard the technical installations as noisy – they only hear a distant buzzing, if the children are quiet.

- Light

They are very content with the daylight even if they have only had wintertime experience. The windows are large and facing north: that gives a lot of daylight, and no need for solar shading. They don't have curtains, and don't think they would need them during the summertime and they would prefer not having curtains. The artificial lighting is functioning well, and they have the possibility to dim the light. For energy saving reasons, they have sensors to switch off lighting automatically if there is no one in a room. They are very satisfied with these solutions.

However; they report they had fun with this solution during the first period: The children should have a daily nap in a room with such a sensor. But every time one of the children moved, the light turned on – and the children played with this. This is now regulated in another way.

- Use of technology (level of control, information)

- o *Control*

They did not operate anything themselves, and they didn't know anything about the technical equipment, control panels etc. The facility management operators in Drammen Eiendom KF took care of everything, and they monitored the technical equipment from centralized control panels. The employees at the kindergarten have not even been inside the technical rooms to have a look, and they were not very interested in this.

However, they had an instrument measuring the total energy consumption, and they *may* turn this into a modus to "saving energy", and they sometimes used this possibility when they had outdoor activities. They didn't know how it works, and from which functions they then "saved energy", except when the ventilation system was working on the minimum level.

The building had no displays of actual levels of energy consumption. But the users received regularly information from the FM operators in Drammen Eiendom KF about their energy consumption. They were asked what they would do in case of power failure, but they had not experienced this, and they had no idea what to do. They expected that the system had an automatic "reset" function – but they were not sure.

- o *Information*

They were informed that the energy consumption in this kindergarten was approximately half of the normal consumption in similar institutions. But they didn't know how this is expressed in numbers. They assumed that the major reasons for these savings are the use of renewable energy sources (ground-coupled heat pumps) and automated user-related regulation of lighting and ventilation. They were not involved in or informed about the technical aspects of the building or its operational systems. But they were not really interested, so they were content with the level of control and information that they had.

Architecture and aesthetics

- *Energy efficient aesthetics*

The two informants and the personnel safety representative had regular contact with the planners, designers and construction workers throughout the whole planning and building process. These three people also regularly informed the rest of the staff and helped to involved them in the process.

They even proposed the new location on the site themselves. This was stated as a wish from the employees before they knew that the architect wanted to change the localization on site to improve the passive house solutions. The employees were directly involved in the functional planning and other practical solutions.

The two interviewees reported that the employees were happy with the colours. Their comments on the design and architecture of the building were connected to the functions and the design as it related to their activities – they did not regard the design of the building to be a result of a “passive house”. They knew that it was environmental friendly, and they were pleased with that – but they did not think of the design as special related to this.

- Floor plan organization

As a result of their extended participation in the design process, they regarded the floor plans as a direct answer to their wishes for the kindergarten, and they were very content. The only element they would have changed if they could, was the size of a small office.

The floors have a rubber surface, and they are difficult to clean. The floor provides a bit too much friction both in its use and cleaning. Linoleum would have been easier.

- Identity / Image

The interviewees were proud of the building – but mainly because it was “nice and new”, and because they appreciated the architecture, the colours and the educational concept. The passive house concept was only regarded as a “bonus value”.

Observations from the site inspection

It was noticed that there were signs of moisture damage on the outside sections of the massive wooden elements close to the ground, where the snow covered the lower wall sections. In addition, it was noticed that the inside sections of the massive wooden elements were cracking and there were several gaps of up to 1,0 – 1,5 cm. The effect of this on the building’s physics and the calculations of energy losses etc. should be investigated.

Summary

General attitudes

The general impression was that the two informants liked the architecture of the building, and that they were proud of it. The building had fulfilled their expectations, regarding all functional aspects. They had no expectations regarding the passive house concept except for the possibilities for delays, and were positively surprised when it was finished on schedule. Now, this represented an added value for them (especially since they have status as an “Environmental Lighthouse”) – but changes in their attitudes or behaviour were not significant.

References

Written information from the architect and Drammen municipality, given by the employees.

All pictures are taken by Sidsel Jerkø, SINTEF Building and Infrastructure.

Contact: sidsel.jerko@sintef.no

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