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Working with models: Social and material relations entangled with energy efficiency modelling in Sweden

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ABSTRACT

Modelling the energy use of buildings during the planning process is a well-established practice within the construction industry today. This article studies how these models are handled in practice and the issues that arise around them. This is a case study that follows the planning process of a block of rental buildings in Sweden. With an Actor Network approach this article shows how the complexity of the energy model affects the relationships between the energy consultant and the professionals from the construction company. Since the construction company professionals do not understand the calculations behind the model, they have to trust the energy consultant's expertise. Furthermore, the energy modelling practices create tensions when proposed architectural designs are at odds with the energy efficiency goals. Lastly, the article shows how the uncertainties connected to the model's calculations provide an arena where personal feelings are allowed to be part of the process. From the perspective of the involved professionals, energy modelling is shown to entangle social and material relations in ways that have not previously been studied in relation to energy efficiency in the process of planning new buildings.

1. Introduction

> Erik: If we make mistakes with the airtightness, we won't be helped by pretty calculations. This [the calculation of energy] is fragile; we are balancing… we are stressing the theories a bit.
>
> Valter: Yes… We are building on hopes!
>
> Erik: Yes, this is what we believe; now we have to wait and see how it turns out in reality.

Predicting energy use is an important practice in planning a building. However, it is not an easy practice to work with. There are great uncertainties involved in predicting the future energy use of buildings; air might flow differently than expected, there might be small mistakes in the construction process which can greatly influence airtightness, or there might be more thermal bridges than calculated. We need a better understanding the limitations of the model itself to make more robust predictions [1] and more research is asked for when it comes to modelling the tenants' behavior [2]. This article presents how professionals from a construction company, energy experts and other consultants handled these issues in the process of planning a block of rental buildings in Sweden. Earlier research has studied either the energy model (cf. [3–5]) or the design side of the planning process (cf. [6,7]) but no studies have focused on how the energy model is used in practice by the building professionals involved in the planning process from an ethnographic lens. In addition, this study utilizes ideas from Actor Network Theory which have been sparsely used in energy research. Thereby, this paper will contribute with new perspectives, both theoretical and empirical, on energy research and energy modelling.

The residential sector uses 24.8% of Europe's total energy consumption [8], and it is an important factor in making the transition towards a more energy efficient society. The European Union has issued a directive requiring its members to intensify their work on this issue. In response to EU directive 2010/31 on the energy performance of buildings, Sweden has pledged that all new buildings will be (or come close to being) zero energy buildings by 2020 [9]. Sweden has already regulated the amount of energy newly constructed buildings are allowed to use; current regulations state that apartment buildings can use 80 kWh/m^2 per year (excluding energy used for appliances). The plan is to launch a new policy for near zero energy buildings in Sweden, lowering the requirements for apartment buildings not heated by electricity to 50 kWh/m^2 per year [10]. To reach these targets, construction companies in Sweden work with energy models to predict how much energy their buildings will use. Energy simulations of whole buildings are now an integrated part of most leading building environmental rating schemes [11] and it is therefore of a wider interest to study how these affect the planning process. Different types of

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software are used for this purpose, and there is a well-established market for energy consultants in Sweden and internationally.

Energy simulation and calculations have been well studied in academia (e.g. [12–14,4]). Research has shown that there often is a large gap between the simulated energy use and the measured energy use [3,15,16]. Energy modelling has been studied in different ways in social sciences; for example, Jefferson [17] studies the use of climate modelling in the World of Internal Contradictions scenario and studies have followed architects in their work with energy modelling [18,19]. However, studies focusing on how energy modelling is handled in practice on construction sites by the building professionals involved in the planning process is lacking. This study will contribute new knowledge about modelling energy use in buildings using a qualitative approach. The article is based on a case study which includes observations, interviews and analysis of the energy modelling software.

The analytical approach in this article comes from science and technology studies (STS). Many studies in this multifaceted research field focus on the dynamics in technology and human interaction. In this paper, Actor Network Theory (ANT) is used to bring attention to both the human and the material actors and to tell the stories behind the hard work of what in hindsight can be made to look like a straightforward process. Telling ethnographic stories is a way of carefully slowing down [20] and through following the energy modelling in a construction process, this article shows how the model sometimes black boxes some issues while in other instances brings about new complexities. ANT will provide a way to show how relationships, between humans as well as devices, affect the planning process.

