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Preface

This book compiles the papers presented at the 4th International Conference on Energy & Environment: bringing together Engineering and Economics (ICEE2019) that took place in Guimarães, Portugal in May 16-17, 2019

The conference was organized by the School of Engineering, University of Minho and the School of Economics and Management, University of Porto.

ICEE2019 brought together leading academic scientists, researchers and scholars from the energy and environment science community to interchange knowledge, to discuss and to disseminate new ideas towards a low-carbon, sustainable future.

Indeed, energy and environment transition issues require much more than pure technology knowledge. Instead, they involve processes of technological transfer where economics, social sciences, and even politics play decisive roles. Recognizing this quest for interdisciplinarity, papers covered the following issues: Energy Economics; Renewable Energies; Sustainable Mobility Solutions; Sustainability in Energy and Buildings; Environmental and Social Impact Assessment; Energy Modelling; Sustainable Development; Energy Storage; Environmental Management and Technological Change; Energy and Environmental Policy; Energy Markets and Efficiency; Climate Change; Biomass/Biofuels; Economic Growth and Sustainability; Energy Systems Analysis and Waste Management.

The Editors would like to thank all the authors and reviewers for their valuable contribution and for making ICEE2019 such a big success.

Paula Ferreira
Chair of the 4th ICEE

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ENVIRONMENTAL AND ENERGY QUALITY: SOBANE METHODOLOGY ADAPTED TO CANTEENS

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SOBANE; Indoor environment quality; Canteen

ABSTRACT

In the construction market, particularly in the maintenance and rehabilitation segment, users' input is not often considered before selecting any refurbishment procedures to improve indoor comfort. The objective of this work is to present a methodology to evaluate the indoor environmental and energy quality in canteen buildings, and suggest indoor rehabilitation measures in a more efficient way, through the perspective of the user. The risk management strategy SOBANE – Screening, Observation, Analysis and Expertise was used as a reference to develop the methodology for canteens. Each one of the four levels, and its tools, were adapted to suit the object of the study. The first two levels – Screening and Observation – were tested in the canteen of the Polytechnic Institute of Bragança – IPB. First level results revealed that the building needs to be refurbished. The second level results obtained from a questionnaire revealed that the respondents found the indoor confort in the canteen as: an indoor environment without air-flow (63%); with stuffy air (61%); a clean space (75%); high temperature (63%) and noisy (80%). Additionally, a comparison was made between the actual and estimated energy consumption profiles for the verification of parasitic load consumption. The results show that estimated and monitored energy consumption profiles have similar behaviours.

INTRODUCTION

The present work proposes a methodology to evaluate the quality of the indoor environment of canteen buildings through the perspective of the user. The main aim is to use the information obtained through technical tests to reduce the number of variables of analysis, and propose solutions for adapting the space to the comfort requested by its users in a timely and cost-effective manner.

The requirements provided in the environmental confort in buildings regulations do not always go with the space specificitiies and the sensitivity of each user (Fanger 1982). In addition, buildings constructed before the enactement of the regulations were not required to comply with comfort requirements, as is the case of this study.

The methodology presented here was developed from the application and adaptation of the risk management strategy SOBANE – Screnning, Observation, Analysis and Expertise – to museums, known as Environmental and Energy Performance (EEP). The first two steps were tested in the canteen building of the IPB, in Bragança

SOBANE – Screnning, Observation, Analysis and Expertise

The SOBANE methodology was developed due to the need to identify problems associated with work activities, to propose timely solutions – in a more independent way – and involving local workers. When adapted, it can be applied to any object of study (Malchaire and Piette 2006).

An adaptation of the SOBANE methodology to museums was made by Lucchi. It is named Environmental and Energy Performance (EEP) and is also divided into the same four levels as previously described. Each level has a specific objective (Lucchi 2016a):

• Screening: to identify the physical characteristics of the building and diagnose the energetic, environmental, structural and architectonic aspects of the structure.

