The Window - a Poetic Device and Technical Tool to Improve Life in Energy Positive Homes

a Case Study of an Active House

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The Window - a Poetic Device and Technical Tool to Improve Life in Energy Positive Homes - a Case Study of an Active House

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Summary

The aim of this paper is to illustrate how a holistic approach to the window as a design element can be used as a poetic device and technical tool to improve quality of life in energy positive homes.

- Through a case study of the residential building Home for Life, built in accordance with the Active House vision, 'fictive user statements' from the design phase and the end users' experience of living in the house form the primary source to define and evaluate the potentials of the window. We explore the interaction between the window used as a technical tool to optimise indoor climate through fresh air, comfortable temperature and functional daylight and provide the house with solar heat and the window used as a poetic device to create living environments where expression of space and materials are evoked through daylight and where indoor and outdoor relations are essential elements for the quality of the life in the building.

The analyses are based on the definition of four window design elements used in the house: the south facing active window façade, the east and west facing square windows, the north facing roof windows and the light cross. The window design elements are analysed and their potentials as a poetic device and a technical tool to improve life are accentuated.

The paper concludes that all four analyzed window design elements have potentials to provide the people living in the house with poetic qualities such as expression of space and material evoked through daylight and indoor and outdoor relations. Not all window design elements are contributing with technical values in all aspects. Three of the four window elements have a neutral or negative energy balance and two window elements will have a negative effect on comfortable temperatures if they are not regulated by external sunscreens and natural ventilation. The hypothesis; 'a holistic approach to the window as a design element can be used both as a poetic device and a technical tool to improve quality of life in energy positive homes' can be verified. It is clear that the poetic aspects have an important role in the design. The paper points out that these aspects do not always correspond to the technical needs.

The paper explore the challenge to develop tools, design strategies and legislation where the valuable synergy between technical needs and human needs for the poetic aspects can be united by the window as a central design parameter.

Keywords: Window, Poetic Device, Technical Tool, Energy Positive Building, Active House, User

1. Introduction

The window is essential for the quality of life. Windows affects our senses and perception of surrounding environments to a great extent. In Northern Europe people spend up to 90% of their time indoors; often in poorly designed buildings shutting out daylight and creating artificial environments [1]. Restricting windows as a tool for solar heat gain rather than utilising its qualities is an increasing tendency in new buildings as a result of the narrow demand for saving energy for heating. Focus on the possibilities of harvesting energy directly from sunlight by energy optimised holistic design and development of new technologies offers unique challenges and opportunities for designing buildings with the best possible natural environments for people. This paper, therefore, addresses the interaction between daylight in technical terms and daylight in poetic, architectural terms.

1.1 Active House vision and seven experiments

Improving quality of life in future buildings is an ambition pursued by Active House which represents a vision of buildings that ‘give more than they take’, a vision of designing a house that has low energy consumption, produces energy, has a healthy and comfortable indoor climate and is carbon neutral. At the same time the house is to be designed with respect for the local and global environment and optimised to utilise natural resources such as daylight to improve technical as well as poetic and aesthetic aspects. [2]

As a case study lab for exploring the potentials of the Active House vision in a full scale context, seven single family houses are currently being designed, constructed and tested in five European countries. A test family moves into each house to live in and with the house. Thereby, it will be possible to explore and learn from the relations between objectives, design strategies, animations, and calculations on one side, and reality on the other, when real people play, sleep, eat, relax in and enjoy their homes. [3] [4]. This paper focuses on a single case study, the first experiment and house built in accordance with the Active House vision, Home for Life near Aarhus in Denmark.

2. Home for Life – design process

The development of Home for Life was an interdisciplinary design process through workshops with participation from architects (AART Architects), engineers (Esbensen Engineers), window industry specialists (VELFAC and VELUX Group), daylight specialists, anthropologists and a philosopher. This team developed and defined the design principles and vision of the building through ten workshops. The description here is based on the authors of this article as Ellen Kathrine Hansen was the project manager of the process.

2.1 2020 statements, objectives and parameters

To define a set of parameters in support of the life in the house, the objectives were built on a scenario of a family living comfortably in the house after a 10-year period – not on the parameters of the physical properties of the house at the time when it was constructed. Therefore, the overall objectives define qualitative parameters with focus on how a family will experience the house after 10 years (in 2020) of *living* in it. For this purpose a fictional interview was set up, placing the design team in the occupants’ position in year 2020 which led to the definition of the following ‘Fictional interview statements from ‘users’ year 2020. Based on this we define following parameters to analyse the window as a poetic devise and technical tool.

