Model-Monitoring for maximum livability with minimal footprint

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Introduction

How to maximise well-being and living comfort of the inhabitants, whilst minimising the environmental impact? A unique interdisciplinary research carried out on a climate renovation of a typical 1950s Settler House in Hamburg aims to verify the theoretical planning and calculations in terms of quantitative and qualitative measures, and to map how the two are closely intertwined.

LichtAktiv Haus

LichtAktiv Haus is the German contribution to the European VELUX Model Home 2020 project, situated in Wilhelmsburg within the framework of the IBA Hamburg international building exhibition 2013.

The design of the half double house was the winning scheme in a student competition at Technical University of Darmstadt, which suggested a design true to the original expression of this house type, however modernized and restructured substantially inside, and supplemented with an extension – **Figure 1** The extension is built in full length in the demonstration house, yet it can be left out or resized depending on demand for renewable energy, space and finance. The neighbour occupying the other half of the double house has modernised the climate envelope in the same design, and utilised the top attic as a living room.

Interdisciplinary monitoring team

The Family Oldendorf has in 2012 moved from their apartment in Hamburg into the climate renovated LichtAktiv Haus in Hamburg, to test it for 24 months.

The family of four is closely followed by a research team, developing methodologies and learnings as a model for monitoring and learnings to pass on to practice and theory to further qualify other climate renovation projects. Following the residential living experiment is an interdisciplinary team of comprehensive scientific monitor-

Figure 1. Katenweg 41 before and as LichtAktiv Haus after climate renovation.

Figure 2. The Lichtlanterne, the core of the old house.

ing in cooperation between the Technical Universities (TU) of Braunschweig and Darmstadt, and Humboldt University in Berlin. The monitoring team set off on common ground together with the client VELUX, and developed a mutual point of departure for the interdisciplinary investigations, in short: How can we achieve maximum livability with a minimal footprint?

The quantitative aspects are monitored in a subgroup led by Dipl.-Ing. Thomas Wilken from Technical University of Braunschweig; the leading motive is: *what is the correlation between the theoretical assumptions on energy consumption and production?*

The qualitative monitoring is led by M.A. Soz. Percy Scheller from Humboldt University in Berlin with a leading motive of: *how well are the inhabitants feeling?*

The monitoring concept brings together quantitative and qualitative diagnostic techniques, making the methodology a model on its own included in the investigations on this particularly project.

Outdoor climate and corresponding indoor values are quantitatively recorded and documented, alongside input from the test family Oldendorf by means of qualitative research regarding their experiences of living and well-being in the house. The results of the quantitative and qualitative monitoring is presented and discussed regularly in the entire team, where evaluations and possible counter-measures are taken up and pursued.

Natural ventilation as key principle for modular and feasible adaptation

The LichtAktiv Haus is designed to be carbon-neutral in operations, with renewable energy production from windows, solar collectors and photovoltaic panels, controlled by a solar based heat pump with an outdoor unit. The house is based on automated natural ventilation as key principle for air exchange throughout the year. The Settler House type is widely spread in Germany; there is around 13 million of this house type. The modular design of the LichtAktiv Haus is suggesting a number of modular solutions which can be adapted on idea basis into other similar existing houses, due for climate renovation. The natural ventilation as key principle was chosen based on the assumption, that a modular model for climate renovation would not feasibly suppose mechanical ventilation to be installed in existing housing in general.

Methodological approach of the qualitative monitoring

The team from Humboldt University working with the well-being of the family base their work on a three-dimensional structure of attitudes. The tripartite model distinguishes between three categories of reactions to attitudes: cognitive, affective and conative reactions, which can manifest themselves verbally and non-verbally and can be measured:

- Affective attitude components (feeling)
  - Feeling, evaluation, reactions of the autonomic nervous system
- Cognitive attitude components (thinking)
  - Evaluation, conviction, opinion, knowledge, notion, judgement
- Conative attitude components (acting)
  - Behavioural tendency, behavioural intention, willingness to act