• Observation: to define areas of risk and indicate the main factors that target this risk. It also analyses other potential risks that may exist, even when it is possible to implement cut –and- dry solutions.,

• Analysis: After diagnosing the building and defining clear risk zones, it is necessary to analyse other factors that are not so evident in these areas, such as: indoor climate problems, energy problems; potential damage to structure; among other causes. This is done by conducting more specific research over longer periods of evaluation.
• Expertise: In view of the results of the analysis and observation phases, it is possible to define specific guidelines to manage the evaluated risks, prioritising solutions related to prevention, human comfort and energy efficiency.
For the first two levels - Screening and Observation - tools were defined to analyse relevant parameters to ascertain the energy quality and indoor environment. The tools, as well as the parameters evaluated, were adapted to the reality of the canteen and will be presented in the Materials and Methods section.
For Observation, one of the tools used is the Post Occupational Evaluation (POE) methodology. This methodology is used to ascertain the quality of a building for the people who frequent it. It is especially applied to assess how the building is being managed and to evidence design improvements and envelope performance. The method consists of asking participants to comment on the building as they walk through it (Watson 2003).
There are three types of POE's: Indicative, Investigative and Diagnostic. In this work, an adapted version of the Investigative POE was conducted, focusing on the human comfort assessment and by using a questionnaire as Data Collection Instruments (DCI) (Cooper, Ahrentzen, and Hasselkus 1991; Preiser, Rabinowitz, and White 1998). The selection of the DCI (interviews, questionnaires, direct observation, tests, etc) was according to the recommendations of Cohen, Manion, and Morrison 2005. The population of the present study was defined by the number of meals served per day in the canteen and for that reason, a questionnaire was adopted as DCI.
The MM questionnaire was used as a reference. This is a standardized epidemiological research tool, defined to implement the analyzes foreseen in the Örebro Model. It was developed between 1986 and 1989 in Sweden by the Department of Occupational Medicine, Hospital Örebro Medical Center, to evaluate problems of "sick buildings" (K. Andersson et al. 1993; Kjell Andersson 1998). Through this tool it is possible to evaluate the perception of the indoor environment by the user, observed symptoms and their potential relation with the indoor environment. It also provides information about psychosocial issues of the place and other personal information (Kjell Andersson et al. 1998). As the research object of this study is a canteen, the MM040 questionnaire was deemed suitable for the evaluation of the indoor quality of the environment.

Energy Efficiency

The SOBANE methodology applied to canteens seeks for the quality of the indoor environment and also aims for the quality of energy supply systems and energy efficiency.
Understanding energy consumption and energy wasted in a system is the concept of energy efficiency. This does not mean to limit the use of energy, decrease productivity or production performance, and does not imply loss of quality of life (Ribeiro 2011). The objective of energy management is to improve the relationship between energy consumption and the comfort generated by its use, increasing the energy efficiency of a system. And to have this improvement it is necessary to evaluate economic, environmental, operational and legislative variables (Direcção Geral de Energia - Ministério da Economia 2002). The total electricity consumed by State Buildings represents 2.9% of national electricity consumption (PORDATA 2018) and any action should only be put into practice if it does not interfere with the minimum requirements for workers in terms of lighting, temperature, minimum humidity, among others. These minimum levels are accessible in specific standards such as EN 12464-1, which shows minimum limits for, to give an example, lighting (Ferreira and Ferreira 2004).

MATERIALS AND METHODS

The adaptation of the SOBANE methodology to museums was applied to the IPB canteen, in Bragança.
Some adaptations were nedded to adjust the methodology, and its tools, to a canteen reality and it will be presented in this section (Lucchi 2016a, 2016b).

Screening

The first step of the methodology is to check the quality of the indoor environment and the energy systems of the building through the tool Environmental and Energy Quality (EEQ). This tool is an indicator that quantifies the quality of the indoor environment and the supply of electricity to the building.
The parameters evaluated through the indicator are subdivided into two categories - envQPI and enQPI - and are defined as present or absent, assigning 1 for present and 0 for absent. Thus, the Qualitative Performance Indicator (QPI) and the final mark of the building identifies its performance with regard to human comfort and energy efficiency (total EEQ).
The envQPI category evaluates parameters of lighting, air temperature, relative humidity, air pollutants, pests and noise, among others, divided into a total of 70 sub-items. The enQPI category evaluates parameters of the construction scenario, mechanical systems, electrical installations, renewable energy resources and internal energy management, divided into a total of 30 sub-items. The final mark obtained represents the total EEQ and evaluates a total of 100 different categories (Lucchi 2016b). Equation 1 shows this relationship:

Total EEQ = envQPI + enQPI Eq. (1)

