

World Sustainable Built Environment Conference 2017 Hong Kong

Transforming Our Built Environment through Innovation and Integration:

Putting Ideas into Action

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Cooperative Research for High Performance Buildings

ABSTRACT

This paper represents two research projects with the aim to define what “High Performance buildings” should be and the steps to reach the highest goal, the user satisfaction and contentment with the building.

The quality optimization of buildings demands the consideration of the principles of life cycle assessment (LCA and LCC) and occupant satisfaction, particularly with the aim to create sustainable buildings and high comfort standards. However, these high expectations require expertise to an extent which cannot be covered by an institution or research unit by its own. This paper features the basic principles, the results and findings of two completed government funded research projects. These achievements emerged from a cooperation of several Austrian Universities of Applied Sciences.

The focus of the first research project LQG (life cycle improvement of the building quality) is on developing, analyzing and evaluating methods to assess planning decisions with their consequences on the life time of a building while normally, investment costs often serve as the only basis for decision making. Two main outputs of the project are firstly the creation of a comprehensive guideline on sustainable buildings (=Database of Quality) and secondly a common database of both economical and ecological building life cycle data.

The goal of the second research project MOFNUG (Modular questionnaire for the user satisfaction in buildings) is to determine the whole spectrum of user compliance in buildings by implementing different work packages, ranging from scientific research over purchasing of measurement tools to the improvement and optimization of the questionnaire, which is one of the main topics of the research group at the FH Wels.

The online accessibility of the project’s results and tools is important in terms of the usability in research and teaching.

Keywords: cooperative research; Life cycle quality; user satisfaction

1. INTRODUCTION

The Topic “quality optimization of buildings” includes a steadily growing number of relevant aspects. Technological advances in product development and building simulation as well as changing relations of influencing life cycle factors often bring institutions and research projects to their limits so that cooperation is needed to cope with the complexity of these issues.

This paper is intended for introducing results and findings of two finished FFG (Austrian Research Promotion Agency) research projects, firstly the project LQG (life cycle improvement of the building quality) and secondly the project MOFNUG (modular questionnaire for user satisfaction in buildings). In the spirit of integration of knowledge and transforming cooperation into action, an association of several Universities of Applied Sciences has explored the complex questions of the topic just mentioned and achieved following results.

2. LQG - LIFE CYCLE ORIENTED QUALITY OPTIMIZATION OF BUILDINGS

Within the FFG research project which has been finished in 2013, five Austrian universities of applied sciences compiled, among other issues, a “qualitative database” which is used as a collection of “tools” for building quality assurance, helping to reach a degree of quality optimization that was hardly achievable before. In addition, a “quantitative database” was created as a practical deliverable, leading to an “energy certificate plus” which is an energy certificate added with life cycle aspects [10] [11].

The life cycle cost development of sustainably optimized buildings, compared to standard buildings and the effect of decisions during the early planning phases on the cost development gradient is shown in figure 1.

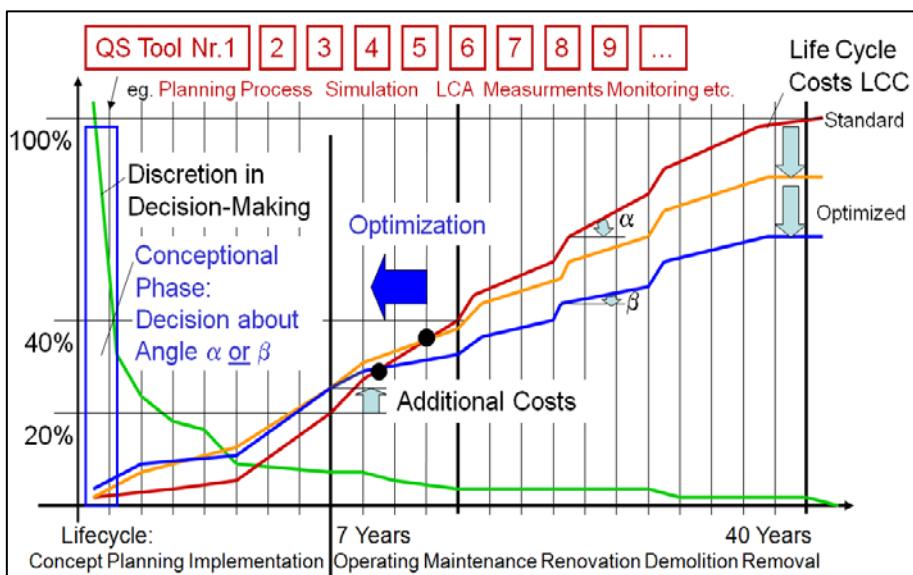


Figure 1: Diagram of LCC and the impact of decisions [3]