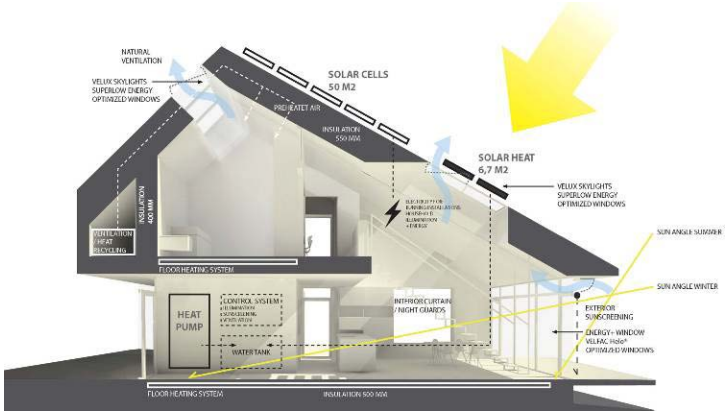
The fictitious future year 2020 is employed in continuation of the current discussions going on related to the future aims of sustainable architecture. The year 2020 in many regulative formulations and tool appears to represent a common milestone in the development [14].

Table 1 User statements, objectives and parameters identified through the design process.

Users statements year 2020		Objectives and approaches referring to Active House parameters		Parameters for analysing the window
"Our home has an **atmosphere that makes us feel at home**, we enjoy the seasons of the year and the rhythm of the days, the house has a **close relation to nature and the surroundings**, which gives us endless variations and narratives."	⇨	**Has a positive impact on the environment** - Modifying the house to suit local housing estates. - Designing a house of **high architectural merit based on space and indoor/outdoor relations**. - Choosing materials that have minimum impact on the environment. - The atmosphere allows the expression of material and space (through daylight).		- Expression of space and materials evoked through daylight - Indoor and outdoor relations
"In our home we have **plenty of fresh air and daylight**, which we enjoy, and we are hardly ever ill."	⇨	**Creates a healthier and more comfortable life** - **Optimised daylight conditions** with a large window area (40% of the floor area) distributed round all four façades and the roof, with most of the glass facing south. - **Fresh air** with hybrid ventilation, in which automatic natural ventilation is supplemented by mechanical ventilation in the heating season. - A **comfortable temperature** automatically controlled by sun screening products, ventilation and heating systems. - Maximised poetic potential of daylight in the main spaces of the house.	⇨	- Functional daylight conditions - Fresh air and comfortable temperature
"Living here provides us and our children with a sound understanding of the balance with nature and a good feeling that we give back more than we take – **in our house we produce more energy than we consume**."	⇨	**Contributes positively to the energy balance of the building** - Meeting the energy demands of 2020 building regulations. - Minimising energy consumption to building regulations Energy Class 1 via energy-optimised design by making **use of passive solar thermal energy** through the windows. - Producing CO_2 neutral energy with a combination of solar heating, solar-driven heat pumps and solar arrays.	⇨	- Solar heat gain

2.2 An interdisciplinary design process

With offset in the 'users'' 2020 statements, objectives and parameters defined in Table 1 the team designed Home for Life. Various methods were used to communicate the poetic and technical elements, often with the window as a central element - from traditional architectural drawings, paintings, renderings and models, to studies of scale models in light laboratories to 3D animations in VELUX Daylight Visualizer2 [5]. Estimated energy consumption and production as well as indoor climate values were continuously calculated in the Danish programs BSim [6] and Be06 [7]. These calculations were used at all workshops to identify relationships between technical elements in the different design strategies to be able to communicate across disciplinary boundaries.



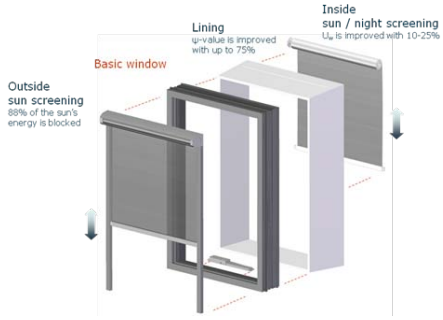


Fig. 1 Energy concept section through Home for Life.

Fig. 2 Principle of intelligent window elements.