The performance of a project (total EEQ) is classified into four levels: Initial level: <30%; Intermediate level: 30-60%; Good level: 60-90%; Excellent level:> 90%.
According to the EEQ, a performance of more than 90% denotes a comfortable indoor environment and balanced energy costs. The performance between 60-90% indicates that the building could receive interventions to become globally more efficient. Between 30-60%, the building presents a risk of conservation and, finally, the buildings with less than 30% need a readjustment (Lucchi 2016b).
EEQ values less than 60% are already indicators of a building with a poor quality of indoor environment, and it is necessary to use an in-depth analysis, through specific instruments and techniques, to re-adjust the building and achieve optimal energy parameters, quality of the indoor environment and indoor management (Lucchi 2016b).
It is suggested that the levels that classify museums will be used to classify canteens until an appropriate metric is defined for this type of building.
The need to make the indoor environment comfortable for its visitors and protect the pieces of art makes the museum a very delicate environment. On the other hand, in canteen and kitchen rooms, people become the priority in relation to the comfort of the environment. The preparation of the meal provides some details in the process, but does not overlap with the requirements to provide a comfortable environment.
In this context, the canteen is an environment with less restrictions than museums and this means that some parameters defined in the evaluation tables envQPI and enQPI do not apply, and that others need to be added. It is worth noting that, in addition to the preparation of meals, the canteen offers an experience to the user - from the entering the space moment, where is served, until leaving - and how this user experiences the built environment.
A total of 34 new items relevant to the canteen replace also 34 out of the 100 items from the original methodology. In order to understand the need for what items should be included, meetings with the canteen's management and maintenance staff were held. Addicional authors' contributions were also included. Examples of changes are: the replacement of "rotation of artifacts" in museums by the presence of "air-condicioning control" in the canteen. The majority of the changes target the need to guarantee the preservation of museums objects by energy and indoor air-quality parameters for the canteen case, which was used as a pre-test to evaluate the coherence of this changes.

Observation

The Observation level should be done only in buidings with an EEQ level <60%. In the original work for museums it is analysed the compatibility between the space - comfort needs of the museum users - and the museum - art pieces exposed. The parameters considered in this stage were separated into two categories (Lucchi 2016a; Thumann and Younger 2008):
• Exhibits Conservation Performance Programme (ECPP) - which proposes a diagnosis of the characteristics and conditions of conservation and management of the heritage ;
• People Comfort Performance Programme (PCPP) - which indicates the appropriate climate references for the site users.
Through these two categories, the Museum Performance Program (MPP) compatibility indicator is defined, considering conservation and human comfort (Lucchi 2016a).
As in the canteen environment there is no concern with the conservation of an artistic or cultural heritage, the comfort of people - users and workers – does not conflict with any other restriction. Thus, the indoor environment does not demand compatibility between comfort limits, thus discharging the need for a compatibility indicator.
However, the People Comfort Performance Program (PCPP) category contains variables relevant to the characterization of an indoor environment and will be used. Of the five steps that compose the PCPP (Lucchi 2016a), steps 4 and 5 are justified for the canteen.
Step 4 analyzes the behavior of users in the Post Occupancy Evaluation (POE) scenario - the most relevant variable within the PCPP for the study of the canteen - and in step 5, a map of uncomfortable zones for visitors and workers were made. As users of the canteen space spend little time inside the space, a map of the rooms is not justified. However, it is recommended to do make a map for the kitchen, since it is the area in which workers spend more time and can tell the differences.
Additionally, an energy survey was conducted to define the building's energy consumption profile (Lucchi 2016a; Thumann and Younger 2008).

Data Collection Instrument - DCI

The adaptation of the questionnaire included the evaluation needs of the canteen. Two questionnaires with different focuses were carried out: one for the users and the other for the workers. The users' questionnaire was translated into English to incorporate users from other nationalities.
The dimension of the sample was determined for an average of 1000 meals served per day with a 95% confidence interval yielding in a sample dimension of 278. A total of 300 questionnaires were printed to prepared for any contingency, 250

in Portuguese and 50 in English. For the kitchen, composed by 30 employees, the calculations were made following the same assumption for the confidence interval yielding a sample dimension of 28.
The questionnaires were applied in the spring, on May 29, as recommended by the idealizing team of MM040, to avoid seasonal extremes (Kjell Andersson et al. 1998). The chosen weekday was a Tuesday, since it is very common for students to leave on Friday and return home on Monday from their homes.
The users' questionnaires were applied in the meal rooms and hand-delivered to the users during the lunch period with a brief explanation of the project. For the workers, questionnaires were delivered the day before and there was a breffing about the questions, their importance and how to answer them, before starting their shift. They were left in the worker's commom area, so they could fill it during their intervals, as suggested by the canteen's manager. The amount of response of workers was bellow the accepted threshold being excluded from this study. The statistical information collected from the questionnaires was used to comprehend the human confort inside both canteen and kitchen.

