CommONEnergy

DELIVERABLE 2.2

Shopping malls inefficiencies

European Commission
DG Research and Innovation
SP1 - Cooperation
Collaborative project
Large-scale integrating project
FP7-2013-NMP-ENV-EeB

GRANT AGREEMENT No. 608678

CommON*Energy*
Re-conceptualize shopping malls from consumerism to energy conservation

FP7 European Union Funding for Research & Innovation

Technical References

Project Acronym	CommON*Energy*
Project Title	Re-conceptualize shopping malls from consumerism to energy conservation
Project Coordinator	Roberto Lollini Accademia Europea Bolzano, Viale Druso 1, 39100 Bolzano/Italy roberto.lollini@eurac.edu
Project Duration	1 October 2013 – 30 September 2017 (48 Months)

Deliverable No.	D2.2
Dissemination Level	PU
Work Package	WP2
Lead beneficiary	SINTEF
Contributing beneficiary(ies)	D'APPOLONIA. Acciona, BLL, DSCon, TU-WIEN,
Author(s)	Ruth Woods, Sofie Mellgård, Reidun Dahl Schlanbusch, Kristian Stenerud Skeie, Matthias Haase
Co-author(s)	Antonio De Ferrari, Maria Victoria Cambronero Vazquez, Andreas Ampenberger, Raphael Bointner
Reviewed by	BPIE, UNIUD
Date	30.01.2015
File Name	WP2_D2.2_20150130_P07_Shopping malls inefficiencies

This document has been produced in the context of the CommON*Energy* Project.

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 608678. The content of this document does not reflect the official opinion of the European Union. Responsibility for the information and views expressed in the document lies entirely with the authors.

Contents

Executive summary

The CommONEnergy project aims to reconceptualise shopping centres through deep retrofitting, developing a systemic approach made up of innovative technologies and solution sets as well as methods and tools to support their implementation and to assess their environmental and social impact in a life-cycle approach.

This report is a WP 2 deliverable. The main aim of WP 2 is to define the retrofitting drivers for shopping centres, namely the building demands in terms of energy efficiency that motivate intervention and which are the main basis for developing energy retrofitting concepts: including technologies, solutions and scenarios for shopping centres. This report presents an analysis of the existing commercial building stock, primarily the systemic efficiencies and inefficiencies related to its technical systems and multi-stakeholder decision processes. The research is based on an extensive review of already existing research and on analysis of data collected though tailor-made questionnaires for each major stakeholder category related to shopping centres. Through a socio-technological analysis the report elucidates the systemic inefficiencies that have a negative effect primarily on the energy-use but also on the shopping centre building itself, including architectural composition, logistics, and other constructional properties. Complex processes involving stakeholders that may lead to the selection of inappropriate and energy-consuming technical solutions, building and land design, and choices of operations and maintenance are studied. The report provides an in-depth analysis of the building envelope and technical systems aiming to identify factors that influence the functional efficiency and energy consumption in shopping centres. The social environment, behavioural aspects are assessed and their influence on the decision making process when implementing energy renovation measures.

The analysis considers six main fields:

- Facilities
- Functions
- Management
- Ergonomics
- Logistics
- Economic models

The analysis has been guided by the understanding that inefficiencies in shopping centres are not just found within the physical environment in shopping centres but are also associated with decision making practices and user behaviour. The systemic analysis therefore considers behavioural, managerial, technical and physical systems in shopping centres.

The six fields have not been considered individually but as required in relation to the report's four main sections:

1. The methodology used to collect the data used and presented in the report. The methodology section provides background information to understand how data has been collected and used, and is not further discussed here.
2. User behaviour, primarily customers and decision making structures associated with owners/managers and tenants.
3. The systemic inefficiencies associated with the function and use of a shopping centre building.
4. Economic models that are used to sell energy investment to tenants.

The three final sections are summarised here and presented according to their chapter headings.

Section two: includes a chapter on user behaviour and a chapter on decision making structures among owners/managers and tenants, and considers the causes of energy use in shopping centres. User needs which are being served and the stakeholder groups, customers, tenants, owners and managers have direct or indirect influence, and how energy is used in shopping centres.

The influence of user behaviour on energy performance

The aspects which achieved the highest ratings among the customers in the three shopping centres are: customer satisfaction, safety, logistics, the range of products, access to public transport and car parking. These qualities are important when customers are choosing where to shop. Customers are satisfied with the shopping centres where the surveys took place, “City Syd” in Trondheim, Norway, the “Valbisagno” and “l’Aquilone” shopping centres in Genova, Italy. However they are also keen to improve the energy efficiency of shopping centres in general and energy efficiency is one of the aspects where they saw the greatest possibility for improvement.

There are three main aspects associated with user behaviour and energy performance:

1. Customer knowledge or lack of knowledge is an important factor to be dealt with if shopping centres are to gain approval for actions associated with energy efficiency issues, or if customers are themselves going to demand energy efficient shopping centres.
2. Energy efficiency does not influence customer choice of shopping centre. Location is the most importance factor influencing customer choice of shopping centre. This is closely associated with the importance customers place on car-parking.
3. The physical framework provided by shopping centres does influence customer choice. However customers involved in the CommONEnergy survey placed little importance on architecture and design when choosing where to shop. Owners and managers placed much more importance on physical structure and architectural quality ranked as highly as customer satisfaction and energy efficiency when suggesting the main reasons for a shopping centre upgrade. Tenants had customer satisfaction was their focus. The physical structure received less focus from tenants.

A shopping centre is more than what is directly perceivable to each customer and a fair judgement of i.e. recycling, energy efficiency or environmental friendliness in shopping

centres requires more insight into the day to day operation of a centre and behind the scenes management. Importantly, the customer survey suggests that an environmentally friendly profile is not being communicated to customers.

Decision making structures for customers, tenants and owners/managers
Three stakeholder groups have been considered: customers, tenants and owners/managers. The main findings from the three stakeholder groups are as follows:

Customers: Shopping centres are not chosen because of their energy efficiency, although the appearance of an energy efficient shopping centre could encourage “green” thinking. Customers have low awareness of energy efficiency in shopping centres. Customers are interested in lower prices and a wide range of products and this is not directly associated with an energy efficient renovation.

Tenants: the energy efficiency of shopping centres is not of primary importance. It is important to improve the flow of information about energy efficiency among employees in shopping centres. Energy performance certificates could be used to strengthen awareness of how energy efficiency influences stores or retail units.

Owners and managers: equal the main decision making group and they are interested in energy efficiency. However they are reluctant to spend large amounts of resources on renovation. The value of the building is important to this group and therefore energy investments may be expected. Common certifications for energy efficient buildings are not considered suitable for shopping centres by this group, but a certification specifically for shopping centres could be a step towards encouraging interest about energy efficiency amongst owners.

Section three: primarily considers the effects or resulting energy use within shopping centres, and the problems and solutions associated with it.

A list of systemic inefficiencies
This chapter considers four main areas which are a source of energy inefficiencies in shopping centres: lighting, HVAC measures, ergonomics and safety and building envelope.

1. Lighting

There are large inefficiencies associated with lighting as a general concept and among different lighting systems. Managers of shopping centres may not have strict restrictions from owners, but they are generally responsible for lighting only in common areas and exteriors and lighting represents a key area for savings. Lighting is often spread over a large area, and centrally controlled systems are crucial to overall lighting management. It is essential to extend the use of daylight to additional floor areas and this can be achieved by opening additional building surface areas or by redirecting light in the building depth. Common areas are often daylit but shops and other sales areas are seldom daylit. This leads to an additional inefficiency, the use of daylight to an unreasonable level, due to overlit areas often found in common areas. Display lighting is important for drawing attention to

showcase items and enhancing aesthetic quality, but many retailers use inefficient spotlights. LED together with a controlled beam lighting can save energy, while maintaining excellent colour rendering. If windows also supply daylight, then integrated concepts for display lighting, daylighting (and inside exhibition of merchandise at shelves) must be developed. Sensitive adjustment of indoor luminance values generates the requested result. Often daylight levels are higher than necessary which needs to be compensated for by the use of more artificial light in shops and sales areas.

In order to establish sufficient light levels the use of efficient light sources and electronic gear concerning energy demand is important. The environmental impact and life-cyle performance (including maintenance efforts) needs to be considered when choosing the most appropriate luminaires. Finally, automatic control regulation is essential and occupancy sensors for less used areas (such as back-of-store areas, staff rest rooms, storage areas and office space) that do not require light 24 hours a day should be installed. Replacing fixtures with T5 or T8 compact fluorescents will save even more energy.

2. HVAC measures

Quality control of the complete energy system is necessary throughout the entire building if energy-efficient solutions are to be met. This requires adequate information about building systems and assessment tools. A second requirement is a commissioning procedure that enables follow-up of the building performance during the building lifetime, thereby helping to detect systemic inefficiencies. A third requirement is comparative analysis including a detailed monitoring system to track energy use and fault detection, with yearly and hourly energy consumption profiles analysed in a holistic manner.

3. Building envelope

Recommended levels of thermal insulation in the building envelope depend on the climate. Building energy use should be calculated and insulation levels optimised in relation to these variables. Single measures often do not yield cost-effectiveness but deep retrofitting (a number of measures implemented together) achieves high levels of energy savings. Ideally, this should be simulated using building performance simulation tools.

4. Ergonomics and Safety

Shopping centres are complex buildings with a complicated layout, with sophisticated utility plants and a very high concentration of customers and workers, the latter making repetitive material handling tasks. These factors, as well as the large amount of young workers, imply serious ergonomic issues and H&S hazards. There is a consistent set of regulations and guidelines related to ergonomics and H&S, but the options for their implementation are diverse and may have implications for energy efficiency.

Section four: the final section investigates which economic models are used by owners and managers in shopping centres to sell energy investment or energy efficiency measures to tenants.

Economic models used to sell energy investment and energy efficiency to tenants

There are four important factors associated with economic models encouraging energy efficiency among tenants:

- There are some energy efficiency programmes in place, for example, green leasing programmes, but these play a minor role and are not well-known among tenants.
- Current business models in shopping centres do not offer many incentives to increase energy efficiency. No standardised economic models to increase energy efficiency in shopping centres have been identified by the CommONEnergy survey or the interviews.
- The best way to achieve greater awareness and reduced energy use would be to move from all-in and revenue-based rents towards a clear pricing of running costs, which are mainly based on energy consumption, and thereof independent rents. However there was no interest during interviews amongst owners and managers in changing the system. Individual billing based on actual running costs, is more time consuming and would require the installation of new management systems and possibly also supply systems.
- The level of ambition among decision makers may be influential. More ambitious approaches may result in lower prices and reduced construction costs due to the effort put into achieving a better environmental performance.

Each chapter is concluded with a summary of the main results and areas covered and conclusions based on the results.

1. Introduction

The CommON*Energy* project aims to "re-conceptualize shopping malls through energy efficient renovation, developing a systemic approach made of innovative technologies and solution sets as well as methods and tools to support implementation and to assess the environmental and social impact in a life cycle approach." The project will encourage the development of sustainable shopping centres by supporting the energy efficient rehabilitation of existing shopping centres and providing knowledge which will further the efficient design of new shopping centres. This aim is to be achieved with support from seven work packages. Work package 2, which is responsible for the development of this report, has as its main focus the defining of retrofitting drivers. The drivers will provide the basis for developing energy retrofitting concepts, offering amongst other things, constructive technology, an understanding of typical function patterns and socio-cultural aspects and an understanding of potentials associated with interaction with local energy grids.

1.1. Rationale of the report and reader's guide

The aim of this report is to identify the main inefficiencies regarding energy, comfort, operations (maintenance) and logistics. The report presents an analysis of systematic efficiencies and inefficiencies associated with both built and social environments found in shopping centres today. The analysis primarily considers the fields of facilities, functions, and management. Ergonomics, logistics and economic models are also considered. The intention is to define existing requirements and specifications within shopping centres to enabling future specifications upon which to base effective energy investments to be proposed. Achieving an energy efficient environment also requires action, interest and collaboration amongst all stakeholders involved in shopping centres, not just those making the decisions and defining the energy investment. It also involves people working and spending money in shopping centres. Inefficiencies in shopping centres are not just found within the physical environment in shopping centres but include inefficiencies associated with decision making practices and user behaviour. Studies covering inefficiencies, both technical and social, will provide an understanding of the technical challenges needed to achieve innovative solutions thereby paving the way for new practices. A deeper analysis of socio-cultural patterns associated with shopping centres is provided in CommON*Energy* report D 2.3.

The report is divided into four main sections. The first part provides detailed information on the methodology which was used to collect the data presented in this report and to a large extent in D 2.3 (Woods, et al, 2015). Part 2, including chapters 2 and 3 focuses on user behavior and decision making structures associated with owners, managers and tenants. These two aspects focus on the causes of energy use in shopping centres. The third main part looks at the systemic inefficiencies associated with the function and use of a shopping centre building. This section primarily looks at effects, resulting energy use and problems

and solutions associated with it. A number of areas with inefficiencies have been considered, although the main focus is on the use of lighting systems in shopping centres. Finally the report considers economic models that are used to sell energy investments to tenants.

The report concludes with a summary of the main inefficiencies found and that can be associated with the European shopping centre building stock today. The causes and effects are discussed, as well as potential solutions for reductions in energy use.

Figure 1 – A consistent colour pallete helps identify the survey results from the three questionaires targeted to different stakeholder groups.

1.2. Towards a holistic approach in identifying systemic inefficiencies in shopping centres

Policies and research often focus on technology and buildings and not on social aspects associated with future developments. There are many reasons for this, and one of the most pertinent may be that behaviour is both difficult to control and to predict and that the technological solutions that are introduced are perceived as part of a purely technical system. The CommON*Energy* ambition to identify the systemic inefficiencies of shopping centres requires a more holistic systems view, which cannot be achieved by simply studying isolated parts or individuals in the shopping centre. It is necessary to study the system and its inefficiencies as an interrelated whole. Inefficiencies: are understood as the use of resources, equipment or time, which is not utilized in the best possible way. Shopping centres as systems consist of many relevant factors. In order to ensure a holistic view throughout the analysis of the shopping centres the study aims for a socio-technical systems approach. In a socio-technical system, the user(s) are parts of the system itself making it a socio-technical system rather than a purely technical one (Ingelstam (ed), 1996). This approach allows us to handle and analyse multiple interrelated actors and factors in four fields: facilities, functions, management and logistics.

A socio-technical systems approach is more likely to be able to point out inefficiencies associated with both components and users. The overview of the total system increases the chances of identifying and providing possibilities for how to solve the inefficiencies rather than if these actors and factors were handled separately. In addition, a socio-technical systems approach increases the chances of identifying inefficiencies that are not only affecting isolated parts or members of the system, but those having a negative influence on the system as a whole, so called systemic inefficiencies.

A list of definitions of key concepts referred to in the report[1]

System: consists of some form of components and the connections between components.

Components: the different parts of something.

Socio-technical system: in a socio-technical system, the user(s) are parts of the system itself making it a socio-technical system rather than a purely technical one

Systemic: something that does not only affect isolated parts or members of a system, but has an influence on the system as a whole.

Inefficiencies: refer to that the use of resources, equipment, or time is not done in the best possible way.

Facilities: something designed, built or installed to serve a specific function of offering a convenience or service

Functions: any of a group of related actions contributing to a larger action

Management: the process of dealing with or controlling things or people

Logistics: the process of planning, implementing, and controlling the flow and storage of goods and services.

[1] For comparison, see *www.oxforddictionaries.com* , *www.collinsdictionary.com*.

2. Methodology

Task 2.2 requires an analysis of the systemic inefficiencies associated with the fields of facilities, functions, management, ergonomics, economic models and logistics for European shopping centres. Data was therefore collected in a broad number of fields and over a wide geographic area. In order to achieve the broad base of information required for the study a number of different methods, including quantitative, qualitative and desk top approaches, was selected. This chapter provides an overview of the different methods, starting with a in-depth description of the activities associated with the questionnaires which has provided data for a number of activities associated with D 2.2 and D 2.3 (Woods et al., 2014). In addition the interview method and literature reviews, as well as the engineering related methods are described.

A short methodology introduction is given at the beginning of each chapter, providing information about which methods were used in association with the activities and data presented.

2.1. Shopping centre Stakeholders

To develop optimal concepts and solutions which ensure the effective retrofitting of shopping centres, in relation to both technical and social aspects, knowledge about the needs and views of relevant stakeholders is required.

Three main groups of stakeholders in shopping centres have been identified; the owners and managers, tenants and, finally, customers. The three groups were chosen because they provide a framework to understand the day to day activity in shopping centres. Hence, the stakeholder groups have not been chosen because they are specifically associated with or interested in energy efficiency or sustainability issues. A more detailed description of three main stakeholders groups is provided in D 2.3 (Woods et al., 2014) and only a short presentation of the three stakeholder groups is provided in this report. Various differences between the stakeholder groups are also further elaborated upon in a number of the following chapters, for example in chapter 3, the impact of stakeholders on the inefficiencies found in shopping centres is described, as well as how they may potentially be involved in the process of overcoming inefficiencies. The following chapters help to recognize and provide a common understanding of the stakeholder groups which supports the analysis presented in this report:

- Owners and managers: work primarily with shopping centre support and operation, for example leasing, brokerage and maintenance. It is suggested that there are essentially five main types: owners, developers, investors, management companies and facilities companies. Their role and activities within the shopping centre varies

according to these different types. For example developers and investors are involved in initiating and planning shopping centres. Management and facilities companies are involved in the shopping centres day to day activity.

- Tenants: are broadly defined as those who lease retail and other property in shopping centres. The tenants provide direct employment in the form of sales jobs and retail store management. Tenants may also work with food or the supply of other services in the shopping centres, such as hairdressing. Tenants are often part of a consortium, managed by owners or a management company.
- Customers: may be defined as those who shop. There is more than one kind of customer and different customer groups may be broadly categorised by gender, age, life-style habits, and socio-economic background. Customer typology is identified according to purchasing method, and this is characterised elements such as: spending power, how to buy and how much time.

2.2. Questionnaires

A survey or questionnaire is used when a research question requires a quantitative or numeric description of trends, attitudes or opinions from a population sample (Cresswell, 2009). A questionnaire is often understood as a quick and effective method to collect statistical data; it provides a set of questions with a choice of answers. Quantitative methods, such as questionnaires, provide numbers and offer the means to understand describe and explain them. Quantitative research relies on an objective standpoint; this means that different points of view may be compared; making it in theory possible to verify, if necessary, the results at a later date (Olsen and Sørensen, 2003). It should be possible to repeat the same questionnaire, hence achieve the same results (Joppe, 2000). Quantitative research approaches have their roots in positivist theory where the intention is to empirically test hypotheses explaining and predicting the what, where, why, how and when phenomena occur (Gilje and Grimen, 2002). However, due to the exploratory nature of this research project, the intention has not been to test a hypothesis but to provide indicators with which to understand societal trends associated with energy efficiency and sustainability issues in shopping centres. The research project requires information about the current situation in Europe and a quantitative approach was chosen mainly due to a need for a quick and effective collection of data. Therefore, a web based questionnaire was developed and distributed to the relevant stakeholders with the aim of providing a statistical understanding of phenomena associated with energy efficiency and sustainability in shopping centres, and of the relationships between them.

The development of the questionnaires and their respective scopes is presented below. However key research questions which are part of this task are not all of a nature which is easily quantifiable. For instance, respondents are asked about their opinions, experiences and preferences. Such aspects are to a large degree based on subjective experience and taste, making the answers less unambiguous and more subject to fluctuation. It is difficult to measure subjective data quantitatively (Thomsen and Eikemo, 2010).

The form and function of a questionnaire, as described above, is a well known practice, making it possible to repeat. Data collection through digital technology is also an ordered process and there exist a number of tools which simplify the process[2]. Once an address list with relevant stakeholder groups was established (see "The Development of the Questionnaires, below), the questionnaires were sent out to the three separate stakeholder groups. Everyone within each stakeholder group received the same set of questions and had the opportunity to respond digitally to all questions asked.

2.2.1. The Development of the Questionnaires

Identifying the population to be studied, the size of the population to be studied and the means of accessing them are central aspects in any survey (Cresswell, 2009). The expectation is that a questionnaire will provide objective measurable data from a random statistical group (Yates, 2004). This assumes ease in developing a large well-functioning address list, accompanying interest within the stakeholder group/s about the theme of the survey and a subsequent high response rate to the invitation to participate. Achieving this ideal in the CommON*Energy* project had its challenges and this has influenced the amount and the kind of data that was gathered, the results and the analysis. The challenges and achievements are presented in the following section.

To understand where and how inefficiencies and efficiencies occur in shopping centres a broad understanding of shopping centres in general is needed. This has influenced the structure, content and length of the questionnaires that were developed. A certain amount of data about shopping centres may be collected through desk-top analyses such as literature reviews. However, the data collected through desktop research is not necessarily completely up to date and does not tell us directly how energy use and/or sustainability issues influence the day to day running of shopping centres or its implications for the three stakeholder groups. The three questionnaires provide up-to-date data about energy use and physical conditions associated with a broad group of European shopping centres; for example the questionnaire for owners and managers, using questions such as:
"*Approximately what are the main energy sources in the shopping centre?*" and
"*What is the approx. net floor area of the shopping centre in m^2?*"

The questionnaires for tenants, owners, and managers also provide data about opinions and needs associated with energy use and sustainability issues, for example:
"*What in your opinion are the main barriers against an energy efficient upgrade of shopping centre facilities?*" and
"*What in your opinion are the most important areas to be addressed when considering upgrading the shopping centre?*"

[2] Survey Monkey is an example of this kind of tool. The CommONEnergy project used a company, SENTIO, a Norwegian marketing and opinion poll institute, who has extensive experience within the collection of survey data.

Both types of data were necessary due to the assumption that there is a causal relationship between them. This meant that the questionnaires for owners and managers and for tenants were relatively long. The length of the questionnaire was also influenced by the number of themes or issues that D 2.2 covers:

- facilities
- functions
- management
- economic models
- ergonomics
- safety
- logistics

Another option would have been to send a multiple of shorter questionnaires, each covering a limited number of themes. This was not considered a useful option as the project group did not wish to overwhelm the shopping centre industry with numerous questionnaires.

Three different questionnaires were used in the study, one for each stakeholder group: owners and managers; tenants and customers. The tenants' questionnaire asked for detailed information on the type of businesses and technical data on the premises and lease contract. The questionnaire for owners and building managers also asked for technical data about the premises, but focused on the building as a whole. The intention was that both questionnaires should take approximately 20 to 40 minutes to complete. In addition, both the tenants and the owners and building managers questionnaire were asked questions related to the informants' knowledge on issues related to energy saving measures and the importance of different aspects in relation to their respective role in the shopping centre.

The customer questionnaire was the least extensive, and it asked questions related to the customers' preferences when choosing shopping centre (approximate time to finish it was 5 to 10 minutes). The aim of these questions was to explore the influence of energy saving aspects and environmental profile on the customers' choices. It also, for instance, asked for information on the customers' acceptance of possible energy saving measures. The three questionnaires were related to each other. They covered similar themes, particularly the questionnaires prepared for the tenants, owners, and managers. Some of the questions were the same for all three groups, for example "How would you rate the shopping centre in terms of..." and "What would you improve?" This kind of question allows for a comparison of the attitudes and expectations found within the three different stakeholder groups.

2.2.2. Testing the questionnaires

All partners involved in D 2.2 and D 2.3 were involved in the development of the questionnaires. The partners provided feedback on the kind of questions, the formulation of questions and the length of the questionnaires. In addition, the partners directly associated with the shopping centre industry were involved in testing the questionnaires; City Syd, INRES and AVA all provided feedback. However, AVA was less involved because their role is municipal rather than retail. Representatives read and suggested changes to the questionnaires providing insight into whether the stakeholders would be able to understand

and answer the questions. They also considered whether the questionnaires would be too long for the different stakeholder groups.

In addition, the tenant questionnaire was tested by a Norwegian tenant at the City Syd shopping centre in Trondheim. This informant was chosen as an average shop manager at City Syd and whose response was very positive and constructive and it influenced the further work with the questionnaire. Hindsight tells us that this test tenant was probably trying to be helpful but did not know enough about energy issues to be critical. The response to the questionnaires after the survey was closed shows that the questionnaire for tenants was too long and the questions were not of a nature easily answered by tenants working with the everyday running of businesses in shopping centres. In fact, approximately 50% of respondents had given up answering the questions before they reached the end of the questionnaire.

The project group was aware that the questionnaire was long and was prepared for some difficulties. However, they were not prepared for the results showing an extensive lack of knowledge amongst tenants about energy issues. These aspects will be further elaborated upon in the presentation of the analysis. Retrospectively, the questionnaire could have been tested on a broader group. The assumption was that the industry partners would be aware of possible issues in answering the questions, but the industry partners involved were probably influenced by their involvement in the project and by the same project blindness affecting all involved in the CommON*Energy* project; namely, as we are all interested in energy efficiency and sustainability issues in shopping centres we assume that everyone else must also be engaged with the subject. This is a common problem in research projects, and is sometimes referred to as projection bias' (Loewenstein et al 2003). Among owners and managers, 30% dropped out before the questionnaire was completed. The response does point to the questionnaire being too long and complex in order to be answered easily and quickly (Dillman 2007). However, the main problem with this stakeholder group was getting them to respond at all.

The customer questionnaire was not tested amongst customers; it was only tested by the retail industry partners. This questionnaire received a good response in Italy and Norway, which suggests that extensive testing is not always necessary when developing and implementing a successful survey.

2.2.3. The invitation to participate

The questionnaires were translated from English into German, Norwegian, Italian, and Spanish, as was all correspondence associated with the invitation to participate in the survey.

The invitation to participate in the questionnaire was centrally distributed using email and was conducted by the Norwegian marketing and opinion poll institute, SENTIO. SENTIO reviewed the quality of the email addresses used before sending data, collected the responses to the questionnaires and organized the data ready for analysis by the project

partners in D 2.2 and 2.3. A number of the potential Spanish respondents preferred not to share their email addresses with the project group. The invitation to participate was therefore sent directly by the project partner CARTIF, who provided respondents with digital links to the questionnaire. A total of three reminders to participate in the questionnaire were sent during the survey period. The third and final reminder was sent directly by partners to their contacts. The aim was to increase the chance of receiving a response because contacts already had a relationship with the person sending the invitation, and we believed it would help that the invitation was coming from their own country of origin, for example Spain rather than Norway (Dillman 2007).

When working with questionnaires it is common to approach a randomly selected group. Random selection is considered important because it reflects a commitment to the production of findings, which may be generalised beyond the confines of those who participate in the study. However it is rarely possible to gain contact with all parts of the population, which may result in a survey ending up with a limited number of contacts. This is often understood as a representative sample (Bryan and Cramer, 2004). Within the CommON*Energy* project the approach to achieve a sample group within the three stakeholder groups varied and the resulting response varied in relation to stakeholder group and their interest in participating in the survey. The response also varied amongst the participating country.

Owners and managers

In this survey, the intention was to reach as many respondents as possible within the European shopping centre industry. Partners were asked to provide lists of potential contacts within the industry. The number of contacts within participating countries varied (in Norway the invitation to participate was sent to 512 potential respondents and, in Italy, 21 invitations were initially sent (see Table 1)).

Table 1 – Response to the owners and managers questionnaire

Owners and managers			
Country *	**Number of invitations sent**	**Invitations sent not answered**	**Total answers incl. direct respondents**
Germany	24	23	**1**
Austria	10	5	**5**
Italy	21	7	**14**
UK	32	31	**1**
Belgium	7	6	**1**
Spain	271	265	**6**
Norway	512	470	**42**
Denmark	0	0	**16**
Sweden	55	55	**10**

*Comment: Steen og Strøm where sent a direct invitation after the second round of invitations and returned data from 38 of their shopping centres located in Norway, Sweden and Denmark. No direct invitations from the project group were sent to Denmark and the responding answers from Sweden were not a result from the first round of invitations but were due to direct contact with Steen og Strøm.

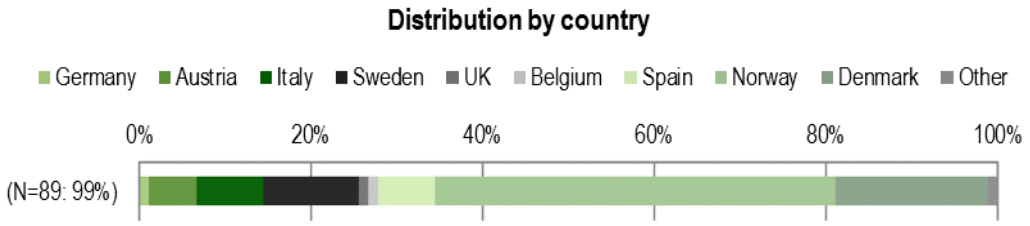


Figure 2 – Total answered by owners and managers

The response after the first round of invitations was very limited. Therefore, a second round of digital invitations was planned and set in motion, and partners in the CommON*Energy* project were encouraged to approach their contacts in the retail industry. The response in Scandinavia was doubled after the second round of invitations, but in the rest of Europe there was only a slight improvement in the response rate. In relation to the number of invitations sent, the response rate was disappointing. Norway provided the largest number of responses (42 in relation to 14 for Italy and 6 for Spain). There are a number of possible explanations for the poor response rates and for the difference between the response from Norway and the rest of Europe. The Norwegian address list was much longer than the lists from other countries (see
Table 1). This list was provided by City Syd's management and was developed by Andhøy AS, a company specialising in records and statistics for the Norwegian retail industry. However, 112 of the addresses on the list did not work and within a wider statistical perspective, in relation to the number of invitations sent, the response rate was low. However in relation to the response to the questionnaire from the rest of Europe, the Norwegian response was high. The Spanish address list was relatively long, but almost half of the addresses were outdated. According to a Spanish informant, the Spanish are traditionally sceptical to participating in surveys and responding to questionnaires and if so, this factor may have been influential during the CommmON*Energy* survey.

In general, there were few addresses from the European partners outside Norway and the quality of the addresses was poor. With so few addresses, a personal connection between potential respondents and the project in addition to a pre-notification of the study was assumed an important potential advantage (Dillman 2007). However, this personal connection was lacking, and even though the number of respondents increased after trying to improve the situation by establishing personal contact, the number of responses did not increase significantly.

Tenants

Tenants are more directly connected to day to day activity within shopping centres. The owners of stores may be national and international companies, with retail units in a large number of different types of shopping centres. In the CommON*Energy* project, focus was on actual energy use and interest in sustainability issues amongst tenants in the three demo-cases. The differences in the three demo-cases particularly in relation to how actively they functioned as shopping centres during the period that the survey was taking place caused challenges.

The invitation to the tenants to participate to the questionnaire was, in contrast to the approach toward owners and managers group, sent to a selected and limited number of participants. Three invitations to participate were sent to tenants, of which the first two were sent digitally. The third invitation was done through direct contact with tenants by partners. Table 2 shows the responses of the tenants.

Table 2 – Response to the tenant questionnaire

Tenants questionnaire			
Country	**Number of invitations sent**	**Invitations sent not answered**	**Total answers including direct respondents**
Germany	-	-	**5**
Italy	18	14	**4**
UK	-	-	**9**
Spain	22	21	**1**
Norway	67	55	**12**

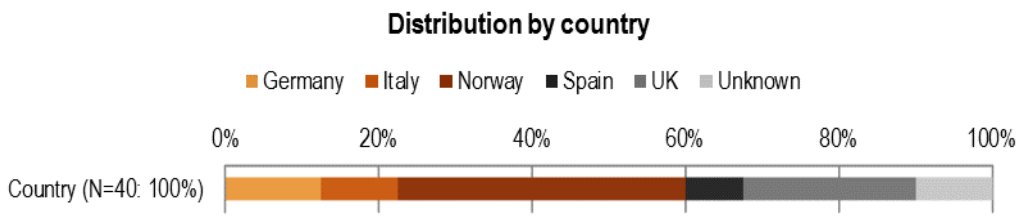


Figure 3 – *Total answered by tenants*

At present, only City Syd has a large group of tenants associated with the existing building structure. Valladolid's tenants are located in market stalls outside the building that is to be converted into a future shopping centre. The Genova case is currently operating as a supermarket and does not have a group of tenants associated with it. Only City Syd's tenants were easily accessed by email and could be sent a digital version of the survey directly. The low response to the questionnaire suggests that the tenant questionnaire should have been sent to a wider European group although feedback from tenants and owners and managers may suggests that interest in energy efficiency and sustainability issues is low amongst retailers and tenants. These two aspects suggest that even if the number of respondents to tenant questionnaire had been increased, it is unlikely that the response would have been substantially higher. To compensate for the low response the digital survey was supplemented with interviews (please see comments in the subsequent chapters).