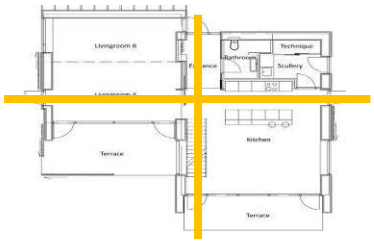
The house is located in Lystrup in Denmark. It is orientated to the south, which also gives a view of the landscape and the bay. The geometry originates from a traditional Danish single family house of 1.5 storeys. The roof pitch is moved north to establish a larger south facing roof slope to harness the energy directly from the sunlight for hot water and electricity. The house is simulated to produce more energy than needed for its operation. [7] [15]

2.3 The window as design element

Throughout the design of the house window elements and daylight have played a central role. The window area is 70 m^2 corresponding to 40% of the floor area. The window area of the four façades is distributed as follows: 70% south, 5% north, 11.5% east and 11.5% west. During the heating season, automatic natural ventilation from the window openings is supplied by mechanical ventilation by heat recovery. The energy frame simulation program BE06 estimates that 50% of the energy needed for heating is covered through passive heating through the windows [7].

The house can be defined and analysed by the four window design elements outlined below.

Table 1 Window design elements.

South facing active façade		
		- Constitute all south facing façades of the kitchen, the living room and the south facing room on the first floor. - Vertical fixed windows and doors, over which are installed a number of horizontal windows for automatic natural ventilation. - External automatic sunscreen and internal roller blinds adjust the heat gain and light.
East and west facing windows		
		- The three windows are placed parallel to each other in the kitchen and in the living room in the north-west corner. - The windows are fixed parts with no pane sections. - Internal roller blinds and external manually operable shutters adjusts light inlet.
North facing roof windows		
		- Two bedrooms and the bathroom on the first floor are supported with light from six north facing roof windows. - The pivot windows have automatic window operators, external awning blinds, and internal blackout blinds.
Light cross		
	  	- Four doors giving view and access to the north, south, east and west are visually connected in a cross at ground level. - The concept is repeated on the first floor with openings facing east and west. - The door facing north serves as main entrance. A ventilation window is placed over each of the three remaining doors.

3. Analysis

3.1 The hypothesis

The hypothesis is that a holistic approach to the window as a design element can be used both as a poetic device and a technical tool to improve quality of life in energy positive homes.

Through this paper the hypothesis is tested via exploring how the window (defined as four window design elements) can be used as a poetic device (expression of space and materials evoked through daylight and Indoor and outdoor relations) and technical tool (functional daylight conditions, fresh air and comfortable temperature and solar heat gain)

To explore whether the stated hypothesis can be verified or not the case study house Home for Life is analysed. There are three main data sets used: the technical performance measures; the experiences of occupants; and the phenomena of light as captured through photography and daylight modelling. The analyses put forward here not only focus on user perspectives and

experiences from living in the house but sets these within wider cultural contexts. Methods and data are part of an ongoing research project called MIMA [8]. The analyses in this paper has its focus on the user perspective reflected in the quote ‘Just imagine if the quality of our buildings was measured by their ability to improve life’ [8].

3.2 Methods for data registration and analyses

“*For the purposes of this kind of research the only reliable instruments of observation are the human senses*.” – Dean Hawkes [9]

A wide range of data registration has been made in relation to the case study. Concerning qualitative registration the triangulation of methods has been a key approach in order to create as colourful an illustration of the house as possible. Methods for qualitative registration include semi-structured interviews [10] [Kvale], participants observations [11], cultural probes such as monthly diaries and photos [4] [17], observations of the house by architects [4] [12] [11]. Methods for quantitative registration are from the natural scientific and engineering fields and include energy simulation with solar heat gain and losses in BE06 and Bsim [BE06 and Bsim], Simulation of indoor climate conditions in Bsim [Bsim], simulation of natural ventilation, simulation of daylight, measurements of daylight, Luminance mapping [4],

Together the quantitative and qualitative methods will attempt to measure, register and capture the poetic and technical aspects of the house [4].

3.3 Analysing window performance through poetic and technical means

The following analysis focus on analysing the qualitative and poetic aspects of the window design elements in the case study house Home for Life [15].

3.3.1 Expression of space and materials evoked through daylight

Fig. 3 Daylight variations in the kitchen/dining area in strong midday light, with sun screens and in the afternoon sun. Photos by Adam Mørk.