Canteen's energy analysis

In this level it was necessary to conduct an energy survey. The main purpose was to estimate the energy consumption profile of the building (Lucchi 2016a; Thumann and Younger 2008).
A visit to the canteens equipment and kitchen was made during maintenance day along maintanence manager for the inspection of the existing equipment, determination of nominal power of equipment and the approximate periods of use and maintenance frequency.
For the energy analysis the equipment was grouped into twenty-six classes to enable, as close to reality as possible, the estimation of the hourly consumed electricity consumed. The classes were defined rekoning the shift's division of the canteen. From this information, a 24-hour hour diagram was prepared to define which equipment classes were connected into electricity in that period in order to estimate the hourly power required for the network. For any equipment considered in a certain period, it was assumed that the equipment was turned on during the whole period. An electrical energy meter located at the entrance to the canteen measured the hourly requested power from the grid. This data is collected and then processed by GridVis 3.1.1 software. A random summer and winter day were taken from the database and compared to the projection created with the control diagram. This helped to understand the cycles, the network peaks and any eventual leakage.
The Descriptive Technical-Economic Indicator was computed from electricity and natural gas costs data from 2016 to 2017. The monthly number of meals was calculated with holidays and vacations.
The cost per kWh was estimated by the average of the costs from each consumption levels determined by the energy provider. Because there is only one gas meter for the whole canteen coumpond, the kitchen natural gas costs were obtained by reflecting the volumes of the different parts of the building.

Analysis

The next step of the methodology, Analysis, would be conducted once the result of the MPP indicator – from the Observation level - showed partial or critical/impartial compatibility. As in the situation of the canteen it does not make sense to carry out a MPP in its entirety, as discussed in the previous section, the Analysis stage should be carried out with reference in the conclusions obtained in the second level (Observation).
Through the results of the DCI and the energy analysis it is possible to identify the equipment with the highest consumption, the periods with the greatest energy expenditure and problems that most disturb canteen users, and to undertake a a more thorough investigation of these critical points through technical and monitoring analysis.

Expertise

From the diagnosis performed in the stages of Screnning, Observation and further investigations in the Analysis stage, it is possible to suggest cost-effective solutions for the problems identified in the indoor environment, in the energy system or in the equipment of the canteen.
The opinion of the managers of the canteen to make suggestions for improvement of the canteen were also considered.

CONCLUSIONS AND FURTHER RESEARCH

The Environmental and Energy Performance (EEP) methodology is an adaptation of the SOBANE methodology for museums, for which tools have been developed in order to promote the complete diagnosis of a museum. In this work, the EEP methodology was adapted for canteens, as well as their tools.
The Screening level evaluates the indoor environment through an indicator - Environmental and Energy Quality (EEQ). Out of 100 items that were evaluated due to their relevance to the canteen, 34 items of the original methodology were replaced.

The tool used in this step provides an indicator, in percentage terms, and makes use of a metric - built from the application of EEP - to define building performance in levels. Through this metric, the canteen was defined at the intermediate level (43%) and this means that the building needs to be investigated in systems that will addressed in the next level.
The Observation level assesses the impact of the indoor environment on the user, through the optics of human comfort. It uses the Post Occupancy Evaluation (POE) tool and it also includes an energy survey to outline the profile of energy consumption in the building. This level should be explored by buildings with EEQ <60%, as is the case of the canteen. A questionnaire was adopted as a data collection method. The questionnaires elaborated were adapted from the epidemiological research model MM questionnaire developed to evaluate problems of "sick buildings" (K. Andersson et al. 1993; Kjell Andersson 1998). From the 300 questionnaires produced, 293 were ansewered, 15 more samples than the required number required to make it statistically significant. The results of the questionnaire discussed here refer to the opinions of the users of the canteen only, once the required number of respondents from the kitchen workers was not obtained to make it statistically significant in the discussion. So, it was only possible to understand the indoor environment cenario of the canteen, not the kitchen, through the user's opinion.
The questionnaire allowed to see the main perspective, from canteen user's, about air-quality, dirt and dust, temperature and noise, throughout 45 questions. More than half of the respondents (63%) observed that thay did not feel air flow in the canteen's dining rooms and 61% of them were uncomfortable with stuffy air. Despite this, almost all the respondents (96%) found that the canteen has acceptable air quality This leads to the understanding that, for these people, the fact that they do not feel any bad smells and smoke is synonymous with good air quality. However, this does not exclude the fact that the lack of air circulation is an element to be investigated in the Analysis stage.
Most of the repondents (75%) did not feel bothered with dirt and dust so it is possible to state that the conditions of the canteen are within the cleanliness standards.
More than half of the respondents (63%) felt high temperatures and 52% and 69% of them, respectively, did not notice temperature variation during the day and did not feel cold temperatures. This means that the canteen was deemed as a warm environment by the users.
Most users (80%) found that noise in the canteen was a great concern. For 56% and 26% of the users are concerned, respectively, with the noise from conversations and from kitchen equipment/kitchen team.
The comparison between the actual and estimated energy consumption profiles of the canteen served as a verification tool for unwanted equipment and parasitic load consumption. No variation was observed between the curves that could not be justified.
The average Descriptive Technical-Economic Indicator for energy cost in 2016 was 0.26 Euros per meal and in 2017 it was 0.27 Euros per meal. This shows a constancy in the energy consumptions, since the indicators are very close to each other. The value paid by the users in the main menu is 2.30 Euros and of this amount, 11% was spent with energy in 2016 and 12% in 2017.
The Analysis and Expertise steps of the SOBANE methodology suggested for canteens were not performed in this work because they required technical tests in the structure and monitoring of the equipment to evaluate the problems identified in the Screening and Observation stages and this is beyond the scope of this work.
The methodology proved to be effective in its purpose once it presented consistent results for a 22-year-old building that has not undergone any rehabilitation procedures.
Their were group in 4 items com subitens.