Currently, City Syd operates as a shopping centre housing 69 stores. 67 invitations were sent to addresses provided by City Syd management, resulting in 15 responses. A number

of the City Syd email addresses were associated with owners of the chain of stores and not directly with City Syd, which may have had implications for the number of responses. The Genova Ex Officine Guglielmetti currently includes one grocery store. Therefore, 18 invitations to the addresses (provided by INRES) of tenants in other stores and shopping centres in Genova were sent to tenants in other stores and shopping centres in Genova, resulting in 4 responses. The tenant questionnaire was followed up by INRES throughout the survey period, but the response remained low. During the survey period the Mercado del Val is a 19th century iron market was not in use due to ongoing renovation plans. Meanwhile the markets tenants have their stalls in a temporary location in the centre of Valladolid. AVA provided a list of tenants and tenant organisation email addresses not specifically associated with Valladolid. 22 invitations were sent, resulting in 1 reply. Naturally, the limited number of addresses influenced the response rate. Also, it was assumed that the tenants would have a relationship with the project because of their interest in the rehabilitation the existing building, but these tenants were not accessed due to the reasons stated above.

The limited response rate associated with the tenant questionnaire indicated that it is difficult to conduct a statistical analysis of the collected data. However by combining the data from the questionnaires with the data from the interviews it is possible to show some tendencies amongst this stakeholder group which are relevant to consider, particularly in relation to decision making practices and user behaviour. The results are presented by showing percentages associated with the tenants' response, which allows for comparison between the data collected from the three different stakeholder groups. However, the reader should bear the data limitations in mind.

Customers

Getting in touch with both customers and tenants has its challenges. Customers belong to the "general public" and are not necessarily associated with shopping centres and the retail industry. Shopping is for convenience and leisure and there is no automatic link between a customer and a shopping centre; customers choose the type of shopping centre according to retail needs, location, weather conditions, habit or impulse (Woods et al., 2015). Increasing the chances of getting in contact with customers may require a researcher being on location in a shopping centre and approaching customers as they enter or leave the shopping centre. Alternatively a digital survey which sends the questionnaire to customer clubs or shopping clubs associated with shopping centres may be used. Both these methods were used in this survey. However, the choice of methods meant that the physical and social range of the survey activity was limited to three shopping centres. The use of a digital survey through customer clubs was also limited because not all shopping centres have a customer club.

Table 3 – Response to the customer questionnaire

Customers questionnaire	
Country	**Number of respondents**
Germany	**8**
Italy	**481**
Norway	**232**
Other	**13**

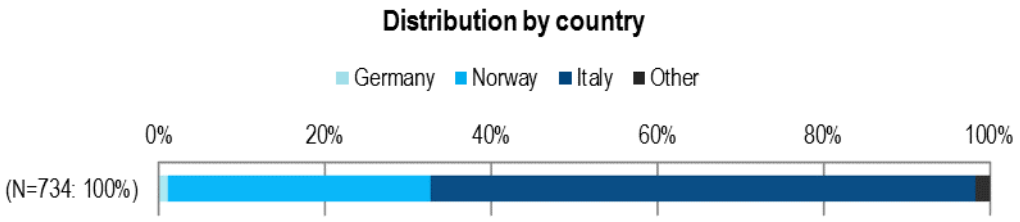


Figure 4 – Response to the customer questionnaire

The three CommON*Energy* demo-cases were the main focus of the customer survey, and two main methods were used to getting in touch with customers. In Norway the majority of responses were gathered by sending an invitation and link to the questionnaire by email. City Syd provided a random selection of 2000 addresses from its customer club address list. The City Syd representative indicated that we could expect a low response from customers, and the final result of 232 was considered a good result by both the project group and the City Syd representative. Customers were informed about the survey through the shopping centres' Facebook-page, and only one customer club member complained about the use of their email address for the survey.

In Valladolid there was no customer club and an internet survey was therefore not an option. Representatives from the Spanish partners collected some questionnaires, but the number of responses was low (4 respondents). Some interviews were also carried out in Germany. In Italy the Italian partners INRES were able to include the questions from the CommON*Energy* questionnaire in a parallel customer survey that they were also working on. This survey was carried out outside two Genova shopping centres and resulted in 481 responses. The results from this survey were included in the results of the Italian customer survey.

The results from the three questionnaires are presented in the following sections of this report as well as in reports D 2.3 and D 2.5.

2.3. Interviews

A consideration of the shopping centre environment from a stakeholders' point of view provides the background for understanding efficiencies and inefficiencies, and to derive relevant performance indicators. However, the data from the questionnaire does not give in-depth information on the respondents' motivations, personal perceptions, preferences or knowledge. Qualitative methods such as structured in-depth interviews can provide this kind of information. Whilst quantitative methods rely on numeric data, qualitative procedures rely on text and image data (Cresswell, 2009). The goal is, through direct contact with informants, to achieve a detailed description of a particular set of circumstances. Quantitative methods often assume that words or terms have universal or fixed meanings (Yates, 2004). For example it may be expected that all respondents to a questionnaire will have the same understanding of words such as energy or shopping centre, this however may not necessarily be the case. The intention by working with all three stakeholder groups, was to gain as much insight as possible on the way shopping centres function, technically and socially. In-depth qualitative interviews from a cross section of respondents were chosen as a method to gain background information about the respondent's answers to the questionnaires. In-depth interviews were also used to gather supporting data about facilities, functions and management. Where possible, issues associated with economic models, ergonomics, safety and logistics were included.

An in-depth interview is most commonly conducted face to face, although telephone interviews may also be used. An interview guide typically contains an open-ended fixed set of questions, which are ideally carefully worded to elicit a broad range of responses (Cresswell, 2009), often referred to as semi-structured interviews. Accompanying each question, the interviewer uses an available a set of prompts which are designed to steer the interview/conversation into areas of particular interest, ones which would perhaps not be raised by the interviewee. The use of a short tailored interview guide is ideal for this use. However, the close association between the questionnaires and interviews in this study has required a cross-methodological approach which involves more than just collecting and analysing data from the questionnaires and interviews. It requires using both approaches in "tandem" or in support of each other. This methodological approach is often described as "pragmatic" because it arises out of actions and situations rather than predefined conditions. A pragmatic approach focuses on what works and on solutions to actual problems. Research questions lie at the centre of the activity rather than on the implementing the ideal method (Cresswell, 2009). In a cross-methodological pragmatic approach all available approaches are used to understand the problem. When working with CommON*Energy* the intention has been to collect robust data about three stakeholder groups associated with a number of shopping centres (demo-cases, reference buildings and shopping centres outside the project have been used) across a wide geographical area. The challenges were dealt with and the intention was to solve issues in a dynamic but robust way.

The three questionnaires were used as interview guides. This was because of the aforementioned need to gather more information about the stakeholder response to the questions, and it allowed the project group to cross reference the quantitative data with the

qualitative data. The questionnaires are, as mentioned previously relatively long, this meant that the interviews with representatives from owners and management as well as tenants were often long, taking from 40 to 90 minutes. Appointments for interviews were agreed upon beforehand, allowing potential informants the opportunity to set aside time to be interviewed or to say no to the request. The interviews were audio recorded. Due to the limited length of the customer questionnaires, no appointments were made. Instead, customers were approached in the shopping centres and asked to answer the questions there and then. The number of interviews completed by SINTEF is presented in Table 4. In addition a number of interviews were completed by DSCON in the UK and Germany. These are presented in more detail in section 4.2, Table 5 (page 47).

Table 4 – Number of interviews completed by SINTEF in the UK and Norway

Stakeholder group	Norway	UK
Owners and managers	2	2
Tenants	4	2
Customer	3	0

2.4. Literature review

The different sections of the report are all, to some extent, based on literature reviews, also known as desk-top analysis, from the different subject fields associated with the aims of the analysis. A literature review discusses relevant and up to date published information in a particular subject area. A review is often used to establish whether or not a research inquiry has already been addressed previously and, if so, how it has been addressed. This allows a researcher to look at previous findings to gauge the validity of the work and its current standing, what the findings are and if new information has come to light. Information from a literature review may be used to discuss new findings and statistics, and to support new insight into the field. The literature review provides a framework for establishing the importance of the study as well as providing a benchmark or level to compare new findings with (Cresswell, 2009).

3. Identification of the Possible Influence of User Behaviour on Energy performance

3.1. Aim

The aim of this analysis is to identify the possible influence of user behaviour on the energy performance of shopping centres. The assumption is that needs, expectations and values associated with the three main stakeholder groups will affect energy consumption on a daily basis. Furthermore, it is suggested that user behaviour will influence energy efficiency in the planning of future shopping centres and during the rehabilitation and running of existing shopping centres. Achieving an energy efficient environment requires the implementation of a number of actions within the fields of facilities, functions, management and logistics. It also requires action, interest and collaboration from all the stakeholders involved in shopping centres, not just those making the decisions and defining the energy investment, but also the people working and spending money in shopping centres.

3.2. Method and Analysis

Questionnaires were developed to gather information about facilities, functions, management, ergonomics, economic models and logistics for European shopping centres. The questionnaires were also designed to gather information about energy use, and attitudes and expectations concerning energy use. Different questionnaires were directed at three stakeholder groups; customers, tenants and owners and managers. In addition, a number of in-depth interviews were conducted amongst the same three groups. The methodology associated with the three questionnaires and the in-depth interviews was described in detail in chapter 2.

An analysis of the data collected through questionnaires, interviews and observations performed at shopping centre sites is presented here. Relevant literature has been used to interpret and complement the empirical results.

Achieving customer satisfaction is the primary aim of shopping centres. Satisfied customers shop which, in turn, generates retail profits important to owners, managers, and tenants. The manager of a British shopping centre stated, during an interview, that "*Everything we do is customer driven*." However customers are possibly the least influential or involved in processes when plans are being made to implement energy efficiency measures in shopping centres. Owners and managers and tenants play a more directly active role in planning and implementation while customers influence is indirect. Results from the questionnaires and interviews which will be presented in the following sections show that there is little focus within the retail industry on customer energy use or knowledge, and there are few activities which actively aim at achieving increased engagement among customers towards increasing customer focus on energy efficiency or sustainability issues. With this in mind the analysis

starts out with the issues targeting customer knowledge, interest and expectations about energy and sustainability issues. There was a good response to the customer questionnaire in Italy and Norway. The analysis will therefore focus on this data. Tenant actions and expectations will be considered in light of the customer response. The response of owners and managers to the questionnaires and interviews will provide background to understand the analysis.

3.3. Customer Knowledge

Customers were asked a wide range of questions relating to sustainability in shopping centres. Energy efficiency and the building fabric were not the only factors considered. Customer's habits and preferences were also considered, in relation to for example transport, merchandise, thermal comfort, accessibility and architectural quality.

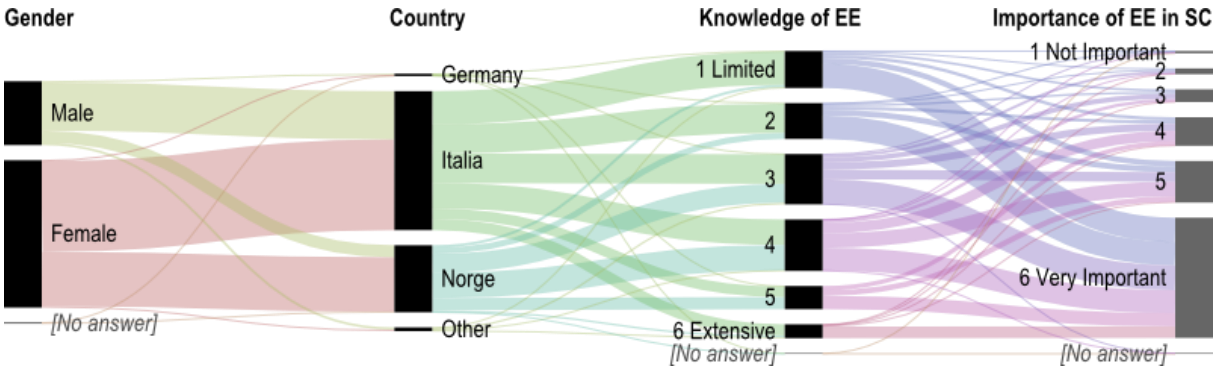


Figure 5 – Visual mapping of customers by countries, knowledge of energy efficiency (1-6) and opinion on the importance of energy efficiency in shopping centres (1-6).

70% of respondents to the customer questionnaire were female. This is related to the factor that women dominate global spending and are in the majority amongst shopping centre customers.[3] The survey shows that female respondents claimed to have limited knowledge about energy efficiency, and it also shows that men claim to have more extensive knowledge. In addition the data suggests that female Norwegian respondents have more knowledge about energy use in shopping centres than female respondents in Italy. It is difficult to generalise about the reasons for the differences in perceived knowledge about energy and sustainability issues amongst men and women, and from country to country, without conducting a separate survey since there is a danger of introducing old and outworn stereotypes. However it is important to note that the main customer group in shopping centres considers themselves to have limited knowledge about energy efficiency. Customers are not one homogenous group, campaigns aiming at increasing customer knowledge and interest in energy issues should therefore be tailored towards the needs and interests of different customer groups, such as teenagers, seniors, women and men.

[3] http://www.fastcodesign.com/1663594/women-dominate-the-global-market-place-here-are-5-keys-to-reaching-them

Representatives from John Lewis, a large British retail company, which has stores all over the UK, told us that sustainability issues were very important for the company. This was because "*Customers want to be associated with brands that are deemed to be sustainable and are looking after the environment*." They believe that they have to improve the energy use in stores because of customer awareness and that there are signs of increasing interest in sustainability issues in the retail market. However the customer survey shows that in general customers do not have extensive knowledge about energy efficiency. Two main questions arise from this, is the limited interest amongst owners and managers and particularly among tenants to retrofitting shopping centres to be more energy efficient influenced by the lack of knowledge amongst customers? And are stakeholder groups interested in changing this factor? Amongst informants interviewed, only John Lewis claimed to be influenced by customer interest in sustainability. Data from the questionnaires and interviews will therefore be used to discuss these inefficiencies associated with stakeholder knowledge and actions.

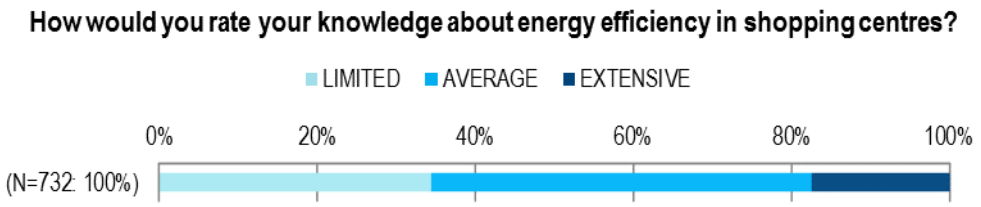


Figure 6 – Customer questionnaire. Answers to the question "How would you rate your knowledge about energy efficiency in shopping centres?"

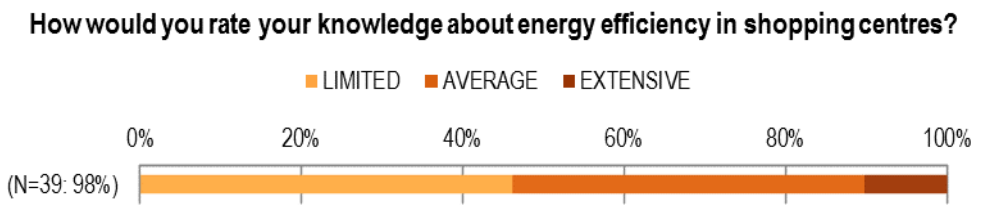


Figure 7 – Tenants questionnaire. Answers to the question "How would you rate your knowledge about energy efficiency in shopping centres?"

The questionnaire data also shows limited tenant knowledge. 40 % of customers rated their knowledge as limited, whilst over 40 % of tenants also rated their knowledge as limited, as shown in Figure 6 and Figure 7. Only 10 % of tenants considered their knowledge to be extensive. The question about which systems are already implemented in the store, suggested an energy efficiency strategy for tenants and energy efficiency strategies for customers as possible measures to improve energy efficiency. These two measures/ systems give an indication about whether there are efforts being made in stores to improve knowledge and actions relating to energy issues. Less than 10 % of tenants answered that they had an energy efficiency strategy for tenants and less than 5 % answered that they had a strategy for customers. When asked whether they had plans to apply this kind of strategy within the next 12-18 months, almost 30 % answered yes to apply a strategy for tenants and

almost 60 % answered yes to applying a strategy for customers. Customer strategies, along with installing AMS/ BEMS systems and improving the building envelope were the systems which scored highest. The results suggest that tenants see a potential in including customers in their work with energy efficiency. Another possibility is that a customer strategy is a low cost measure which is easy to apply?

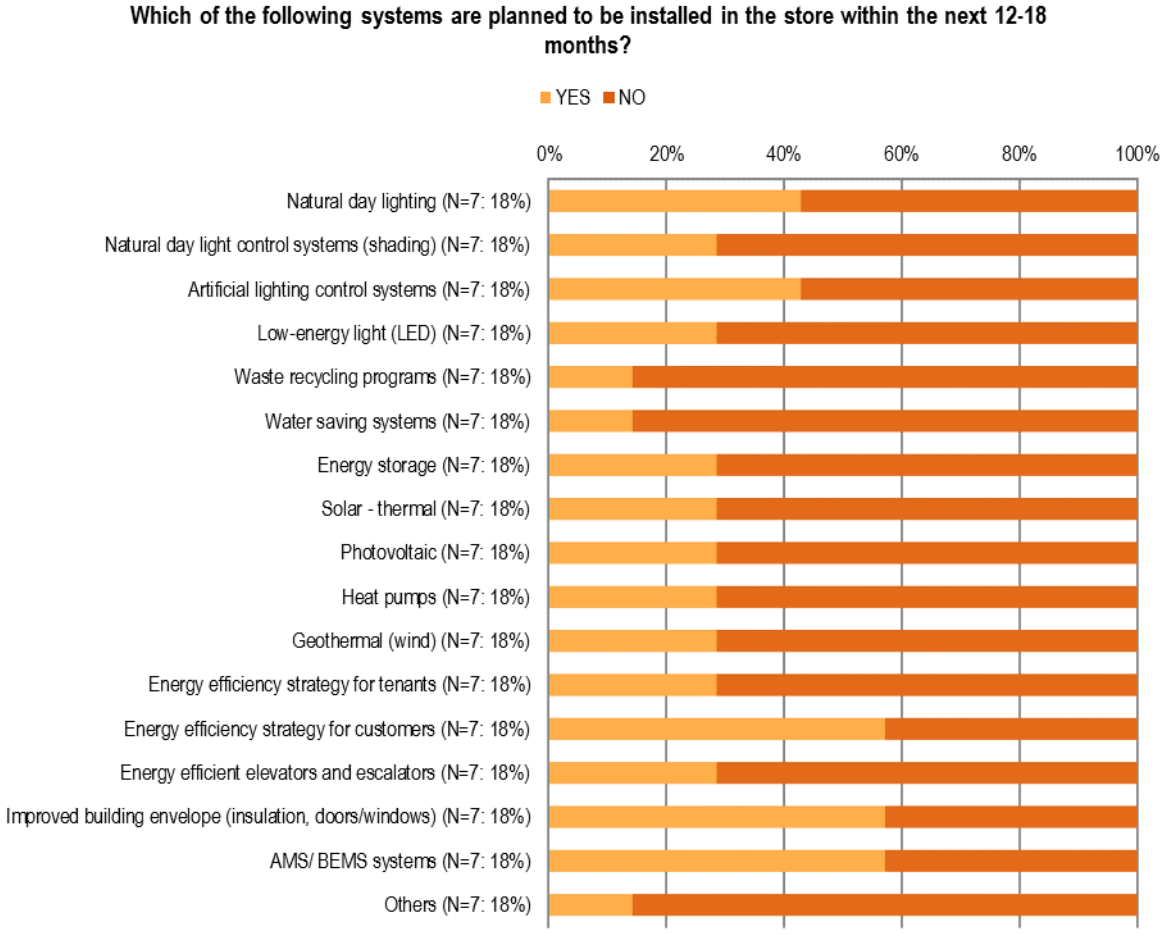


Figure 8 – Tenants questionnaire. Answers to the question ""Which of the following systems are planned to be installed in the store within the next 12-18 months?"

Owners and managers were asked the same question. More than 60 % answered that they already had in place an energy efficiency strategy for tenants, while less than 10 % had a strategy in place for customers. When asked if they had plans to include energy efficiency strategies for these two groups within the next 12-18 months, more than 70 % answered yes to a strategy for tenants, but less than 10 % answered yes to applying a customer strategy. Owners and managers therefore see the potential of including tenants in their work towards improving energy efficiency for shopping centres. The results suggest that less potential is associated with customer knowledge and inclusion in energy actions. There is little data from the interviews about what actions are taken. For example none of the four informants amongst tenants interviewed at City Syd had any experience with strategies for customers or tenants for improving energy efficiency. An owner and managers example was given by

Hammerson PLC's Head of Sustainability, who described actions on both tenant and customer levels. For tenants there are regular group meetings where environmental issues are on the agenda. Hammerson also present positive growth awards to tenants who make an effort to reduce waste, for example waste water, and the John Lewis department store at Brent Cross won the Hammerson sustainable retail award for 2013. In 2014 a sustainability roadshow will be visiting different shopping centres over nine different weekends; the intention is to highlight "*positive action for shoppers*". This action is intended to improve customer awareness.

3.4. Customer Choice

In the questionnaires, the customers were asked how important it was for them that a shopping centre is energy efficient. The customers were also presented with an extensive list of factors that can influence a customer's choice of shopping centre, and were asked to choose the five most important influencing factors for them. The factors listed ranged from location to energy efficiency, architecture, prices and so on. Customers were asked to answer "yes" or "no" to whether they were willing to accept measures like higher prices or lower indoor temperature in winters to increase energy efficiency. They were asked about the importance of product origin, the transparency and availability of "organic/bio" and "fair trade" products. Furthermore, customers were asked to rate specific shopping centres according to a long list of factors, many of which were the same as list of factors influencing choice of centre. Customers were asked what they would improve in the specific centre. Finally, customers were asked by which means of transport they usually travel to the shopping centre.

Figure 9 – Customers questionnaire. Answers to the question "How important is to you that a shopping centre is energy efficient?"

Most customers thought that energy efficiency was important, but few of them let it influence their choice of shopping centre. Interestingly, there was a distinct discrepancy between the customers rating of the importance of energy efficiency in shopping centres, and how much energy efficiency actually influenced their choice of shopping centre. On a scale from 1 (not important) to 6 (very important), nearly 80% of the customers rated energy efficiency in shopping centres as highly important (5-6). However, when asked to pick the five factors that most influenced their choice of shopping centre, less than 5% added energy efficiency to their list (Figure 10).

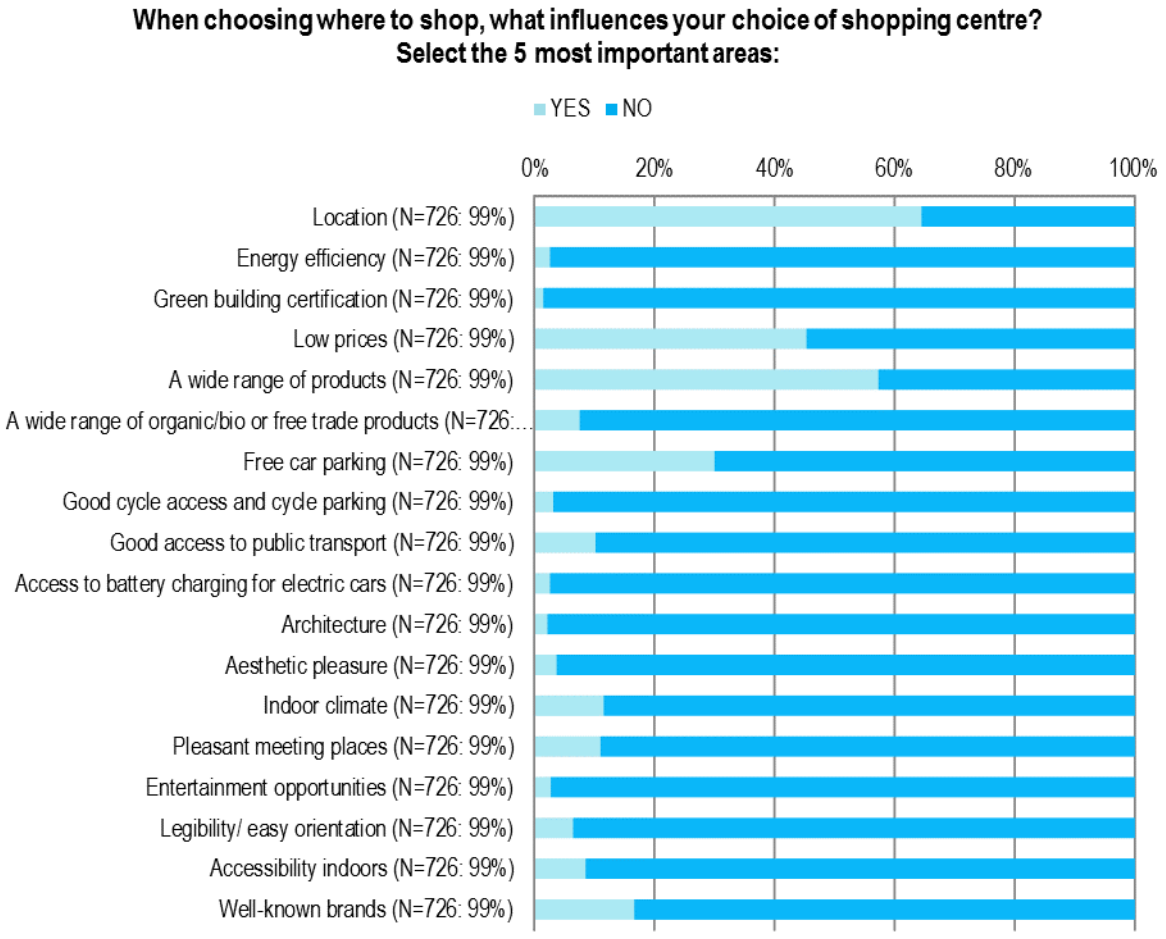


Figure 10 – Customers questionnaire. Answers to the question "When choosing where to shop, what influences your choice of shopping centre?"

3.4.1. Location, transport and shopping preference

Location had most influence on the customers' choice of shopping centre. Over 60% of customers agreed that the location of the shopping centre influenced their choice (Figure 10). Furthermore, all factors in the list associated with location and transport scored relatively high in the customer's selection of the five most influential. Free car parking and good access to public transport were chosen by many. Norwegian customers in particular rated free car parking as factor that influenced their choice of shopping centre. When asked how they usually travel to shopping centres, over 70% answered "car/motorbike" (Figure 11). The answers to the questions related to cycle access and cycle parking suggests that this area is not so important to the customers, and very few used bicycles as their main means of transport. There are some differences between countries. Over 80 % of Norwegian respondents said that location was the most important. 53 % of Italian respondents replied that location was important. So although location was the most important factor for Italian customers, it is not as important as it is to Norwegian customers.

The Norwegian customer survey was carried out by members of the City Syd customer club. City Syd is a suburban shopping centre which serves a broad catchment area. Shopping is primarily car based and there is free parking. There is bicycle parking which serves the local community, but the majority of customers drive to the centre and this is supported by the results from the survey. The customer survey in Italy was carried out outside two shopping centres in suburban areas outside Genova and car based travel is also important. Customers are looking for locations which are easily accessible, particularly by car. A town centre survey would potentially have gathered a different response with regard to the means of travel, however we may surmise from its dominance within the existing survey, that location would still be an important factor.

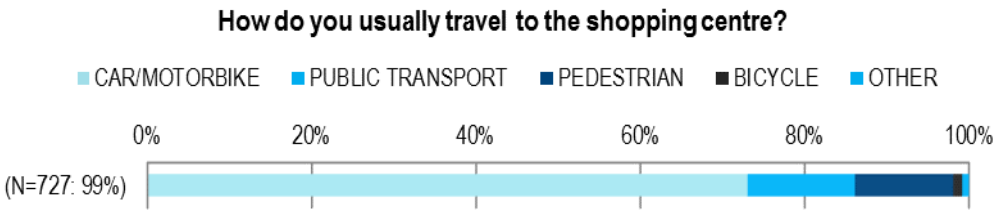
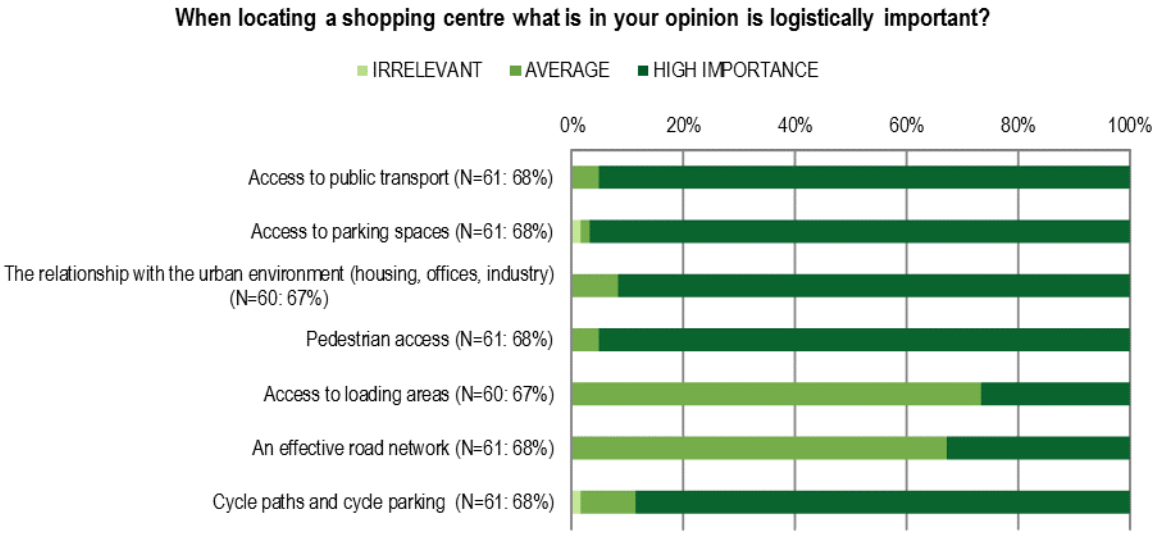


Figure 11 – Customers questionnaire. Answers to the question "How do you ususally travel to the shopping centre?"

The need for more parking spaces scored low in both the tenant and owners and managers questionnaires when they were asked to select the most important areas to be addressed when considering upgrading the shopping centre. Less than 20 % of tenants proposed this as a reason and under 10 % of owners and managers. However the centre manager at City Syd which experiences pressure on parking spaces during peak periods, such as around Christmas and Easter, rated increasing the number of parking spaces as one of the most important factors. This correlates with the customer's interest in free-parking at City Syd (See also Figure 10).

Figure 12 – Example of parking area at City Syd, Trondheim, Norway [4]

However the response of owners and manager to the question, "when locating a shopping centre what is in your opinion is logistically important?" suggests that they are more interested in the question of parking than the general response to the previously mentioned question implies (Figure 13).



