A CASE STUDY ON ACTORS, TECHNOLOGY AND THEIR COMMUNICATION FOR BETTER DISTRIBUTION OF ENERGY USE

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Summary

In a World where availability to energy resources is scarce and the threat of climate change forms a backdrop for human activities, managing energy use in buildings is an important step towards a society consuming less energy resources. This paper advocates a shift from static energy indicators for buildings such as kWh/m^2 to energy indicators related to the actual function of the building, and further the introduction of a zone concept for better utilization of energy use. However, neither new energy indicators nor introduction of the zone concept will have any effect without the alignment of human actors, technologies and measurement techniques. Through a case study of energy management at a university college, the paper shows the misperceptions and difficulties involved in obtaining the proper alignment.

Keywords: energy management, user flexibility, energy parameters, zone concept

1 Introduction

The Manage Smart in Smart Grid [1] project has looked into the potential offered by Smart Grid technologies. For the case study, user flexibility has been a special focus as it can be utilized to achieve more optimal energy use and power peak reductions. Flexibility is represented in the case study through users allowing different degrees of deviation from the indoor climate “sweet spot” and the changing of facilities or scheduled classes on short notice. An example is concentrating lecturing activities to one zone, making it possible to shut down other zones and lowering the energy use there. To achieve this, understanding the users and how to make the best use of their latent flexibility is needed, as well as finding out to what degree the facility’s areas are utilized today. Second, one must understand how the existing Energy Management Systems (EMS) and building characteristics support the correct application of the flexibility. And third, the way in which actors with different responsibilities, or representing different flexibility potential, should communicate and cooperate must be found. However, the latter topic is not addressed in this paper.

1.1 The energy effectiveness back-drop

Energy efficiency is typically expressed in terms of technical parameters such as kWh per square meter per year. This classic parameter used to assess and benchmark the energy characteristics of a building can be insufficient for energy management due to the exclusion of much important aspects like the function of the building in relation to the users' needs and productivity. One can obtain paradoxical results since e.g. a large building with few people will get a good score on an energy efficiency indicator. For the case study of a university college, examples of relevant energy indicators can be the number of graduating students per energy used each year, the comfort level of the users and their production levels (grades, papers etc.), or the level of facility occupancy with regards to the total energy use. In essence, sustainable buildings require an approach and indicators for measurements beyond the traditional energy efficiency focus and more tuned to users' needs, flexibility to adapt to changing needs and low material consumption, energy use and emissions. This latter approach, seeing energy use in light of the purpose and function of the building and its users is coined *energy effectiveness* [2].

1.2 The zone concept

A zone concept has been developed in the research project [3], from a prosumer (both consumer and producer of energy) in a Smart grid setting, partly inspired by the an approach to resource efficiency of data centres, as presented in [4] and [5],and partly by the energy effectiveness approach described in section 1.1. The zone concept is two-fold: On one hand the idea is to optimise the use of different areas at any given time, as exemplified above: Shutting down parts of the facilities given that energy use can be lowered or completely shut off in one zone while giving a good working environment in the zone that is actually used. The other idea is to define the main functions and its related energy use of each zone and, if possible: support functions whose energy supply can be lowered at peak power situations, without jeopardising the primary function or service. Basically all energy usage in the case study university college we found to be supporting its main functions: Be the provision of an optimal study environment in an area, through the means of heating, ventilation and lighting. In the case study it then became interesting to see if the service level of the primary functions could be temporarily lowered e.g. in moments of peak power hours. The primary and secondary function approach is fully described with its mathematical framework in [3]. When describing a building with zone main and support functions, inter-zone dependencies and interactions can be mapped. Based on this information, more qualified choices for the application of energy with regards to the main functions of a building can be made.

Applying the zone-concept and more refined energy effectiveness parameters together with combining information on building physics, long term planning and real-time control make it possible to react quicker to user needs for facilities or energy characteristics such as price, better management of the facility areas and buy energy smarter.

2 The university college case study

The case study comprises a 25,000m2 university college campus supporting 2,500 students and 200 employees. The campus has traditional rooms (group and classrooms etc.) and more specialist facilities (swimming pool, sporting arena). The campus facilities (one huge building) are rented by the Østfold university college from Statsbygg, which operates the facilities. Statsbygg is the Norwegian government's key advisor in construction and property affairs and owns and manages another 2,300 buildings in Norway, many of which are similar in design and users. The college administrates their employees and students, and performs all planning for the use of the facilities.

