Measuring life by real people

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Published in:
European Sustainable Week

Publication date:
2010

Document Version
Early version, also known as pre-print

Just imagine if the quality of our buildings was valued on their ability to improve quality of life - according to the Active House vision of buildings that give more than they take in relation to people, energy and the environment.

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This article describes how information about Active House is obtained through tests done on demonstration buildings. Tests in which life in intelligent and energy-optimised homes takes centre stage, and where ratings are obtained via human behaviour and wellbeing. The article also describes experiences harvested to date after a six-month trial period in the first of 8 demonstration houses, 'Home for Life'.

If the buildings of the future are to be independent of non-renewable energy sources and are to be carbon neutral, we need to develop entirely new methods for their design and valuation. Instead of regarding energy and environmental requirements as limitations, they should be seen as offering an unprecedented opportunity for devising new strategies. We need to do away with calculations based solely on theoretical energy consumption, and instead develop design parameters and metrics that produce holistic buildings that cater for the whole person, in balance with the environment.

But this calls for new methods of building valuation. Methods which allow energy calculations to be juxtaposed with the qualities that creates value for the people who live and spend time in and around the building. Basically, for the occupants of the homes we build, we have to preserve immediate liveability factors such as being able to sense the warmth and changeability of daylight, the scents (and sounds) of fresh air, of having visual contact with the surroundings, while catering for the need for intimacy and privacy. Buildings of the future must also ensure healthy and comfortable living conditions for their occupants. For these qualitative values to become integral design criteria and requirements for future newbuilds and refurbishment projects, we need to have a means of qualitative valuation and comparison with the quantitative values and requirements such as metered energy consumption and energy generation.

Active House

Active House is a vision of buildings of the future that *give more than they take*; a vision of a world in which our buildings cater for healthier and more comfortable living, but which also make a positive contribution to the environment without having negative impacts on the climate. This is why Active Houses have a low energy consumption and generate their own energy, and have a healthier, more comfortable indoor climate and are carbon neutral.

VKR Holding has decided to realise the vision by initiating and financing a project under which three subsidiaries, VELUX, VELFAC and Sonnenkraft will be building a total of 8 houses in 5 different European countries over the period 2009-2011.

The first four houses have now been built: Green Lighthouse at the University of Copenhagen, Denmark and the single-family homes Solar Aktiv Haus in Austria, Haus der Zukunft in Germany and Home for Life near Aarhus, Denmark.

These buildings are experiments in which both state-of-the-art and tried-and-tested technologies and components are combined in different contexts. The experiments are tested by having families move into the homes, and their experiences of residing and living in them are logged and compared with measurements of energy consumption and generation together with indoor climate data.

MIMA

In order to build on and pass on the knowledge and know-how about Active House and as a way of supporting the vision of bringing daylight, fresh air and a better environment into people's everyday lives, VKR Holding have defined the MIMA research project. In MIMA, methods and know-how are built up scientifically through "Monitoring, Interviews, Measurements and Analyses" of Active Houses, their occupants and their environments. The project is intended to generate expertise in techniques for valuation of comfort, health and energy efficiency with a focus on living factor in and around the buildings.

View MIMA poster

The project is allied with the PhD project 'A Method for Holistic Valuation of Active Houses', a joint project between Aalborg University (Architecture & Design and Strategic Research Centre on Zero Emission Buildings) and VKR Holding (Active House & Strategic Projects). In addition, local research agencies are contracted to the individual houses, which under the MIMA project survey and analyse the methodological development and findings generated via the PhD project for purposes of application-oriented knowledge transfer to new Active House projects.

Measuring life by real people

Home for Life, the first of the 8 experiments, has now been occupied for six months by the Simonsen family, a test family who will be staying in the house for a year. This makes it possible to set the family's life in the house against the house's performance and the theoretical estimates and thereby produce unprecedented and documented insights into how to optimise houses of the future.

The measurements are conducted by the research project entitled 'Minimum Configuration & Home Automation', financed by the Danish National Agency for Enterprise and Construction.