The kitchen/dining space is the central and most expressive room in the house as all of the four window design elements are represented in this space. The room is characterised by the sloping ceiling, which is a result of the extended south facing roof optimised for generating energy. This effect is strengthened by internal windows to the middle bedroom and toilet plus the south facing bedroom. The sky is visible through the north facing roof windows in this south facing room. In the kitchen/dining space the light comes from five directions. In May 2011 the female occupant of the house family 2 female (F2F) writes in her diary: “*We still notice the many beautiful details of the house, including both the slated façades and the changing light in the house. We don’t have to get up from the chair and walk to the window to look out. The big windows provide a view, whether we are cooking, sitting in the living room or in our rooms*” [17]. There is constantly sunlight in the kitchen/dining space throughout the year from sun rise till sunset. The entering sunlight adds varying and dynamic markings in the space which can be adjusted by pulling the external and/or internal blinds.

The modernistic motif of the south facing active glass façade creates a contrast to the east and west facing windows which appear as classic holes in the façade, through which the hot and low sunlight is transmitted in the morning and evening hours. The thick well insulated walls and the insulating qualities of the glass make space for creating a window recess with a place to sit. In her diary in March F2F writes: "*The window sill in the east facing window is quite naturally used as a seat several times a day. It is a good place to get lost in one's own thoughts with a cup of tea after work, or a good place for a break*" [17].

Fig. 4 One photo and two simulations of the luminance distribution made in VELUX Daylight Visualizer [5]. Photo by Gitte Gylling.

Daylight also enters the kitchen dining space from the North facing roof windows in the upstairs bathroom. A glassed wall between the bathroom and hall area provides for this diffuse light from to access from above resulting in a very comfortable daylight environment in the space. Fig. 4 shows both in simulation and registration that the space has a very well distributed daylight environment, through the four window elements and the roof top windows in the roof.

3.3.2 Indoor and outdoor relations

The two east/west facing windows and the south facing glass façade create a strong connection to the outside via its transparency. The light cross also contributes to opening the house and creating relations to the west through the living room and to the north through the hall. In the participant observation the Anthropologist writes: "*Sitting in the kitchen/family room you easily let your eyes wander to follow life outside the house. The 6-year old boy of the family tells how the family from the dining table can watch the sun rise and the mother of the family fancies looking out of the windows and compares the windows to pictures. One window represents one picture; another window is a new picture, etc. And they are always different. Actually they enjoy the view so much that they like to let in more light and heat than permitted by the system. Then they override the system and roll up the awning blinds when the system tries to control the heat*". [19]

The south facing active façade opens the room to the south accentuating the slated floor and walls continuing out onto the terrace. Family 2 (F2) are especially satisfied with the windows to the floor and in their diary express the joy in seeing snow right on the other side of the window, in December: "*It feels like sitting right in the drift, without being cold. The snow provides additional light – white in white. The frosty sky looks extraordinarily beautiful from the house, because from there we have a view of the entire horizon and its cool pastel shades*" [17]. This is an interesting observation pointing to a new potential made possible by the new energy optimised windows with very low heat transmittance. In March F2F writes: "*The snow around the house has disappeared, and the terrace in front of the kitchen is visible again. It suits the kitchen with the slate tiles that continue out on the terrace, one of the details we have fallen in love with…*" [17].

The south facing window façade is facing the road in front of the house causing inconvenient insight resulting in the occupants pulling down the sun screen to have privacy [Werner]. This interferes with the expected amount of energy gained through the façade. The Anthropologist points to: "*At the beginning the family asked for blinds on the first floor, in the living room and in the kitchen/family room. They are much used, and at the same time the family is excited about the great view from the house, which is considered a great asset to the house. So in general, there is a*

Fig. 5 View from the house over the city- and landscape. Photos by Gitte Gylling.

conflict between the need for screening as a means of controlling the temperature on the one hand, and the view and the daylight admittance on the other hand" [18].

On the direct access to outdoor spaces from inside in March F2F writes: "*On really good days in March it has been possible to enjoy the sun on the south facing balcony above the sitting room. It has been comfortable – just what we had been waiting for. We look forward to enjoying life outdoors during the summer half-year. There is ample opportunity for living around the house throughout the year. If we need shelter, the covered terrace at the living room is a suitable place*" [17].

3.3.3 Functional daylight conditions

The two large square windows facing east and west, the south facing active window façade and roof windows in each side of the south facing roof slope result in a daylight factor average in the kitchen/dining room around 10% with large areas of the space exceeding daylight factors of 20%.