2.1. Web based LQG database

This database follows the initial idea that a holistic improvement of the quality of buildings over the entire lifecycle can be achieved by adding a lot of quality assurance methods with one important aim in mind: the satisfaction and comfort of the user of a building. Building certification systems offer a possibility for a high level of quality performance. For this aspect some national and international certification systems – such as klimaaktiv, TQB, DGNB, BREEAM, LEED – have been considered and compared [11].

The qualitative database has been filled extensively and grouped into five life cycle stages: concept, planning, execution, use and deconstruction whereby these stages were further subdivided. Within the third level, filtration by information out of certain areas, for example project management, ecology, energy, etc. is possible. The fourth level is used to describe different complexes of themes, followed by the fifth level, where the results of the research project can be shown, for example quality assurance tools. Supplementary information like literature, hyperlinks and project-external documents, is provided within the sixth level. The optical appearance and the structure of the LQG-database are illustrated in figure 2.

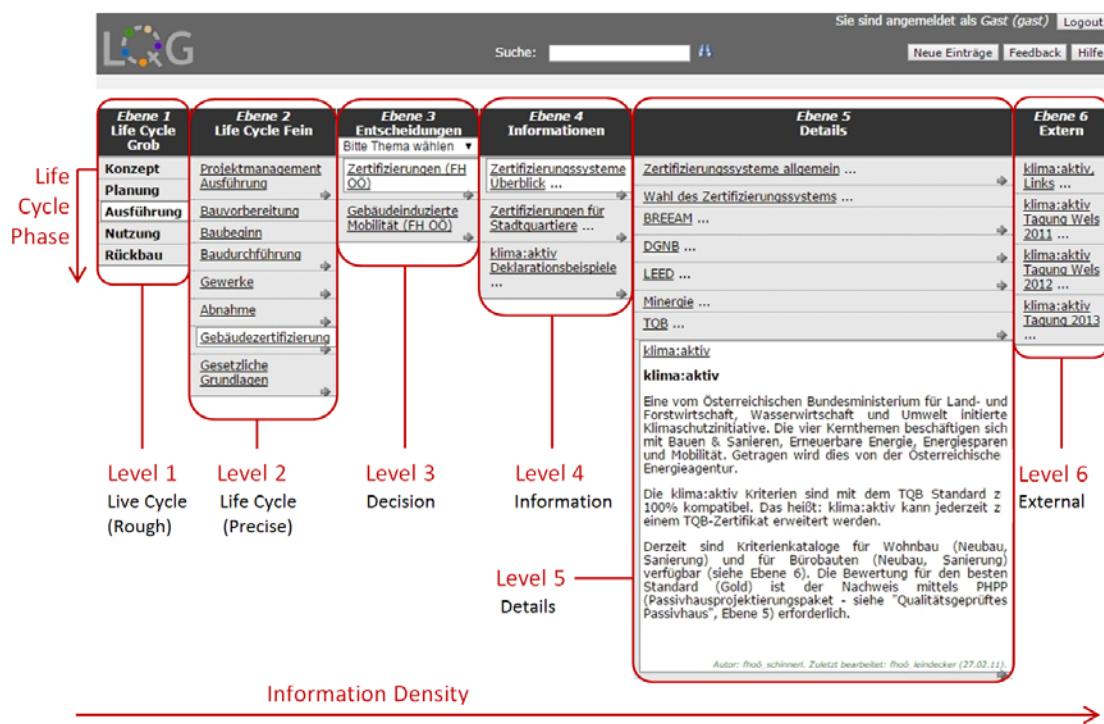


Figure 2: Appearance of the LQG database [6]

2.2. Results of LQG

When complex issues of quality assurance arise, the project partners, as well as the interested persons (limited) can be supported by the online database, which is used on the one hand for commissioned projects, on the other hand also for teaching and research [3].