[4] http://commonenergyproject.eu/uploads/lib/image/image/18/Norway_present.png

Figure 13 – Owners questionnaire. Answers to the question "When locating a shopping centre what is in your opinion is logistically important?", limited extensice focusing on accessability issues

Access to public transport and pedestrian access score high when locating a shopping centre, but access to parking spaces scores higher, over 90 % rate it as important. It is therefore suggested here that customer interest in car-based shopping influences the development of new shopping centres, although it is not a driving force in the upgrading of shopping centres. The future of sustainable shopping needs to be less car-based. The challenge is to encourage all three stakeholder groups to reduce their focus on car parking and shopping by car.

3.4.2. Product availability and price

Close to 60 % of the customers agreed that a wide range of products influenced them in their choice of shopping centre (Figure 10). Norwegian and Italian customers both rated this as having a high importance, almost 50 % of Italians and close to 60 % of Norwegians. Again the use of City Syd as a case for the customer survey influences the response to the questions. City Syd is popular amongst its customers because it allows an *one stop shopping* (Woods, 2012). A wide range of products from food and clothing to hardware and pharmacy products, and veterinary services are available to the customer during one shopping trip.

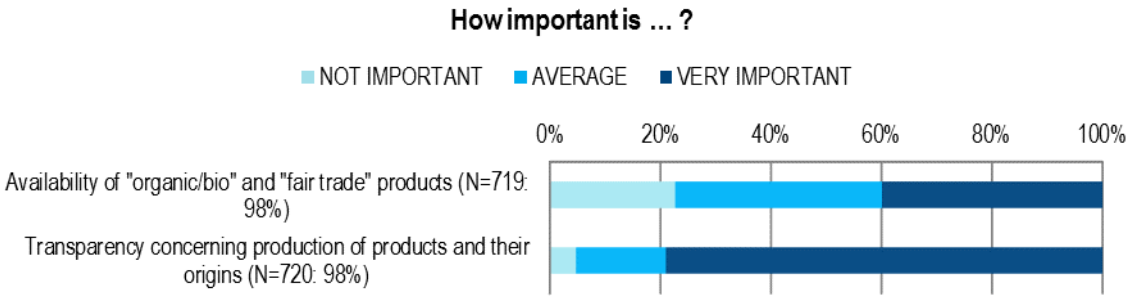


Figure 14 – Customers questionnaire. Answers to the question "How important is…?"

The importance of product availability was also supported by the fact that almost 20% of the costumers answered that well-known brands were among the five most important for their choice of shopping centre. A store manager in the UK suggested that customers are more interested in the price of goods, than they are in energy issues, but that they are also becoming more aware of product origins. However despite the suggested interest in the UK, few customers in Norway and Italy put the availability of organic/bio and fair trade products on the list of five most influential factors for choice of shopping centre. The response in Italy and Norway was similar, under 10 % in both countries. However when asked in a later question about the importance of access to bio/organic products and product origins when

doing their shopping in the shopping centre, both aspects rated much higher and, 40% answered "very important" (Figure 14).

The response to this question was different in Norway and Italy. More than 50% of Italian respondents rated availability of bio/organic products as very important (in Norway less than 20 % rated it as very important) and more than 90 % suggested that product origins were important (less than 50 % said this in Norway). The sale of organic products has struggled on the Norwegian market, although the Norwegian Ministry of Agriculture and Food has a on-going focus upon increasing the availability of organic products and their share of the market (Gibalova, et al., 2010)[5].

The third most popular factor on the list of five influential factors, were "low prices". When asked if they would accept a higher price for a product sold in an energy efficient store, 21% of the Norwegian customers and 45% of the Italian customers answered "yes". Price has traditionally influenced our shopping habits, but consumer response to price is based on an evaluation of the products benefit or utility, which also corresponds to their notion of value (Kyoung-Non & Schumann, 2001). Price is therefore not the only factor which influences shopping habits and the value placed on purchases, and this therefore allows for the possibility of paying more for a product sold in an energy efficient store.

Tenants were asked about the importance of sustainable products when aiming to achieve a sustainable retail environment. More than 70 % rated this as an important factor. Only accessibility (almost 80 %) and recycling systems (80%) scored higher. Owners and managers were asked the same question, and less than 25 % rated sustainable products as very important. Investment in energy efficient technology was considered the most important aspect, although recycling rooms and energy efficient shopping centres were also considered important (see Figure 15). It is suggested here that tenants have more direct contact with customers than shopping centre owners and therefore they prioritize directly serving the customers everyday needs. Shopping centre owners and managers are also interested in customer needs, but work in an indirect way considering physical needs and practical managerial issues, rather than consumption and products.

[5] http://www.regjeringen.no/nb/dep/lmd/dok/regpubl/stmeld/2011-2012/meld-st-9-20112012/6/5.html?id=665092

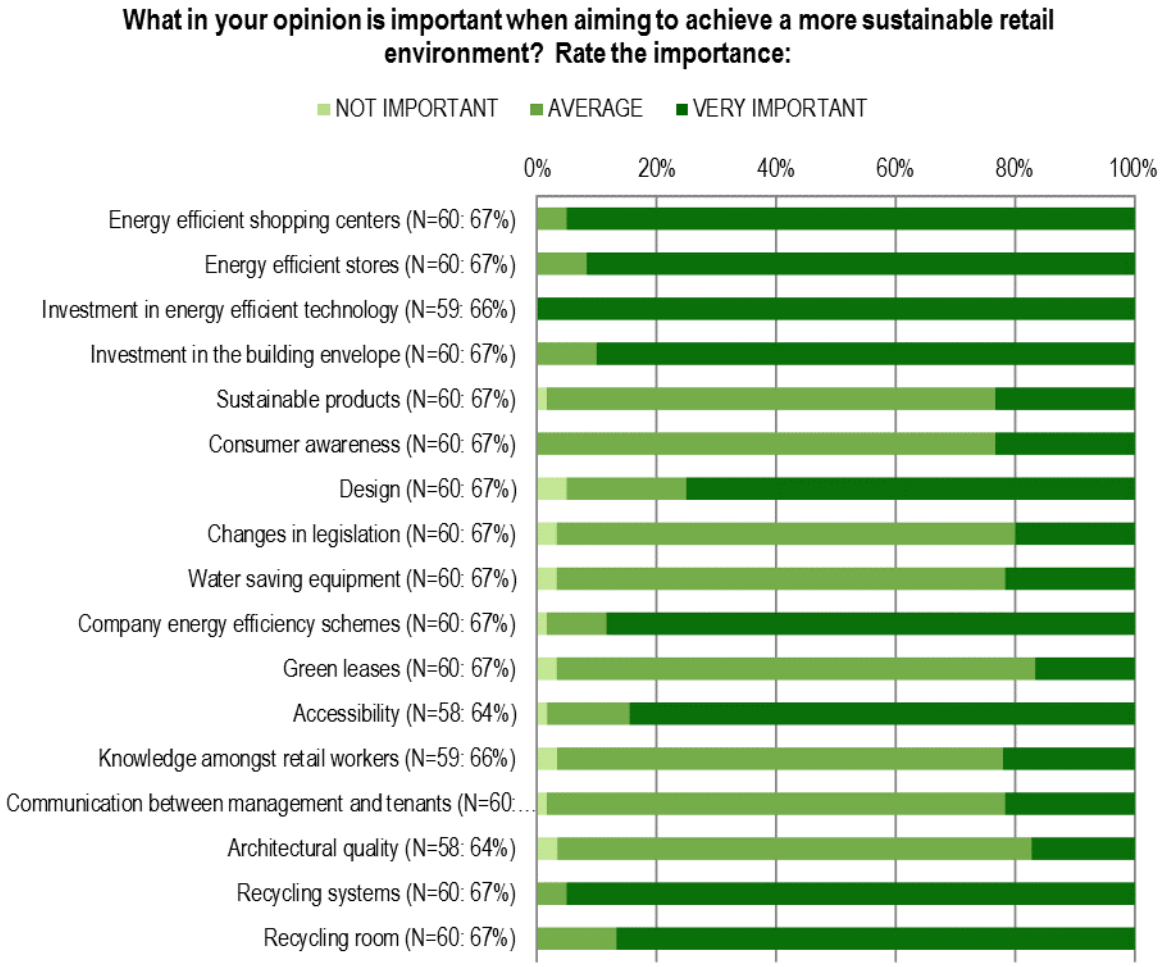


Figure 15 – Owners questionnaire. Answers to the question "What is in your opinion is most important when aiming to achieve more sustanable retail environment?"

3.4.3. The role of the physical environment

Customer response to the physical environment is important when considering an energy efficient upgrade, because although management systems such as BEMS and AMS are important in an upgrade, changes to the physical environment may be expected and this may have implications for eventual customer satisfaction. Customers were asked to rate the existing shopping centre in terms of a number of physical and environmental aspects, lighting, acoustic comfort, thermal comfort, user friendly design (ergonomics and logistics), meeting places, architecture and design, and aesthetic quality (Figure 16). The results show that only accessibility and organisation (logistics) score high amongst respondents. Customers were least content with the thermal comfort and meeting places, less than 50 % stating that the shopping centres were very good. Although only under half were dissatisfied, the response does point to a pressing need for improvement in these areas. In general customers in both Norway and Italy were satisfied with the physical environment associated with the three shopping centres who participated in the survey. As mentioned earlier car parking and the range of products are critical factors. Improving energy efficiency in

shopping centres has implications for the physical environment; therefore increasing customer awareness/ expectations about the physical environment in shopping centres is relevant. Satisfying shopping centre customers has the potential to be about satisfying their sustainability requirements.

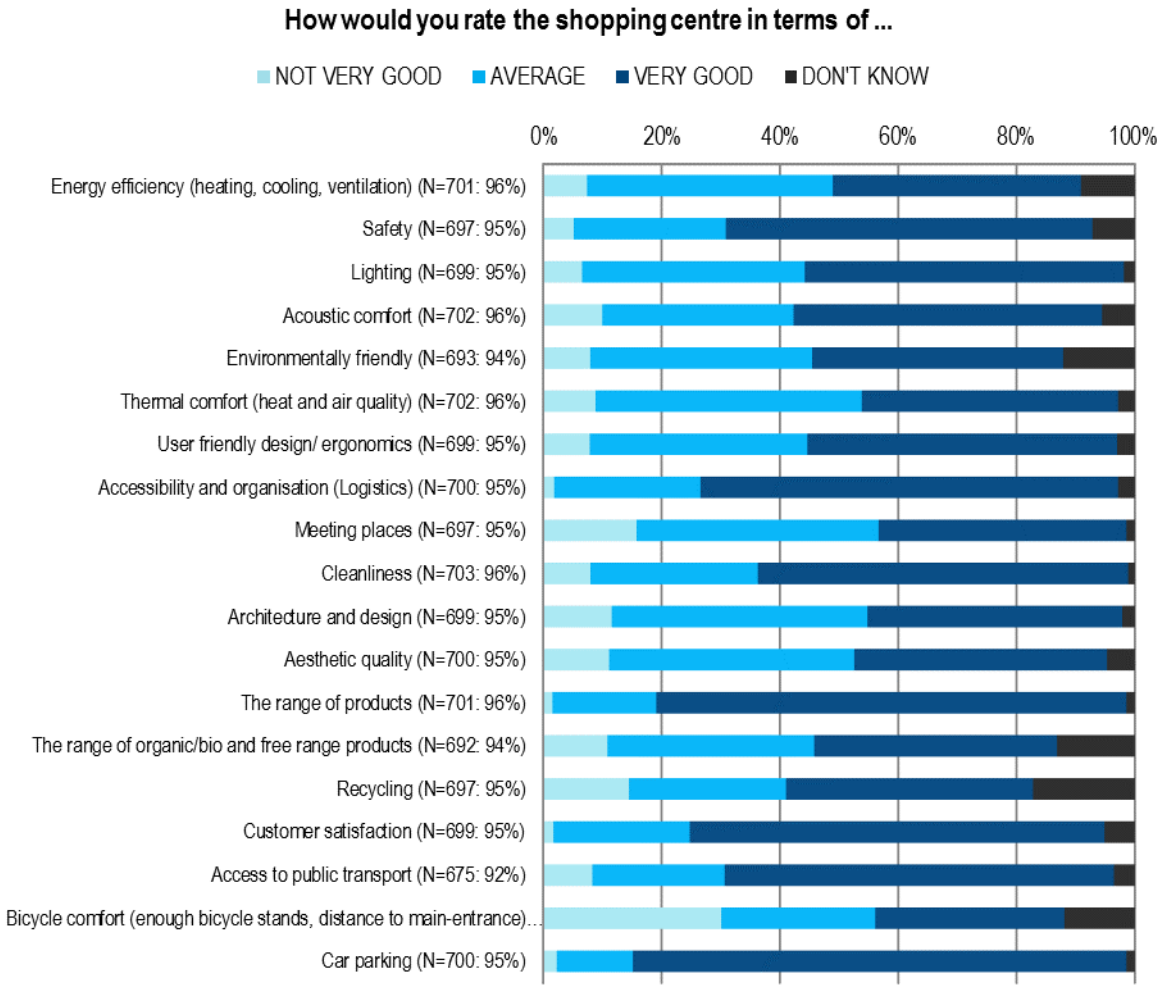


Figure 16 – Customers questionnaire. Answers to the question "How would you rate the shopping centre in terms of…?

Architecture and design also received a lower rating, with less than 50 % stating that this aspect was very good. Shopping centres are not often associated with architectural or aesthetic quality (Woods, 2012). Although according to the results from the owners and manager questionnaires shopping centre managers' place a great deal of importance on architectural quality. The managers were asked about the most important areas to be addressed when considering upgrading the shopping centre. In the questionnaire, the managers chose the five most important areas out of 19 possibilities listed in Figure 17. The majority did not choose "cost", which was unexpected based on the results presented in Figure 15. Customer satisfaction, architectural quality and reduced energy demand, were proposed as areas of importance. Amongst tenants architectural quality was not considered

such an important factor with less than 40 % choosing it as one of the most important areas. Thermal comfort (almost 60 %) and customer satisfaction (almost 70%) were regarded as the most important.

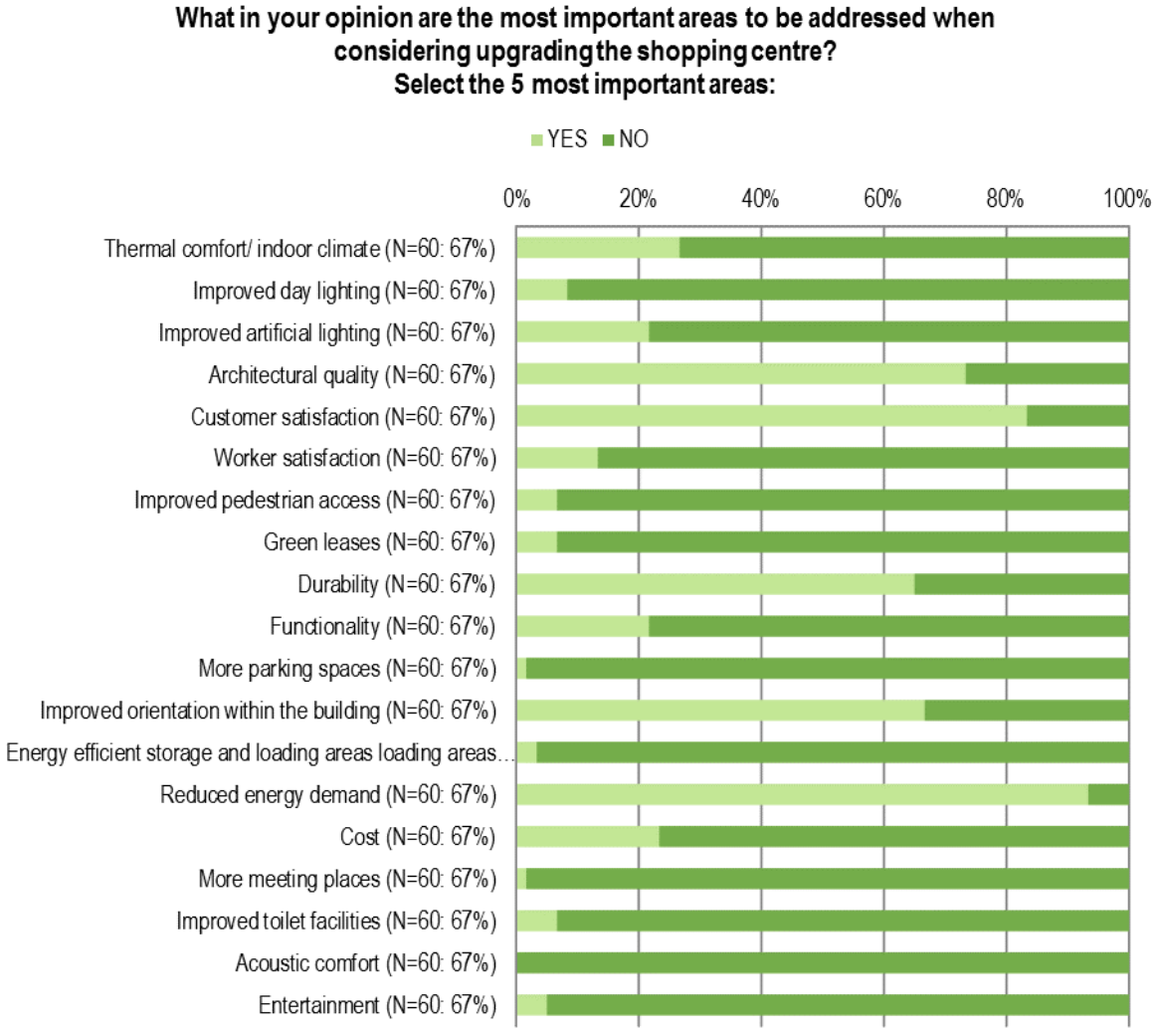


Figure 17 – Owners questionnaire. Answers to the question "What is in your opinion are the most important areas when considereing upgrading the shopping centre?"

3.4.4. Thermal comfort

When considering energy efficiency in shopping centres, there is a greater willingness amongst customers to accept lower temperature in winters and higher temperatures in summer than to accept higher prices (Figure 19). In fact, 87 % of the customers would accept lower temperature in winters, and many also suggested this in their comments, stating that they would wear their outdoor clothing inside the shopping centre. Interestingly, tenants were much more reluctant to lower winter temperatures in the shops (50 %), but more forthcoming in the common areas (Figure 18). It is questionable if they regard

maintaining the current temperature level in winter as important for their customers or for their own comfort. The majority of tenants interviewed at City Syd were positive to the idea of reducing temperatures in the summer and they also saw the benefits for customers of reducing the temperature during the winter. Customers are often more warmly dressed during the winter and struggle in high indoor temperatures (Figure 19). However one informant amongst the tenants commented that it "*was worse if you were working*" if the temperature was low, and that employees in shops located near entrances and in common areas find lower indoor and outdoor temperatures during the winter a problem. Although customer satisfaction in shopping centres is of primary importance, thermal comfort should also take tenants requirements into account.

66 % of the customers state that they would also accept higher indoor temperatures in the summer, but in this case a significant difference can be noticed between the countries (respectively 79 % in Italy and 43 % Norway). It is unclear why there is such a difference in the response between the two countries, but it is suggested here that Italian customers are going into shopping centres from a warmer outdoor environment and this affects their indoor expectations. Tenants were in general much more sceptical to changing temperatures in shopping centres, and particularly sceptical to temperature increases (see table below). Several of the tenants interviewed mentioned that they receive customer complaints when customers are too warm. A tenant in a UK shopping centre said that "*Higher temperatures in the summer would lead to customers being irritable.*" The implication is that higher indoor temperatures would reduce customer satisfaction, something that both owners/managers and tenants wish to avoid.

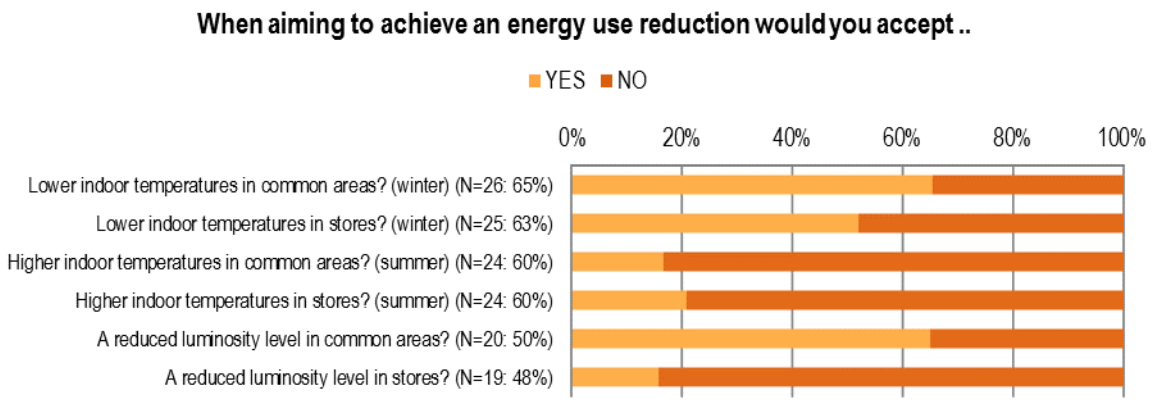


Figure 18 – Tenants questionnaire. Answers to the question "When aiming to achieve energy use reduction would you accept…?"

The use of lighting in stores and shopping centres also has implications for customer satisfaction. The willingness amongst customers to shop in stores less brightly lit is high (73 %), and in this case Norwegians were slightly more inclined (85 %).The results are discussed further in chapter 5. Lighting was an issue which harvested the greatest number of personal comments during the gathering of questionnaire data. Customers would prefer

stores to be less brightly lit for two main reasons, firstly they believe it would help to reduce the in-store temperature, secondly they suggest that a reduction would improve visual comfort. The reasons for the customer interest in reducing light will be discussed in the section about lighting in shopping centres.

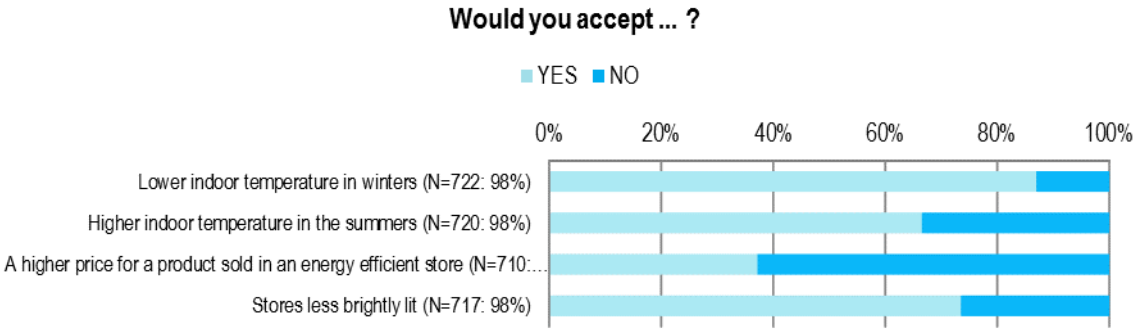


Figure 19 – Customers questionnaire. Answers to the question "Would you accept…?"

3.5. Tenant behaviour

As mentioned in the introduction to this chapter the focus is on customer behaviour. However there are a number of aspects particularly relating to tenant behaviour which are a source of inefficiencies and if dealt with effectively, would encourage substantial reductions in energy use.

The billing system in shopping centres is one of the sources of inefficiencies. As mentioned in the methodology section the tenant questionnaire struggled with a low response rate for a number of reasons. We have already suggested that this was caused by the limited knowledge about energy issues among tenants and the length of the questionnaire. Another aspect which also influenced the response by tenants is access to information about energy use. This aspect was mentioned by owners and managers and by tenants during interviews, and it relates to how tenants are billed for their energy use. A retail manager working in a store selling perfume and cosmetic products in a British shopping centre explained that they receive monthly graphs which present the shopping centres energy use. These are compared with the year before. There is no further information about the actual in-store energy use. The store's energy use is paid for by a basic service charge "*there is no way we can find out exactly how much we use or if we use less or more than last year. The shopping centre doesn't know either because it is not an individual account. The bill is calculated in an order that gives the tenant a set amount every month for payment*." They were therefore unable to give an answer to for example the question "Approximately how much of the total energy use in kWh per year provides, heating, cooling, lighting and ventilation" or suggest what the total in-store energy use is. There is no diagram for this question because only 2 tenants answered this question and the data they provided is incomplete. It is suggested

here that limited information on in-store energy use will also limit the interest in reducing in-store energy use. However there are constraints with regard to what tenants can actually do alone to reduce energy use. The lack of natural daylight in most stores means that they are unable to turn off the lighting and thereby achieve a reduction in energy use in relation to providing light, reducing in-store temperature and reducing the need for cooling. Knowledge is therefore not the whole answer. However changes in the billing system allowing insight into actual energy use over the whole year, along with actions to improve knowledge about energy use and sustainability issues could potentially improve the impact of a shopping centre retrofit.

The results from a question which aims to identify the main barriers against in-store energy efficient upgrades indicate that economy is an important issue for tenants (Figure 20). This supports the suggestion that a more detailed billing system would interest shopping centre tenants. In addition, based on the importance placed upon these issues by tenants, it would be useful to explore the implications and potentials associated with pay-back time and the relationship with the overall costs necessary while carrying out an energy efficient upgrade. Hammerson PLC use a system of forward funding when redeveloping common areas in their shopping centres. Actions are paid for out of the service charge after implementation. This has proved a positive incentive in the Hammerson shopping centres were the system has been tested.

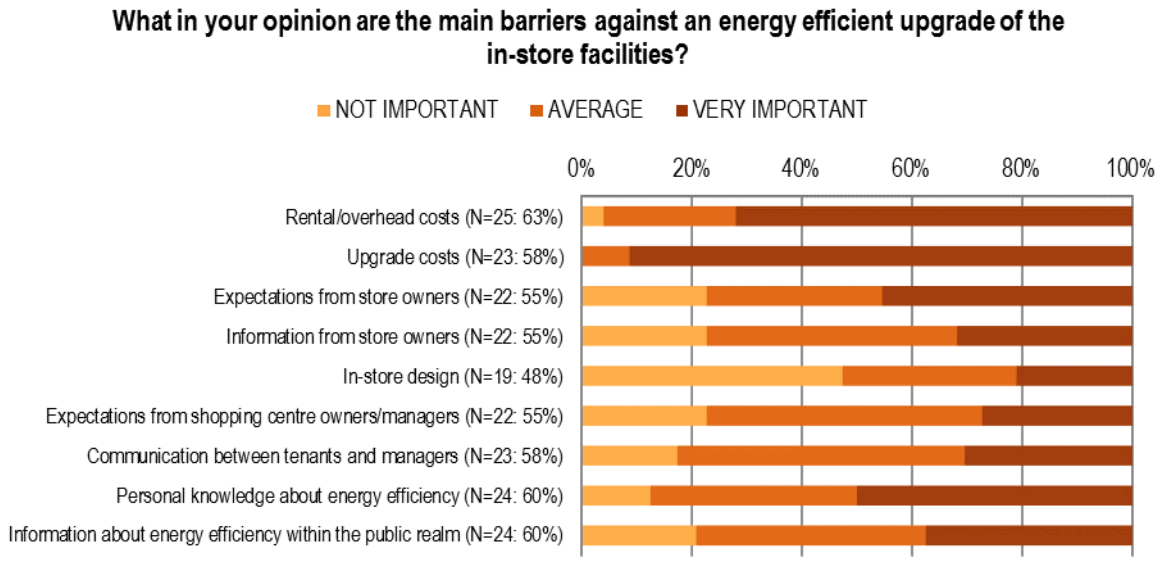


Figure 20 – Tenants quastionnaire. Answers to question "What in your opinion are the main barriers against energy efficient upgrade of the in-store facilities?"

However inefficiencies and actions relating to the billing system or pay-back time do not just depend on willingness or unwillingness among tenants. They also depend on support among owners and managers to implementing the same systems.

3.6. Management behaviour

The term "managers" here includes the stakeholders that are directly involved in the management of the shopping centres, titled as owners, managers, and developer or similar. A major aim for owners and managers is increasing the attractiveness of the shopping centres that they are working with, providing amongst other things sales maximization for tenants. Improving attractiveness and sales maximisation dominates all strategic, tactical and management issues. Shopping centre attractiveness affects the price of rental spaces and how effectively the shopping centre is able to get its tenants to cooperate in marketing efforts (Teller, 2008). As mentioned earlier the manager of a British shopping centre maintains that everything they do is customer based. Sustainability for this informant was an important issue, but it had to be understood in relation to what is the main issue in shopping centres which is giving "*the customer what it wants*." The efforts shopping centre managers in general make towards energy efficiency will therefore be closely associated with their continued efforts to encourage and improve the attractiveness of the shopping centre both for tenants and customers.

3.7. Summary

The customer survey established that there are three main areas where inefficiencies connected to user behaviour on energy efficiency in shopping centres may be found. These are customer knowledge, customer choice and the role of the physical environment.

Customer knowledge or lack of knowledge is an important factor to be dealt with if shopping centres are to gain approval for actions associated with energy efficiency issues, or if customers are themselves going to demand energy efficient shopping centres. A representative from John Lewis suggested that customer engagement and staff awareness were the most important factors when aiming for in-store reductions in energy use, "*You need to tell people what you are doing, if you are going to get them to buy into it. Otherwise they are just going to think that it is very dark and cold* (in the store)". It is unclear how customers could actually reduce energy use when visiting a shopping centre, but their interest in energy use and sustainability issues has the potential to influence owners, managers and tenants. Without a customer demand there will be less interest in investing in energy retrofits in shopping centres. However, as with many other retail factors, it is the market, in this case shopping centres which creates the demand. Therefore when working towards energy efficient shopping centres owners managers and tenants should also work at increasing customer focus on these issues.

Customer choice - transport and shopping preference, product availability and price Energy efficiency does not influence customer choice of shopping centre. Location is the most importance factor influencing customer choice of shopping centre. This is closely associated with the importance customers place on car-parking. Customer's in the survey shop primarily at suburban shopping centres which are convenient to reach by car. However car dependence does not support sustainable shopping, and this may be understood as an

inefficiency associated with user behaviour, it is not directly associated with the retrofitting of the physical structure of shopping centre which is the primary focus of the CommONEnergy research, but it should considered when working with a broader issue of sustainable shopping centres.

A wide range of products and the price of products also influenced a customer's choice of shopping centre. Customers are less focused on the availability of organic/ bio and free trade products. They do believe that these are important factors when aiming to achieve a sustainable retail environment, but it did not significantly influence their choice of shopping centre. Tenants however placed emphasis on the availability of more sustainable products, they believed that their availability will in the future influence shopping habits. As with car-based shopping, this aspect does not directly relate to retrofitting the physical structure of the shopping centre, but it does point to the level of interest amongst shopping centre customers about sustainable shopping, which in turn has the potential to influence those making the decisions in shopping centres.

The role of the physical environment - thermal comfort. Customers are in general satisfied with physical environment in the shopping centres where the surveys took place. They were not exceptionally critical of, for example the aesthetic quality, meeting places or acoustic comfort. Owners and managers placed much more importance on physical structure, for example architectural quality ranked as highly as customer satisfaction and energy efficiency when suggesting the main reasons for a shopping centre upgrade. Tenants placed focus more on customer satisfaction than on the physical structure. Tenants were critical of the thermal comfort in shopping centres, as were customers. Where the physical framework directly encroaches on their physical comfort or the perceived functionality of the place, both tenants and customers were more critical and were more aware of inefficiencies in the physical environment. In addition customers were willing to accept changes to the heating and lighting systems in order to save energy, even though these measures would have a negative influence on their physical comfort. They were positive to the suggestion that temperatures could be changed (lower in winter, higher in summer) and that lighting levels could be reduced. Tenants did not want these kinds of changes; the suggestion is that these aspects would negatively influence customers comfort and attitude towards the shopping centre. Energy efficiencies will therefore be more easily achieved if there is acceptance on three stakeholder levels.

