THE "VITALI-VELTI" HOUSE: A MONITORED MINERGIE HOUSE IN THE SOUTH PART OF THE ALPS

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ABSTRACT

The "Vitali-Velti" house is a certified Minergie house in the south part of the Alps. The simple but efficient house concept is described. The results of a 1 year monitoring campaign are presented and analysed, including thermal comfort aspects. The energy measurements are compared to the energy quantities calculated for the Minergie label.

RÉSUMÉ

La maison "Vitali-Velti" est une maison Minergie certifiée dans le sud des Alpes. Le concept simple mais efficace de la maison est décrit. Les résultats d'une campagne de mesure d'une année sont présentés et analysés, incluant également des aspects liés au confort thermique. Les mesures d'énergie sont comparées aux valeurs calculées pour l'obtention du label Minergie.

RIASSUNTO

La casa "Vitali-Velti" è una casa a Sud delle Alpi, certificata Minergie. Il concetto semplice ma efficiente della casa è descritto. I risultati di 1 anno di rilievi sono presentati e analizzati, tenendo conto anche degli aspetti legati al benessere termico. I rilievi energetici sono confrontati con i valori calcolati per il label Minergie.

INTRODUCTION

In the county of Tessin, south of the Alps in Switzerland, a low energy house has been constructed, taking advantage of the rather temperate and sunny climate in winter. The site is in a densely built-up area at the bottom of a south-facing valley. The project demonstrates that low energy housing can and has to take into account local limitations (shape, orientation, local and distant shadowing, etc.). Architecture, aesthetics, costs, reliability and simplicity were all carefully considered in evolving the design. The simplicity of the house design and energy concept justified a monitoring project to quantify the heat balance and thermal comfort of the house. The objective of the paper is to present the house and discuss monitoring results, including summer conditions and comfort.

The "Vitali-Velti" house

The "Vitali-Velti" house (see Figure 1), designed by the two architects A. Velti and B. Vitali; was completed in 1999. Each house half has approximately 250 m^2 of heated floor area (5 ½ rooms on three floors). The main house entrance is on the ground floor. This level includes the kitchen / dining area, which also have direct access to the garden. The living room / office is on the first floor. The three bedrooms on the second floor are separated from the rest of the house. Each house has an individual, unheated basement for the laundry, the utility room and the storage room. The basement is accessible from the inside of the house.

Figure 1: South-east façade and interior of the "Vitali-Velti" house.

Building construction

The structure of the house is massive. Each floor is a concrete slab construction. Part of the walls are also made of concrete. In order to reduce the number of thermal bridges, the house bearing structure is built inside the polystirol insulation envelope (13 to 20 cm of insulation thickness). The exterior of the wall is a brick masonry construction. The overall wall construction achieves a calculated U-value of 0.21 W/m^2K. Special care was given to reduce the remaining thermal bridges.

Large windows have been integrated in the south-east façade. Windows have a global U-value of 1.1 – 1.3 W/m^2K (frame included). They are made of two panes (selective surface / filled with argon gas) and a wood frame.

The flat roof was partially prefabricated (10%) and includes two layers of polystirol and foamglass insulation . The resulting construction U-value is about 0.15 W/m^2K.

Technical systems

Fresh air is provided by means of a two-flow ventilation system with a cross-flow heat recovery unit, each house having an independent system. The system operates with a constant airflow rate in the incoming and exhaust air channels. The simplicity of the design and its ability to guarantee good air quality in all conditions were the reasons for its selection.

The southeast facade has a large window area for spaces mainly used during the day (i.e. kitchen, dining-room, living-room and office). This provides large passive solar gains as well as daylight. The solar heat gains are stored in the extensive building mass. Indoor curtains control glare. External louvered blinds provide an effective solar overheat protection.

The remaining heating requirement is covered by a wood stove in each house. Heat distribution is assured by free radiation and room air convection, thanks to openings in the south and north areas of the first floor.

Hot water is produced by two independent solar hot water systems, one in each house. Each system is sized at one square meter flat plate solar collectors per person (4 people per house). An electric resistance heating element in the hot water tank delivers auxiliary heat as needed.

Cost

The saving by not installing a conventional heating system offsets the extra cost for the superior envelope of the building, the two air controlled ventilation units and the two solar hot water systems. The house construction cost does not exceed that of a conventional house. Energy saving resulted in substantial reductions in operating costs.