In order to map the house's performance, measurements are obtained and data are collected on energy generation, energy consumption together with room temperature and CO_2 content. These data are recorded via WindowMaster's control system and collected by the School of Engineering in Aarhus. In order to determine family wellbeing in the house, the family's behaviour and experiences are also logged. These qualitative data are collected via anthropological participant observations of the Simonsen family in Home for Life by Johanne Mose Entwistle, an anthropologist from the Alexandra Institute, Aarhus. The observations are followed up by interviews of the family members. These are then compared with the technical data obtained for factors affecting indoor climate such as room temperature, CO_2, human presence, window control, lighting, awnings and blinds. In addition, a log is kept of any changes made during the measurement period and the family keeps a diary describing their experience of living in the house.

These observations, combined with the technical measurement data provide an insight into the family's behaviour and interaction with the system, while the subsequent interviews provide a picture of the family's stated perceptions of their own and the system's behaviour. This multidisciplinary method is being developed in the project with the aim of reinforcing interaction between the qualitative and quantitative data.

Interaction between building, people and technology

In the house, experiments have been done to integrate several state-of-the-art technologies, building technologies and intelligent systems. In the initial operational period, a number of adjustments were made, especially regarding the family's needs and technologies and products in the efforts to create a comfortable and sound indoor climate and then to energy-optimise the house. An experiment of this kind requires careful adjustment to achieve the full benefit of and lessons to be learned from interaction between the family's wellbeing and behaviour and the building's energy optimisation.

The family's experiences

The family generally like living in the house. At the beginning of the heating season, they were not warm enough, and this has now been resolved. They appreciate the large windowspace, which connects them with the surroundings, the view and not least the abundant daylight – and heating. This has also meant that the energy expended on artificial lighting has been less than expected. The family uses the window coverings against privacy intrusion, mainly when it is dark outside. Observations have shown that they also use the window coverings during daytime hours when the mother is at home on maternity leave – but this minimises the solar radiation which is intended to boost heating of the house.

The family are very enthusiastic when they can see that the house is generating energy and that their own energy consumption is low: "*That was obvious here on Sunday when the sun came out. I just had to go and check: Was it really affecting energy output? Yes it was! That was a real 'ta-da!' moment!. Yes, it's really good fun, and it's marvellous! Simply marvellous! […]Those little discoveries: Yes! It makes a difference. Something in our house is actually producing energy. It really makes sense. There's something to rely on. It's brilliant!".*

Both the parents and the children are taken up with energy and environmental issues, and the family is constantly motivated by the energy account visualised on the monitor. But they can't see directly where they can reduce their energy consumption.

Solar heating

Home for Life is heated via SolarCompleet from Sonnenkraft – a prototype combined solar heating system and solar heat pump. At the beginning of the test period when the family felt the room temperature was not high enough, an attempt was made to raise the supply temperature of the underfloor heating to increase the room temperature from 20 to 22 degrees C. The lowering of the room temperature at night and during the hours when the family is not at home was also cancelled. In addition, the automatic natural ventilation was adjusted, water was topped up in the heating system and a leak in the system was repaired. Since December, the family has found the temperature agreeable – in spite of it being one of the coldest winters on record, and, as the family had a baby daughter in December, it is safe to assume that they have high demands for a comfortable indoor climate.

Intelligent control

The house is controlled by intelligent technology via WindowMaster. It has been observed that the family often overrides (makes manual adjustments to) the automatic control – especially when it comes to regulating the heating and sunscreening. In spite of the many overrides, the family appreciates the automatic control. The children tell us: 'I wouldn't mind if this was our house. It's fun to listen to, and you can just press the buttons to make it how you want it.' The children are also very interested in the monitor, which is set up centrally in the house and displays the energy consumption and generation and indoor climate conditions.

The house is aired by automatic natural ventilation combined with mechanical ventilation with heat recovery. When the natural ventilation was switched off in November, the family missed the fresh air and the sound of the windows opening automatically, so they started airing the house manually by opening windows and doors.