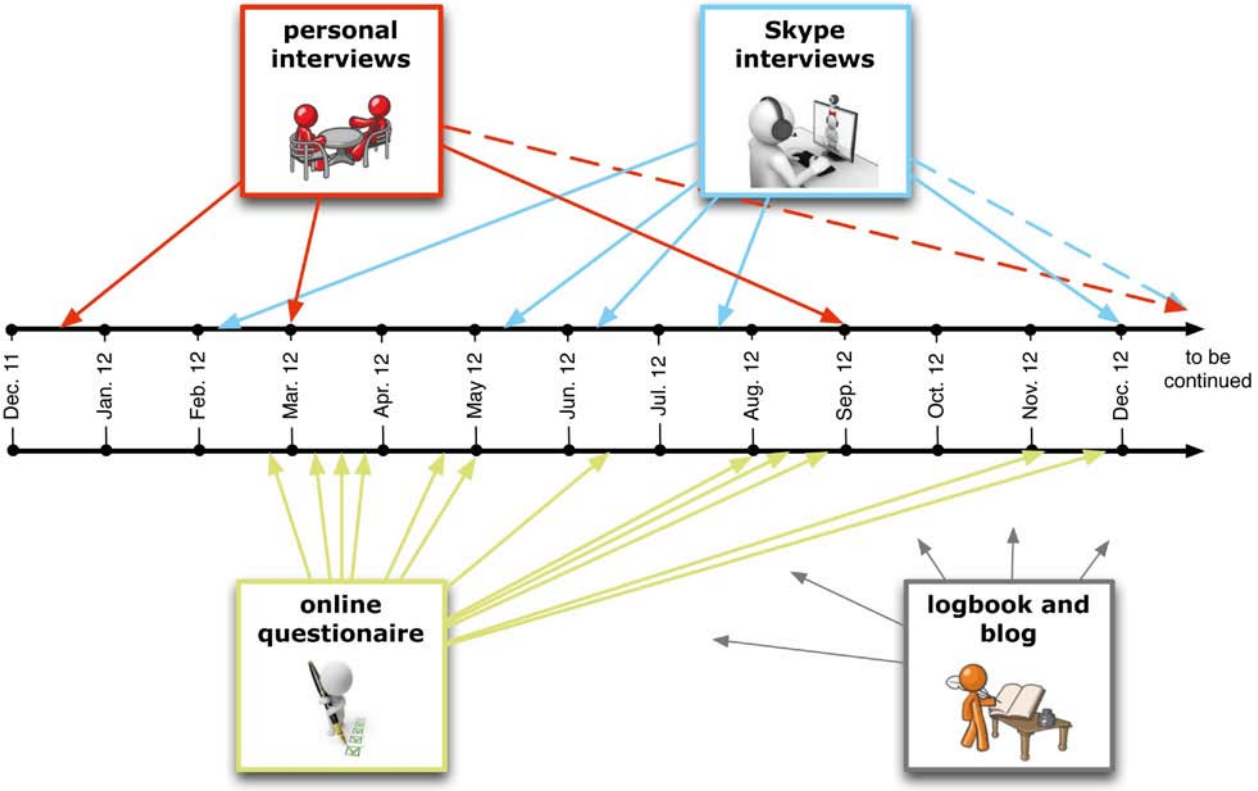

Figure 3. Overview of the qualitative study design.

The team is monitoring via different investigative methods, **Figure 3**:

- Diary format in a digital logbook and a public blog, both maintained by the family, recording their living conditions.
- Approx. every 4 weeks the respondents complete an online questionnaire including both open and closed questions about the various dimensions of well-being.
- Approx. every 4 to 8 weeks, more in-depth structured interviews are conducted with the parents in the form of video calls.
- Longer structured interviews are conducted in the house at the end of each season.

This allows statements to be recorded in detail, and to be set into context with the respective evaluations (evaluation problem).

Interim results of the quantitative monitoring

The LichtAktiv Haus is designed according to the Active House principles[1], and the indicators for comfort, energy and environment can be read in **Figure 4**. The indicator levels express the designed levels, which are monitored in practice. Differences between design and measure, from factory to field, are subject to examination and evaluation in the monitoring team. The measured levels will be communicated as an overlay onto the design radar later in the monitoring phase.

