Measurement in Sustainable Building

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Measurement in Sustainable Building

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Abstract: **Measurement is a necessary aspect of planning and constructing buildings. However, recent attempts to integrate the social dimension of sustainable building into building design and specifications demand measurement of non-technical qualities, such as well-being. The Active House Alliance, in lieu of facing the disparity between the measurement of quantities and the experience of quality, seeks to bridge the gap with thorough evaluation programs and engagement with market and sociological research. Whereas well-being is not technically measureable, these evaluations lead to improvement of the metrics and continued provision of sustainable buildings to market demand.**

I. INTRODUCTION

Measurement is key to the adoption of sustainability in corporate practice, spanning from identifying issues to reporting progress. It is important for legitimacy, communicating with other practitioners, and for identifying the direction in which to aim development. In the building industry, it is imperative that sustainability factors can be measured so that they can be integrated into building design, engineering, construction, evaluation; and ultimately so that they might be incorporated into legislation. Historically, the measurement of energy in buildings has been the main focus; which in and of itself has been redefined and refined since the 1960's. Yet the anticipated energy performance of buildings consistently underestimates how much energy is actually used in practice, known as the *performance gap*. This is usually attributed to the behavior of people using the buildings [1]. Further, as the understandings of holism around sustainability in building expand, factors that affect behaviour come under scrutiny as to their measurability. In moving beyond the measurement of electricity usage -- which can be directly recorded through metering, builders are confronted with qualitatively embedded, inherently social phenomenon that are difficult to not only record, but to even define.

II. ACTIVE HOUSE

The Active House Alliance, a multi-stakeholder sustainable building alliance, represents an interesting case of sustainability measurement, as they seeks to incorporate human well-being into building specifications. The ideology is that a high level of well-being, underpinned by comfort and health, drives sustainable behaviour in buildings. One of the alliance's founding members, VELUX, a roof-top windows manufacturer headquartered in Denmark, has spearheaded a number of demonstration building projects around Europe and North America (21 buildings in 12 countries) in order to both demonstrate that wellness can be specified for measurement and to improve these measurements. These demonstrations are primarily a tool for influencing policy (Interview 8 September 2014), but can also be described as a way of bridging theoretically-based simulations and real measurements. Peter Holzer, a Vienna-based building researcher quips, "Simulation: It's this thing nobody trusts, with the exception of the simulating engineer. Measurements: It's the thing everybody trusts, with the exception of the measuring engineer" [2].

The alliance has developed a set of building specifications detailing the Active House standard's demanded measurement ranges. These include: daylight factor (DF), direct sunlight availability, maximum and minimum operative temperatures, standard fresh air supply (by CO2 concentration), annual energy demand, percentage of energy supply from near or far sources, annual primary energy performance, life cycle factors (such as acidification and ozone depletion potential), improvement of freshwater consumption, recyclable content of the building, and percentage of responsibly sourced wood (Table 1). As comprehensive a set of specifications as this is, it begs two confounding questions: Are these measurements sufficient to describe the construction of a sustainable building? And even if so, is this a model of specification that is marketable on a large scale?

III. MEASURING ACTIVE HOUSE DEMONSTRATIONS

In order to address the first question, it has been necessary to evaluate the demonstrations for how well their performance matches the specifications to which they were built. To do this, VELUX studied five Active Houses that were also part of their earlier Model Home 2020 program, a major inspiration for the Active House Alliance. Five families in these Active House demonstrations partook in post-occupancy monitoring and lived "in the house for a full year to help measure, monitor and assess what they think about each" [3]. The result of the social side of the evaluation was that "the families show high satisfaction with the indoor environment, that their expectations often are fulfilled, that house automation is acceptable, and being able to follow energy consumption and production increase awareness of their behavioural influence" [3]. On the other hand, this does not reflect the technical performance of the building during habitation -- and for this, the evaluation is supplemented with technical measurements. These are compiled into radars, which compare the expected building performance and the actual outcome (Figure 1).

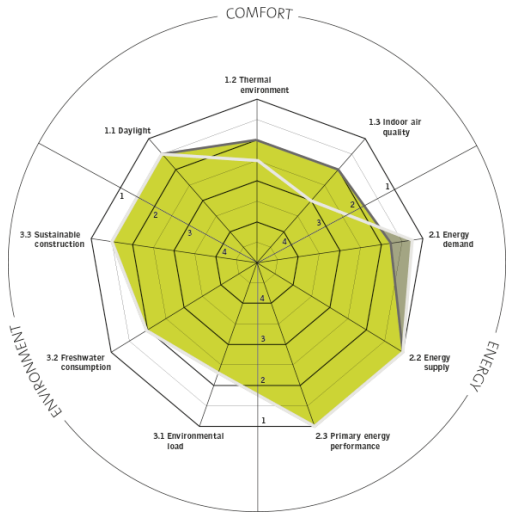

FIGURE 1: ACTIVE HOUSE RADAR FOR SUNLIGHT HOUSE CALCULATED ACCORDING TO THE ACTIVE HOUSE SPECIFICATIONS. DISPLAYED WITH PERMISSION FROM THE ACTIVE HOUSE ALLIANCE.