HOUSE HEAT BALANCE

A house heat balance is performed on the basis of measurements executed from July 2001 to July 2002. The heating period is limited to 4 – 4½ months per year (from November to February – partially March). The annual space heating requirement is measured to about 13 kWh/(m^2a) for the Velti house, which has a heating reference area of 260 m^2. It is covered by wood (80%) and electricity (20%). The consumption of electricity is explained with an electric resistance (max. 0.9 kW) in the ventilation system (post-heating of the fresh air) and an electric radiator to maintain the house temperature during the coldest periods (max. 2 kW). The quantity of wood burned was measured at 1’100 kg (about 2 steres) for the heating period. In Figure 2, the mean power of the energy vectors used for space heating (wood and electricity) are shown with 10-day average values and reported in relation to the mean outdoor air temperature.

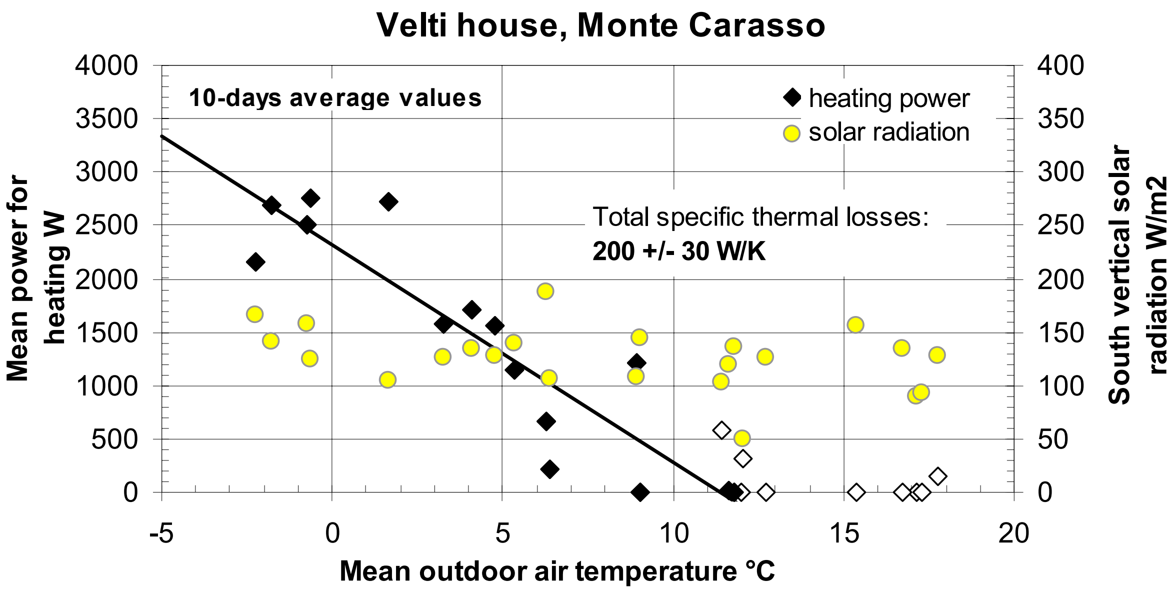

Figure 2: The mean power of the energy vectors used for space heating (wood and electricity) are reported in relation to the mean air temperature (diamonds). The corresponding mean solar radiation in the south vertical plane are also shown (circles).

The linear regression in Figure 2 provides an estimation of the total specific heat losses of the Velti house to about 200 W/K. With an outdoor air temperature of -2°C (local temperature value to size the heating power), the heat losses would amount to 4’400 W. In figure 2, the power requirement at -2°C is about 2'700 W. Taking into account the wood stove efficiency (60%), the net heating power is about 2'000 W. The difference with the losses is explained by the passive solar gains. The coldest days are sunny days, and a mean solar radiation of about 150 W/m^2 is always available in the south vertical plane. Having a solar effective area estimated to 15 – 20 m^2, the passive solar contribution in the Velti house amounts to an equivalent constant heating power comprised between 2'000 and 3'000 W during the coldest period .

The ventilation system operates only when the house is heated. The lowest regime is in practice always selected, providing 60 to 70 m^3/h of fresh air in the house. This air flow is sized in relation to the number of people living in the house and not to the volume to be ventilated. It is adequate for the four non-smoking inhabitants. However it only ensures an air change rate of 0.1 h^{-1}. The heat exchanger efficiency of the ventilation system is assessed with measurements to 50 – 60%.

The low hot water consumption and the large hot water solar fraction have limited the hot water energy index to only 2 kWh/(m^{2}y) for both houses. A representation of the annual energy fluxes [1] for the space heating, the domestic hot water and the ventilation system is shown in Figure 3 for the Velti house.