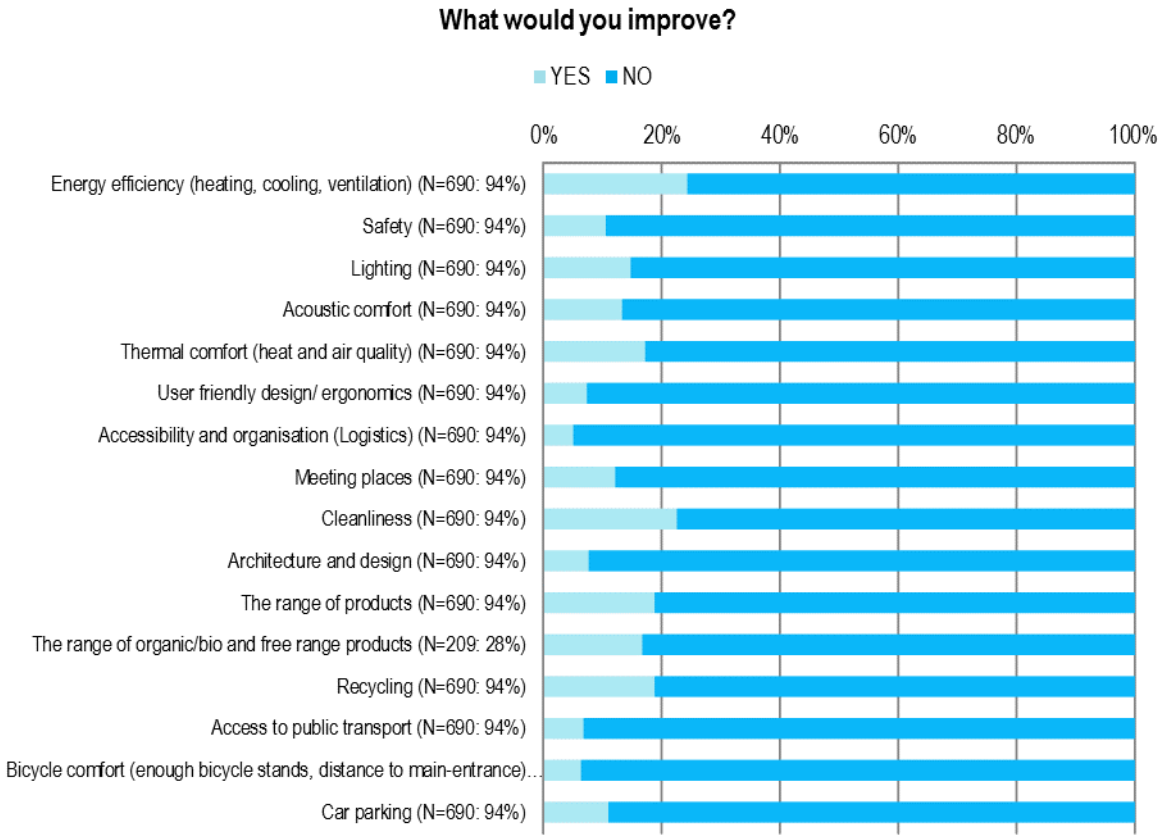


Figure 21 – Customer questionnaire: Answers to the question "What would you improve?"

In general customers are satisfied with the shopping centres where the surveys took place. Besides customer satisfaction; safety, logistics, the range of products, access to public transport and car parking received the highest ratings. Most of these aforementioned qualities are also highly appreciated by customers when choosing where to shop. When it comes to architecture and design related considerations, including aesthetic quality, meeting places and thermal comfort (heat and air quality), reception is slightly more mixed, with ratings on the average (3-4) in the same magnitude as very good (5-6). Some customers (at least 10 %) were also less impressed with the current bicycle comfort, recycling and the range of organic/bio and free trade products at the shopping centres. In addition to the general environmental friendliness of the shopping centre, these also stand out as areas, which customers find difficult to assess (meaning at least 10 % chose "don't know" when asked for an assessment). This result implies that a shopping centre is more than what is directly perceivable to each customer and that a fair judgement of i.e. recycling, energy efficiency or environmental friendliness requires more insight in the day to day operation of the centre and behind the scenes management. It also suggests that an environmental friendly profile is not being communicated to the customers.

An aspect which comes across through the results from the survey is the difference in the knowledge, expectations and understandings of the three stakeholder groups. This is to be

expected, they have different roles and interests in shopping centres. However it is suggested here that greater communication between the three stakeholder groups, enhancing knowledge about energy efficiency and common understandings would reduce the inefficiencies associated with user behaviour in shopping centres.

The results show that customers are generally satisfied with the centres which were included in the survey (City Syd in Trondheim, Valbisago and Aquilone shopping centres in Genova) and do not necessarily see a need for improvements, but at the same time they are also keen to improve the energy efficiency of the shopping centres and that this is one of the aspects where they saw the greatest possibility for improvement.

4. An analysis of the Decision making Structures for Owners and Tenants

4.1. Aim

The main aim of this task is to gather information about management requirements concerning energy efficiency in shopping centres. Furthermore this task focuses on gathering information about whether tenants are willing to take the consequences and thereby increase energy efficiency in shops and how far they are willing to go. In addition the task also shows the advantages of energy efficient shopping centres amongst stakeholders, which will encourage them to become involved in decision making related to energy efficiency activities. Two different points of view were compared; the interests of the owners whose goal it is to increase property values and tenants who want to minimize rent and ancillary rental costs. The main common goal shared by the owners and the tenants is maximizing the customer experience during their stay.

4.1.1. The operational level – facilities management

Energy efficiency in shopping centres will help reduce operational energy and thereby the costs of running a shopping centre. However, cost savings cannot be looked at separately without considering the gain in value. Awareness amongst stakeholders of the extent to which value for money can be improved by facilities management, may not be present. This suggests that it is not the final outcome that needs to be examined, but the decision-making that leads to it and the assumptions it is based on. Organisational decisions and real economic ownership refer to decisions that are made, such as investment and resource allocation, while decisions concerning more direct operations are dealt with by a day to day management. An organisation's business plan when combined with its space strategy embodies the goals of an organisation and makes clear what is needed to support and enhance its performance (Atkin & Brooks, 2009).

During the last forty years a large number of the buildings used in the retail trade have been maintained, serviced and cleaned without considering aspects other than cleanliness that may influence the attractiveness of the centre. Few common facility management procedures have been in use. More innovative organisations, such as the media sector and banking have devised effective ways of managing their buildings. There has been a rise in the service sector targeting facility management. Facility management has evolved into a new professional discipline with its own codes, standards and technical vocabulary (Atkin & Brooks, 2009). It is a management system that is conducive to carrying out the organisation's primary operations, allowing for an integrated view of the services infrastructure, and using this to deliver customer satisfaction and the best value through support for and enhancement of the core business. This kind of management system will enhance the organisation and thereby:

- Supply effective and responsive services

- Make the physical assets highly cost effective
- Allow for future change in the uses of space
- Provide competitive advantage to the organisation's core business
- Improve the organisation's culture and image

One important issue in Facilities Management is how to plan, develop, manage and use space. The main focus in Space Management is how space may support the core businesses and their performance, and how the spatial resource can be used efficiently (Blakstad, *et.al* 2010). Space Management in facilities management is based as much on the measurement of the ongoing effectiveness of the work environment, as it is on the provision of space based on the assessment of future business needs (McGregor & Then, 1999). Measurement is vital when assessing performance.

> *A key performance indicator (KPI) is a measure that provides essential information about the performance of facility services delivery* (EN 15221-1:2007).

In their literature review, (Loosemore et al., 2001) found that the main KPIs that have been derived for application in Facilities Management are related to costs of operating, maintaining and running a facility, revenue generated, space management, and environmental and safety issues. Since the 1980s, facility management associations (e.g. IFMA since 1984) have engaged in developing generalised sets of data and industry-wide KPIs to enable external benchmarking. Previous studies show that the most frequently used measures in facilities management are related to occupancy cost and operational space (Massheder and Finch, 1998). These studies highlight the need for specific standards of measurement, metrics, as essential for ensuring a common understanding of performance and for identifying performance gaps, for categorisation of life cycle costs and for the measurement of space. The terms gross and net area, as well as usable area (net usable area), are defined in the standards. This is in line with definitions applied in benchmarking networks, e.g. the Danish FM (Jensen, 2008).
In EN 15221-1:2007, benchmarking is defined as the process of measuring performance (including price) of facility services, and comparing the results internally and/or externally. Benchmarking is a tool which can be used to support a process of continual improvement (e.g. Atkin and Brooks, 2009). In most cases, benchmarking of space focuses on square meters, but in cases of more advanced benchmarking, and for the purpose of research, there are additional measurements that may be used, related to space and occupancy:

- Categories of types of space and rooms
- Data of occupancy (use of different space categories or rooms (occupation / time), churn rate, booking)
- Occupancy or space related costs (such as cost / move, cost / workplace, etc.)

4.1.2. The shopping mall – a market place

Shopping centres represent important arrangements for customers, tenants and landlords because of their size and format (Musa and Pitt, 2009). The shopping centre industry has evolved from smaller shopping centres and been through considerable innovation, wherein new formats have been instigated for example regional shopping centres, retail warehouses or retail parks and outlets (Musa and Pitt, 2009 with reference to NRPF, 2000).

The centre should provide attractiveness through architecture, aesthetics, form, and fashion in order to promote and encourage identity among tenants and customers. Hence, it is important to identify the different aspects of shopping in the experiential economy (i.e. Marling and Zerlang (2007), Klingmann, 2007) that have an impact on decision making processes and become drivers or barriers. In order to increase the amount of green shopping centres, an identification of the drivers and barriers among owners and managers will increase the understanding of the decision making structure that may have an impact on environmental goals, priorities and choices. However, there is not much research or theory developed about the management of shopping centres and decision making related to environmental goals (Eichholz *et. al*, 2005).

In a study from Academy of Management about factors that make impact on tenants in commercial buildings and their choice to rent green, four factors were identified. The factors influenced the environmental decision-making with respect to corporate space-leasing decisions (Eichholz *et. al*, 2005). The first factor is that the occupancy of a low-energy building can be economically profitable because of lower operating costs. The second factor is that a green corporate headquarter may act as a signal. The third factor is that by accepting the highest legal environmental standards now, firms can anticipate future legislation. The last factor is that there is a distinct group of potential tenants with non-profitable interests.

According to Klingmann, architecture can be used as a strategic tool for economic and cultural transformation (Klingman, 2007). Branding architecture means the expression of identity, whether it be a commercial enterprise or a city; New York, Paris, Bilbao and Shanghai have all used architecture to enhance their images, to generate economic growth, and to evaluate their positions in the global village. Klingmann (2007) also points to the dangers of brandscapes, claiming that by favouring the creation of signature buildings over more comprehensive urban interventions and by severing their identity from the complexity of the social fabric, today's brandscapes have, in many cases, resulted in a culture of the copy.

4.2. Method

The applied method for gathering information about management requirements concerning energy efficiency in shopping centers is associated with the method that has been discussed in section 2. The chief source of information is the analysis of the web based questionnaire

that has been distributed by SINTEF to the previously described shopping centre stakeholders: owners, managers, tenants, and customers. Knowledge about the needs and views of the relevant stakeholders is necessary to be able to develop energy efficient solutions which stakeholder's are satisfied with. The three groups were chosen because they provide a framework to understand the day to day activity in shopping centres.
The invitation to participate in the questionnaires was conducted centrally. The reaction to the invitation to participate in the owners and managers questionnaires was unsatisfactory, except in Norway. After a few reminders DScon proceeded to find more potential contacts that could participate in Germany. The focus was on Germany because DScon had most contacts to shopping centres in this country. There was, unexpectedly, low interest in cooperating with the project from large management companies in Germany. DScon therefore decided to conduct personal interviews in selected shopping centres in Germany and in the UK. In Germany the interviews were done on the spot during the normal working hours in shopping centres. The scope of the interviews was a problem for the managers and tenants because an interview took about a half an hour to 1 hour. In the interviews with management and tenants, the questionnaire served as a guide. The majority did not have the time to go through the whole questionnaire. In the UK there was a better reaction toward the personally conducted interviews. All the results from the interviews were transferred to the online questionnaire system. Table 5 shows the shopping Center DSCon have visited.

Table 5 – List of Shopping Centre visited by DSCon.

Country/ City	**Shopping Center**
Germany/ Esslingen	DasES
Germany/ Bielefeld	City Passage
Germany/ Bad Oeynhausen	Werre Park
Germany/ Minden	Hagem eyer
Germany/ Hannover	Ernst - August - Passage
Germany/ Cologne	Köln Arcaden, Hürth Park
Germany/Oberhausen	Oberhausen
Germany/ Düsseldorf	Bilk Arcaden
Germany/Berlin	Boulevard Berlin
UK/London	Brent Cross
Germany/ Stuttgart	Schwabengalerie

4.3. Objectives and goals in relation to renovation

Through inventory measures an effective and active energy management significantly reducing energy use can be reached. A lowering of operational costs and higher operation

efficiency provide competitive advantages, as well as conserving natural resources, and the total of reduction in CO2 footprint that can be used for marketing purposes. The inventory has been successfully implemented in commercial buildings in Germany[6].

4.3.1. General Goals in relation to renovation

The objectives of energy optimization:

- Conservation of natural resources
- Protection of the environment through lower emissions
- Reduction of operating costs
- Ensuring efficient management
- CO2 reduction (CO2 footprint) as a marketing strategy.

The introduction of energy management is often presented as a difficult decision to make. The review and implementation during the first period may incur costs and the savings potential is uncertain. The advantage of energy management is that it makes operation transparent, making it possible to track savings and optimization measures (Bauer et al. 2012).

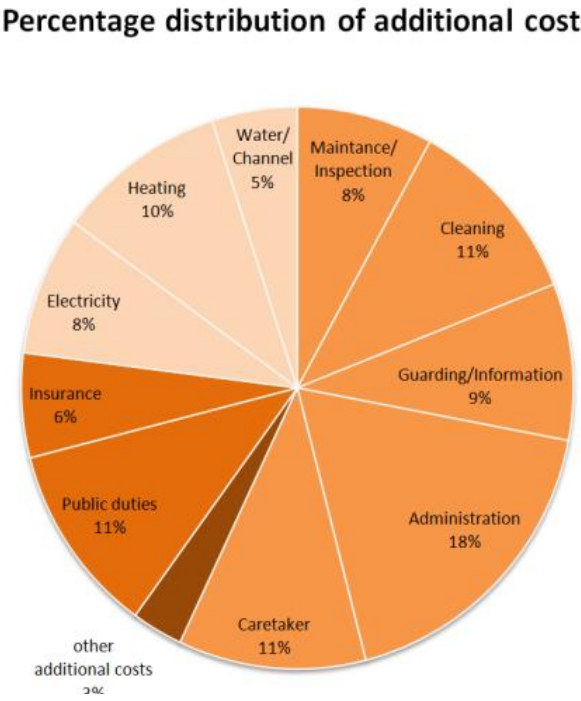


Figure 22 – Jones Lang LaSalle, Retail Oscar

The amount of operational costs depends on the features and characteristics of the property. Nevertheless, the mean values published as a result of a large survey provide a good indication of the overall cost structures (Jones Lang LaSalle, Retail Oscar, 2012). Table 6 shows a value of 3.79 EUR / sqm / month as average in the shopping centres investigated.

[6] http://www.dreso.com/en/

Table 6 – Average value of additional costs (Jones Lang LaSalle, Retail Oscar, 2012)

OSCAR	Amount of Centre	Average costs in €/m²/month
2002	22	3,82
2003	35	3,78
2006	58	3,79

To ensure that the shopping centre meets the numerous needs of its tenants – for example with regard to location, layout of floor space and internal finishes – tenant interests must be involved in the decision making process at an early stage followed by governing through all the later stages, with systematic organization of the implementation of results during construction. These are some examples of things that must be taken into consideration, for example, sales areas must be optimally linked with the catering and leisure units to create a high quality experience for customers. Urban issues such as the integration of sports facilities into the environment must be reconciled with retail concepts and parking for visitors and personnel must be conveniently linked to the shopping centre itself[7].

4.3.2. Owner/Tenant Goals in relation to renovation

The main motives for owner investment in renovation, in order to make their shopping centres more energy efficient, are the competitive advantages gained and marketing strategies. According to staff and store managers energy-efficient modifications are only performed for monetary reasons. The barriers are a lack of funding, low knowledge about the possibilities and initial problems caused by modernisations, such as, the loss of profits during renovation work. For tenants the incentives should be reduced rents due to lower overhead costs, but results from the questionnaire, shown in the figure below, indicate that tenants do not think that rehabilitation leads to lower overheads. On the contrary the majority believes that overheads will increase when rehabilitating the shopping centre. Tenants need to be informed of the advantages associated with rehabilitation. For example they do think that overheads will decrease due to lower energy use. So the main problem here is that they do not connect rehabilitation with a decrease in energy use.

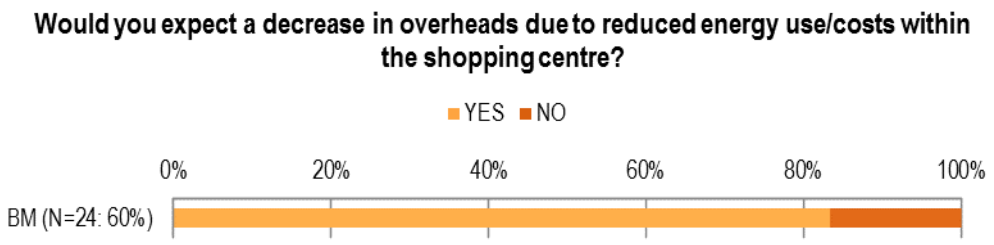


Figure 23 – Tenants questionnaire. Answers to the the question "Would you expect a decrease in overheads due to reduced energy use/costs with the shopping centre?"

[7] http://www.dreso.com/en/: Kompetenzbroschüre Shoppingcentre, Drees&Sommer

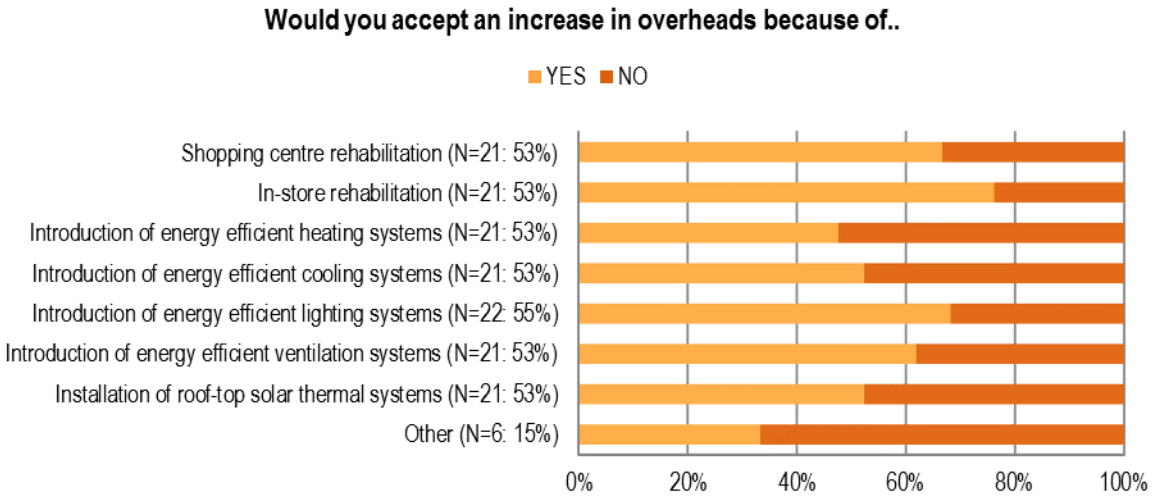


Figure 24 – Tenants questionnaire. Answers to the question "Would you accept an increase in overheads *because of..*"

For tenants the main goals in relation to renovation would be a decrease of overheads and an energy efficient profile. The graph below indicates that an energy efficient profile is of high importance when choosing a new location for more than 40% of the tenants.

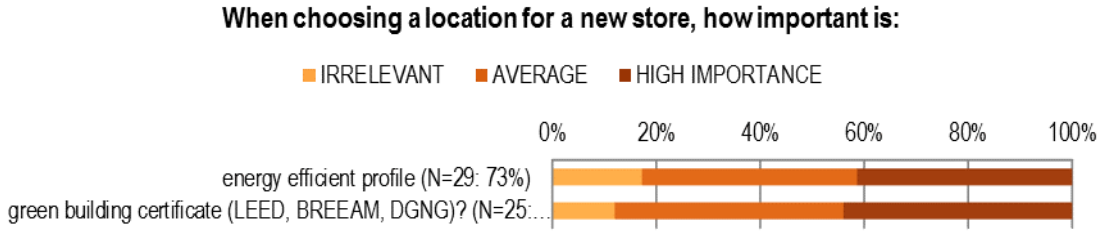


Figure 25 – Tenants questionnaire. Answers to the question "When choosing a location for a new store, how important is: - energy efficiency, - green building certificate?"

4.4. Property value and rent increases

The interests and goal of the owners are to increase their properties' values, while the interest of the tenants is to minimize the rent and ancillary rental costs. A building needs care throughout its lifetime. There are three ways to preserve buildings:

- maintenance
- modernization
- conversion

If you just maintain the building over a long time the building's value will not increase. The aging of a building without maintenance, or even with regular maintenance will lead to early demolition. A main goal for an owner of a shopping centre is to increase the value of the building. This is possible by doing a modernization or a conversion, see in Figure 26. Modernisation or conversion can lead to rent increases for the shopping centre tenants. To avoid this kind of conflict the modernisation/conversion should bring significant improvements for the tenants (i.e. more customers = more turnover, reducing of overheads).

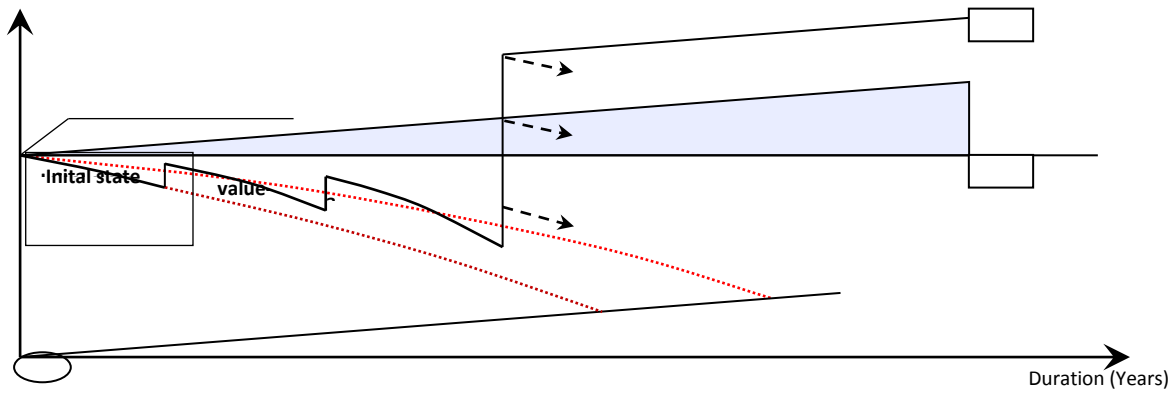


Figure 26 – Principles of preservation and renewal (Bauer et al., 2013)

A representative of Norwegian owners and managers stated in an interview that "*for us as owners, sustainability is a mainstay. It should permeate all our work. It is a long-term project, one that is present in all our shopping centres*." In answer to the question, what do you see as the most important areas to be addressed when considering upgrading the shopping centre? A representative from John Lewis said that thermal comfort was the most important issue, but that entertainment was also important because "*you don't want to come to a depressed environment. As a customer you want to shop where you feel comfortable*."

In his description of the reasons for a shopping centre redevelopment, the manager of a British shopping centre said "*When we grow we will be a show-case centre. Entertainment coupled with leisure are big growth areas, food, gyms, extreme experience. You can't eat online. We encourage people to come here to do more than shop. The other side is the impact on the environment, water use, wastage, the impact on the local environment.*"

4.5. Reduction of rent and overheads

Results from the questionnaire suggest that tenants as well as owners and managers expect a reduction in the additional costs as a result of an energy efficient rehabilitation (see figure 27).

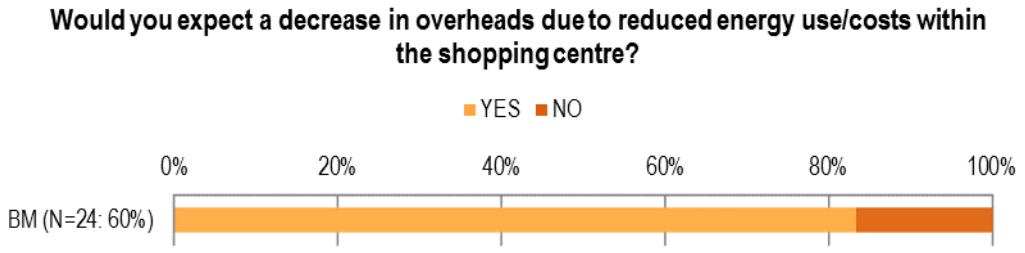


Figure 27 – Tenants questionnaire. Answers to the question "Would you expect a decrease in overheads due to reduced energy use/costs within the shopping centre?"

Owners are reluctant to invest in making their shopping centres more energy efficient. As seen in Figure 28 and **Error! Reference source not found.** owners and tenants think one of the main barriers against an energy efficient upgrade are the retrofitting costs as well as the rental/overhead costs. It is assumed that the additional costs rise as a result of energy-efficient renovation.

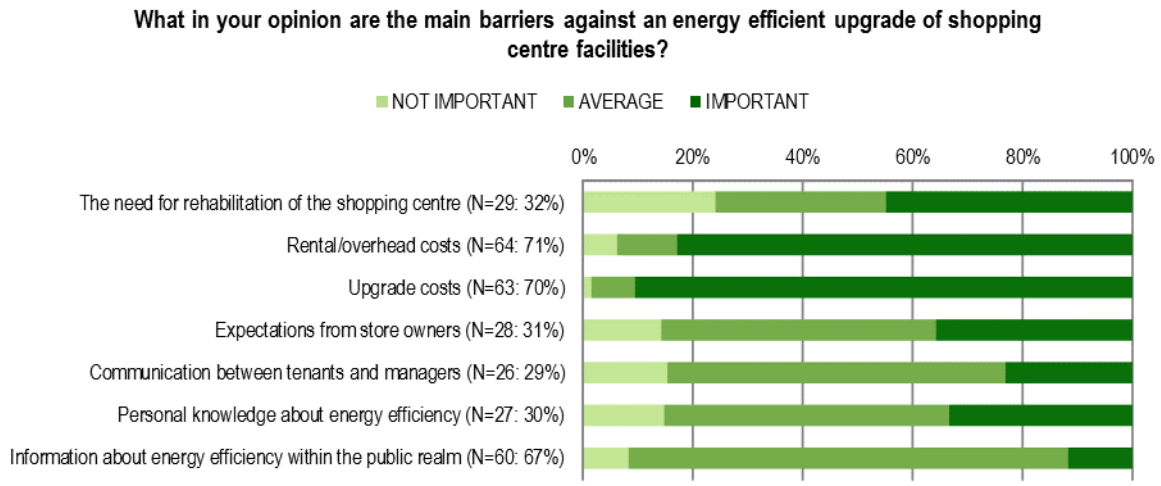


Figure 28 – Owners questionnaire. Answers to the question "What in your opinion are the main barriers against energy efficient upgrade of shopping centre facilities?"

Furthermore, more than 70% percent of the tenants do not expect that stores will be willing to invest money in refurbishment even though store overheads may be reduced. It is clear that there is little awareness about energy efficiency in shopping centres, which leads to the question, why are stores are not willing to invest money in refurbishment? When talking to the tenants, the impression was that they did not know how the company management would assess this issue. This could also be a result of the modest number of tenants who answered the question. In addition they said that they have less influence on such decisions.

When asked what she thought were the main reasons for an energy efficient upgrade a representative of Norwegian owners and managers said, "*The stores do not signal any focus on it. It is the centre-management who has focus on it. There are never any questions about it from tenants or customers. Competitiveness, turnover and market potential are what are*

important." The same informant also claimed that "*Tenants don't demand an environmental profile. We encourage them to participate and to have their own environmental plan. These are themes which we sometimes discuss during tenant meetings. Even when a centre has an environmental management certificate, it doesn't mean that tenants have to work on it or send in reports, but those what want to be involved have an environmental performance certificate.*" In answer to the question "Are tenants required to have an environmental profile?" a Norwegian shopping centre manager, suggested that there was not much focus on this kind of issue among tenants. He explained that "*the smaller companies change their lighting systems but this isn't because of energy. They do it to save money.*"

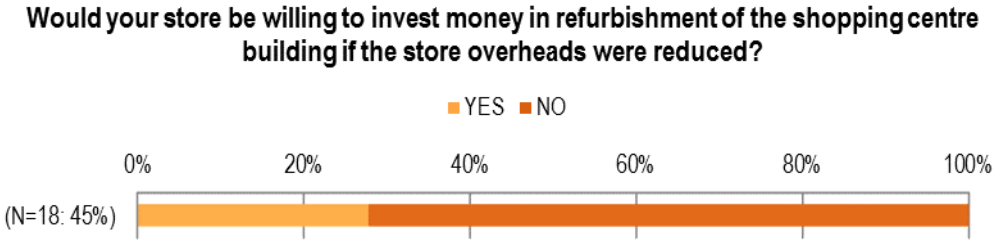


Figure 29 – Tenants questionnaire. Answers to the question "Would your store be willing to invest money in refurbishment of the shopping centre building if the overheads were reduced?"

4.6. Customer satisfaction

Customers prefer shopping centers that optimally combine retail outlets, cafés and restaurants and leisure activities under one roof. Retail areas must be linked to food and beverage areas and leisure facilities to ensure a high-quality experience for visitors. Parking for visitors and personnel must be conveniently linked to the shopping center itself (Kompetenzbroschüre Shoppingcentre, Drees&Sommer). This is also shown in the results from the questionnaire, where the majority of the customers travel to the shopping centre by car (**Error! Reference source not found.**). Furthermore location and free car parking are some of the five most important areas that influence the customer when choosing a shopping centre.

For the shop managers and the tenants it was important that the customer satisfaction was very high inside their shop. This is due to the fact that when the shopping centre has a harmonising concept and architecture which fits to the customers' needs it will guarantee a secure and sustainable return (Kompetenzbroschüre Shoppingcenter, Drees&Sommer). For example tenants would not accept a lower indoor temperature because most of them think that this would negatively affect the customers' comfort. Interestingly, among customers there is a greater willingness to accept lower temperature in winters and higher temperatures in summer than to accept higher prices (see section on lighting and HVAC below). A more detailed description for the indoor environment can be found in the next section.

An important point is that customers do not look at the energy efficency of a shopping centre or a green building certificate when choosing where to shop. This might be a reason why shopping centre managers do not see the need to invest money in energy efficient systems. Customers focus on low prices and the range of products when choosing a shopping centre and they don't see the need to make shopping centres more energy efficient, which may influence the shopping centre owner (see **Error! Reference source not found.** and Figure 30).