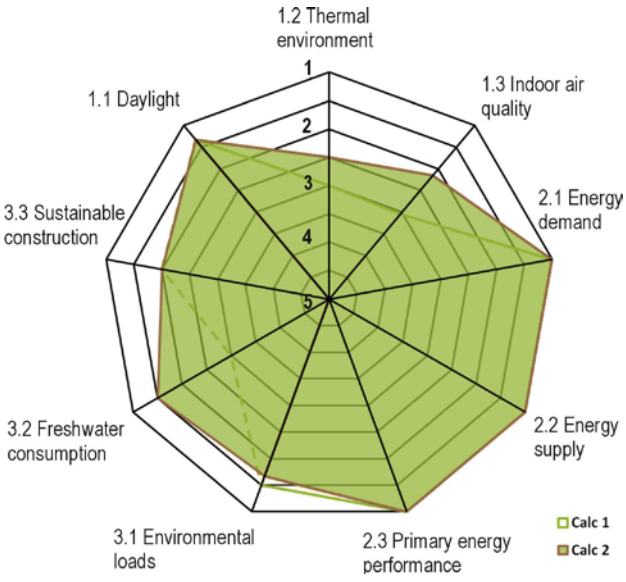

Figure 4. The Active House radar diagram - designed indicators

1 Activehouse.info. See also the article on Active House Specification by Eriksen at al. in this issue.

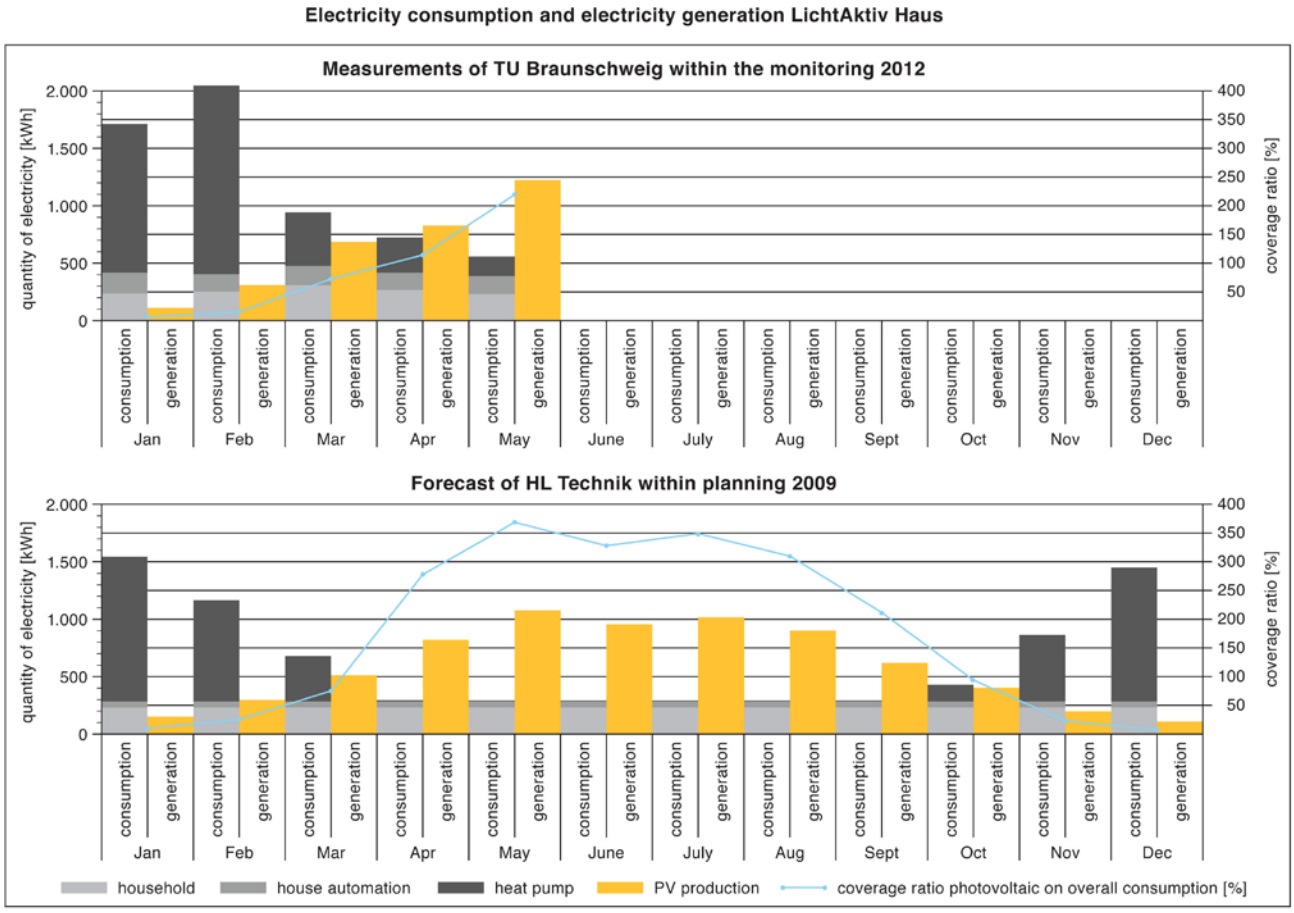

Figure 5. Designed vs. measured energy consumption and production.

The interim results from the first months of test living in the house show some interesting indications, some of which are the following:

Energy *(indicators 2.1 + 2.2 in Figure 2)*

The heating energy consumption in the LichtAktiv Haus first test period corresponds to the forecasts – despite the fact that the average indoor temperature of 22-23°C is around two degrees above the standard calculated values. LichtAktiv Haus does not achieve an electricity surplus before April; although the power consumption corresponds to the predicted data and the photovoltaic yields are above the calculated values (**Figure 5**). The reason is the heat pump´s electricity consumption which still is higher than calculated owning to the fact that it has still to be adjusted. [1] The family has rated the functionality of the heating as working perfectly. [3]

Thermal Comfort *(1.2) – quantitative indicator*

No overheating was seen in winter, but three episodes of spring overheating (light green dots are seen – **Figure 6**). This happens when the outdoor temperature is below 26°C, and the most likely cause is that the control system is in "spring" mode where it maximizes solar gains and not in "summer" mode where it is set to minimize overheating. Some summertime overheating is observed with episodes where category 3 is exceeded. Relatively low temperatures are observed during summer, with episodes with temperature drops below 21°C. This can be caused by night cooling, where the temperature decreases during the night to reduce overheating the following day, which in some situations lead to temperatures in the morning between 20°C and 21°C. [2]

Thermal Aspect *(1.2) - qualitative indicator*

This aspect reflects the perception of temperature, air draught and humidity. A certain difference between the two grown-ups perception is detected during the studies, in general the occupants the room temperature as satisfactory over the entire year – **Figure 7**.

High satisfaction and living comfort

The first investigations show that the LichtAktiv Haus offers the test family a high level of living comfort and, apart from a few minor criticisms, the family is very