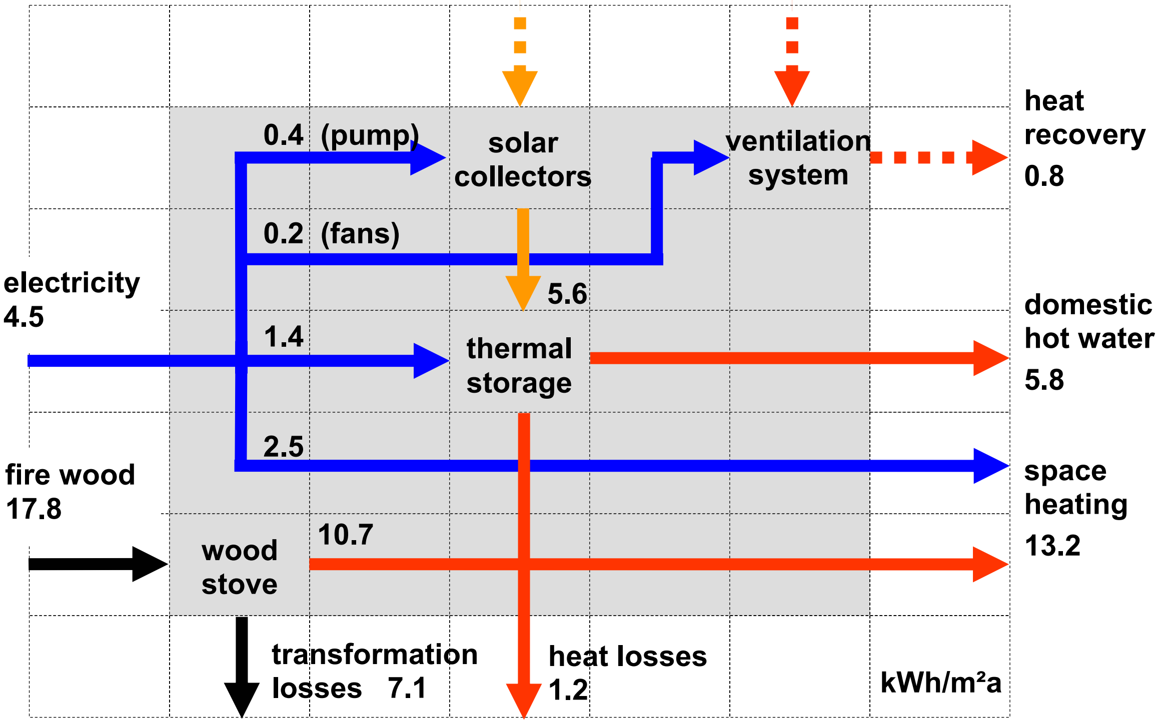

Figure 3: Energy fluxes (measured or estimated) for the space heating, the domestic hot water and the ventilation system of the Velti house.

MINERGIE CONFORMITY

Measurement results allowed us to calibrate the monthly heat balance calculation of the house [2]; performed according to the SIA 380/1 method [3]. The calculation is then re-executed with standard parameters fixed by the SIA 380/1 norm and the Minergie standard [4] to prove the Minergie conformity. The determination of the Minergie index is shown in Table 1 and can be compared to the corresponding measured values .

Energy index in kWh/(m^{2}y)	Minergie verification		Monitoring 2001 - 2002	
Annual heat demand		**18.6**		**14.0**
heat recovery from ventilation system		3.3		0.8
heat from wood stove		12.2		10.7
heat from electric heaters		3.1		2.5
Space heating Minergie index wood	(12.2/0.75)x0.6=	9.8	(10.7/0.6)x0.6 =	10.7
Minergie index electricity	3.1x2 =	6.2	2.5x2 =	5.0
Ventilation Minergie index for the fans	2.8x2 =	5.6	0.2x2 =	0.4
Hot water Minergie index electricity	(6.9/0.9)x2 =	15.3	1.8x2 =	3.6
Minergie index (satisfied if < 42)		**37**		**19**
Electric energy index for domestic use		**22**		**9**

Table 1: Minergie conformity of the Velti house and comparison with measured values.

As for the Velti house, the Minergie standard is easily satisfied with the Vitali house. Calculations show that the Velti house could even reach the "Passivhaus" energy requirements [5] only by improving the heat recovery efficiency of the ventilation system to 80%.