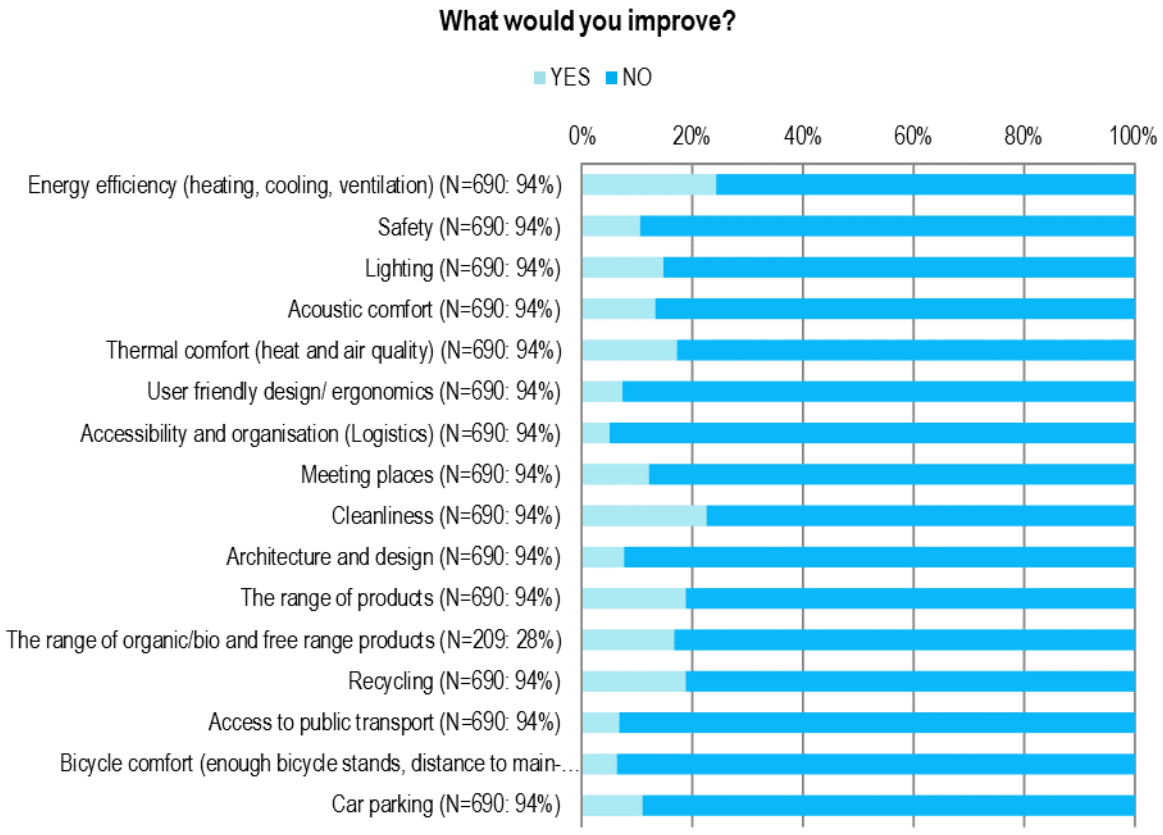


Figure 30 – Customer questionnaire. Answers to the question "What would you improve?"

From the interviews it can be concluded that for the shop managers it was very important that the customer satisfaction is very high inside their shop. For example they would not accept a lower indoor temperature because most of them think that this would affect the customers' comfort negatively. In conclusion a high level of customer satisfaction is good for the tenants, for the shopping centre image and for the shoppers.

4.7. Summary

The "customers" stakeholder group has a low awareness of energy efficiency in shopping centres and perhaps gains the least direct benefits from an energy efficient renovation of shopping centres. Customers like lower prices and a wide range of products, but this is not

the result of an energy efficient renovation. In addition customers do not choose shopping centres because of their energy efficiency level. However the appearance of an energy efficient shopping centre could encourage more awareness and “green” thinking.

Tenants showed interest in energy efficient shopping centres, but it is not of primary importance. For this group it is highly important to improve the communication of energy efficiency between management and employees. Furthermore an energy performance certificate could be used to strengthen the awareness of how energy efficiency influences the shops, which would also bring a stronger transparency to the topic.

For the owners, as the decision making group and builders, energy efficiency is a topic they focus on, but they are reluctant to invest too much money on a renovation. For them the value of the building is the main interest. During interviews, several shopping centre owners mentioned that common certifications for energy efficient building are not suitable for shopping centres. They noted that a tailor-made certification for shopping centres could be a step to get greater benefits from energy efficiency for the owners.

5. A List of Systemic inefficiencies

In this section the inefficiencies of technical systems are analysed. But, as argued in the introduction, the use and operation of technical systems imply that users and operators have the potential to influence efficient operation. Thus, in this section systemic inefficiencies are listed, i.e. inefficiencies that are grounded within the technical system, mainly the improper design, operation and maintenance of the various technical systems in shopping centres.

5.1. Aim

The main aim is to identify inefficiencies in four systems: facilities, functions, management and logistics and to identify different practices that make the shopping centre less efficient in terms of for example increase of costs, internal comfort, management and accessibility during retrofitting or redesigning processes in shopping centres. Different inefficiencies within the fields (lighting, HVAC, cleaning and maintenance, water, logistics, control and others) will be defined, and an explanation of why these inefficiencies are associated with shopping centres will also be provided.

5.2. Method

A list of systemic inefficiencies has been developed that builds upon the experiences during an analysis of building commissioning. Building commissioning takes the same approach to new buildings, and it is practice in the same manner in for example the ship building industry: When a building is initially commissioned it undergoes an intensive quality assurance process that begins during design and continues through construction, occupancy, and operations. Commissioning ensures that the new building operates initially as the owner intended and that the building staff is prepared to operate and maintain its systems and equipment[8] .

A detailed analysis of the characteristics of the CommONEnergy demo buildings provided some of the inefficiencies that are typically found in shopping centres. Further information was extracted from the results from the questionnaires for owners and managers, tenants and customers. The reference buildings provided possible inefficiencies in shopping centres not identified within our demo buildings and answers from the questionnaires. Finally, a literature review was used to identify other inefficiencies.

Inefficiencies are defined here as

(1) Energetic inefficiencies, e.g. building physics and technical solutions.
(2) Comfort inefficiencies and inefficiencies in providing an effective retail environment.

[8] http://cx.lbl.gov/definition.html

(3) Other inefficiencies, e.g. maintenance.

Careful attention will be drawn to comfort inefficiencies and inefficiencies in providing a effective retail environment in two respects: Firstly the project “CommONEnergy” is committed to considering comfort aspects as similarly important as energetic issues, as both are very important for human well-being and health. In addition they can contribute to a successful retail environment (satisfied customers). Secondly, the level of achieved comfort quality is influenced by the amount of energy that is used. A comparison of currently implemented technologies in existing buildings which are built or refurbished prior to the year of 2000 with modern available solutions – based on:

(a) minimum requirements form standardization or guidelines or
(b) advanced planning standards

will lead to a list of energetic inefficiencies.

5.3. Lighting

The section on lighting is the longest section in the chapter about systemic inefficiencies in shopping centres. There are three main reasons why we have chosen to go into some detail about the subject: (1) The CommONEnergy project has a focus on lighting and will be testing lighting systems in the demo-cases. (2) There was the opportunity to do a detailed analysis of two of the demo-cases, Mercado del Val and City Syd. This allowed the presentation of the inefficiencies and efficiencies associated with the lighting in two very different shopping centre cases. Mercado del Val, which is a historical building, on a relatively small scale, with very specific lighting issues and City Syd, which is a typical Norwegian shopping centre built in 1987, which has similarities with a large number of shopping centres built in Europe during the same period. (3) Stakeholder interest in the subject of lighting in shopping centres. This was particularly apparent in the customer survey, where we had 240 direct comments from customers to the question: “What in your opinion are the most important actions to be taken when aiming to improve the shopping centre's environmental profile?” Fifty of these comments were about lighting issues. For example a Norwegian respondent suggested that there should be "*Less lighting. The lighting makes it also often quite hot*". Another Norwegian customer suggested that the shopping centre should "*Reduce the lighting a good deal - it's really uncomfortable being in some stores. Lights are hanging right over customers heads*". In Italy a customer suggested that the shopping centre should "*take advantage of natural light*." Customers are therefore pointing to a number of issues that cause inefficiencies in relation to lighting systems in shopping centres.

When asked questions relating directly to lighting customers responded positively to the suggestion that stores could be less brightly lit, over 70 % answered yes to this,although they were less keen on the idea of paying more for goods that were sold in energy efficient stores. Customers are therefore not interested in paying for the cost of upgrading lighting systems in shopping centres. Under 40 % said yes to this.

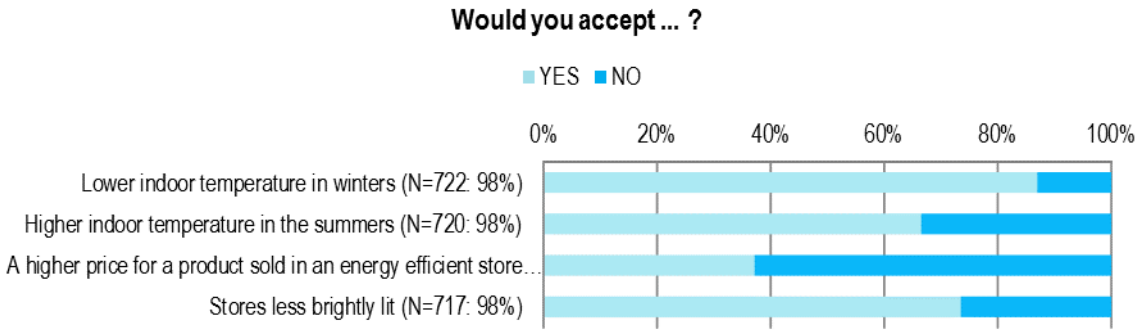


Figure 31 – Customer questionnaire. Four questions relating to lighting , indoor temperature and product price

Tenants also responded positively to the suggestion that the lighting systems in shopping centres should be improved. Almost 70 % said yes to accept an increase in overheads due to the introduction of an energy efficient lighting system.

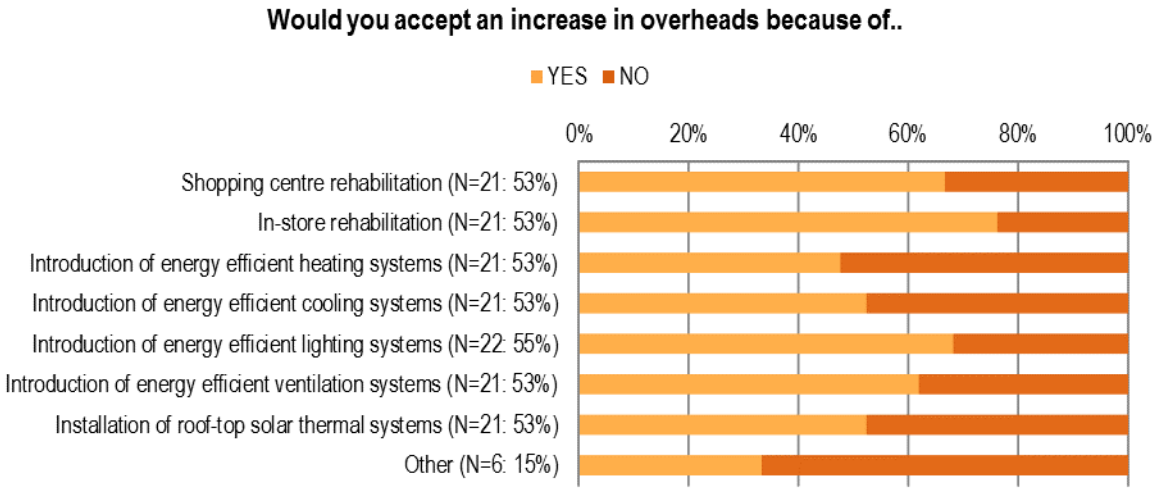


Figure 32 – Tenants questionnaire. Questons related to increase in overheads

Lighting is therefore considered by customers as being the source of inefficiencies in shopping centres, something which is primarily associated with customer comfort, thermal and visual. It is also considered as being a system where there is potential for achieving efficiencies. It is however unclear why they are more positive to applying new lighting solutions than they are at applying other energy efficient measures in shopping centres. A number of informants amongst owners and managers and tenants did tell us that they had improved or were in the process of improving the lighting systems in their retail facilities. Improvement to lighting systems is therefore a measure that is already documented as efficient in retail environments.

5.3.1. Methodology in determining inefficiencies

Three parameters which act on the electricity demand for artificial light will be considered:

- the illuminance target,
- the operation hours and
- enhanced artificial lighting installation efficiency.

Harvesting daylight is an important strategy to reduce the demand while reducing operation hours by means of a control strategy which matches the interior daylight situation. This will mainly be discussed in section 5.3.3. Section 0 is dealing with artificial lighting installation efficiency, which transforms electrical energy into light, starting with the power connection (grid) and ending with the luminance of the room surfaces (visual environment) (Pohl, 2009). Besides these direct savings by reducing electricity demand for operating artificial light, indirect saving potentials have to be considered through reduction of solar heat gain by daylight technologies and reduction of internal heat gains by efficient artificial lighting technologies. As retail shops and malls are conditioned by mechanical cooling and mechanical air handling units reduction in internal gains leads to energy savings for these mechanical devices.

Careful attention will be paid to two areas which affect comfort inefficiencies and inefficiencies when providing a healthy and also effective sales environment: Firstly the project “CommONEnergy” is committed to considering comfort aspects as being of similar importance as energetic issues. This is because they are very important for human well-being and health and in addition they can contribute to a successful sales environment. Secondly only comfort analysis indicates what room quality is achieved by which amount of energy use and it is therefore is needed to judge the applied energy demand.

5.3.2. Energy consumption for retail lighting

2003 data from US DOE’s Energy Information Administration shows the importance of light within the energy balance of retail facilities (see Illuminating Engineering Society, 2011). Lighting accounts for 42% of electricity use in retail buildings. Retail buildings themselves account for about 21% of electricity use by all commercial and institutional buildings. In addition for 2005 the global lighting electricity consumption of commercial buildings was equivalent to 43% of the total lighting electricity consumption and over 30% of total electricity consumption (Halonen, 2010).

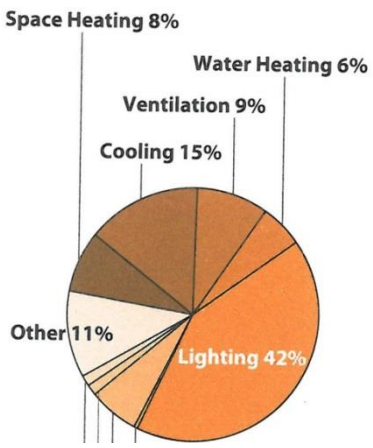


Figure 33 – Electricity Use Of Retail Facilities (Illuminating Engineering Society, 2011)

A big project management company in Germany – specializing in shopping centres - estimates that about 60% of the energy demand accounts for lighting. The average overall energy demand is assumed to be up to 400 kwh/m^2 (Licht.de, 2011).

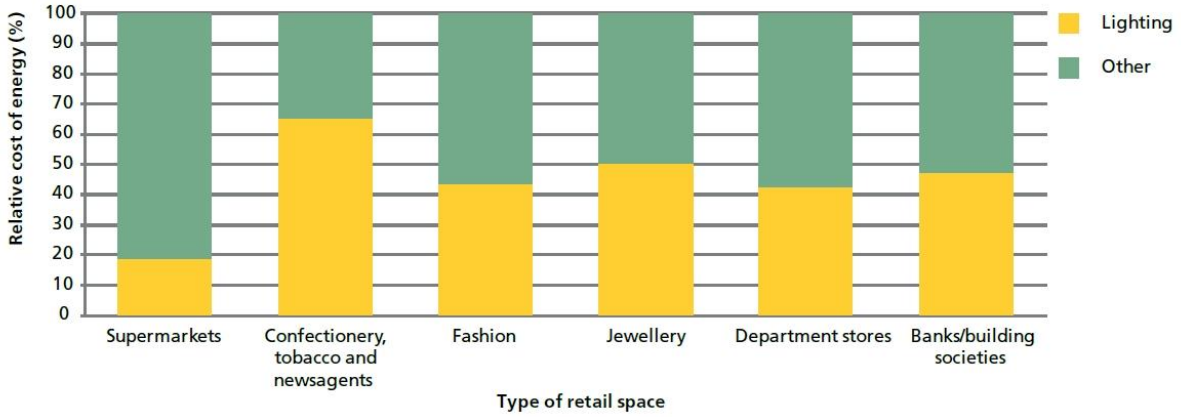


Figure 34 – Lighting as a proportion of energy costs for different types of store (Ticleanu Cosmic C. , Littlefair P. J., 2013)

Figure 34 indicates that the share of energy costs for lighting varies in different store types. For example supermarkets usually use general or shelf lighting with a lower illuminance target and also operate many other energy-consuming devices like refrigerators or ovens. These proportions could affect the willingness of the operator to invest in the field of lighting.

5.3.3. Using Daylight As Preferred Light Source

Daylight has determined the development of human vision. The eye reaches its highest capacity in daylight; the subjective judgment of a lighting situation is made in conscious or subconscious comparison with daylight experiences. Daylight is changing throughout the day and year in its intensity, its spectral power distribution and its direction (strong parallel beam with clear sky, scattered skylight without sun from cloudy sky), dependent from time, location and climate. This complex and variable behaviour of daylight is essential for its visual and biological impact on humans and on physical/chemical impact on materials.

Recent worldwide efforts to decrease the energy consumption of buildings (key word nearly zero energy buildings) put daylight back into focus. Beyond the energetic issues, the psychological, physiological and biological benefits for the occupants are of the same importance. The most important psychological effect is the connection to the outside, which is needed in order to be informed about the daytime and the weather. Other effects are improved motivation and mood, higher driving force, lower fatigue, reduced eyestrain, etc. Physiological and biological effects are important in maintaining health and well-being: light has a major influence on bodily health, for example the secretion of the hormones melatonin (stimulating the circadian rhythm) and serotonin (well-being hormone), and others.

The use of daylight as a primary light source has the potential to reduce the need for electric lighting if realized with a lighting control system which is able to adapt to the daylight variability. The aim should be to provide generous levels of daylight with reasonably low associated solar gains (to avoid additional cooling and ventilation needs) and sufficient glare protection. A direct view to the outside is considered not so important in shopping centres as it is in office buildings. However shops should also be considered as a working place for

sales staff and as a place that hosts people over a longer period. In view of the fact that people end up staying a long in closed rooms with little daylight supply (90% of the day in closed rooms, more than 50% in situations with light intensities lower than 100lux), harvesting of daylight during shopping can help to relax this situation of permanent light deficiency which is able to act on our biological rhythm (Bassa, 2013)(Fleschner, 2011).

A US study analysed for a particular retail chain the effect of adding skylights on the energy and the sale results (Heschong, 2003). The analysed chain consists of 73 stores in California, whereof 24 stores had a significant amount of daylight illumination. The skylights effectively provide daylight into rooms but allow only a limited view to the outside, as only a portion of the sky is visible. The study discovered an average increase in sales for all daylit stores by 0% to 6%, depending on the type of model and time period considered. With a conservative estimate it was determined that the profit from increased sales is at least worth more than 19 times higher than the energy savings.

Besides the named issues – danger of overheating and glare - daylight utilization in a retail environment ensures a high-quality room appearance which can be summarized as follows:

- The full spectrum of daylight ensures ideal colour rendering, so that merchandise can be examined under ideal daylight condition.
- Direct sunlight can provide variations in light intensity, pattern and colour. It makes a retail space more lively and attractive. It has the potential to disturb the display of goods in shop (or even destroy food or sensitive goods) by spots of high illuminance and strong contrasts.
- Diffuse skylight provides a more uniform impression to the room with less dynamic effects on the interior.

In urban context external obstructions may limit daylight availability. Daylight may be used as side-lighting and top-lighting, both of these have limited potential in retailing because the façade connection and roof access is limited. Further issues with side-lighting are the dependence on orientation and an uneven distribution (high levels at the façade/decreasing amounts further away in space), for top-lighting the higher risk for overheating. Daylight systems help to overcome the problems with vertical openings (uneven distribution) by redirecting light into room depth and with horizontal openings by providing effective solar shading. A smart daylight device is able to implement all needs in a single element (Figure 35).

- View to the outside
- Glare protection
- Light redirection in room depth > replace artificial light
- Sun shading > minimize mechanical cooling

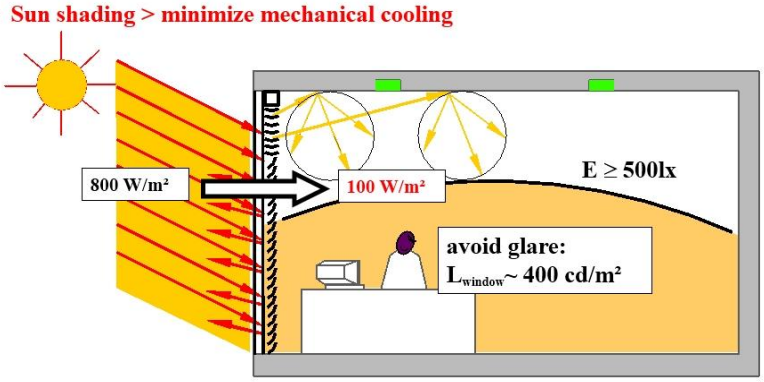


Figure 35 – Requirements for a daylight system

Daylight could be used as a strategic roof-light which illuminates and accentuates naturally the merchandise with the mentioned positive characteristics like optimal colour rendering. It contributes to interior architecture appearance with a dramatic staging, in addition space feeling is generous and natural.

Figure 36 – Daylight used in the function of accenting and displaying goods, Selfridges, Oxford Street, London (Ticleanu, 2013).

5.3.4. Artificial Lighting Technology

To evaluate the efficiency of an artificial lighting installation it is necessary to be aware of the following relations and terminology regarding both lamp and luminaire technology and room properties. Figure 37 shows the involved factors schematically.

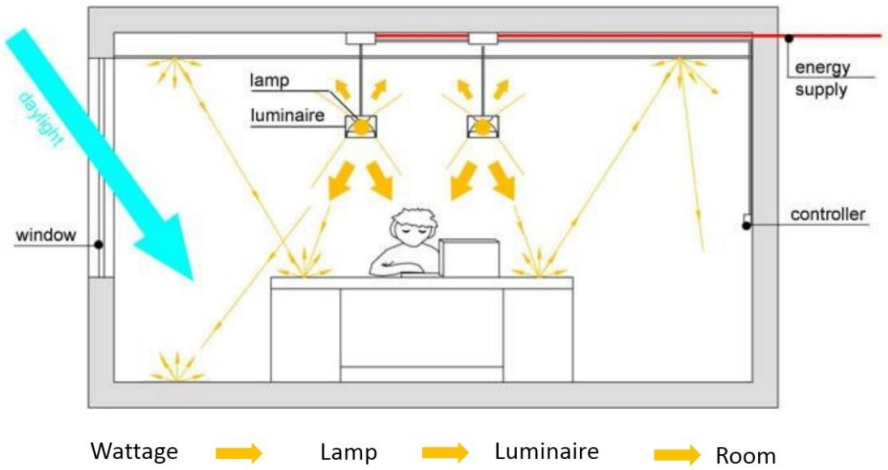


Figure 37 – From generation of light to its perception in the room

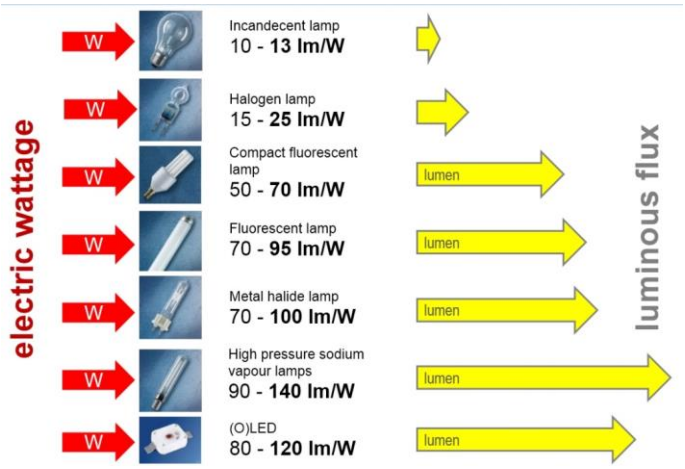


Figure 38 – Luminous efficacy of different light sources

Luminous Flux, wattage and luminous efficiency

Luminous Flux is the quantity of visible light radiated in all directions by a light source. It is measured in lumen and takes into account the brightness sensitivity of the human eye.

Luminous efficacy η indicates how much luminous flux (in lumen) a light source generates from the electricity (Wattage in W) it consumes and is thus a measure of light source efficiency. The unit of measurement is lm/W. Figure 38 indicates the different luminous efficacies of common light sources. In the next section the proportions of lamp types for different kinds of retail premises are discussed.

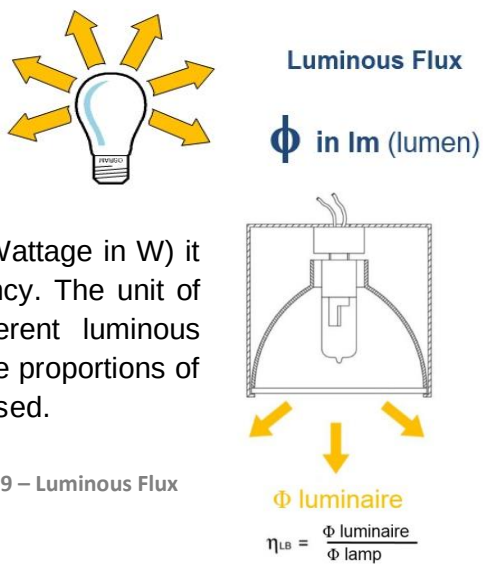


Figure 39 – Luminous Flux

Luminous intensity and light output ratio

Luminous intensity I, measured in candela (cd), is the amount of luminous flux radiating in a particular direction and is defined as luminous flux per solid angle. It is significantly influenced by optical control elements such as reflectors or lenses (parts of a luminaire).
The radiant characteristics of a luminaire are illustrated by a luminance distribution curve (LDC). The Light Output Ratio is the ratio of the radiant luminous flux of a luminaire to the luminous flux of the fitted lamp.

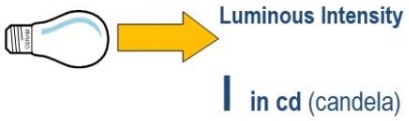


Figure 40 – Luminous intensity and light output ratio of a luminaire

Illuminance E and surface efficiency

Illuminance E indicates how much luminous flux from a light source falls on a given surface (measured in lux). It is indifferent, whether the light reaches from a primary light source or from secondary reflections of surface materials of the room or furniture.

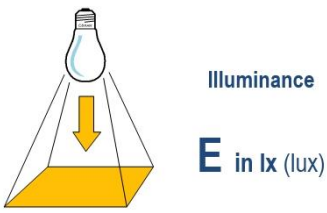


Figure 41 – Illuminance E for a given surface

Figure 42 – Room efficiency: Different reflectivity grades for floors lead to a 50% reduction in necessary electrical wattage

Figure 42 shows that reflections from surfaces (room efficiency) play an important role as a white (bright) floor (reflectivity about 80%) compared to a deep red floor (reflectivity < 10%) accounts for a reduction in necessary wattage of 50%.

Maintenance factors

The maintenance factor MF is defined as the ratio of maintained illuminance to the value on installation and is the product of four factors: lamp lumen maintenance factor (LLMF), lamp survival factor (LSF), luminaire maintenance factor (LMF) and room surface maintenance factor (RMF). Power consumption, lighting loads in stores are limited to 15 W/m^2 (Luxmagazine, 2011a)

EN 15193 (EN 15193, 2007) provides benchmark data as recommended limits for connected lighting power dependent on 3 quality classes from 15 W/m^2 for building class 1 to 35 W/m^2 for building class 2 (see Figure 43). The corresponding building design criteria for the 3 building quality classes are listed in Table 8.

Table 7 – Typical average power densities for different retail premise (Ticleanu, Littlefair, 2013).

Retail park	Supermarkets	High-street stores	Shopping Centres
16.3 W/m^2	22.3 W/m^2	27.8 W/m^2	49.5 W/m^2

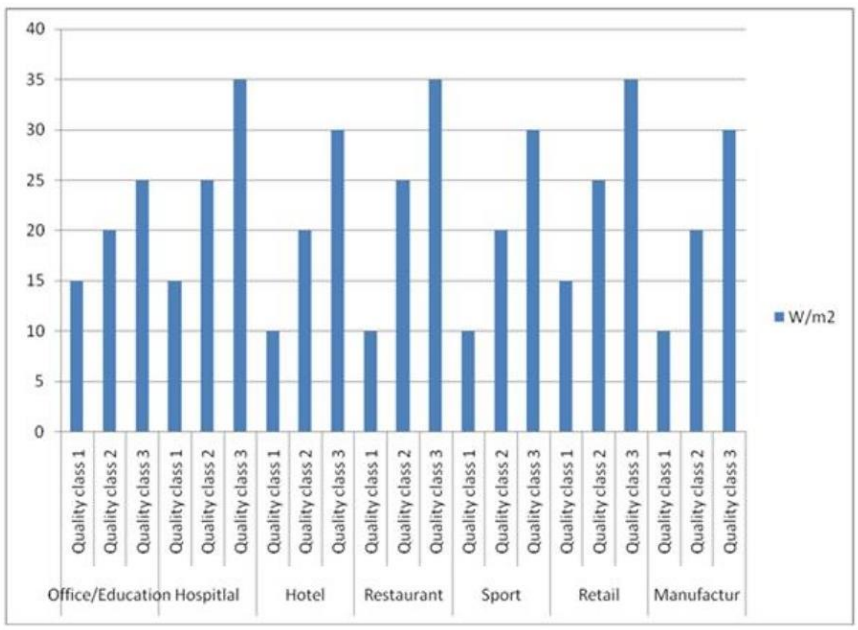


Figure 43 – Limits for connected lighting power in W/m^2 according to EN 15193 for different building types and quality levels

Table 8 – Lighting Design Criteria for building classes 1(*) to 3(***), EN 15193

	Lighting design criteria class		
	*	**	***
Maintained illuminance on horizontal visual tasks ($\bar{E}_{m\ horizontal}$)	☑	☑	☑
Appropriate control of discomfort glare (UGR)	☑	☑	☑
Avoidance of flicker and stroboscopic effects	✓	✓	✓
Appropriate control of veiling reflections and reflected glare		✓	✓
Improved colour rendering		☑	☑
Avoidance of harsh shadows or too diffuse light in order to provide good modelling		✓	✓
Proper luminance distribution in the room ($E_{vertical}$)		✓	✓
Special attention of visual communication in lighting faces ($E_{cylindrical}$)			✓
Special attention to health issues (Note)			✓
☑: has to comply with required values from Tables 5.3 in EN 12464-1:2002. ✓: has to conform to verbally described requirements from EN 12464-1. NOTE Health issues may even require much higher illuminances and therefore higher W/m^2. The maximum power density load (*PN*) connected to the lighting design class is given in the benchmark Table F.1.			

Corresponding to the three building quality classes a so-called Lighting Energy Numeric Indicator LENI is introduced which indicate the total annual lighting energy required for the building class. Based on the limits for connected lighting power and taking into account annual operation hours at daylight and at night and also parasitic power consumption, the following 3 values for the 3 quality classes are named:

Building class 1: 70.6 – 78.1 kWh/(m^2 a)
Building class 2: 115.6 – 128.1 kWh/(m^2 a)
Building class 3: 160.6 -178.1 kWh/(m^2 a)

Limits on energy use can also be set by shopping centres for their tenants. The owner of a new shopping centre in Johannesburg, South Africa, set a limit of 34 W/m^2 for lighting energy consumption. Oreb, a designer clothing store in this shopping centre, installed LED fittings that helped achieve 18.9W/m^2, which was 84% less than OREB's other stores, where lighting loads vary from 115 to 150 W/m^2 (Luxmagazine, 2011b)

5.3.5. Minimum Requirements

Minimum requirements for illuminance level, as determined by EN 12461-1, are not very relevant in practice. Actual targets for illuminance levels are usually much higher. In the next section reasons for higher targets are listed, but in (Amann, 2012) it is stated these minimum values are even objectively not suitable for sale and counter areas. This might be because EN 12461 targets requirements for working spaces, but does not aim to support sale

activities effectively. EN 12461 – 1 prescribes 300 lux for sale areas and 500 lux for the counter area. (Amann, 2012) reports typical illuminance levels for different shop types:

Table 9: Typical reported illuminance targets for different shop types (C. Amann, 2012)

Shop type	Typical illuminance target
Supermarket	500 lux
Food store	300 - 500 lux
Clothing, Technical goods	300 - 500 lux
Watches and jewellery	1000 lux
Flowers	500 lux
Car	1000 lux

Table 10 – Minimum requirements for retail premises according to EN 12461 (Lighting in work place, Indoor places)

Area of application or task	Illuminance E_m (lux)	Unified Glare Rating UGR	Uniformity Target U_0	Color Rendering Index CRI
Sale area	500	22	0,40	80
Counter area, packing station	300	19	0,60	80

In EN 12461-1 minimum requirement are also prescribed for Unified Glare rating, Uniformity Target and Colour Rendering Index (see Table 10)

Illuminating Engineering Society recommends maintained illuminance targets and uniformity targets. Illuminance targets are determined for horizontal targets Eh and vertical targets Ev. In addition they recognized a strong varying demand for different age groups <25, 25-65 and >65 years. Values are provided in a high level of detail regarding differing applications, tasks and associated areas. Table 11 shows an extract for important areas.