Considering these evaluations, it is clear that something is missing from the measurements. Some of the factors linked with wellness in buildings include: temperature, air quality, light, size and layout of space, sound, and view. For example, the evaluation of the LichtAktiv Haus demonstration in Hamburg, Germany showed that the family's satisfaction was primarily related to daylight, fresh air, and space [2]. Other interviewees indicated the significance of indoor details such as interior design (Interview 28 May 2014) and historical quality (Interviews 8 September 2014 and 23 November 2014). Indeed, the specifications cover temperature, air quality, and light; but air quality is the only one of these typically regulated; and no standard accounts for the size or layout of space. Nor would it be considered possible or even desirable to specify furniture design or historical features (for an overview, see Table 1). This is not to say that they cannot be designed into a building, and in fact they are key components. Building professionals and integrated design make this possible. It is instead to argue that not all of these are practical to measure; and sustainable building thus faces the challenge of communicating and standardizing features that represent a sustainable building.

Active House's efforts to set these standards do not occur in a vacuum, which touches on the second question regarding marketability and scale. Rather, the European Commission, the International Standards Organization (ISO), the European Committee for Standardization (CEN) seek to develop and refine sustainable building standards for Europe -- while both raising the bottom line and establishing fluidity with building markets around the world. However, it is arguably the voluntary standards that have the freedom to advance the holism underlying sustainable building, as these do not run into trade restrictions (consider for example, the trade implications of mandating that only sustainability certified wood products can be used). Other sustainable building standards range vastly in their approaches. For example, Leadership in Energy & Environmental Design (LEED) from North America offers an expansive point-based system for certification -- so that focus can fall anywhere from building materials to neighborhood embeddedness; whereas Passivhaus from Germany, focuses on building energy demand. Active House seeks to balance energy, environment, and comfort within a simple message. And as it is not privatized, nor a certification, Active House can be used as a guide without conflicting with other certification systems.

TABLE 1: BUILDING DESIGN FACTORS AND THEIR RELATION TO THE ACTIVE HOUSE SPECIFICATIONS, EU REGULATIONS, AND WELLNESS.

Factor	Specified	Regulated (EU)	Wellness-linked
Daylight factor	Y	N	Y
Direct sunlight availability	Y	N	Y
Min temperature	Y	N	Y
Max temperature	Y	N	Y
CO2 concentration	Y	N	Y
Annual energy demand	Y	Y	N
Energy source	Y	N	N
Annual primary energy	Y	Y	N
Life cycle analysis	Y	N	N
Freshwater consumption	Y	N	N
Recyclable content	Y	N	N
Wood sourcing	Y	N	N
Space	N	N	Y
Sound	N	Y/N	Y
View	N	N	Y
Interior design	N	N	Y
Historical quality	N	N	N

However, to scale sustainable building, these standards must adapt the products towards what the market demands, towards what society is willing to pay for. Two contexts in particular drive Active House to engage sociological researchers to better understand upon which priorities sustainable building demand is based. Firstly, behaviour in the home has hardly been studied -- ostensibly because the home has historically been a place of sanctity. As culture shifts, and homes (and indeed our entire lives) open up through social media and blurred boundaries between workspace and private space, people are more accepting of sharing their home experiences. Secondly, sustainable building taps into *latent demand* -- demand which has gone unsatisfied due to unavailability -- but also unconscious demand. In other words, people have not necessarily brought to consciousness what is most important to them in a building and why, nor are they be aware of the impact their building design choices will have upon their lives. As such, Active House has engaged a number of researcher teams, and has found a particularly research partner through Wegener et al.'s 2014 socio-psychological work. Early indications are that (1) well-being is the most important factor for people in buildings, even over energy savings (Meeting 11 April 2014); and (2) that factors contributing to well-being in buildings can be measured [4].

IV. CONCLUSION

Altogether, there is a gap between measured factors and the holism needed for sustainable buildings. This gap is gleaned over if the suggested outcome is demonstrable, and the product is in demand. By engaging market and sociological research, and by orienting their specifications towards sustainable buildings that emphasize a high well-being potential, Active House can simultaneously improve upon the metrics for sustainable

building and appeal to a market that forgives imperfect measurability so long as the product is in high demand.

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