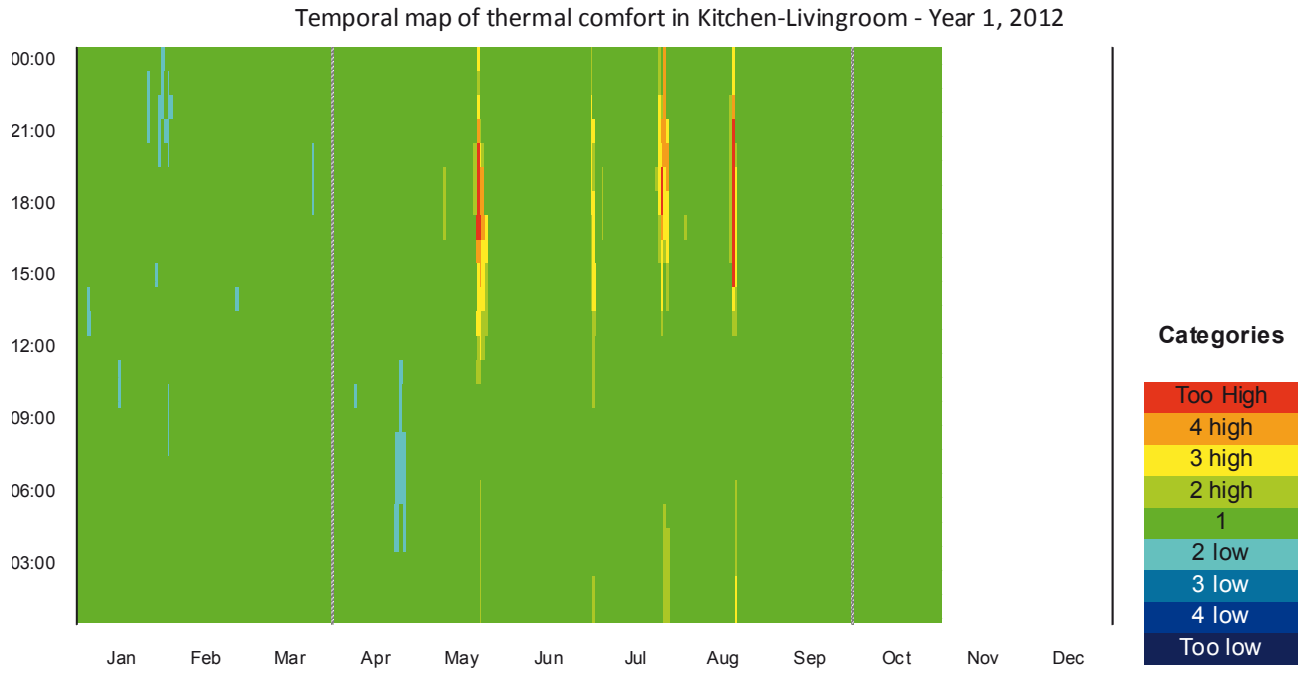

Figure 6. Living room in LichtAktiv Haus. The comfort category of each hour of the year is plotted as a temporal map colors. See Table 1 in the article by Peter Foldbjerg and Thorbjørn Asmussen on this issue for the explanation of the categories.