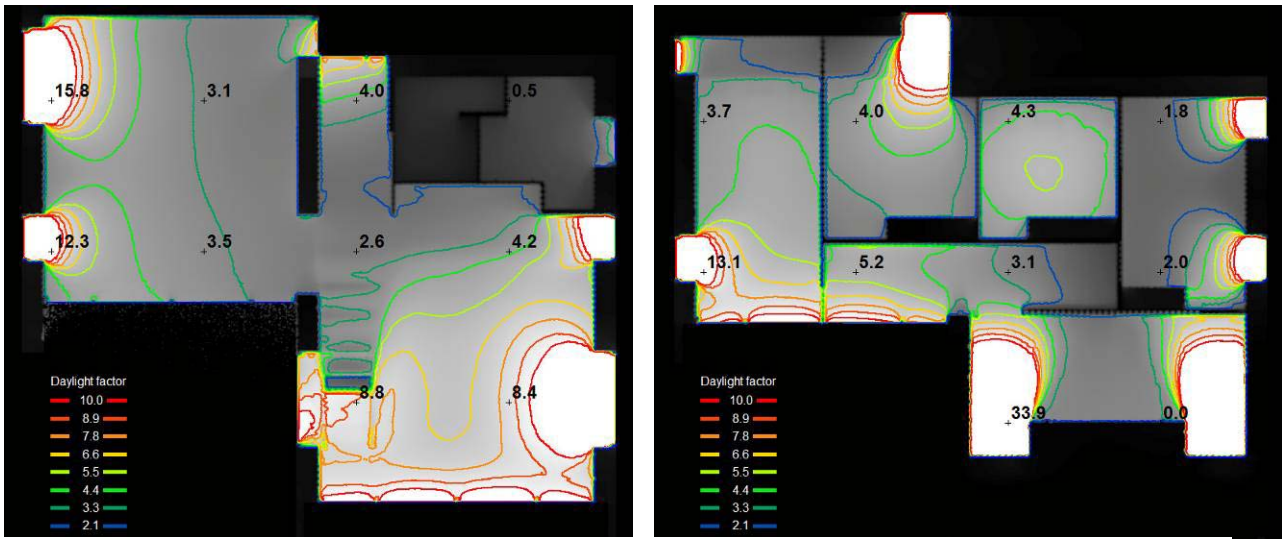


Fig. 6 Plan 1 and 2 of Home for Life with Daylight Factor (DF) curves.

Glare might occur. [11]. Family 1 (F1) pulled down the internal and external blinds to dim the light level and create privacy, which has resulted in reduction of possible solar heat gains [20].
The South facing active façade is critical in the South West facing room on first floor. F2F writes: "'*It is nice to have so much light in the house. The character of the light changes with the weather. However, my husband has to pull down the external sunscreen at the balcony in the office during the day. The internal blinds are not enough. Too much reflection in the computer screens makes work impossible*". She adds: "*Awning blinds and sun screening have started to go down later, meaning that we can enjoy the days getting longer. The timing is perfect*". This accentuates the experience of the house following the rhythm of day and year.

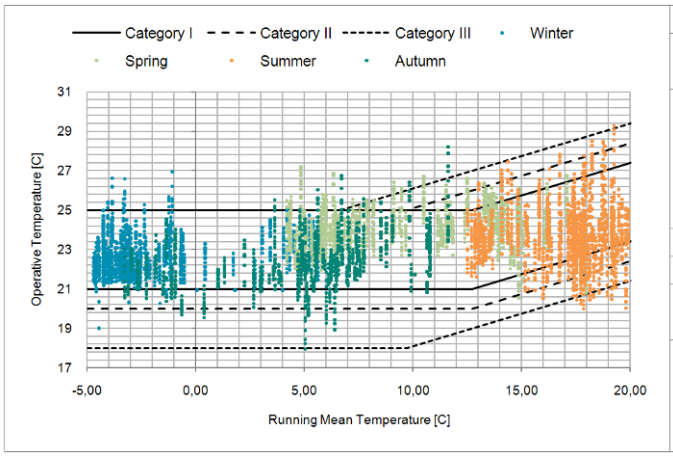
As a contrast to the dynamic daylight in the kitchen/dining space, the bathroom on the first floor appears to have the most even daylight distribution at an appropriate high level of illumination with an average daylight factor at 4.3% and daylight factor at wash basin height around 5% [12]. This is due to the high placement of the north facing roof windows in the room which allow the daylight from the northern sky to be brought down softly to the level of the wash basin via reflections in the room.

F1 experience using very little electrical light due to level of daylight and the Anthropologist notice: "*The family has the experience that they use less electrical light than in their old house and they mention the great amount of daylight intake as one of the things they will miss the most, when they move back to their old house from the 1970s*".