The preceding tables and statements give an overview about recommended values for important parameters like illuminance and uniformity level. These parameters are of great influence for the energy demand of the artificial lighting system. The variety of applications or tasks (as noticeable in Illuminating Engineering Societys recommendations, Table 11 summarizes only a small excerpt) shows the complexity for the planning task with focus on energy efficiency.

The values are exceeded often in practice, with the purpose to attain a reinforced sale effect, whereas the CommONEnergy customer survey indicates, that reduced lighting intensities

would be preferred because of visual and thermal comfort and as measure to enhance the energy efficiency of the building (see section 5.3).

Table 11 – Illuminating Engineering Society: Values for illuminance and uniformity target for different retail areas

	HORIZONTAL Illuminance targets (lux)			**VERTICAL Illuminance targets (lux)**			**Uniformity target**
	Visual ages of observers (years) where at least half are			Visual ages of observers (years) where at least half are			Avg: Min (1st ratio Eh/ 2nd ratio Ev, if different uniformities apply)
Area of application or task	< 25	25 - 65	> 65	< 25	25 - 65	> 65	
Mall, Indoor							
Entertainment areas, e.g. demo.	500	1000	2000	250	500	1000	3:1
Service Corridors	150	300	600	50	100	200	1,2:1/1,5:1
Retailing, Indoor							
Discount, Grocery, Supermarket							
Circulation	100	200	400	37,5	75	150	1,2:1
General retail	250	500	1000	100	200	400	1,5:1/3:1
Perimeter	-	-	-	250	500	1000	2:1
Designer, Boutique							
Circulation	37,5	75	150	10	20	40	1,2:1
General retail	100	200	400	37,5	75	150	3:1/6:1
Perimeter				100	200	400	4:1
Feature Display							
- Dazzle	Apply strategically to < 10% of display, 10 times general Eh of adjacent retail area						2:1
- Highlight	Apply strategically to < 25% of display, 5 times general Eh of adjacent retail area						2:1
- Total Display	Apply to entire display, equal to general Eh of adjacent retail area						1,2:1

Furthermore, the coexistence of different Illumination strategies like general lighting, shelf lighting, accent lighting, which interact in a complex way with each other, combined with frequently changing exhibition and sales layout, makes it difficult to implement a energy efficient detailed planning. The complexity between lighting and frequently changing layout might result in higher illuminance.. Further research or conceptual work should be carried out to determine reliable and practice-oriented recommended values as well as to ensure their effective implementation and monitoring in a very flexible sales environment.

5.3.6. Inefficiencies

Lack of daylight entries

Shopping centres usually provide daylight at points like a plaza, atrium or entrance. These areas are façade-near or are combined with vertical circulation function and a skylight. Many other areas in shopping centres do not have easy access to daylight because the building type and layout do not favour daylight penetration into internal areas. This is the case with the demo-case building City-Syd which has a ratio of façade area to floor area of about 0.13.

If daylight entry is potentially available through facades or in one-story buildings… (something is missing in this sentence). The wall or roof areas in question often remain opaque because natural daylight often is perceived as an enemy (Luxmagazine, 2011a). Owners are afraid of negative impacts like high solar gain and glare. Owners or tenants worry about the negative impact of daylight and distracted customers. In addition they have little experience of the positive effects of daylight on shopping.

The following barriers can be mentioned:

- In chain stores branding has a strong impact on store interior design. Changes in the façade and interior design are therefore are not easily implemented, on the other hand – if the owner shows interest – there is the chance of large-scale adaptions at many locations.
- Utilizing daylight through the façade needs detailed planning to satisfy different requirements at a typical shop façade, i.e. areas for display from outside, areas for goods inside (shelves) and an area for a daylight element.
- In general daylighting for a store needs sensitive and detailed planning in order to ensure that daylight does not disturb the efforts in displaying the goods and attracting customers with sophisticated light concept. Daylight should be able to interact with the lighting concept.
- Owners are afraid of negative impacts like high solar gain, glare and direct sunlight that cause damage to merchandise by UV exposure.

Dealing with daylight in stores needs extra and competent planning efforts (e.g. to prevent entry of direct sunlight), but as soon as store owners are aware of the positive effect on human well-being and the enhanced shopping experience they like it. There is a general need for a drive towards introducing observable daylight (Luxmagazine, 2011a).

Excessive entry of daylight

Daylight openings in shopping centres are often not planned accordingly to the complex needs of the interconnecting zones (see previous section). Planning is requires to introduce provide the correct amount of daylight to reduce glare, to avoid excessive solar gains and to contribute to a balanced illuminance distribution. Often additional requirements apply to the façade area, e.g. ventilation openings interaction respective integration is often not sufficiently considered. Daylight openings are often too large or are not provided with a highly-effective daylight system (see Figure 44 for a comparison of variations in opening sizes and Figure 45 for an example of an advanced daylight element for an equatorial region). In addition, due to overlit daylight areas in the centre, the adjacent zones and stores

often appear gloomy. Store owners therefore tend to exceed the recommended illuminance values for their store to counteract the effect.

Figure 44 – Left: Mall with excessive entry of daylight, right: Mall with limited entry of daylight (Oxford Properties Group, 2010)

Figure 45 – Example for a specialized roof daylight system: Changi Airport in Singapore, Development by Bartenbach and DURLUM

Inefficient lamp technology

A key point in energy efficient lighting design is the choice of efficient lamps, which produce the proper spectrum (colour temperature T_f and colour rendering R_a) and offer the required operating features (Pohl, 2010).

To investigate the current proportion of lamp stock in existing retail buildings, Building Research Establishment BRE conducted a survey of retail lighting early in 2011(Ticleanu, 2013). The strategy was to survey stores from a representative town (Watford), extrapolating the data to estimate the UK-wide distribution. The survey covered 89 premises in total, with a total floor area of over 40.000 m2, featuring over 20.000 lamps. Using estimates of floor area for each of the above sectors, a UK-wide picture of lamp stock proportions was produced both for each sector and in total. The proportional results for the overall stock (Figure 46) showed that fluorescents represent the majority of lamps, with approximately 64% of the stock. There are approximately twice as many T8 fluorescents as T5 fluorescents. Very few T12 fluorescents are still in use. Tungsten halogen lamps have the next largest share, with nearly 12% of stock, and then compact fluorescent (CFL) with 11%.

The stock of LED lighting was approximately 1.5% in 2011, although this is expected to rise in future years.

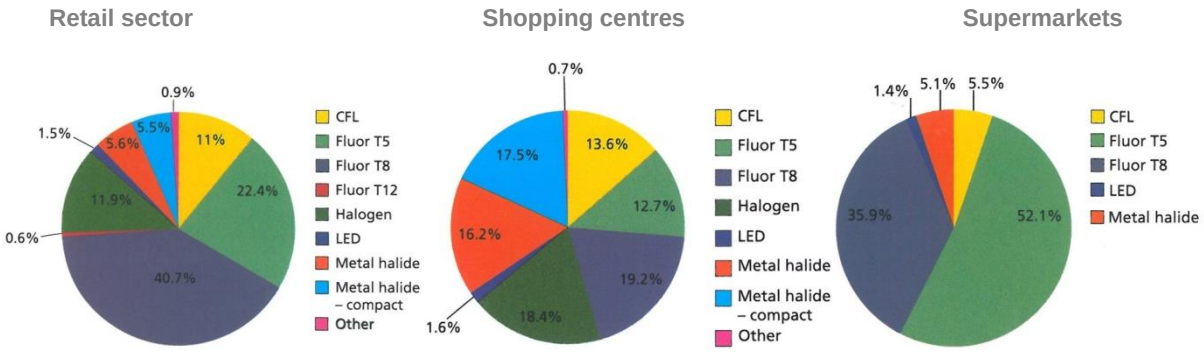


Figure 46 – Estimate of proportion of UK lamp stock in retail lighting (left), shopping centres and supermarkets (right). Distribution related to respective number of lamps. (Ticleanu, 2013)

In UK shopping centres the lamp with the highest stock proportion is T8 fluorescent (19.2%), closely followed by by tungsten halogen (18.4%), compact metal halide (17.5%), metal halide (16.2%) and CFL (13.6%). The more efficient T5 fluorescent is estimated to represent 12.7% of the lamp stock for these stores. There is a small proportion of LED (1.6%), but this is likely to increase rapidly over the next few years as LEDs become more widely used. The results reflect the fact that many of these stores have lighting designed to highlight products and displays. Halogen and metal halide lamps are commonly used for these tasks.

In supermarkets the general lighting has to illuminate a large area, but there is also a focus on product displays. Fluorescent T5 are the dominant lamp type for supermarkets in the Watford project with 52.1% of the lamp stock. Fluorescent T8 are the next highest in number, with 35.9%. These are not used just for general lighting, but also for display lighting, for example in refrigerated shelving. Accent lighting with CFL accounts for around 5.5% of the stock, and metal halides (5.1%) are used to highlight products, for example in the fruit and vegetable section. LEDs are being used (1.4%) for refrigerated displays, and this is predicted to increase, as LEDs replace fluorescents for this task (Ticleanu, 2013).

For some applications, like supermarkets, new generation linear fluorescent lamps T5 together with a high frequency ballast are still a good choice as they are highly efficient with a typical luminous efficacy in the range of 50 – 100 lm/W and a long life (typically up to 24.000 hours).

Figure 47 – Consider replacing T12 and T8 fluorescent lamps with new T5 fittings, lamps and ballast

For metal halide lamps a newer technology based on ceramic arc-tubes is available which offers excellent colour rendering. They have less light loss over time and a longer lamp life (up to 20.000 hours).
Light Emitting Diodes (LEDs) are undoubtedly the most revolutionary innovation in lamp technology in recent times. Powered by several Watts, emitting white light with an efficacy of more than 90 to 130 lm/W, and with a colour rendering index (CRI) greater than 90, they will soon outperform most traditional lamps.

The benefits of LEDs are a long lifespan up to 100.000h, the possibility of colour mixing (flexible colour temperature T_f), 'cold' spectrum (no infrared), design flexibility and brilliant light due to its small size, easy control and dimming, safety due to low-voltage operation, ruggedness, and a high efficacy (lm/W) compared to incandescent lamps (Pohl, 2010). Predicted efficacy of LEDs for the year 2020 is assumed with 180 – 230 lm/W (Figure 48).

Figure 49 shows that not only LED has significant development potential but also HID shows promising laboratory results up to 150 lumen/W (Offer, 2012).

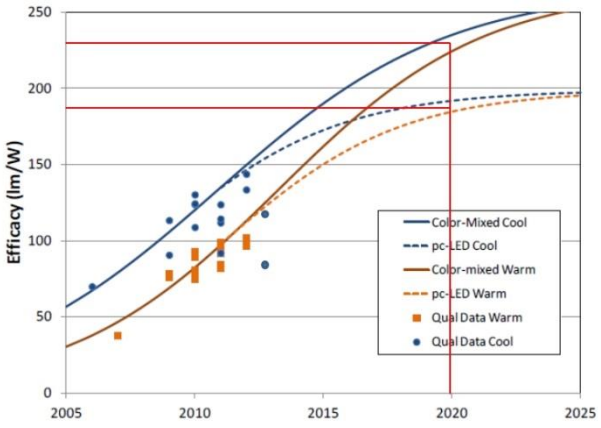


Figure 48 – Predicted efficacy for LEDs

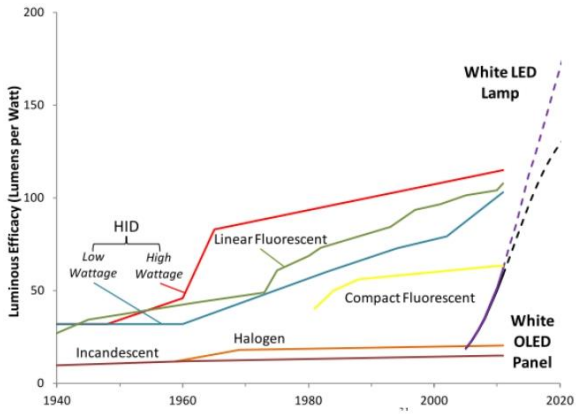


Figure 49 – Development potential of conventional light sources and LED regarding luminous efficacy

Denk, Jimenez, and Schulz investigated the impact of light source technology and colour temperature on the well-being, mental state and concentration of shop assistants (Denk, 2014). They examined whether shop assistants who are exposed to different lighting technologies (LED/HID) or different colour temperatures (warm-white/neutral-white) differ in the degree of their positive and negative attention-stress performance and the evaluation of the environmental atmosphere. Results showed effects of the colour temperature on the well-being and mental state of the shop assistants. No effects of light source could be found for the explored variables. Warm-white colour temperature positively affects the intensity of well-being and mental state and negatively affects the power of concentration.

Compared to HQI, LED light contains no infrared or ultraviolet radiation. Heat is generated at the printed circuit board (PCB) but is not radiated in the direction of the illuminated object. Heat is dissipated at the heat sink and gives the opportunity to remove it from there targeted area e.g. by means of an exhaust air luminaire or by a mounting location which is disconnected from the actual room (suspended ceiling). Combining them with cooling ceilings is also possible. High heat loads from artificial lighting are a major problem for retail premises.

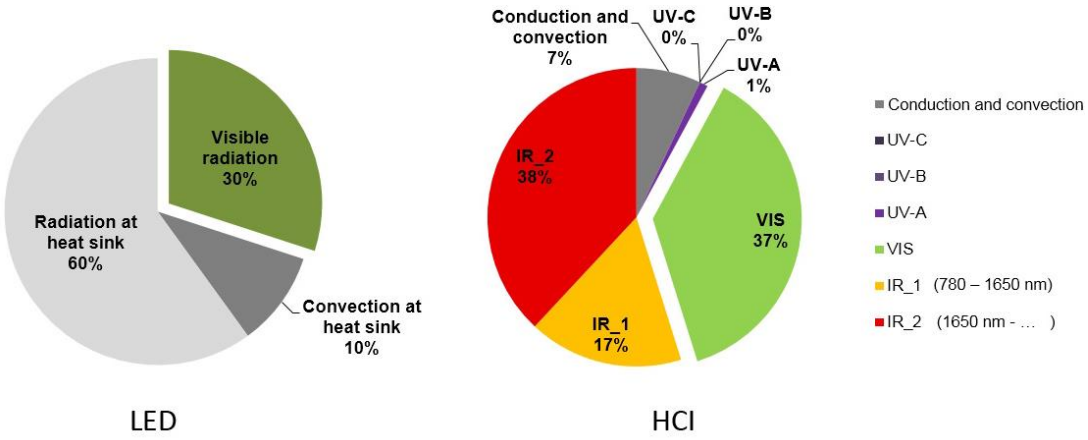


Figure 50 – Power breakdown by spectra for HCI and LED lamp: LED light contains no infrared or ultraviolet radiation (Pohl, 2013)

Spotlighting sensitive merchandise with LED – cosmetics, foodstuffs, sensitive fabrics or leather – implies less problems because the light contains no harmful infrared or ultraviolet rays; supplementary filters are no longer necessary. As a result, spots and LED luminaires can be installed directly in shelving systems, so the energy needed to illuminate merchandise is less than where conventional accent lighting is used (Licht.de, 2010). But it is essential to mention that all visible light is radiation, even where IR or UV content is zero.

The US Department of Energy conducted a study concerning life-cycle energy consumption as well as the environmental impact of 3 lamp types (U.S. Department Of Energy, 2013). As the three lamp types are not equivalent in terms of their lumen output and lifetime, the life-cycle energy estimates were multiplied by the number of lamps needed to reach a value of 20 million lumen-hours as functional unit. It was found that the average life-cycle energy consumption of LED lamps and CFLs was similar, and was about one-fourth the consumption of incandescent lamps. If LED lamps meet their performance targets by 2015, their life-cycle energy is expected to decrease by approximately one-half, whereas CFLs are not likely to improve nearly as much (see Figure 51).

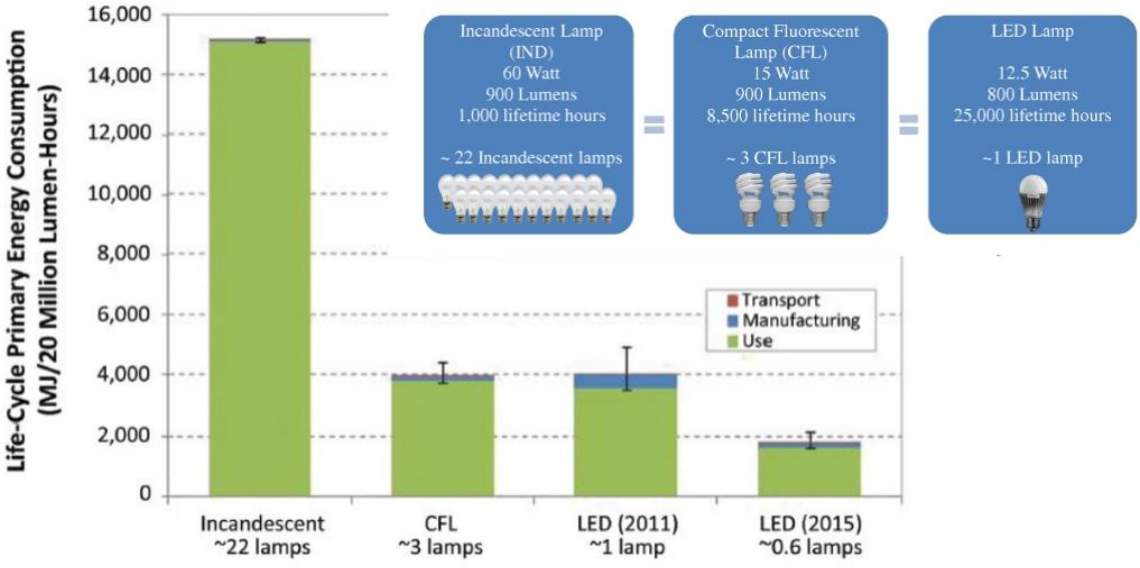


Figure 51 – Life-cycle primary energy consumption of 3 lamp types: Incandescent, CFL and LED lamp

For the environmental impact analysis it was found that because of its low efficiency, the incandescent lamp was found to be the most environmentally harmful of the three types of products, across all 15 impacts examined in the study. The LED lamp had a significantly lower environmental impact than the incandescent, and a slight edge over the CFL. The CFL was found to be slightly more harmful than today's LED lamp on all impact measures except hazardous waste landfill, because of the LED lamp's large aluminium heat sink. As the efficacy of LED lamps continues to increase, aluminium heat sinks are expected to shrink in size—and recycling efforts could reduce their impact even further. The light source that performed the best was the LED lamp projected for 2017, whose impacts are expected to be about 50 percent lower than the 2012 LED lamp and 70 percent lower than the CFL (see Figure 52).

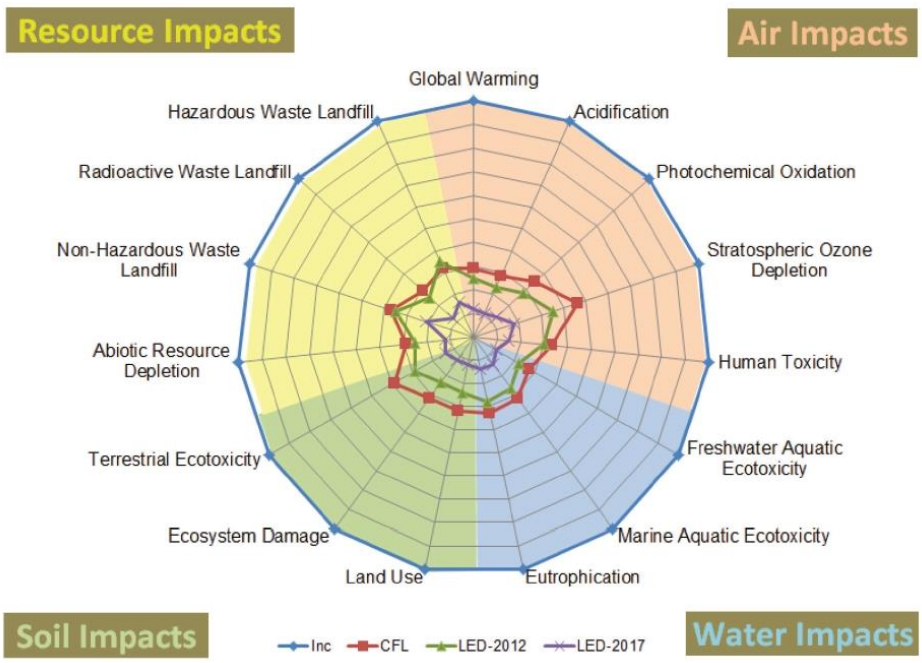


Figure 52 – Environmental impact analysis of 3 lamp types: Incandescent, CFL and LED lamp

Inefficient Luminaire

The efficiency of a luminaire is characterized by the light output ratio (LOR), and if its intensity distribution curve is tailored to the application. The development of high reflective (high specular or diffuse) surfaces for lighting purposes, of complex surface calculation methods and of new manufacturing technologies (e.g. injection molded plastics with Al-coating) has improved the efficiency of luminaires reaching now 70% or more.

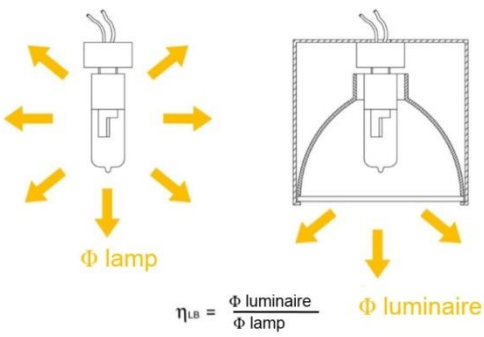


Figure 53 – Light output ratio

Luminaires are often not sufficiently optimised against glare protection, especially new technology luminaires (LED) lack glare protection. This has an impact on energy demand after improvement. Sometimes “design luminaires” are used, not technical luminaires which are more optimized towards high efficiency. LED needs efficient thermo-management, the design of the luminaire can contribute.

Control gear

Most of the stores show a lack of control regarding the adaption of artificial light to daylight levels as shown in Figure 54 for a supermarket with a bakery.

Figure 54 – Picture shows a supermarket with bakery: Artificial light is kept on at a sunny afternoon in May. The façade of the bakery consists at two sides of a fully glazed façade. Artificial light is kept on inside as well as even on at the outside area around the bakery

Careful attention should be drawn to the algorithm of control:

- Limit daylight entry to a reasonable amount (do not overlit).
- Add artificial light where and when necessary. Lighting zones need to be defined to match the target in zones with different daylight penetration and requirement.
- Control mechanism should allow that the dynamic of daylight still can be experienced.
- Adapt target for illuminance level to outdoor conditions and the time of day, e.g. do not over-illuminate when outside conditions are overcast or dim (morning, evening) and adjust the target to the natural activity level of customers.

Missing sensors for secondary rooms or less important circulation areas, e.g. presence sensor for fitting rooms, also cause inefficiencies, as does the lack of scheduling, lack of scene setting, and lack of timers. Some tasks with less demanding visual tasks permit lower targets for illuminance, e.g. during a stocking or cleaning period. Different scenes for different illuminance targets or switching off lighting groups should be managed by area. The associated control system must be easy to set up and easy to operate (e.g. graphical interface, WIFI functionality). Timers can turn off or reduce lighting levels when required at a specific moment, e.g. window display lighting for the hours after midnight or gradually increasing or decreasing illuminance during morning or evening hours. Integration in central building management (iBMS) brings together a daylight system, climate measurement and

artificial light, and allows central shut-off, programming and monitoring for a proper functioning system.

Over time, the light level of the LED luminaires decreases due to natural ageing, which is why the lights are always 'over-specified' to compensate for lumen depreciation. You can save energy by dimming at the beginning of the lamp's lifetime and gradually increase the lumen output over time to keep the same light levels. This can bring an energy savings up to 15% (Philips Lighting Division, 2014). Out of order control gear is another reason for inefficiencies. This may be due to inadequate commissioning, changes in facility management, unreliable technology, too-complex algorithms or control devices, difficult maintenance (high ceilings, long operation hours). Existing control devices are often set wrongly.

Inefficient room distribution /surfaces

Surfaces cause illuminance inefficiencies and there are a number of examples of this in shopping centres. Floors surfaces with high gloss level induces virtual mapping, which doubts the desired light- and room ambience. Attention is misguided. Floors should communicate a constant picture of illuminance, and should be dull and diffuse. Bright surfaces with a high reflexion grade can reduce energy consumption by 50% (see section 0) Goods are at the center of attention, they should be brighter than environment. The height of luminaires is another challenge, however a reduction in the mounting height may lead to savings due to the fact that targeted areas are better illuminated.

Figure 55 – High gloss level of the floor surface induces virtual mapping

Avoid high maintenance effort

An important aspect during maintenance of the lighting system is the replacement of the light source after the end of life. LED solutions with a lifespan of more than 50.000 hours (see Figure 56) will show a definite advantage. If we assume average annual operation hours for retail premises of about 3000 h/a (10 hours/day), then 50.000 hours of operation life span means 15 years of operation. In this period it is likely that whole lighting plant (or the whole shop interior) will be refurbished. As a consequence there would be no change of the light source due to aging.

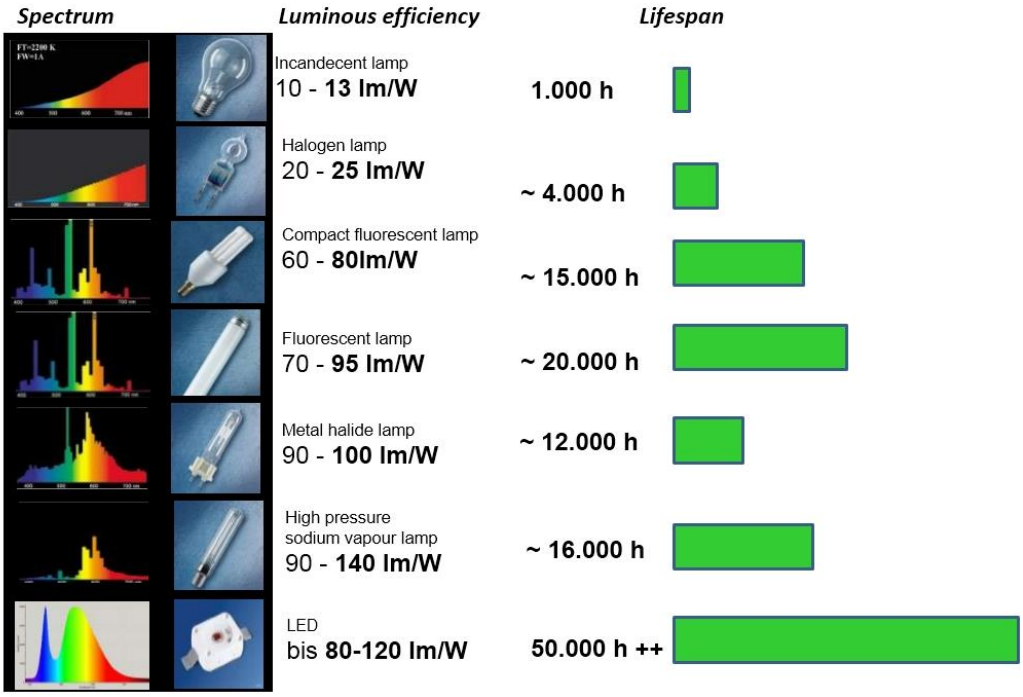


Figure 56 – Operation life-span of lamp types

Further aspects regarding shopping centre/store spaces

Vertical glazing in the entrance area should attract customers to the inside by providing an inviting view of the stores, but a satisfying visual transparency in entrance areas is often not achieved. During the day with relatively high outdoor illuminance values outside and lower values inside, cause the direct view to inside to be to some extent blocked due to the glazing's reflective properties. Little improvement is achieved by choosing another glass quality, but sensitive adjustment of indoor luminance values will generate the requested result. This should be done by carefully setting accents over the entire distance with a maximum at the view boundary – which is the inviting shore entrance. Figure 57 shows two shopping centre entrance situations with different grades of daylight transparency.

Figure 57 – Different grades of daylight transparency for an entrance area of a shopping centre. © Bartenbach

A retailer sales strategy is to attract customers with higher lighting levels, rather than by other mechanisms such as contrast, highlights, and brilliance. Simon Thorp from LAPD

consultants mentions in an interview, "It's really hard work, with the larger retailers, to get them to reduce light levels. If your ambient level drops, then you need less light to make products stand out, but contrast means that on the high street someone's sitting next to somebody else, so if someone drops their light levels, and someone beside them is at 1,500 lux and they're a similar retailer, there's pressure for them to stay up there" (Luxmagazine, 2011a). Improvements in the lighting systems potentially decrease energy demand for artificial light by reducing general lighting level. A study involving 57 clothing stores in the Netherlands revealed the effect of different lighting attributes (brightness, contrast, glare and sparkle) on the image of the retail space, and on shoppers' perceptions, feelings and moods. The findings showed that sparkle adds most to space liveliness, whereas the brighter the space, the more unfriendly and less relaxing the atmosphere (Custers, 2010), (Ticleanu, 2013).

Retail sales strategies ignore the effect of accent lighting on general lighting levels. From our planning experience we know that mid- and high-end stores use more and more accent lighting to present goods, but they neglect the impact on general lighting level (a high illuminance level for general lighting is preserved). Planning often does not consider this. Implementing a solution with accent lighting and reduced general lighting level is a sophisticated planning task as it is important to ensure a balanced illuminance distribution.

Another retail sales strategy is to compete with adjacent shops by rivalling light intensities. Increased illuminance levels aim at attracting customers to the store and prevent the loss of customers to adjacent stores.

5.3.7. Summary and recommendations

Shopping centres managers are generally responsible for lighting only in common areas and exteriors. Within direct energy costs, lighting presents a key area for savings and because lighting is often spread out over a large area, centrally controlled systems are crucial to overall lighting management.

The previous analysis has considered the inefficiencies and efficiencies associated with lighting as a general concept and different lighting systems. The following selection presents best practice recommendations and how this may be put into practice in shopping centres.

- **Extend the use of daylight to additional floor areas (a) by opening additional building surface areas or (b) by redirecting light in the building depth**:
    - Daylight as a natural, high-quality source of light has positive impact on the well-being of people and reduces operation hours of artificial lighting. The use of the sun light is equivalent to using directly a renewable energy source.
    - Develop building typologies that support daylight entry through roof or façade for example zones with atria, daylight adequate layout (e.g. no storage area next to the façade), one storey buildings (or parts of the building). Convince shop or mall owner/operator of the positive impact (energy, health and turnover) of daylight.