THERMAL COMFORT

The large mass of the house optimally dampens the temperature variations induced by passive solar gains or the released heat from the chimney. Thanks to the external solar protections and sometimes the nocturnal ventilation, the house has never overheated during summer. The aestival thermal comfort, which can be critical in this climate, proved to be satisfactory at all times (see Figure 4).

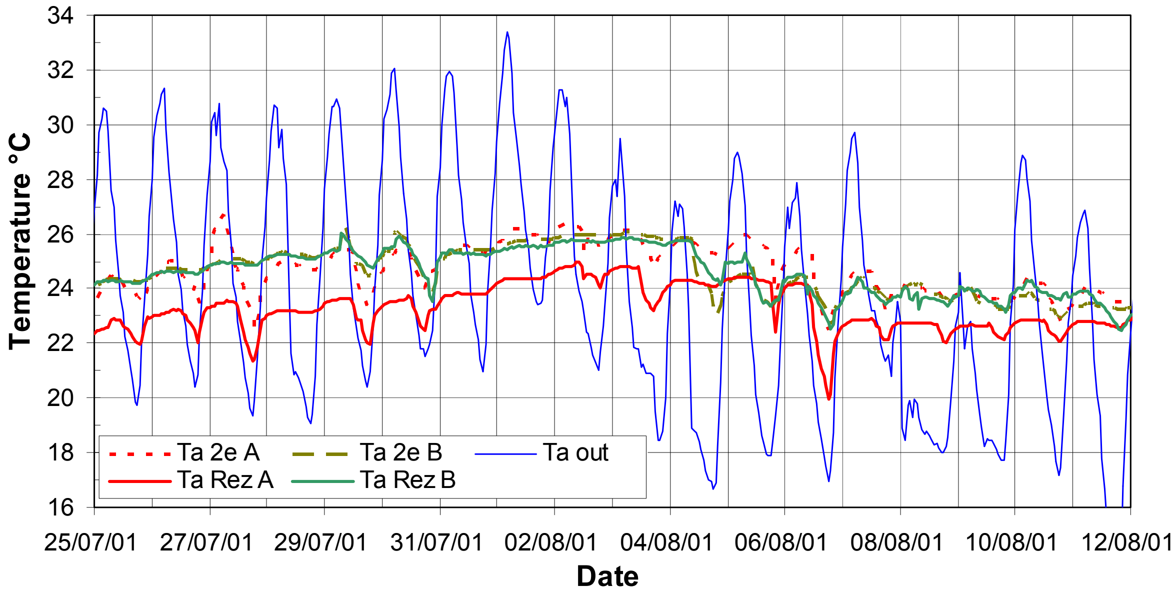

Figure 4: Evolution of indoor temperatures during the hottest period of the year. Ta Rez: ground floor; Ta 2e: second floor. Letter A is for the Velti house and letter B for the Vitali house. A large daily variation of the outdoor air temperature (Ta out) is an indication of a sunny day.

The thermal comfort has been assessed during three short periods in winter, spring and summer [1]. Comfort parameters remain within standard limits most of the time. Due to the inhabitants choice as to heat, the operative temperature may sometimes drop below the minimum limit that characterises standard comfort. This highlights the subjective aspect of the comfort feeling.

DISCUSSION

The "Vitali-Velti" house has demonstrated that it is possible to decrease the energy requirement of a house below the level fixed by the Minergie standard without supplementary investment relative to a conventional solution. The simple house concept and the careful execution of the building have lead to the success of the project. The adopted solution requires more attention and resources on the building envelope, so that the technical installations can be simplified and reduced to the minimum necessary. Thanks to the passive solar gains and the large storage capacity of the house, a 2 kW heating power is enough to heat one house during the coldest periods.

The monitoring project has shown low energy consumption for the hot water, the ventilation system and electricity for domestic use. It highlights the importance of the habits of the inhabitant on the energy consumption of a house. It shows that an "energy conscious" inhabitant can halve the Minergie index of a Minergie house.

The inhabitant has full control over the indoor climate of the house (heating, free or mechanical ventilation, solar protections). Thermal comfort measurements confirmed that the comfort conditions remain within standard limits most of the time. The large mass of the house (inside the insulated building envelope) contributes to comfort by damping temperature variations that could result for example from a wrong decision of the inhabitant. The house concept (insulation envelope without discontinuity, external solar protection, large internal heat capacity) has demonstrated to be efficient in guaranteeing the thermal comfort during summer.

ACKNOWLEDGEMENTS

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