3. MOFNUG- MODULAR QUESTIONNAIRE FOR USER SATISFACTION IN BUILDINGS

The idea for the second cooperative FFG-project was born by scientists who worked on the previously mentioned LQG-project. User satisfaction still is the highest and most difficult target during the planning and operation of a sustainably optimized “High Performance Building” [2].

Because a very wide range of factors, hard to quantify, is covered by the topic “user satisfaction”, four universities of applied sciences where cooperating between 2013 and 2016 to shed light on this issue from different perspectives like marketing, psychology, energy technology and facility management. One main focus has been developing an online survey platform, which is used to “measure” relevant aspects of a building. This tool is able to respond to different circumstances (changing types of buildings or user structures in a flexible way as it is modularly structured [1][12][13].

The participation of the different universities has an impact on the variety of the modules and therefore on the increased platform flexibility. These modules range from aesthetic aspects and social interaction opportunities to building service engineering oriented topics. Improvements of already existing questionnaire parts (so called clusters) and generation of new modules have been done during the whole project (for example different questions for amateurs and experts and several building types).

3.1. MOFNUG online platform

To ensure easy usage of the platform for participants and prospective customers too, a clear and simple structure is necessary. Future customers can extend the questionnaire with minimum effort due to the modular design. Figure 3 shows the current visual appearance of the MOFNUG-project (just available in German). The different Clusters, as well as the number of included questions can be found by clicking “Fragen-Katalog” (questionnaire). If the page is scrolled down, each question of the currently open cluster can be seen.

The cluster “Thermischer Komfort” (thermal comfort) has been checked and optimized by practical measurements, simulations and interviews after comprehensive literature research [2].

This was followed by an extension of the literature research and an inclusion of additional modules by cooperation partners, for instance acoustic or visual comfort, cleanliness or the room layout. For a high degree of visual comfort, an even illumination without considerable disturbance is required as well as individual adaption to the individual user’s needs. A visual connection to the outside world allows the user to inform about daytime, location and weather subconsciously and therefore should not be underestimated in importance. These criteria give a direction for the development of promising questions.

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The screenshot shows the Mofnug online platform interface. On the left, a navigation sidebar includes links for Dashboard, Projekte, Template-Umfragen, Fragen-Katalog, Fragen-Cluster, Kalender, Ausführbare Umfragen, Benutzer, Umfrage erstellen, and Meine Kontakte. A red box labeled 'navigation' points to this sidebar.

The main area is divided into two sections: 'Frage-Katalog:' and 'Frage hinzufügen'. The 'Frage-Katalog:' section contains a grid of 'clusters' with numbered labels (e.g., 68, 124, 32, 189, 175, 47, 23, 69) and descriptions. A red box labeled 'clusters' points to this section. Below it is the 'Frage hinzufügen' section, which includes fields for 'questions', 'question type', 'target group', and 'building type'. A red box labeled 'actions' points to the 'Aktionen:' dropdown in the building type section. The 'questions' field lists three survey items: 'Wie zugig empfinden Sie die Raumluft?', 'Wie zugig empfinden Sie die Raumluft im Sommer?', and 'Wie zugig empfinden Sie die Raumluft im Winter?'. The 'question type' field shows '7-Point-Custom-Label-Likert-Scale' for all three items. The 'target group' field shows 'Laie & Experten' for the first item, 'Laie' for the second, and 'Alle' for the third. The 'building type' field shows 'Alle' for all three items. A red box labeled 'questions' points to the first survey item.

Figure 3: Screenshot of the questions currently available within each cluster of the Mofnug online [8]

3.2. Results of the MOFNUG project

A main goal of the project was to generate an online platform where the modular questionnaire can be used to create surveys, perfectly tailored to the current needs. Each step, from developing an inquiry to its analysis can be done online without leaving the platform.