  - Develop technologies that supply inner areas effectively with daylight, e.g. via Bartenbach light harvester or heliostats.
  - Integrate daylight via the façade in stores. This requires a need for deep and integrated planning combining solutions such as (a) daylighting (b) visibility from outside and (c) presentation of merchandise on the inside of the façade, e.g. with shelves or torsos.
  - Implement interdisciplinary work between interior architects, architects, planners for outdoor spaces and lighting designers at an early planning stage in order to achieve comprehensive solutions. Competitive applications like BIPV on the roof or a multimedia façade have to be balanced. Integral solution approaches, e.g. usage of skylights to extract hot air in summer and to be part of a ventilation concept (during the day or for night ventilation) are meaningful. Think of supplying daylight to certain important zones like changing rooms because it is a point of customer purchase, the best light is wanted in front of the mirror (Luxmagazine, 2011a).
- **Adjust the use of daylight to a reasonable level:**
  - Avoid glare, avoid that adjacent areas remain comparatively dark, avoid that daylight interferes with sales (attract and lead customers, allow examination of goods, generate an atmosphere of well-being), avoid excessive solar heat gain.
  - Ensure high quality planning to scale daylight openings to a reasonable size and apply daylight elements which redirect light in building depth, reduces high illuminance values close to the entrance (prevent glare) and harmonize illuminance distribution along the space (to ensure stable perception).
  - Develop switchable, but cost-effective and reliable (low-maintenance) daylight elements that can adjust the inside light intensity according to varying conditions outside. Due to the sensitive indoor sales environment it is crucial to react to outdoor conditions, otherwise daylight concepts may fail due to a inadequate indoor lighting causing a loss in turnover. There may be future needs for modular concepts with easily adaptable elements for different locations and climate zones. Offering big chains different concepts at different worldwide locations.
- **Use efficient light sources and electronic gear (energy demand and maintenance):**
  - The proportion of inefficient lamps in stock like CFL, halogen or fluor T8 is high. These lamps should be replaced by LED, T5 or ceramic metal halide lamps depending on application.
  - LED in particular have properties that are extremely valuable for some shopping environments, offering controllable intensity, spectrums to match a daylight situation and a long life span, but also some efficient conventional light sources are competitive for certain applications. Use efficient ballast or lamp drivers with high power factors.
- **Take into account environmental impact and life-cycle performance:**
  - If LED meet their forecast performance target, life-cycle energy demand and environmental impact will be very good.
- **Choosing the most appropriate luminaires**:

- Combining efficient lamps with the suitable luminaires to increase the use of light is essential. Parameters are a high light output ratio and a tailored light distribution to the specific application.
- Often high quality luminaires (with valuable reflector surfaces, designed by complex surface calculation method, glare protection) are not used due to higher prices. Progress in manufacturing technology and competent consulting regarding their energetic and economic potential may help.
- LEDs are very sensitive to the operation temperature, so thermo-management will have impact on luminaire design. Luminaires which are able to conduct heat out of the room could contribute to a reduction of heat loads in the retail space.
- Glare protection is important, as is the development of a smart luminaires with a connection to iBEMS depending upon the application of some potentially dynamic features: Adjustable intensity, spectrum, beam angle, orientation in space.

- **Automatic control regulation**:
  - The various uses in retail space have different lighting needs. The best way to achieve efficient use and considerable savings in the electricity bill is having segmented areas and lighting schedules for each area.
  - Automatic lighting control should be integrated into intelligent energy management. It is particularly important to adjust the artificial light output according to the level of sunlight available. But also automated central shot-off, timer-dependent regulation of intensities regarding daytime or stocking/cleaning activities are important. Monitoring of the system allows control and adjustment for energy-efficient operation, also defined scenes – available at centre level or at shop level – can ensure an energy-efficient layout of the lighting solution.
  - As every store searches for an individual lighting solution (different goals with different types and arrangement of luminaires in different space conditions) the task would be to offer an adjustable and easy to operate platform.
  - Disciplined use of control elements, easy maintenance (integration in iBEMS), simple algorithms, quality commissioning and quality operation by qualified staff are requirements for successful implementation and durable and stable operation.
- **Establish energy efficient lighting solutions/ concepts for malls and shops:**
  - Work on concepts to limit illumination to reasonable levels. Approaches can be to harmonize lighting level in stores and the mall, harmonize lighting levels between different stores, adjust lighting levels at daytime or to different tasks (cleaning/stocking).
  - To attract customer examine other concepts rather than raising illuminance levels (1) change of a high general lighting level to a low level plus pick out, exact the accent lighting of merchandise, floor and wall or (2) change in the spectrum that causes the same comfort and sale effect with lower intensities (change in colour or brilliance).
  - There is evidence that excessive lighting levels will not increase store attractiveness or make it appear unfriendly.

- **Avoid inefficient distribution of light in the room and use appropriate surfaces.** Diffuse floor surfaces avoid misleading attention, bright surfaces with high reflexivity can save up to 50% of the needed wattage.
- **Display lighting** is important for drawing attention to showcase items and enhancing aesthetics, but many retailers use inefficient spotlights. LED together with a controlled beam lighting can save energy, while maintaining excellent colour rendering. Use light sensors in window displays to offer adequate lighting in the day and night. If it is planned that windows also supply daylight, then integrated concepts for display lighting, daylighting (and the indoor exhibition of merchandise on shelves) must be developed.
- **Kitchens** must be well lit to ensure efficient food preparation, minimize the risk of accidents and encourage thorough housekeeping. T12 fluorescents are currently the most common kitchen-lighting fixtures, but switching to T5s or T8s with electronic ballasts will save energy and provide short paybacks. Consider also installing timed switches or low-temperature occupancy sensors in walk-in refrigerators and freezers.
- **Ancillary areas, like washrooms, minor circulation areas** should use time switches and presence control.
- **Back-of-store areas** such as employee break rooms, storage areas and office space rarely require light 24 hours a day. Occupancy sensors ensure lights are on only when someone is in a room. These sensors can reduce energy consumption by 15 to 80 percent, depending on usage. Replacing fixtures with T5 or T8 compact fluorescents will save even more energy.
- **Entrance areas,** which are fully glazed in order to attract customer into the building, often lack the planned visibility. Sensitive adjustment of indoor luminance values generates the required result.

5.4. HVAC Measures

HVAC accounts for some of the highest energy expenses, but these systems are also critical to employee productivity and to the comfort and satisfaction of the customers and tenants. If the facility is too cold or too hot, you can expect complaints. HVAC systems also contribute to the facility's air quality, and fresh air is particularly important in enclosed or high-odour areas. For optimum efficiency, it is important to ensure that the functions of each HVAC component complement the others – especially when ventilation systems help distributes warm and cold air. In shopping centres, the system regulates HVAC in common areas and, in most cases, for the tenants. Different tenants have different needs, and it is essential to meet capacity under varying conditions. High ceilings in common areas, heated entrances and smells associated with food courts require special ventilation.

5.4.1. Requirements

Thermal environments can be divided loosely into three broad categories:

- thermal comfort
- thermal discomfort
- thermal stress

Thermal comfort is where there is broad satisfaction with the thermal environment i.e. most people are neither too hot nor too cold. Another way to regard this is as an absence of discomfort! Thermal discomfort is where people start to feel uncomfortable i.e. they are too hot or too cold, but are not made unwell by the conditions, i.e. they do not suffer medical symptoms due to the discomfort, beyond irritability and tiredness or chills and shivering (CIBSE Knowledge Series – Comfort 2006). The primary need for ventilation is to meet metabolic needs (oxygen and odour control), the minimum acceptable ventilation rate and additional requirements meeting the (polluting) activities of occupants (e.g. smoking, cooking, clothes drying etc.).

- To remove polluted air and replace it with fresh air (air quality)
- To remove heat (cooling)
- To supply heat (space heating)
- To control moisture level

It is argued that too often it falls upon ventilation to accomplish tasks for which it is not intended (AIVC, 2005).

Good indoor air quality may be defined as air which is free of pollutants that cause irritation, discomfort or ill health to occupants. Thermal conditions and relative humidity also influence comfort and health. A poor indoor environment can manifest itself as a 'sick' building in which some occupants experience mild illness symptoms during periods of occupancy. More serious pollutant problems may result in long term and permanent ill-health effects. Since much time is spent inside buildings, considerable effort has focused on methods to achieve an optimum indoor environment, with particular emphasis on health, odour control, thermal comfort and energy efficiency. Aspects of Indoor Air Quality (IAQ) are usually discussed with particular emphasis on providing an overview of indoor air quality in relation to:

- Sources of Pollutant
- Metabolism and Health
- Odour
- Sick buildings
- Comfort
- Reducing Pollutant Concentration

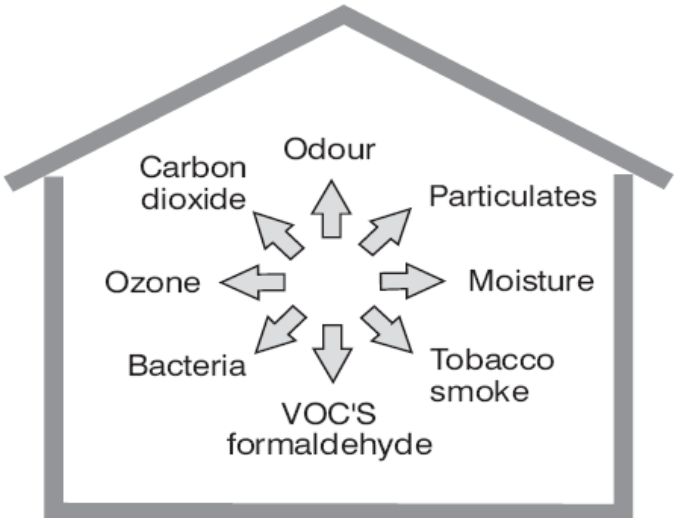


Figure 58 – Different pollutants that a ventilation system needs to remove/control

A ventilation system must be designed to satisfy the required demand. In meeting this need it is necessary to consider a wide range of criteria, varying from meeting the needs of Building Regulations to planning for maintenance and replacement (Figure 2).
It is also necessary to integrate the ventilation system itself into the overall design of the building, especially in relation to air tightness, room partitioning and accessibility.

Since such a wide range of parameters are involved, there is rarely a unique solution to a particular ventilation design. Instead the designer must base a judgment on the individual needs of each building. Ultimately a robust solution is needed which ensures the health and comfort of occupants. Ventilation needs must be based on criteria that can be established at the design stage of a building. To return afterwards in an attempt to mitigate problems as they arise may lead to considerable expense and failure.

A wide range of systems and techniques are available to meet the needs of ventilation with each having its own set of advantages, disadvantages and applications. Sometimes choice is dictated by local climate conditions or building type. Frequently, price competitiveness and an unwillingness to deviate from the minimum specification of relevant Building Regulations or Codes of Practice can further restrict choice and also limit the opportunity for innovation. To justify a complex strategy, it is usually necessary to demonstrate advantages in terms of improved indoor climate, reduced energy demand and acceptable 'payback' periods. Strategies reviewed cover both natural and mechanical systems.

5.4.2. Common HVAC inefficiencies

The following list is compiled from a number of reports. While typical HVAC related inefficiencies can be found in almost all commercial buildings, these become subject to extensive research activities in refurbishment (CIBSE Knowledge Series - Refurbishment for

improved energy efficiency: an overview, 2007) - some special issues can be found in retail environments[9] (Pless et al., 2011).

- **To pick the wrong system** when planning or replacing the HVAC unit, usually at the end of its life cycle. In addition to inefficiencies in energy use, they are often oversized and overweight. Maintenance costs and noise levels are not considered.
- **Outdoor air economizers are not planned in** air-handling units, so outdoor air cannot be used for *free cooling* during the spring and autumn or on cool summer nights when the humidity level is not too high.
- **Simple thermostats** do not provide preset limits for heating and cooling – resulting in unnecessarily high or low settings by staff. These thermostats also miss features of digital controls or readouts so that a low accuracy is provided by sliding levers on traditional units.
- **No night temperature setbacks are installed since it** requires the installation of an automatic thermostat that controls the temperature when the store is closed.
- **No scheduling** so that in practice it is not possible to shut down the HVAC equipment, or run with reduced loads.
- **Missing heat recovery ventilators (HRVs)** and **energy recovery ventilators (ERVs)** with balanced exhaust and supply fans. Unbalanced ventilation systems cannot meet all ventilation needs without creating drafts and air-pressure imbalances. Older HRVs often feature efficiencies as low as 30 to 55 percent, replacement should be considered.
- **Constant-speed drives (CSDs)**, are used with **constant-air-volume (CAV) systems that cannot** adjust fan speeds according to operating requirements at different times of the day. That means that the air volume is higher than necessary during long periods of the day.
- **No zone isolation** or **demand control ventilation** is used. Thus the same airflow is used constantly, even when a room is not in use. More energy is used not only because air distribution is higher, but also because more air must be heated or cooled.
- **Missing insulation** for pipes, valves and fittings. Traditional insulation is often not replaced once it has been removed or damaged during maintenance. This can lead to tremendous heat loss or gain, as well as condensation and safety hazards. Both, improved maintenance access and thermal-barrier replacement should be considered.
- **No use of heat pumps that could** transfer heat from a lower-temperature source to a higher-temperature area. Depending on the heat source, a heat pump can produce two to three times the energy consumed. **Geothermal or ground-source heat pumps** (GSHPs) are particularly efficient but difficult to install during refurbishment. Dual heat pump installations can extract heat in the winter from a heat source i.e. outside air and transfer it to the interior; in the summer, they can be reversed to be part of the cooling system.
- **Improper maintenance** is critical to any system and leads to increased operating costs, shorter operating life and additional costly repairs. For air-handling units, expired, or low-

[9] "Cherry Picking Versus Multiple Measures", Natural Resources Canada, Office of Energy Efficiency. Retrieved from NRCAN Archive: https://www.nrcan.gc.ca/energy/publications/efficiency/buildings/6565

quality filters will hardly reduce airborne dust and contaminants and increase fan power. Cooling units, like fan coils needs to be regularly cleaned to maintain efficiency. Also boilers need proper maintenance and as such have regular maintenance plans.

- **Lack of bioclimatic solutions:** bioclimatic architecture are building integrated solutions that take into account the presence of vegetation, prevailing winds, etc. to design buildings with extended comfort and minimal power consumption. The effect is sometimes difficult to estimate and often forgotten in the design phase.
- **Inefficient air conditioning systems**: The energy demand for cooling in many places already exceeds the demand for heating, and is one of the main causes of the energy consumption in shopping centres. Usually, there is here a great waste of energy. For example, conventional units are oversized (or run on partial power) and do not exploit local cooling (e.g. based on the evaporation of water). Often air conditioning systems are installed without the support of energy return. The free-cooling which could be used when the outside air is cooler than the air leaving the premises is often not exploited (see building envelope section for further details).
- **Energy losses in the ventilation systems**: An improper ventilation system fails to maintain optimum air quality inside the mall. Improper or no air exchange with the conservation of the comfort temperature results in unnecessary energy losses.
- **Lack of recovery systems and "recycling" of energy**: Machines that provide useful energy for air conditioning and even lighting have remarkable thermal energy losses, which usually dissipate in the environment and increase internal loads. Lack of recovery systems multiplies this energy inefficiency. Energy can be recovered by different possibilities: heat recovery from exhausted air from ventilation; in boilers the heat recovery may be both heated water purging and from the exhaust gas at high temperature; in the cold producing capacitors the heat expelled into the atmosphere can be recovered; recovery of heat produced by the dense condensations of luminaires.
- **Lack of cogeneration or trigeneration**: Not using cogeneration and trigeneration systems means an inefficient overall system. **Cogeneration** or combined heat and power (CHP) systems produce two useful forms of energy – usually electricity and steam heat – from a single fuel source. Although conversion to such a system can be expensive, overall efficiencies of 85 percent are often achieved. CHP fuel costs are up to 35 percent lower than those for separate generation systems. For example in a typical CHP system, inserting an electric generator at the point where the gases are produced at high temperature by burning the gas, electricity is obtained. The exhaust gases have still enough energy to be used in air conditioning, heating both directly and indirectly through a heat exchanger. Using a trigeneration configuration, all the energy requirements (heat, cold and electricity) will be supplied.
- **Inefficient heat and cold distribution system**: One of the main sources of energy wasted is located in the ducts that distribute heat and cold throughout the facility. They often are very long which makes the surface where heat or cold can be lost large. This is mostly due to missing insulating coating. At the same time, pumps pumping water also contribute a lot to unnecessary energy losses
- **Suboptimised HVAC terminal units**: It's about choosing the best system (underfloor heating, fan coils, radiators, high efficiency and low temperature, ceiling, floor or radiant

walls, etc.). In addition the wrong location of the heating elements can lead to losses of 5%.

5.4.3. Heating-Specific inefficiencies

- **Wrong fuels for HVAC**: The return of less useful energy per unit than energy consumed does not allow a more accurate liquid or solid fuel regulation. The age of the boiler is an important factor. Over seven years of operation, replacing an oil boiler with a gas one is amortized over five years (depending on operation times).
  - **Low efficiency boilers** (non-condensing and high temperature boilers): low performance boilers are outdated machines that do not deliver a high percentage of useful heat in exchange for fuel burning inside (in opposition to high efficiency boilers). They are less effective in combination with low efficiency radiators and without a system of temperature sensors. Condensing boilers are a good option.
  - **High-efficiency condensing boilers** will save a great deal of energy when it is time to replace old boilers which often can achieve seasonal efficiencies as low as 75 percent (compared with 96 percent for high-efficiency condensing boilers). 50% lower initial costs (and being able to keep the initial piping distribution and terminal-heating units) tempt building owners to purchase (or simply keep) less efficient boilers and the calculation of incremental paybacks compared with purchasing midrange replacement boilers should be considered (paybacks of two to six years are common).
- **Boilers without flue gas economizers:** missing heat exchangers that could be used to preheat water using boiler-stack and exhaust gases. Without economizers a 5 to 10 percent decrease in efficiency.
- **Missing air preheaters** that preheat fuel and air before combustion.
- **Proper fuel-to-air mixture** is not maintained. Systems that minimize energy loss by reducing the amount of excess air or fuel in a boiler stack are missing (e.g. **boiler combustion** and automated **oxygen-trim control systems)**.

  Hot water that is continuously drained from a boiler. Boiler blowdown heat recovery (which uses a heat exchanger to extract thermal energy) or **Continuous boiler blowdown monitoring and control systems** (which reduce the amount of hot water continuously drained from boilers) are not installed.
- **Residual heat** being drawn up the warm stacks: Automatic vent dampers for boilers could reduce the amount of air that passes through furnaces or boiler-heat exchangers and improve comfort conditions during the winter by helping retain humidity in a building.

5.4.4. Cooling-Specific inefficiencies

- **Regular chiller units** without controls, condensers and compressors. Their low costs, may often yield unreasonable paybacks.
- **Inefficiencies in other parts** of air-conditioning systems, such as pumps, cooling towers and controls.
- **Improper use of refrigerants** that waste energy.

- **Missing thermal energy storage** (TES) fails to store cool water for later use as an air coolant. This function is particularly missing at peak demand times during summer days.

5.4.5. Ventilation system

Ventilation efficiency can be measured by specific fan power of the ventilation system. Ductwork friction and resulting pressure losses have to be overcome by fans. Bends, diameter changes, and other devices in the ductwork lead to an increase in friction resulting in a higher pressure that fans have to overcome.

5.4.6. Summary

Quality control of the complete energy system is necessary if energy-efficient solutions are to be met. To perform good building operation and quality control of a given system, it is necessary to have information about building systems and assessment tools. A commissioning procedure that enables follow-up of the building performance during the building lifetime can help detect systemic inefficiencies. Different assessment tools and different inspection algorithm have been developed. Overall, around 20% of all the defined building performance data can be monitored by BEMS. In a study undertaken in Norway it was found that fault in mass balance prevented implantation of desired temperature control for floor heating system. Comparative analysis including detailed monitoring system helps tracking energy use and fault detection in operation. Yearly and hourly profiles of energy consumption with separated use and energy carriers are important to analyse in a holistic manner.

5.5. Building Envelope

The demo-case and reference buildings study and the literature review revealed that there are a variety of systemic inefficiencies. Some are dealt with in national building regulations but these are often only valid for new constructions. Retrofitting rules are less strict and again vary among countries. See also D2.1 for a more detailed analysis of building regulations related to shopping centres.

The thermal conditions found in the envelope (low levels of thermal insulation in walls, floors, windows, roof) are usually the landlord's responsibility. Many smaller retailers, if located in a shopping centre or multi-use building, may only have an employee entrance or shipping door facing an exterior wall; some do not have exterior walls at all. Although a department store may have multiple customer entrances, even big-box stores and supermarkets generally have only one exterior wall including windows. Most of the following heat-loss prevention measures apply to shopping centres and large retail chains. Old windows and doors with low quality insulation will increase utility costs. Improvements in the building envelope are generally more cost-effective when conducted at the same time as constructing a new part of the building or performing a major retrofit. Unnecessarily high internal loads from improper lighting often reduce heat losses (and increases cooling loads). It thereby seems less

feasible to invest in building-envelope improvements. Once internal loads are minimized cost-effective building-envelope improvements have shorter payback periods.

5.5.1. Windows and doors

- The properties of outdated windows: Single-pane standard glazing is inefficient and there a number of options which improve the relative energy inefficiency of windows. These include **double- and triple-pane glazing**, **tinted glazing**, **reflective glazing**, **spectrally selective glazing** and **insulated glazing with inert gas** between the layers. Wood and vinyl frames are more energy efficient than aluminium. Thermal brakes can be found for both. **Storm-window systems** reduce heat loss in winter.
- A more cost-effective option than new windows is the installation of **solar glazing** or **reflective film** inside existing windows. Energy savings can be as high as 25 percent, with approximate paybacks in less than three years, depending on climate and energy costs.
- **Missing daylighting panels** that are translucent units that diffuse the light throughout the space and reduce glare. Typical are aerogels as fillings with better U-values than conventional windows.
- **Other window coverings** such as shutters, shades and draperies provide insulation benefits, especially in summer when they reduce the amount of sunlight – and heat – entering rooms.
- When replacing **exterior doors**, to choose **well-insulated**, energy-efficient models.
- **Revolving doors** are the best choice for keeping wind and weather out of lobbies. It is necessary to check these doors periodically to ensure there are no leaks along their edges or bottoms.
- **Low-quality weather-stripping** that is less durable and short lasting should be renewed which will help combat unwanted drafts.
- **Missing plastic secondary-door curtains** inside delivery doors and bays.
- **Inefficient insulation** types should be changed to energy-efficient insulation including fiber (usually available in loose-fill and batts) and foam (usually available in rigid sheets and sprays). Optimum thickness depends on the climate, building services system and energy prices. Exterior reflective materials are also available, but offer poor insulation value.

5.5.2. Other Building-Envelope Measures

- **Air leaks and cracks** should be sealed using foams, caulking and weather-stripping. Stuff fiberglass or glazier's foam *backer rod* insulation into areas too large to be caulked.
- **Wall- and roof-insulation upgrades** are best undertaken as part of larger renovation projects. Insulation upgrades in basements and top-floor ceiling crawl spaces can be done anytime.
  - If **wet insulation** is detected, it is important to replace it immediately once the source of the moisture has been identified and repaired.

- **Wrong paint or material on the exterior of the facility:** Choose a light colour, if possible. Applied on the roof this can help reflect insolation, ease cooling loads and reduce energy consumption for cooling.
- **A suspended ceiling** reduces the area to be heated or cooled in big-box or other stores with high ceilings. It is often in conflict with thermal activation of the ceiling for cooling purposes.
- **"Living" or "green" roofs** are popular in Europe. These roofs are planted with grass and other vegetation. In addition to excellent insulating properties, this roof style could present multiple uses – and aesthetic appeal – in larger stores and malls.

5.5.3. Summary

Recommended levels of thermal insulation in the building envelope depend on the climate. Building energy use should be calculated and insulation levels optimized. Single measures often do not yield cost-effectiveness but deep retrofitting (many measures together) achieves high levels of energy savings. Ideally, this should be simulated using building performance simulation tools.

5.6. Other inefficiencies

The following sections try to summarize systemic inefficiencies in the fields of food refrigeration, motors and drives, cleaning and maintenance, water usage, control systems, logistics, and retrofitting process.

5.6.1. Food refrigeration

Tenants are usually responsible for refrigeration and since costs can be high the individual metering of stores with food refrigeration is important.

- **Doors** should be installed on open freezers and refrigerators. It is cost effective to replace old refrigeration units with energy-efficient new ones.
- **Night blinds** should be installed on all open cooling cabinets, if none exist already. For displays with goods that are accessed less often, consider **day covers** or **plastic strip curtains**.
- **Heavy plastic curtains** outside the walk-in cooler or freezer keep the cold air in and the warm air out.
- **Energy-efficient central compressors**, properly sized to match the load, can be one of the most important investments since compressors are one of the largest energy users.
- **Compressor and evaporator fan controllers** for walk-in coolers and freezers, such as the variable speed drives, can cut the voltage to the motor and slow down the fan when full air flow is not needed. They are most useful in units that run between 22° to 4°C, with evaporator fans that run at full speed all the time. Different models include basic units that sense when the refrigerant has ceased flowing through the evaporator coil, mid-range units that monitor data over time and activate warning lights and top-end units that

have a modem for remote or full-time monitoring. Savings can vary from 10 to 60 percent of overall refrigeration energy consumption and have paybacks as low as one year.

- **Remote condensers** allow for the rejection of heat to the building's exterior, instead of into the retail space when the air requires cooling.
- **Demand-defrost controls** initiate defrost cycles only when needed, instead of using automatic timers.
- **Dewpoint controls** on display cases prevent the build-up of fog on glass surfaces and the build-up of moisture on metal surfaces.
- **Larger heat exchangers** are more efficient than multiple, smaller units so when renovating, try to group cabinets together to improve facilitation of heat removal or recovery.
- **Fibre optic lighting** piped into cabinets minimizes heat input from traditional lighting.
- **Lighting occupancy sensors** for walk-in coolers or freezers will ensure that lights are only on when needed and will make it easier for employees to carry food in and out.
- **Insulation** in coolers and freezers should be inspected and upgraded regularly.
- Refrigeration systems. General measures: selecting appropriate storage temperatures, planning and optimisation of the opening of the chambers, programming defrosts, program revisions and maintenance of the facility.

5.6.2. Motors and Drives

Motors are used to run HVAC systems, escalators, elevators, hardware-store tools (key cutters, saws) and other equipment, and can account for up to 50 percent of the facility's overall energy use. Over a typical 10-year operating life, a motor can consume electricity valued at 50 times the original cost of the equipment. Store managers can sometimes have more decision-making power over replacing and upgrading motors than with standardized measures, such as those for lighting and refrigeration.

- **Outdated motors** should be replaced by energy efficient motors. Even if they yield only 2 to 8 percent in energy savings, these motors generally achieve incremental paybacks in 2.5 to 5.0 years compared with buying less-efficient replacement motors (due to relative low investment costs).
- **Constant-speed drives** (CSDs) – should be replaced by **variable-speed drives** (VSDs) and **variable-frequency drives** (VFDs) – regulate motor speeds according to the amount of work required. These drives are particularly useful when combined with high-efficiency motors since they tend to run faster than conventional motors. An added benefit is their ability to reduce noise – an important consideration in the retail industry. These drives can save on the facility's total energy consumption, but tend to be expensive, with approximate paybacks between two and eight years depending on energy costs.
- **Power-factor correction capacitors** are devices that store electrical charges and reduce consumption of reactive power that motors need to generate magnetic fields. These are important only if there are demand charges on the electricity bills.
- **Energy-efficient drive belts** have teeth or longitudinal grooves that improve grip, reduce slippage and are only slightly more expensive than standard V-belts. Ensuring

that drive-belt inspections are performed every few months as part of regular maintenance, and replacing the belts when they wear out is possible to save energy.

- **Wrong motor size** for the job. *Oversizing* is the inefficient practice of employing a larger motor than required for a task. This is a particular concern if the motor is loaded under 50 percent.

5.6.3. Cleaning and Maintenance Measures

The cleaning and maintenance of shopping centres are "invisible" but crucial activities. The relationship with energy efficiency is important, because keeping all equipment and energy consuming systems in perfect working condition, make possible the activities which take place in the shopping centre.

- **Cleaned best with less energy**: A system of organised and systematic cleaning will reduce the need for more aggressive cleaning.
- **Recycling:** Facilities for both customers and tenants to take care of their waste with a suitable arrangement of bins and containers.
- **Cleanness allows more light**: Proper maintenance and cleaning of lighting installations is a crucial activity in a mall. It is important to clean lamps and luminaires scheduled on regular intervals. Changing the bulbs and the proper orientation of spot lighting are other measures. Skylights and translucent facades bring less light in, if not cleaned on a regular basis.
- **Cleaning, inspection and maintenance of HVAC installations:** clean and well maintained technical rooms function more efficiently.
- **Programs and setting reviews about Energy Efficiency**: A good maintenance program is essential to ensure and improve the efficiency of air conditioning systems, lighting and general machinery in a shopping centre. It is essential to hire professional maintenance of facilities with firm specialising in performing the review and commissioning of the climate control system, including cleaning, repair, reinforcement insulation at key points, acting on the automatic temperature controllers, sensors and replacing faulty thermostats. As previously mentioned dirty filters and ductwork in air handling units lead to increased energy use for fans and will possibly have a negative impact on IAQ. Most facility managers have replacement programs for filters at least once per year. To limit energy demand for pumps, especially fan coils and other local cooling units regular cleaning and service inspection is required. Common recommendations are twice per year.

5.6.4. Water Measures

Service hot water (SHW) – for washrooms, kitchen sinks and dishwashers – is supplied either by boilers within the HVAC system in larger facilities or, more commonly, through point-of-use water heaters. Provision and servicing of cold water systems is also an important consideration in larger stores and shopping centres, since energy is often required to pump water for toilets/urinals, fountains, faucets, landscaping, water-cooled air conditioners, cooling towers and humidification. Many drinking-water purification processes also consume energy.

- **Pick the right system** for the facility. A unit that is too small may leave you without hot water, and too large a unit will consume more energy than necessary.
- **Water heater timers** ensure the heaters operate only during opening hours. **Insulating jackets** for water heaters are also an inexpensive investment with short paybacks.
- **Low-flow and/or low-temperature commercial dishwashers** save 35 to 60 percent on water and water-heating energy.
- Low-flow toilets, waterless urinals, urinal sensors and other water management measures can reduce cold-water use by over 20 percent.

5.6.5. Control Systems

Energy management control systems enable facility managers to improve energy efficiency by automating lighting, HVAC and other equipment. Simple controls can be used within any size of retail establishment, but the emphasis should be on simplicity so that retail staff can use them. More complex systems are important in shopping centres or larger stores with maintenance staff.

- **Simple control systems** include time clocks, programmable electronic thermostats, programmable time controls, photocells and occupancy sensors. **Occupancy sensors**, which recognize the presence of people either through temperature change or motion, provide energy savings of 15 to 80 percent in rest rooms, small offices, storage or warehouse areas, staff rooms and other areas. Paybacks on most sensors are about five years. Although motion sensors mounted at light switches are the least expensive, they suit only small, open areas where occupants are constantly within range – not in large rooms or washrooms with stalls. The data network used by an electronic point-of-sale system can sometimes be used by the control system to share information within your facility and with head office. **Carbon-dioxide sensors** adjust ventilation depending on the number of people in a room.
- **Energy management systems (EMS)** are computerised systems that enable the programing of various functions from a central point in the facility and provide the early detection of operational problems. Some systems feature scheduling and monitoring functions that control temperatures and equipment in different zones – including fire or theft alarm systems. Many models can turn off equipment or activate backup generators at peak demand times. Some systems can be controlled centrally – enabling the activation of lighting and HVAC when stores open – while others are based on key-card access or occupancy sensors that manage lighting and HVAC based on room occupancy.
- **Individual metering** can ensure that the tenants or owners are paying only for the energy use – not the neighbours' -and that it is possible to see direct savings from the energy efficiency measures. Sub-metering within a large department store can help track the exact energy use.

5.6.6. Logistic measures

The supply of commercial products through suppliers, transportation to the centre, storage, management and the final transport from the shopping centre to the homes of customers are processes that consume energy.