3.3.4 Fresh air and comfortable temperature

The top windows in the south facing façade and in the doors in the light cross are together with the roof windows programmed for automatic natural ventilation cultivated via the design of the spaces. In March F2F writes: "*In March we experienced that the house changed from winter to summer. The first time the house went into summer state took us by surprise. It acted differently than we were used to. The windows and roller and awning blinds went down. The air felt and smelled fresher – real outdoor air*" [17].

The house is designed with eaves to the south to provide shade for the high warm summer sun. The south facing windows are supported with external automatic sun screening and internal blinds. Temperature during the first test year was measured to be below the criteria of class 2 in EN15251 in more than 95% of the year and thereby fulfilled the active house criteria. However, the measurements and the observations indicate that there are periods especially during spring and fall and shorter periods during summer, when overheating occurs [20].



Hours in each category	Over/under-heating	Over-heating
I	7473	8305
II	832	204
III	231	64
IV	224	187
	8760	8760

Hours in %	Over/under-heating	Over-heating
I	85,3%	94,8%
II	9,5%	2,3%
III	2,6%	0,7%
IV	2,6%	2,1%

Fig. 7 EN 15251 comfort graphs created from values measured in Home for Life through first test year.

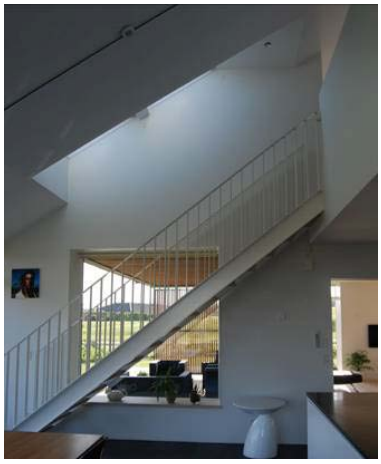


Fig. 8 Inside the kitchen/living room space. Photo: Gitte Gylling.

F2 experienced overheating primarily during winter clearly stated in the diary by F2F from December: "*A Sunday with plenty of sun and more than 27 degrees in the living room we had to have the automatic control ventilate a couple of times, but we felt more like opening all doors to outside, to the 2 degrees below freezing point. We didn't, but sat for a while on the terrace by the living room… The house keeps the warmth, which we could benefit from later that evening and that night. It is still winter, you know*". A couple of months later in February F2F continue: "*We had the pleasure of the sun in February. We came home late on a Saturday afternoon. It was probably 29 degrees in the living room and 27 in the kitchen. When we entered the house, we were cold, so feeling the warmth was actually very pleasant. The sun was also strong the following day. We pulled down the awning blinds in the kitchen, which instantaneously gave us a pleasant feeling, and the temperature stayed at an acceptable level around 24-25 degrees*". The following month, March: "*The sun is higher in the sky, which we can tell by the living room temperature, which has*

not been quite so high as in January and February when the sunlight came more directly into the house". Finally, in May F2F writes: "*When we experienced in January how the low sun could heat the house up to 28-29 degrees by frosty weather, we feared extensive heat in the summer half-year. However, we manage to keep a pleasant temperature. On hot days, the house feels cooler than the temperature outside. It does not take much sun to activate the sun screening and ventilation. Usually the house is prepared to provide heating, and the air in the house is always fresh*". [17]

3.3.5 Solar heat gain

According to calculations the south facing window supports the house with solar heat during the heating season, the east and west facing windows are neutral, and the north facing windows are energy minus [7]. During the design of the house it was simulated that half the required energy need for heating could be covered by solar heat gain through the windows. [16]
After one and a half test year it has become clear that the actual amount of solar heat gain to support the heating of the house is not equivalent to the simulations. The difference is due to different user behaviour than expected in the simulation and that the calculation programs are not adjusted to inflexibly. Another factor is the small energy demand as the house is very well insulated.