Energy performance

The measurement data for the first six-month period provides indications of the house's ultimate energy performance, and not least how its performance can be optimised.The measurements show that the energy consumption for heated domestic water and electricity for lighting and appliances is likely to be below estimate in the test period, while energy generation from solar heating, heat pumps and solar cells is generally on target.

Higher heating consumption

The measured energy consumption for heating indicates that the designers should allow for higher energy consumption than the theoretical estimate in Be06. The higher actual consumption is partly due to the fact that the house is new and needs to be run in, but also due to a number of altered preconditions in practice compared with the estimates in Be06.

The family wanted a higher average room temperate than the estimates had assumed, and the house is airtight, but not quite as airtight as calculated. In addition, there has been less of a heatload from appliances and lighting due to reduced consumption, less passive heating because the blinds have been drawn during daylight hours, and there were spells in which the ventilation and heat recovery were out of operation. These altered preconditions provide a valuable basis for experimenting with reducing energy consumption for heating, but also know-how on how energy estimates can be optimised for a better match with actual consumption. It should however be noted that, if this especially high energy consumption for heating were incorporated in Be06, the house would be rated in energy class 1.

Changes in relation to estimated energy consumption for domestic heating:

1. 1. Change in room temperature from 20 to 22 degrees C
   Changed when the family found the house too cold owing to factors such as radiant cooling.
   In future, when the house's heating system is stable and the house heated through, we will experiment with reducing the average temperature.
2. 2. Change in airtightness from 1.0 l/s*m^2 to 1.49 l/s*m^2
   Better sealing could be achieved around lavatory cisterns, wiring conduits for external awnings, built-in spotlights, internal roller blinds and technical rooms. We estimate that if the above are remedied, it will be possible to achieve airtightness of 1.0 l/s*m^2.
   Going forward, there should be greater focus on sealing during construction but also on how airtight it is reasonable to make the house in practice.
3. Change in interior heatload from appliances and lighting from 3.5W/m^2 to 2.0W/m^2.
   This is based on the family's total estimated and metered energy consumption for lighting and appliances.
4. The change in use of interior blinds as revealed by observations inside the house. It was observed that the family uses interior blinds, given that the interior blinds have been drawn half of daylight hours against privacy intrusion and the risk of glare. Roof windows not included.
   Going forward, WMa control of blinds should be adjusted to cater better for requirements so the family is less likely to override. Inform family of the value of the passive heating via the windows.
5. Greater airtightness before sealing of technical room (1.88 l/s*m^2).
   Doors to technical cabinets sealed.
   It would be helpful to have more precise diagrams of installations so cabling can be better planned.
6. Lack of mechanical ventilation with heat recovery for spells at a time (heat recovery rate reduced to 75%)
   For around a fortnight, the ventilation and heat recovery system was out of operation due to a fault in the system. We assume that the family aired the house by opening windows manually.
7. Automated ventilation not optimised compared with mechanical ventilation. (input corresponding to 0,1h-1)
   The automated mechanical ventilation worked for a spell in the heating period, as if it was summer. It was then disconnected.

In the next period, tests will be done on how pulse ventilation with natural ventilation combined with mechanical ventilation with heat recovery optimises the indoor climate by contributing fresh air in both the cold-spell transition period and heating period. The family's wellbeing should be weighed up against energy to be expended on operating mechanical ventilation and heating.

50% of the altered preconditions are due to factors in the building, control and technology, and 50% are due to the family's behaviour that was at variance with the original estimates.

Adjustments for the next six-month period

In the coming period, adjustments and optimisation measures will be made to reduce heating consumption while maintaining the family's perception of high-level comfort. We will attempt to coordinate natural and mechanical ventilation, and are building a porch by the front door, while seeking to reduce the room temperature. Finally, we will be fine-tuning the ventilation and heating and control system.

After a year of occupancy by the test family, adjustments and a running-in period, the house is expected to be more stable, and we will be commencing a measurement period over a year with the aim of determining the house's actual energy consumption. These data will be matched with relevant European energy calculation programs in order to compare energy estimates and their strengths and weaknesses and the extent to which they permit valuation of home liveability. As the saying goes 'you are where you live'.