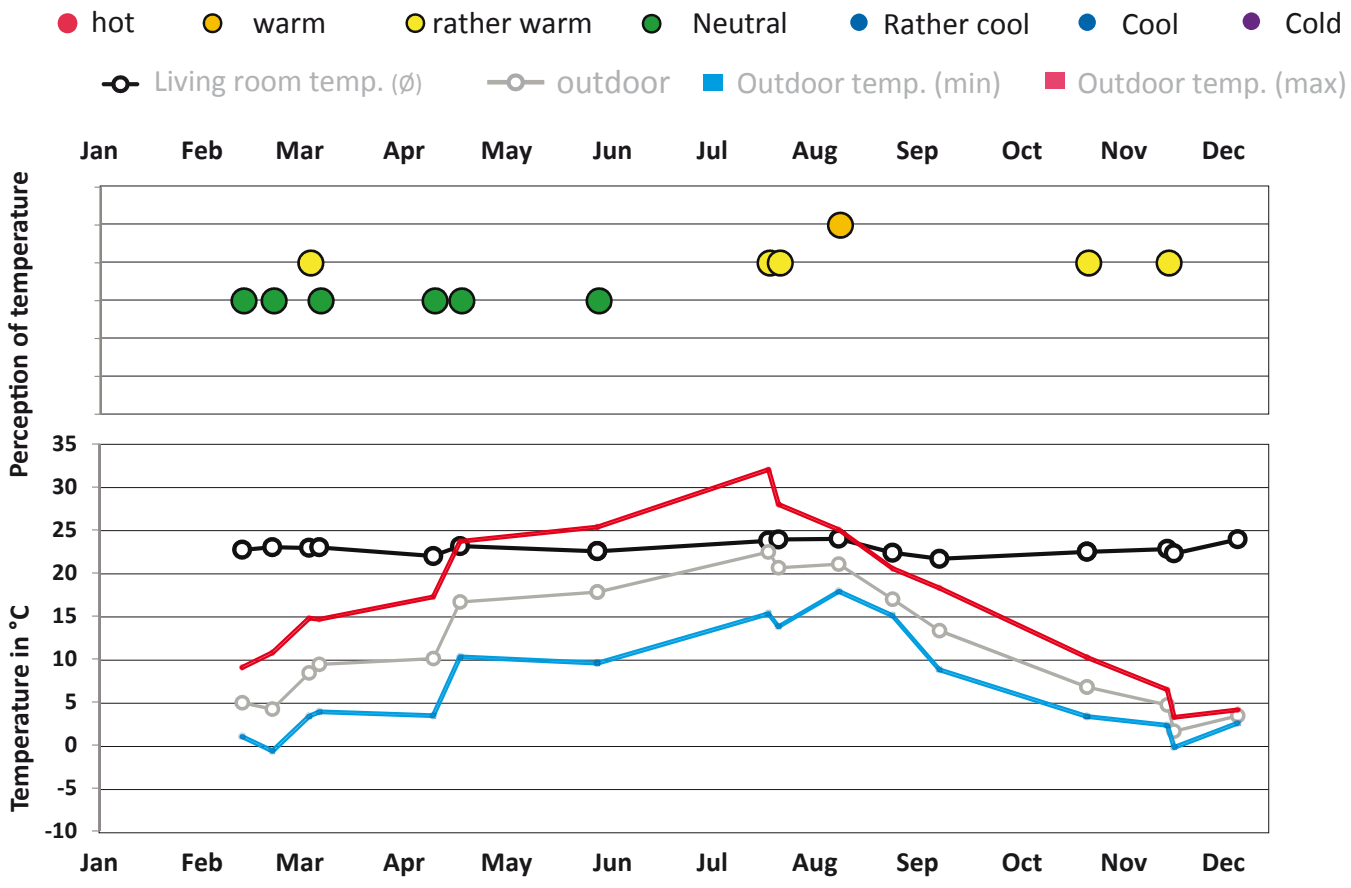

Figure 7. Temperature perception overview.

Figure 8. Irina Oldendorf making observations in the top attic.

The LichtAktiv Haus

is Germany's contribution to the Europe-wide VELUX Model Home 2020 project. The LichtAktiv Haus is a project of the IBA Hamburg international building exhibition and part of the Renewable Wilhelmsburg climate action concept. The family is blogging on lichtaktivhaus.de, giving their experiences and everyday findings their own words.

The house was developed by:

Design planning: TU Darmstadt FG ee, Prof. Manfred Hegger, Design: Katharina Fey (TU Darmstadt), Architects: Ostermann Architekten, Energy concept: HL Technik, Prof. Klaus Daniels, Lighting design: Prof. Peter Andres PLDA, Structural: TSB-Ingenieure, Prof. Karsten Tichelmann, VKR Group partners: Sonnenkraft, VELFAC, WindowMaster

Cooperation partners: Eternit, Gira, Grohe, Keramag, Knauf, Knauf Insulation, Metten, Nolte Küchen, Somfy Find out more at www.velux.de/lichtaktivhaus

satisfied with living in the house (affective dimension). The primary motivation for the positive effects is the abundance of daylight. The automation of the indoor environment is not unconditionally a positive experience, e.g. the systems opening windows at night has proved to be disturbing. However the technical setup does result in increased living comfort, as it optimizes the indoor climate and automates certain processes for the family [3]. ■

References

[1] Wilken et al (2012); Positive interim report for residential experiment in the LichtAktiv Haus.

[2] Asmussen, Foldbjerg, Rasmussen (2013); Thermal Comfort in two European Active Houses, analysis of the effect of Solar Shading and Ventilative Cooling , Clima 2013 Conference, Prague June 2013.

[3] Fedkenheuer, Scheller, Wegener (2013): Residential well-being as a multi-dimensional construct. Interim report on the psycho-social monitoring of the VELUX LichtAktiv Haus during 2012, Berlin.