2. Introducing the case – Vallastaden

This article is based on a case study of the construction of a block of multi-family dwellings in Vallastaden in the city of Linköping, Sweden. Vallastaden is a special case in that it is a part of a housing and society exhibition. The aim is to build a sustainable city district in which social and ecological sustainability are integrated into the infrastructure. For example, the residents of Vallastaden are obligated to take part in a car pool, and there are specific demands on the landowners. Before land lots were sold, interested parties were encouraged to submit applications showing what they wanted to build on them and how they would fulfil the municipality's requirements. One municipally-owned housing company applied and was granted space to build three projects. This article focuses on one of those projects, which consists of seven buildings surrounding a small square. Some of the buildings are to be student apartments, one will have shops at street level with apartments above them, and the rest of the buildings are normal rental apartments. The buildings all have a different design, as required by the municipality. The city district is marketed with an emphasis on diversity and variety [21].

In keeping with the focus on ecological and social sustainability, the municipality has also stated that the buildings in Vallastaden must be 25% more energy efficient than Swedish building rules (BBR) require. However, the municipally owned housing company this study follows require that all their new buildings use 30% less energy than required by the BBR regulations. Since the energy demands vary depending on the types of facilities and apartments, the requirements vary from one building to another. The energy demands are to be followed up on two years after construction is complete. Legally, it is the responsibility of the overall entrepreneur (in this case the construction company) to fulfil the contract that sets out the energy requirements. This means that it is vital for the construction company that the energy model is made as accurate as possible since mistakes in this calculation can cause heavy fines.

3. Method

This study combines observations, interviews and study of the energy modelling software. The researcher participated in all planning meetings for one and a half year, but most of the gathered material comes from specially appointed energy meetings, where discussions focused on the energy models. The study includes 25 building planning meetings and four energy meetings. The meetings were typically two hours long, and the planning meetings had about 12 participants, mostly contractors and personnel from the construction company. The meeting agenda for the planning meetings was standardized and even though energy was on the agenda for all meetings, the subject was only discussed at about half of the meetings. Deeper discussions on energy took place in the specific energy meetings. The energy meetings had fewer participants and included professionals from the construction company, an energy consultant, architects, ventilation consultants and a representative from the housing company. During meetings, the researcher took notes and soon learned to use the same expressions as each of the meeting participants. Although some of the words may have slightly changed due to the need to write quickly when taking notes, the researcher has used the words and expressions the respondents would normally use.

The study includes interviews with the participants of the energy meetings. Interviews are a good complement to observations since they add comments, imagination and clues as to what is not being directly manifested in actions [22]. The interviews lasted between one and one and a half hours, were recorded and later transcribed verbatim. The interview guide was semi-standardized and was adapted for each of the interviews. The interview questions focused on respondents' views on energy issues as part of the planning process, the role energy played in their work and how they perceived their own responsibility for energy issues. Two of the interviews were done with two persons together to allow for discussion between the participants and also to accommodate the respondents' time limitations. To preserve privacy, pseudonyms are used in referring to the meeting participants. An overview of the collected empirical material is given in Table 1.

All observation notes and interview transcripts were imported into the Nvivo coding program. In this program all material was coded according to initial coding principles [23] and in a second process, concepts that caused friction or uncertainties were coded in new themes. Furthermore, part of the study also included documents describing or containing the calculations used in the energy models as a complement to observations and interviews. Studying the energy modelling software gave insights into the workings of the energy calculations which was necessary to understand and support the findings from the interviews and observations.

4. Theory

In order to analyse the processes used by the professionals involved in predicting the energy use of the planned buildings, the study used ideas and concepts inspired by actor network theory (ANT). ANT is an approach used to study science and the orderings of the world in which the network and its relations to the study object are in focus. It is this

Table 1
Empirical material.

Observations (year 2015–2016)
25 planning meetings 4 energy meetings.
Interviews (year 2016)
Energy consultant (Erik, engineer) Project coordinator and project manager (Pernilla, engineer, and Peter, engineer) Architects (Allison and Art, architects) Housing company representative (Hasse, engineer) Ventilation consultant (Valter, engineer)