At the moment, the first surveys have been performed to check and improve the online tool. These surveys were performed within two master theses. The first one is about building automation and user satisfaction [7]. Respondents receive an E-Mail, including a hyperlink which is valid only one time. As soon as the link is clicked, the survey opens and the first cluster is ready to be answered. In figure 4, a typical survey, added by descriptions and translations, is displayed.

After sending invitations, the survey builder can check how many people already have finished the poll. Moreover, an evaluation of the current results is possible immediately.

It is also possible to generate word clouds with the online tool. If the questionnaire includes questions, answered onto free text areas, the system automatically creates a picture, where often mentioned terms are bigger than less frequent called words- commonly used conjunctions and other words on a “black list” will not be displayed to ensure a maximum degree of relevant data. A question of the first master thesis is what does produce noise at their workplace. The “biggest” answers, shown in figure 5, are: heating system, conversations, and employees/persons [7].

World Sustainable Built Environment Conference 2017 Hong Kong

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Currently open cluster Progress bar

Personendaten Steuerbarkeit von Technik Licht Luftqualität (inkl. Geruch) Thermischer Komfort Bewertung Umfrage

Welchem Typ entspricht Ihre Kleidung gerade am ehesten?

[Dropdown selection] short trousers, shirt

Wie würden Sie ihre körperliche Aktivität beschreiben? ⓘ

[Dropdown] rest on sth.

Wie empfinden Sie die Temperatur?

[7pt. Likert Scale] too cold-too warm

Alles in allem, wie zufrieden sind Sie mit dem Raumklima?

[7pt. Likert Scale] not satisfied-very satisfied

Gibt es Veränderungsbedarf in Bezug auf thermischen Komfort? ⓘ

[Free text area]

Figure 4: Typical survey on the MOFNUG platform [8]



Figure 5: MOFNUG word cloud about what could be done to lower the noise level [7]

A relevant indicator for air quality is the number of persons with health problems at their workplace, what is shown in figure 6. In this case, multiple answers are possible.

World Sustainable Built Environment Conference 2017 Hong Kong

Transforming Our Built Environment through Innovation and Integration:

Putting Ideas into Action

5-7 June 2017

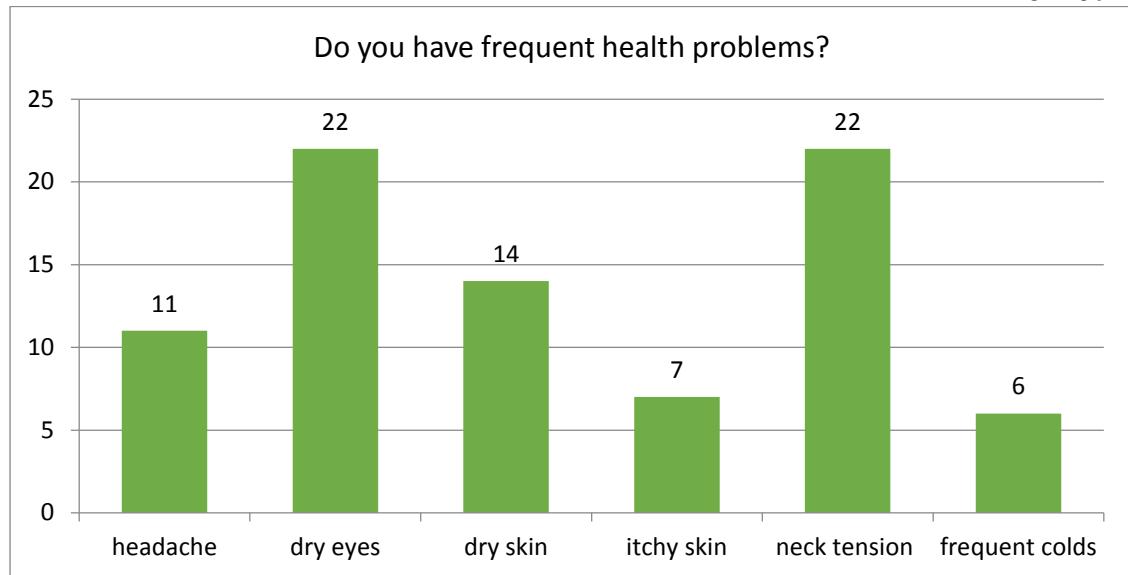


Figure 6: physical problems of care staff at work [7]

A usual question type on the platform is called “7-point custom Likert Scale” which allows the survey participant to answer the question relatively exact by ticking one of seven possible response options, for example reaching from 1-very bad to 7- very good or 1-too cold and 4- neutral to 7-too warm- shown in figure 7 (additionally structured into summer and winter).