An early finding was a lack of communication between the tenant and the EMS operator regarding actual energy management. With the tenant both paying the energy costs and showing few commitments to reducing costs, Statsbygg centrally and the operator showed few initiatives to reduce costs as well. The case study looked into a broad spectre of issues concerning the relationship between actors, the physics and operation of the facilities and the installed equipment and control systems. Two (of many) examples are presented here.

A central problem was the room assignment. Planning for the whole semester by assigning a course to a room the same time every week, coping with ad hoc requests for facilities became difficult. The college stated that the available facilities were depleted. Investigation proved this was not the case. With few means and no plans to have a more dynamic approach for scheduling rooms, the impression that no rooms were available was understandable. (**Fig. 1**) shows the discrepancies between planned and actual room usage over a two week period. One of the rooms in Zone 8 (of 13) at campus is a large auditorium in concrete, hence possessing thermal mass potential. During the course of one weekend the heating and ventilation systems were shut down for the zone. However, indoor climate parameters, captured through sensors installed during the project, showed almost no change for the auditorium (**Fig. 2**). A temperature drop of 0.2 degrees during a 15 hour period indicates that the room/zone had accumulated a large amount of thermal energy that went to waste. This indicates a potential of turning off heat supply periodically at peak situations without compromising the temperature in the auditorium, as well as turning off the heat earlier in the day than what is presently done.

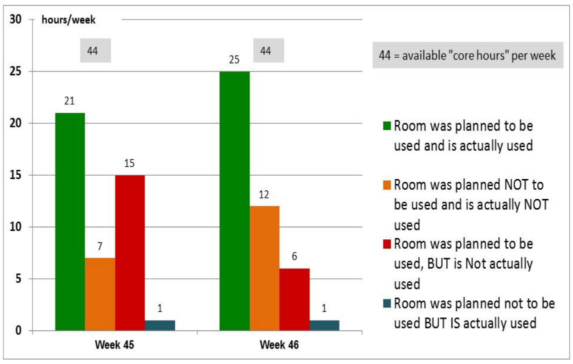

Fig. 1 Room availability

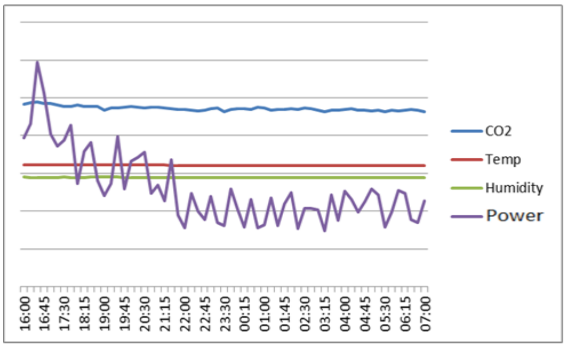

Fig. 2 Thermal mass effects

Exploiting user flexibility requires communication and behavioural changes. Different users are willing to commit to different types of changes, are content with different types of rewards and can be reached through different types of communication. Interviews with students uncovered that knowledge alone regarding saved energy motivated change. Both short time notifications to scheduling or facility changes, as well as deviations in indoor climate, were found acceptable if communicated properly. The communication between the parties, although good, lacked a focus on approaches to further optimize energy use. The EMS operator possesses great knowledge and understanding on how the building functions, yet the tenant dictates its use. Moreover, the largest user group (the students), willingly representing flexibility through behavioural change, was not involved or utilized in the daily operation of the facility.

3 Conclusions

Making use of the zone concept and dynamically utilizing user flexibility as a means to achieve more optimal energy use is possible. It requires more refined understanding of the building and how it is used, of the users and their willingness to change their behaviour, of the contribution of existing systems, and of the communication of needs and results. Even small improvements can result in significant results. To enable fully optimal planning and better use of the facilities and users, introducing the zone concept supporting user flexibility must be done pre-construction. The actors involved in the daily use and operation of the building should be included in the early stages of development, encouraging communication, cooperation and a joint understanding of dynamic energy control.

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