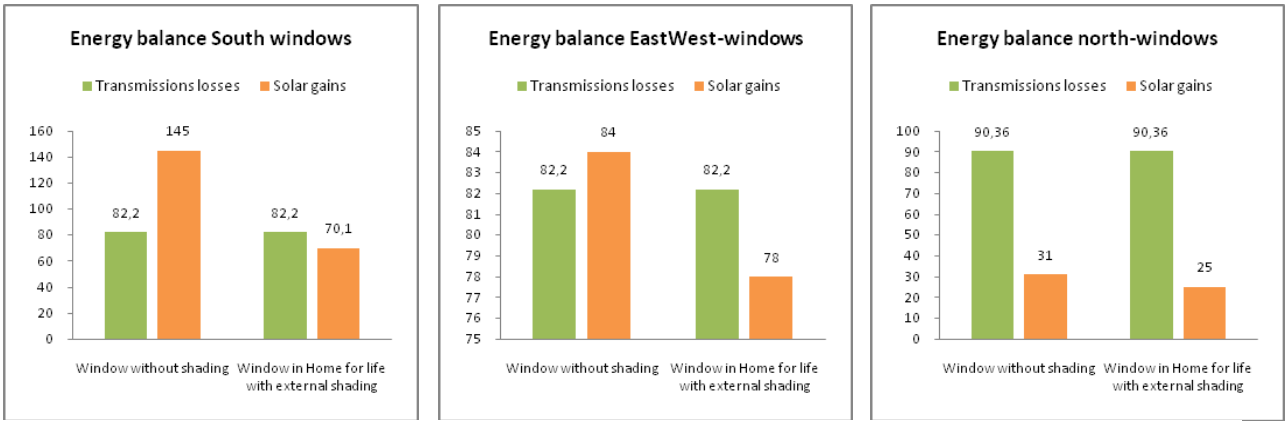


Fig. 9 Energy balance through the different windows.

F2 shows interest in the fact that the sun supports the house with energy. In November F2F writes: "*We hope for a very sunny winter to support the balance of energy. 'Good weather' has a completely new meaning to us now*" [17.]

4. Results

The results from the analysis are presented in Table 2.

Table 2 Results: Window design elements related to poetic and technical parameters

		South facing active façade	East and west facing windows	North facing roof windows	Light cross
POETIC	**Expression of space and material**	- Modernistic motif. - Big variation of direction, reflections and shadows from daylight throughout day and year. - Light inlet moderated and equalised by external sun screening. - Black slate floor moderates reflections.	- Classic window: the view as a picture on the wall. - The window recess creates a space. - The low morning and evening light creates characteristic formations. - Screening adjusts the expression in the room.	- Studio window. - Diffuse and cool daylight inlet. - The light has sufficient direction to make outlines and colours distinct. - The characteristic shape of space is accentuated and opened to the north.	- Classic axis. - Enlargement of spatiality across the house. - View at entry. - Transparency in house layout.
	Indoor and outdoor relations	- Free view of sky, terrace, garden, landscape and bay. - Floor and walls continuing outside and direct access through doors accentuates indoor/outdoor relations. - Large glazed area makes look in, interior blinds required.	- Visual contact with east and west facing terraces and context. - Provides the possibility of looking through the house from east to west.	- Opens the room to the sky in north, which is often illuminated directly by the sun and creates big contrasts throughout day and year. - Privacy due to no peak in possibilities.	- Strong effect caused by opening the house to all four corners of the world. - Exit to terraces in all four directions.
TECHNICAL	**Functional daylight conditions**	- Direct high (summer) and low (winter) sunlight. - Need glare screening - Daylight inlet from other directions required to prevent glare. - Daylight level high.	-Big pane with large light inlet. - Direct low sunlight in the morning and evening. - Manual screening to control light inlet. - Fine reflection of light in recesses.	- Well distributed light from the sky. - High DF via relatively small window areas. - Good light in shower by mirror in the bathroom. - Fine function as light source in bedrooms. - Night screening required.	- Contribute by distributing daylight inlet from east, west and in particular from north at the entrance.
	Fresh air and comfortable temperature	- Good position for fresh air = natural ventilation. - Eaves prevent direct sunlight during summer. - Automatic external sun screening and natural vent. to avoid overheating. - 100% glass not optimal for stable indoor climate.	- The window has no openings = no ventilation. - Risk of temporary overheating in the morning or evening.	- Good opening solution for natural ventilation. - No risk of overheating.	- Ventilation openings (east, west, south) create natural ventilation. - Relatively small glass areas with no contribution to overheating. - Screening in rooms on first floor recommended.
	Solar heat gain	- Energy plus despite reduction of heat contribution due to sun screening. - In practice, the glass area is not utilised 100% for solar heat gain and could be reduced.	- Energy neutral. - The large pane has a relatively high U-value.	- Energy minus due to small solar heat gain, but small window area relative to DF means only little importance for total energy contribution. - Energy loss equalised by energy plus windows in south facing roof.	- Together the four doors are energy neutral.