Further Research

Some suggestions for further development are, thus, put forward::

To carry out the Analysis and Expertise levels from the notes obtained through the users and the energy analysis of the most alarming points of discomfort in the canteen;
To test the methodology in other canteens and propose a metric to classify the canteen in the Screnning stage;
To evaluate the canteen extraction equipment and suggest options for improving air quality and air circulation in the canteen and kitchen;
To conduct air quality studies;
To propose corrective measures at the project level;

REFERENCES

Andersson, K., G. Stridh, I Fagerlund, and B. Larssob. 1993. "The MM-Questionnaire: A Tool When Solving Indoor Climate Problems." *Department of Occupational and Environmental Medicine*.

Andersson, Kjell. 1998. "Epidemiological Approach to Indoor Air Problems." *Indoor air* 4: 32–39.

Andersson, Kjell, Goran Stridh, Inger Fagerlund, and Wenche Aslaksen. 1998. *MM 060 Questionnaire: School Environment Manual*. Sweden.

Cohen, Luis, Lawrence Manion, and Keith Morrison. 2005. *Research Methods in Education*. 5th ed. New York: Taylor & Francis e-Library.

Cooper, Barbara, Sherry Ahrentzen, and Betty Hasselkus. 1991. “Post-Occupancy Evaluation : An Environment-Behaviour Technique for Assessing the Built Environment.” *Canadian Journal of Occupational Therapy* 58(4).

Direcção Geral de Energia - Ministério da Economia, . 2002. *Eficiência Energética Nos Edifícios*.

Fanger, P.O. 1982. *Thermal Comfort : Analysis and Applications in Environmental Engineering*. Malabar, Fla: R.E. Krieger Pub. Co.

Ferreira, João de Jesus, and Teresa de Jesus Ferreira. 2004. *Economia E Gestão Da Energia*. 1ª edição. Texto Editores.

Lucchi, Elena. 2016a. “Multidisciplinary Risk-Based Analysis for Supporting the Decision Making Process on Conservation, Energy Efficiency, and Human Comfort in Museum Buildings.” *Journal of Cultural Heritage* 22: 1079–89. http://dx.doi.org/10.1016/j.culher.2016.06.001.

———. 2016b. “Simplified Assessment Method for Environmental and Energy Quality in Museum Buildings.” *Energy & Buildings* 117: 216–29. http://dx.doi.org/10.1016/j.enbuild.2016.02.037.

Malchaire, J., and A. Piette. 2006. “The SOBANE Strategy for the Management of Risk, as Applied to Whole-Body or Hand-Arm Vibration.” *Annals of Occupational Hygiene* 50(4): 411–16.

PORDATA. 2018. *Consumo de Energia Eléctrica: Total E Por Tipo de Consumo*.

Preiser, W, H Rabinowitz, and E White. 1998. *Post-Occupancy Evaluation*. ed. Van Nostrand Reinhold. New York: Routledge.

Ribeiro, Luís Frölén. *Manual de Boas Práticas Energéticas Para Indústria*. Bragança: Edições NERBA, 2011.

Thumann, Albert, and William J. Younger. 2008. *Handbook of Energy Audits*. 7th ed. ed. The Fairmont Press. USA.

Watson, C. 2003. “Review of Building Quality Using Post Occupancy Evaluation.” *PEB Exchange, Programme on Educational Building, 2003/03, OECD Publishing* 35: 1–5. http://dx.doi.org/10.1787/715204518780%0APEB.