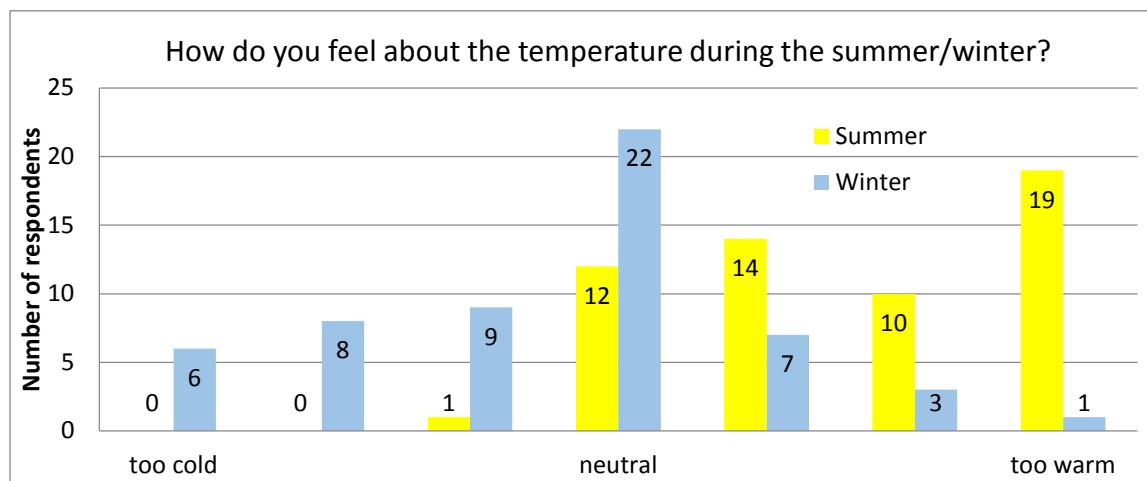


Figure 7: perceived temperature split up into summer and winter [7]

The second master thesis using the MOFNUNG-tool deals with user satisfaction in retirement homes for both inhabitants and staff [9].

Overall, the results of this study give a good overview about the preferences of the care center occupants and point out the differences of residents and geriatric nurses about thermal comfort. It is shown that with relatively simple measures the occupants' comfort and subsequently the care satisfaction could be improved significantly. The main discrepancies have been pointed out about the topic of thermal comfort. Whereas the residents feel relatively comfortable at an indoor temperature level of 23°C which is automatically adjusted by the heating system, this temperature is felt as too warm by the employees who have a higher metabolic rate

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due to their working activity. Additionally, the human thermal model established to regulate the indoor air climate in buildings by using Predicted Mean Vote (PMV) and Predicted Percentage of Dissatisfied (PPD) is not suitable for older people and especially for people suffering from dementia. 60 % of the study participants felt that the room air in the building is too dry and 48 % of employees working in the building are suffering from health impairments caused by dry air. The existing spray humidifier installed in the ventilation system of the building is out of service.

For creating a new survey it is necessary to have enough information about the building, its automation systems and occupants as well as if the survey will be received by laymen or experts. If representative results are required, it is also crucial to perform measurements, such as temperature profile, VOC, humidity or CO₂ [5].

4. CONCLUSION

The cooperation of several Austrian Universities of Applied Sciences helped to partly overcome competitive thinking and led to a significant added value at least for the participants, which is higher than just the sum of the findings.

Both LQG database and the MOFNUG platform are available from now on as supportive instruments to push forward the optimization of buildings in a broad range of fields such as life cycle costs, sustainability and user satisfaction. The online presence ensures a successful application in commissioned projects as well as in teaching and research.

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