5. Discussion and Conclusion

It is now widely accepted that in the future we have to consider different climatic and cultural responses to the problems of global warming. This will help us develop different regional typologies which respond to specific rather than universal conditions. Hence the drive towards EU standardised specifications/legislations for energy efficiency need to be tempered by regional and humanistic understandings such as the Nordic tradition [14]. This development cannot solely rely on standardised specifications/legislations but as Gylling et al state: “The holistic approach calls for new ways to assess and evaluate our buildings, not solely based on quantitative means but particularly also based on qualitative means, so we can determine qualities and life improving factors in sustainable architecture” [4].

With the offset aim to illustrate how a holistic approach to the window as a design element can be used as a poetic device and technical tool to improve quality of life in energy positive homes this paper treats a key subject within the ongoing issues of sustainable architecture. The case study used throughout the paper presents a realised real scale project with real occupants and professionals involved. This provides a unique opportunity to get under the skin of the occupants and their experiences to collect data and knowledge which cannot be simulated, calculated or corrected for. The collected data, obviously, contain a lot of information when considering the poetic and the technical data and their interplay, a quantity much larger than a single paper can treat. However, the focus on the window as a design element is found to strongly illustrate that this approach to researching sustainable architecture is definitely legitimate and carries strong information and important evidence.

There are obvious technical disadvantages to designing energy positive houses with extensive glassed areas if aiming for establishing good and healthy indoor climate conditions as defined by standards such as the European EN15251 ore energy performance defined in the Passive House Standard. However, the occupants’ experiences from present case study that has followed two families through one and a half year of testing point to the importance of experience of the differentiated day lit spaces, fresh air, relation to the site specific surroundings via physical and visual access and views to the surrounding land- and cityscape as life improving factors in future sustainable housing. Thereby it is evident that poetic as well and technical potentials are enhanced by integrating windows as holistic key design elements in energy positive buildings. Integration of the poetic and technical aspects related to windows can support and counterbalance each other in the design. Therefore a holistic approach to the design is central to create environments that can improve life in energy positive homes.

The analyses also illustrate that it is central to take an appreciative approach to window principles that represent different values and in the design process can be combined to one composition. Not least the differentiated daylight inlet from all directions and the differentiated use of the indoor and outdoor relations are important. These are important quality issues which are often overlooked in purely technical analysis. An occupant oriented approach to both programming and analysis of finished houses is valuable to ensure a holistic approach and optimum use of daylight potential in energy optimised houses. Focus on life in the house helps us use common sense and understanding of working with nature instead of fighting it. It also helps us understand how new products and technology can meet traditional and future requirements.

The key finding in this paper is that an energy efficient design with focus on utilising the window as design element brings possibilities of daylight maximisation (less electricity for electrical lightning) and solar heat gain (less energy for heating). This strongly supports the ideals behind the Active House vision of creating sustainable architecture focusing on occupants’ needs and quality of life.

The conclusion of this paper is presented in *Table 3,* summarising the main points to illustrate whether the hypothesis that a holistic approach to the window as a design element can be used both as a poetic device and a technical tool to improve quality of life in energy positive homes can be verified or not.

Table 3 Conclusions presented in table form. The table present where the window is used as a poetic device and a technical tool.

		South facing active façade	East and west facing windows	North facing roof windows	Light cross
POETIC	**Expression of space and material**	+	++	++	+
	Indoor and outdoor relations	++	++	+	+
TECHNICAL	**Functional daylight conditions**	+	+	++	+
	Fresh air and comfortable temperature	+ -	+/- -	++ ++	+ +/-
	Solar heat gain	+	+/-	-	+/-

All four analyzed window design elements have potentials to provide the people living in the house with poetic qualities such as expression of space and material evoked through daylight and indoor and outdoor relations. Not all window elements are contributing with technical values in all aspects. The table illustrate the importance in illuminating the window as an intelligent and holistic design parameter since three of the four window elements have a neutral or negative energy balance and two window elements will have a negative effect on comfortable temperatures if they are not regulated by external sunscreens and natural ventilation. In this paper it is verified that the windows support the building with qualities that are basic elements in creating sustainable living environments. The hypothesis that a holistic approach to the window as a design element can be used both as a poetic device and a technical tool to improve quality of life in energy positive homes can be verified and it is clear that the poetic values have an important role in the design. These parameters do not always correspond to the technical needs.

The challenge is to develop tools, design strategies and legislation where the complex synergy between technical needs and human needs for the poetic aspects can be united by the window.

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