- **Marketing policy for products with reduced energy footprint**: The energy footprint of a product must collect all the energy inputs that have meant their manufacturing, transportation, marketing and end use. It is possible to propose a policy of selling products with low energy footprint as part of the policy to improve the quality of the shopping centre.
- **Improved efficiency of appliances and machines**: A business needs a lot of specialised machines that complement the air conditioning, lighting and information management. All these apparatus consume energy so it is necessary to evaluate the real needs, and if they are even used or could be replaced by elements without energy consumption.
- **Improving the efficiency of the internal mechanical transport property (**elevators **and escalators**): For this, improve availability schedule elevators batteries, replace the old models of lifts with more efficient models, install motion detectors in escalators and sensors to move more slowly when no one is using them.
- **Improve the efficiency of transport and distribution of merchandise**: This is to improve transport efficiency from distribution sites to the point of sale, or from the place of sale to the homes of customers. Some measures are: rationalizing routes (reducing the number of trips collecting matching routes and reducing the number of daily deliveries) and improve the efficiency of the vehicles themselves (changing conventional vehicles by hybrid or electric versions and use efficient driving techniques)
- **Improving transportation efficiency centre workers**: One of the most important steps that can be taken to improve energy efficiency is to implement a plan for efficient mobility for workers in the mall. For example, implementing a company route, encouraging car sharing and the use of high-efficiency cars, facilitating the use of public transportation bonds, creating a bicycle parking or facilitating teleworking in administrative positions.
- Facilitating customer access efficient public transportation:

The shopping centre can cooperate in the overall goal of efficient mobility, through a series of measures that will improve customer satisfaction and public image. There are a number of possibilities: bicycle parking, charging points for electric vehicles, free parking or other incentives for high-efficiency vehicles (such as hybrids) or incentives for client access by public transport.

5.7. Ergonomics and Safety

Energy investments and energy efficiency in shopping centres are the primary focus of the CommON*Energy* project. However this report also addresses a wider range of fields associated with sustainable shopping centres. Sustainable environments are not just energy efficient environments, they are also accessible environments where all sections of society can move around and feel comfortable and accepted, without the implementation of special measures which demand time and resources (Kjølle, et al. 2013).

Safety and ergonomics are key requirements when designing, implementing, managing and retrofitting a shopping centre. This section will focus on how these requirements may have a positive or negative interference with energy consumptions. The study will provide input for interested parties, especially when two different options (one with a positive impact, another one with negative impact) are possible. The study makes a summary of guidelines related to ergonomics and safety which are known to professionals active in designing, constructing, retrofitting and managing shopping centres and related areas, especially when legal compliance is needed.

Input is taken from (1) the questionnaires, (2) literature survey (3) task 2.1 (standard and regulation analysis).

In the questionnaires for owners and managers, and tenants, respondents were asked to rate their shopping centre in terms of accessibility. Overall among owners and managers, most rated their centre averagely on the 6 point scale between not good and very good. They were most pleased with legibility and signage, and least pleased with valeting zones. Among tenants perceptions were more articulated, legibility and signage received a high rating from half of the respondents , but so did also many other aspects. However, in the answers from tenants some were less pleased with certain aspects. Starting in the order of lowest score: outdoor meeting places, children facilities, staff rooms, barrier free delivery, and accessibility for the visually and hearing impaired received the lowest score from tenants.

Rate the shopping centre's accessibility in terms of: (Rate from 1, not good to 6, very good):

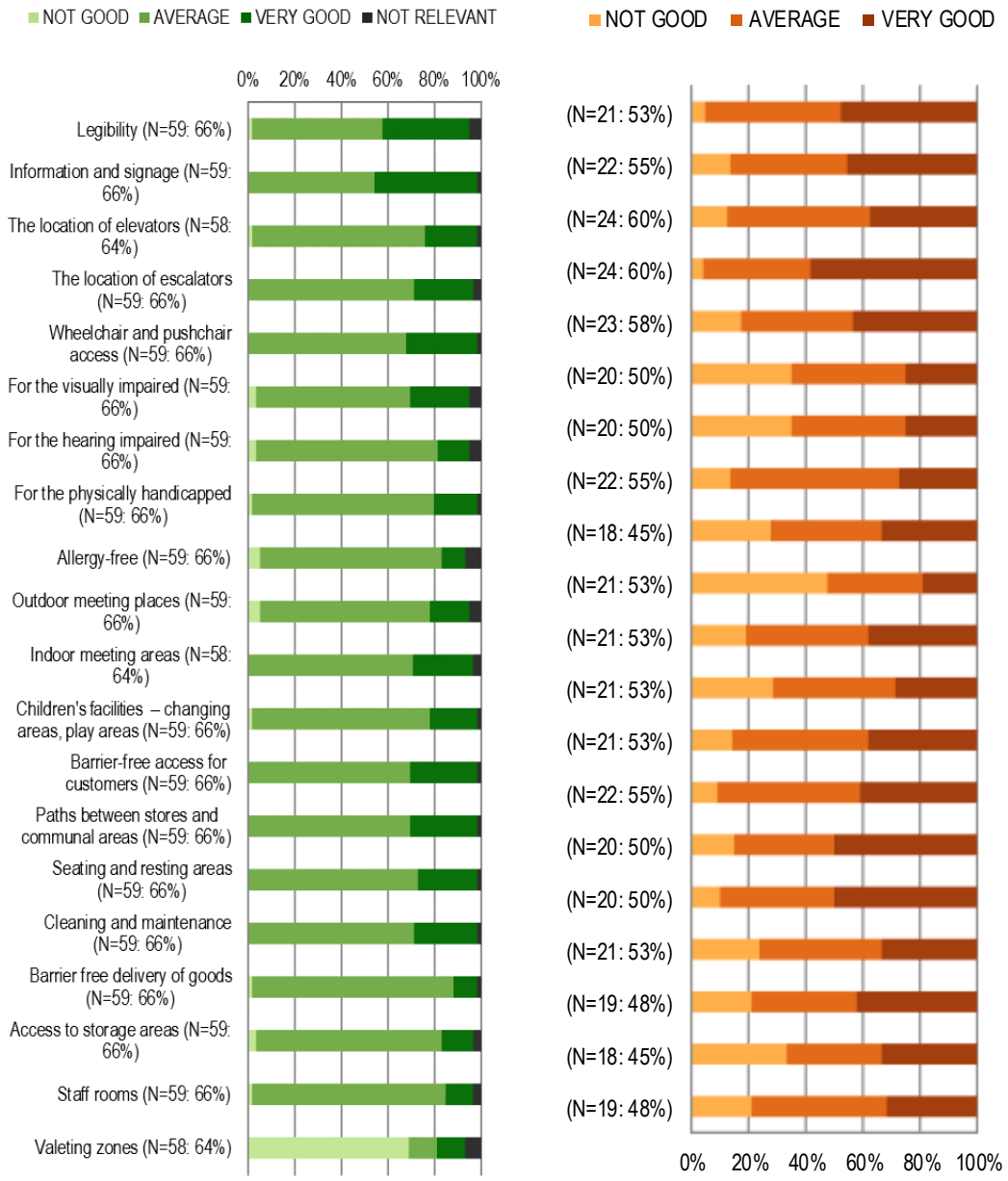


Figure 59 – Owners questionnaire (right) and tenants (left). Answers to the question " How would you rate the shopping centre's accessibility in terms of? (Rate from 1, not very good to 6 very good):"

5.7.1. A definition of Ergonomics

Also called “human engineering”, is the science that tries to optimise the interaction between the person and the environment in order to adapt the positions, environments and organization to the capabilities and limitations of people, and thereby minimize stress and fatigue, encouraging an increase the performance, safety and comfort (ESPADELADA-

project). This is accomplished by designing tasks, spaces, controls, displays, tools, lighting, and equipment to fit the physical capabilities and limitations of the expected user.

In a workplace setting, ergonomics is the science of fitting workplace conditions and job demands to the capabilities of the working population. Effective and successful "fits" ensure productivity, reduce the risks of illness and injuries, and contributes to workforce satisfaction. Typical ergonomic risk factors are found in jobs requiring repetitive, forceful, or prolonged exertions of the hands; frequent or heavy lifting, pushing, pulling, or carrying of heavy objects; and prolonged awkward postures. Vibration and cold may add additional risk to these work conditions. Furthermore, working conditions presenting multiple of these risk factors are more likely cause musculoskeletal problems. The risk level depends on the intensity, frequency, and duration of the exposure to these conditions in combination with the individuals' capacity to meet the force of other job demands that might be involved.

5.7.2. Inefficiencies

Tenants

Tasks can take place in stores. This often serves as means to increase productivity, improve quality, reduce waste, and to save time. There are also a number of ergonomic benefits to shop work, such as controlling work heights, supporting tool weights, and controlling environmental conditions. While some ergonomics-related risk factors can be controlled through shop work, it may create other job-specific hazards including heavy manual lifting, repetitive movements, awkward or static postures and contact stress. Employees should be aware of the potential hazards that are unique to a shop setting (MSA, 2012).

The 4 main inefficiencies in ergonomics for shopping centres can be defined in the following fields:

- Manual handling of loads (MHL)
- Repetitive movements
- Lighting
- Temperature and humidity conditions

A) MANUAL HANDLING OF LOADS (MHL)

In addition to physical fatigue, MHL may cause injuries such as bruises, cuts, wounds, fractures and musculoskeletal injuries in sensitive areas such as shoulders, arms, hands and the back. MHL is a risk factor both for workers handling loads regularly and for those who do so occasionally. In total, MHL constitutes 20-25% of all work place accidents. The injuries that occur are typically not fatal, but cause large economic and human costs due to relatively long and difficult recovery time or because of subsequent disabilities (ESPADELADA-project).

Preventive Measures

To minimize the risks related to the MHL, it is necessary that the employer takes appropriate preventive technical and organisational measures to avoid MHL whenever possible. Examples of preventive measures are use of mechanical aids, reduction of loads or redesign, action on work organisation and improvement of the work environment taking into account the individual abilities of the people involved (ESPADELADA-project).

Not all adoptable solutions are complicated and expensive. Sometimes, the use of common sense may lead to simple, effective and cheaper solutions than major investments in mechanical equipment. In simpler cases mechanical handling equipment can be used. These aids do not totally eliminate MHL, but may help reduce it considerably. These aids are usually relatively cheap and may be versatile enough to adapt to different situations (trucks and cars, lift tables, platform lift trucks, boxes and shelves rolling)(ESPADELADA-project). In addition, very simple mechanisms to help workers in holding loads more firmly and overall reducing the need to bend may be used (such as hooks that serve to manipulate sheets of steel or other material, the pliers for large boards or logs, etc.) (Ministry of Peru, 2013). It is crucial that the employer provides appropriate training and information for the workers through " training programs " that include: Correct use of mechanical aids, information and training about the factors that are present in the handling and how to prevent risks due to them, correct use of personal protective equipment (if required), education and training in safe techniques for load handling and information about the weight and centre of gravity of the load.

When weight values are exceeded (hence, when the MHL is inevitable/cannot be avoided), depending on the particular situation, the following measures may be considered: the use mechanical aids, lifting the load between two people and reduction of the manipulated loads in possible combination with reduced frequency, etc.

Repetitive movements

Repetitive movements can be damaging, a group of continuous movement resulting in muscle fatigue, overload, pain and ultimately injury. A review of actions could define a work is repetitive when the duty cycle takes less than 2 minutes or when the same basic movements represent more than 50% of the cycle length. Moreover, it is classified "highly repetitive" when the cycle is less than 30 seconds, which, only indicates the time associated with the task and not the movements performed (ESPADELADA-project). A good job design or training workers who perform a particular task will help in preventing this type of injury. It is convenient to separate operators into two groups: those who lead the position at some time and the new entrants. For the former, we must determine the needs and content of training by:

- The analysis of their work
- Identifying vicious postures or manoeuvres
- The modification of existing methods and the development of training objectives
- The communication of new techniques by the appropriate methods
- Establish internships to familiarise workers with new methods and allow the correction of wrongly learned manoeuvres

- Ensuring the maintenance of the new methods.

For workers recently incorporated, gradually introduction to the normal rhythm of work is of vital importance; experienced workers should also be informed and properly trained. This group includes workers who are returning to work after the holiday period or a prolonged absence. One of the most widely used measures, but by no means always the correct solution is job rotation. This solution is valid if different assignments promote a relaxation of the structures subjected to overexertion.

Lighting

Inadequate lighting at work can cause eye fatigue, tiredness, headache, stress and accidents. Working with low light damages eyesight. Sudden changes in light can be dangerous, because blind temporarily, while the eye adapts to the new lighting. The degree of security with which the job is executed depends on visual capacity and this depends, in turn, of the quantity and quality of lighting. Achieving a good level of visual comfort must balance the quantity, quality and stability of the light, avoiding reflections and flickering illumination, uniformity, and an absence of excessive contrasts. This should be done according to both, the visual demands of work and personal characteristics of each person. Workplaces should preferably be lit by natural light, but if it is not sufficient or does not exist, lighting should be complemented by artificial light. This should primarily be general lighting, supplemented by localised light when the job requires it. Improper lighting can cause poor posture, eventually generating musculoskeletal disorders. Illumination levels should be adapted to the task at hand and take into account the age of worker and the actual conditions under which the work should be done (ESPADELADA-project).

Temperature and humidity conditions

In a comfortable environment there is no temperature fluctuation, lack of air or drafts. It is impossible to define the exact parameters of a comfortable environment, because of for example different individuals feeling comfortable in different conditions. When people are not able to exercise individual control over their working conditions problems may appear. A bad thermal environment causes reductions in physical performance and may result in mental irritability, increased aggression and tendency for distractions increasing the risk of errors, discomfort (from sweat or trembling), an increase or decrease of the rate heart, etc., and may in extreme cases cause death (ESPADELADA-project).

Humidity

High relative humidity (60-70%) with ambient heat causes sweating, in this humid environment the sweat cannot evaporate and this increases the feeling of heat. In a shopping centre, the relative humidity should be between 30% and 70%, depending on external conditions and internal activities. A relative humidity of less than 30% may result in: dry skin and dermatitis, headaches, stinging eyes and sinusitis, increased susceptibility to infections and the sensation of breathlessness (ESPADELADA-project).

Cold

Workers who interact with freezers and those performing outdoor work are exposed to cold. When exposed to cold environments, the body needs to limit heat loss and increase heat production to compensate for temperature losses. This is achieved by reducing the flow of blood to the skin. Decreased skin temperature chills, uncoordinated muscle contraction increases heat production. Acclimatization of the body to cold is not the same as heat acclimation. The body is less effective in withstanding low temperatures; although it can produce some habituation (reduced sensation) that allows for a better withstanding of the cold (ESPADELADA-project). Exposure to intense cold produces two types of effects, those located in the periphery of the body (numbness in hands and feet, decrease of sensitivity, clumsiness or freezing of cheeks, ears, fingers, toes) and others of a more general type (loss of concentration, confusion, loss of coordination, hypothermic coma).

The measures to control the risks related to exposure to low temperatures will depend largely on the situation: intense cold in special facilities (cold storage) or moderate risk situations. The characteristics of the situation to which we should pay more attention are the physical activity of the worker and the air velocity. Generally, it is necessary to control: the exposure time in high-risk situations, the type of clothing appropriate to the level and activity of cold physics, heated resting places, access to hot drinks, work organisation and the design of machines and tools as a way to facilitate the work and health surveillance to detect early symptoms (ESPADELADA-project).

Heat

Some workers are exposed to very high working temperatures, for instance those who work near boilers or ovens. This constitutes a serious health threat. However, many workers are exposed to temperatures that are higher than appropriate to the nature of their work and therefore endure annoying situations.

Exposure to heat determines the implementation of a series of mechanisms to lose heat in order to maintain the internal temperature. The most important mechanisms are the production of sweat, cardio-circulatory changes and changes in body temperature. To assess the risk of heat exposure it is necessary to consider physical activity (type of work), clothing, age, gender and the health status of the workers. From a preventive point of view, two different situation categories should be considered: 1) Situations at risk of heat stress, typical to some kinds of tasks (e.g. mouths of furnaces), or bad workplaces acclimated in summer and 2) Situations involving thermal discomfort.

5.7.3. Health and safety inefficiencies

Conventionally a “hazard” is defined as work material, equipment, work methods or practices that have the potential to “cause harm” to Health and Safety (H&S). In the retail industry it is usual to consider hazard as a problem affecting both workers and public. According to the “European Agency for Safety and Health at Work” this industry has peculiar characteristics in terms of H&S, mostly related to the fact that the retail sector employs a large proportion of young people and concentrates a large quantity of persons in a confined and closed area. In

shopping centres, young workers are particularly at risk due to some of the characteristics of the work: low pay, casual, part-time and weekend work, and increasing use of shift work with a high staff turnover. Over a quarter of workers work part-time in this sector, and many of these are young workers, especially students still attending school or university.

Risks in the retail sector are not always obvious compared to some other types of work and this may contribute to the fact that these risks are not so well-controlled. Shop and store work may be exposed to a number of different hazards, including; violence from customers, lifting loads, sprains and strains (for example from repetitive work; slips, trips and falls), dangerous equipment (for example box crushers and meat slicers), hazards associated with moving and storing goods (such as objects falling from pallets and racking, stacking that is unstable or difficult to access, and unsafe ladders), moving vehicles in delivery areas, bad air quality and fire and smoke accidents.

Experienced workers are also exposed to safety issues. They often work shifts outside shopping centre opening hours, overseeing the smooth running of the shopping centre. According to the interviews made in the framework of WP2 shopping centres are "alive 24-7": there are repairs and deliveries taking place outside opening hours, the busiest time is often before the shopping centre opens. A technician described the challenges they faced under a fire drill simulation: the drill was supposed to be completed during the space of 20 minutes, but he suggested the two of them who were checking the areas to make sure they were empty had "no chance" of completing this task in the 20 minutes allotted to them. A shopping centre is a complex physical space that often develops over time, amongst other things new technical rooms, extensions to the main building, ventilations systems are added. This adds to the complexity, and there exist examples where the technical drawings of shopping centres are not up-to-date.

In the next sections we will review the most relevant H&S hazards in shopping centres and the main options that are usually taken to reduce those risks. Finally, and most important for the CommONEnergy Project, is the negative or positive impact on energy consumption that can be linked to those risks.

Violence and verbal abuse

Violence and verbal abuse is classified as a serious hazard in the shopping centre environment by a report published by OSHA[10] “Hazards and Risks in the Retail Trade: advice for young workers” (EU-OSHA). Violence from customers is all-too-common in the retail sector. Attacks can occur when staff has to deal with thefts and robberies, troublemakers, angry customers and drunk or drugged customers. Violence against staff includes attacks, intimidation, verbal abuse and harassment. This hazard is usually limited through the following strategies:

- Installation of safety control systems and video cameras
- Staff training

[10] Occupational Safety and Health Organization, an agency charged with the enforcement of safety and health legislation in Europe through EU-OSHA, and OSHA in USA.

- Safety contractors

According to the persons consulted in WP2, the impact of the actions implemented to reduce violence and verbal abuse on energy efficiency is not proven. It is mostly related to the energy consumption needed for the safety control system, which are strictly dependent on the technology providers.

Lifting and/or moving heavy loads

Lifting and carrying is a common cause of injury among shop workers. The weight of the load, how far it has to be moved and how often, its stability, its shape and size, and whether you have to twist or stretch to lift it all affect the risks involved. Cramped storage areas, unstable racking, unsafe ladders and poor planning (such as putting heavy loads on top shelves) will increase the risk of injury. This hazard is partially connected to ergonomics, it is possible in fact that poor care of the movements lead to serious accidents (ref. Hazards and Risks in the Retail Trade: advice for young workers, OSHA, E-fact 05).

The actions which are usually taken to reduce this problem are generally addressed to management, for example:

- management should provide mechanical aids and trolleys;
- management should train personnel in safe lifting, and how to spot and avoid risks;
- management should make beware of overloaded or badly packed 'roll cages' (often used to deliver goods to stores);
- management should report any unsafe conditions, e.g. problems with trolleys, ladders, racking or shelving.

The impact on energy efficiency is low, mostly related to the energy consumption needed for the equipment and the material handling devices, if they are electrical.

Slips, trips and falls

Slips and trips are another major cause of injury in shopping centres (OSHA, E-fact 05). Wet or uneven floors, spillages and things being left on the floor are among the main causes. Management level is mostly involved in training and operations while designers must follow the international standards related to slippery floor materials to prevent these problems. It is important to remark that there are several standards to be observed in the choice of floors in public spaces: the ASTM E303-93 (United States) and BS EN 13036-4:2011 (United Kingdom) slip resistance test standards define the pendulum tester that is now a national standard for pedestrian slip resistance in 49 nations on five continents and has been endorsed by Ceramic Tile Institute of America since 2001. Pendulum, most commonly known as British Pendulum Skid Resistance Tester is used to perform skid resistance test.

Standards Australia HB 197:1999 is particularly interesting for a designer of shopping centres: it gives detailed recommendations for minimum wet Pendulum Test Values for many different situations in commercial buildings: e.g. external ramps, 54; external walkways and pedestrian crossings, 45; shopping centre food courts, 35; and elevator lobbies above external entry level may be 25 or less. The Australian recommendations are presently the world's most detailed standards for pedestrian wet slip resistance.

Figure 60 – Terrazzo" flooring type
***(Photo courtesy of Clean Middle East Magazine*)**

According to CommONEnergy experts in the field of lighting, and as already explained in the section related to lighting and lighting strategies, the choice of a floor affects illuminance levels: when a choosing among several non-slippery floor surfaces, it is preferable to select a floor with a light colour which reduces lighting power requirements, and at the same time retains satisfactory visual comfort and architectural feeling.

Bad air quality

The indoor air quality (IAQ) has been identified by the EPA11 as one of the top five most urgent environmental risks to public health. The Agency (ref. "Indoor Air Quality in Commercial and Institutional Buildings, OSHA 3430-04 2011") estimates that the majority of Europeans spends approximately 90 percent of their time indoors where make-up air (i.e., fresh air added to recirculated air) may be compromised. For this reason, OSHA experts believe that more people may suffer from the effects of indoor air pollution.

Figure 61 – mould and fungi problem in air duct
(Photo courtesy of Clean Middle East Magazine)

IAQ is indeed based on well-known standards requested during design but each building has its own set of circumstances. Air quality may be determined by several factors: site of the building, its original design, renovations, air handling systems, maintenance, occupant densities, activities conducted within the building, and the occupants' satisfaction with their environment.

IAQ problems can arise from a single source or any combination of the said factors: inadequate IAQ may begin with poor building design or failure of the building enclosure or envelope (roof, facade, foundation, etc.). Other issues may be associated with the location of the building and mixed uses of the building. Many common IAQ problems are associated

[11] Environmental Protection Agency's (EPA) report, "*An Office Building Occupant's Guide to IAQ*"

with improperly operated and maintained heating, ventilating and air-conditioning (HVAC) systems, overcrowding, radon, moisture incursion and dampness, presence of outside air pollutants, and the presence of internally generated contaminants such as use of cleaning and disinfecting supplies and aerosol products, off-gassing from materials in the building, and use of mechanical equipment. Improper temperature and relative humidity conditions have, clearly, a high impact on energy consumptions.

The prevention actions to limit IAQ related hazards are very much connected to maintenance of the HVAC system and they usually go in the same direction than energy efficiency since good maintenance reduces the pressure drop in the air distribution system. OHSA provides authoritative guidelines which are divided per technical area:

- Cooling Towers
    - Written maintenance and inspection program
    - Operated in accordance with manufacturer specifications
    - Inspected regularly (monthly, or as required)
    - Treatment of waste to control microorganisms, as required
    - Recordkeeping of biocide use – brand, volume, and results
    - Training of workers for hazards involved
- Humidifiers
    - Written maintenance and inspection program
    - Inspected weekly during operation
    - Cleaned and disinfected as required
    - No visual build-up of mould or slime
    - Disinfectants removed before reactivating humidifiers
- Cooling Coils
    - Written maintenance and inspection program
    - Monthly (or, as required) inspections during operation
    - Removal of dirt, slime, and mould, as required
    - Upstream filters operating properly
- Drain Pans, drainage systems
    - Written maintenance and inspection program
    - Monthly inspection (or, as required)
    - Drains maintained in free-flowing condition
    - No accumulation of stagnant water
    - No build-up of slime, mould, or dirt
    - Removal of dirt, slime, and mould, as required
    - Sample water for microbes, as required
- Duct and Plenum equipment
    - Written inspection and maintenance program
    - Supply, exhaust, return grilles, and ducts clear and clean
    - Routine inspection of ducts, debris, and microbial growth (e.g., semi-annually)
    - Provisions of cleanout (e.g., within four feet downstream of duct expansions, supply air openings, or where particulate deposition may occur)
    - Ductwork attached, not dented
    - Insulation intact, not wet, and no microbial growth

    - Ductwork properly balanced
- Filtration systems
    - Written maintenance, operating, and inspection programs
    - Routine inspection
    - Provision for measuring pressure drops across the filtration system

Safety issues directly related to ventilation strategies

Shopping centres are generally similar to atria with large open spaces between shops. Shopping centres are very similar to exhibition halls and other large buildings where fire and smoke control are important concerns. The atria are often used as smoke reservoirs and for smoke ventilation, with stack ventilation using mechanical assistance and a low level supply of fresh air. The importance of fire and smoke prevention for the specific case of shopping centres is well reported in BRE report BR186 “Design principles for smoke ventilation in enclosed shopping centres” (Morgan, 1990). The report highlights the problem of smoke diffusion: where smoke from a fire in a single store could spread rapidly through the entire centre. A smoke ventilation system in shopping centres is essential to ensure that escape is unhindered, and ensuring that any large quantities of thermally buoyant smoky gases can be kept separate from (i.e. above) people who may still be using escape routes through the centre. Therefore, the role of a smoke ventilation system is principally one of life safety.

Figure 62 – Incident Scene in a shopping mall, 1988 USA
(Photo courtesy of Associated Press.)

Fire and smoke prevention is indeed based on well-known standards and compliance is requested during commissioning. The aim of these codes is to provide design principles for smoke ventilation for the design of efficient systems, with simplified design procedures for an ideal model of a shopping centre and then further guidance on frequently encountered practical problems. The Impact on energy efficiency could be high: fire and smoke prevention codes are not specifically meant to be energy efficient, they provide simplified design procedures for an ideal model of a shopping centre that may also lead to very high energy losses when in normal operation. Equally complying options can be adopted. The figure below is an example showing how good vents and design layout deeply impact on smoke control.

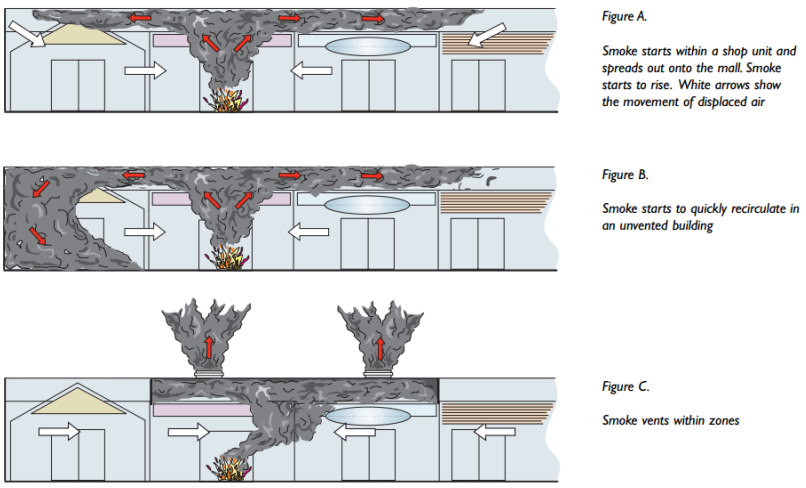


Figure A.

Smoke starts within a shop unit and spreads out onto the mall. Smoke starts to rise. White arrows show the movement of displaced air

Figure B.

Smoke starts to quickly recirculate in an unvented building

Figure C.

Smoke vents within zones

Figure 63 – smoke control scenarios in shopping centres (*Morgan, 1990)* *(courtesy of Colt Design Services, 2012*)

The example shows that the design of the vent system is not only linked to smoke diffusion prevention, but also to choices highly impacting the energy consumption i.e. natural ventilation, natural lighting and IAQ.

A positive example explaining how ventilation strategies can become effective in terms of energy comes from a study by Zhao (2008). This paper reports the case of the Bluewater shopping mall, in the UK, where rotating wind scoops are used to catch wind and supply fresh air. Wind scoops were believed to be particularly effective when supplying large open spaces because air does not have to be supplied adjacent to the occupants. The specific strategies included are:

(1) 6.6 ft (2 m) high conical wind scoops were mounted on the roof to allow cool air to drop and mix within the space. The wind scoops “owe their form to the influence of traditional Kent coast houses”. They are spaced at 49 ft (15 m) intervals along the centre line of the mall.
(2) The scoops were designed to rotate into the wind.
(3) In the event of fire, the scoops can be rotated away from the wind and act as wind towers to extract smoke out of the building.

5.7.4. Summary

Shopping centres are often complex buildings with a complicated layout, sophisticated utility plants and a very high concentration of customer and workers, the latter making repetitive material handling tasks. These factors, in combination with the presence of a high percentage of young employees, imply serious ergonomic issues and H&S hazards. The analysis that we conducted starts from several qualified studies and the evidence that we collected from the interviews in the demo sites and through the questionnaires. The survey showed that, generally, in Europe there is a consistent set of regulations and guidelines related to ergonomics and Health and Safety (H&S). However, the options for their implementation can be diverse and may have a very different impact on the shopping centre

energy efficiency.

Ergonomics and H&S issues have been analysed taking into consideration their impact on Energy Efficiency, both at design level and at operations management level. The most relevant H&S hazard factors for Energy Conservation are “air quality” and “fire and smoke safety”. An analysis of best practice is currently under development and will be reported in D2.5.

6. An Analysis of the Economic Models used to Sell Energy Investment/ Energy Efficiency to Tenants

6.1. Aim

The aim of this chapter is to investigate which economic models are used by owners and managers in shopping centres to sell energy investment or energy efficiency measures to tenants. In addition, existing models used in the commercial sector will be briefly introduced.

Retail activity originates from fulfilling consumer wants, needs and desires in a context of scarcity (O'Brien et al., 2013). People, whoever they are, need "basics" such as food, clothing, warmth and shelter. In Western society the problem of supplying basic needs has largely been overcome yet acquisition of material, goods and events still remain important and need to be further defined for the different consumer groups targeted in this study. In this chapter the focus in the economic aspects associated with shopping centres and retail activity. Shopping centres are systems, social, physical, technical and economic, which support retail activity. Economic models are part of the aforementioned system. All the three main stakeholder groups are associated with the economic models to be presented in the following text, but consumers are in general understood as being less in control of their own consumption than the producers, retailers and shopping centres which are providing them with the goods and opportunities to buy them (Miller, 1998). The focus here is therefore the economic models associated with owners and managers and tenants.

6.2. Method

Three questionnaires were developed to gather information about amongst other things attitudes and expectations about energy use among customers, tenants and owners and managers. The methodology associated with the three questionnaires was described in detail at the beginning of the report, as well as the aims and intentions. During this activity the response from owners and managers is the primary focus, however it is suggested here that tenants are also influencing which economic models are used and why, as well as the actual or planned energy investment in shopping centres. The response to the questionnaires by owners and managers and tenants will provide a basis to understand the role of energy efficiency measures in shopping centres.

In addition to the questionnaires some stakeholders were interviewed. The intention was to provide a background to understand the response that was received digitally from the questionnaires. The role of energy costs was in focus during these seven interviews with shopping centre managers, representatives of shopping centre associations and one architect. In addition a desktop analysis of the available literature on economic models used in shopping centres was made.

6.3. Economic Models Found in the Commercial Sector

Shopping centres are important to the European economy and its commerce (ICSC, 2006). There are four main aspects which create the system which provides a background to understand the economic models presented in the following sections. The first is the consumer. Consumption accounted for approximately 60 % of gross domestic product in Europe in 2006. Understanding and supporting the activity of consumers is therefore a primary activity in shopping centres. The second aspect is that for retailers a shopping centre offers a concentration of goods and services, which support a retailer's income and growth and which they are also competing with. The third main aspect is the community around the shopping centre which is provided with economic benefits, such as jobs, tax revenues and the potential regeneration of under used or depressed areas. The fourth and final aspect is the associated with the owners, manager and real estate investors. This stakeholder group regards shopping centres as a major real-estate asset (ISCS, 2006). In the following sections we have chosen to focus on the real-estate investment associated with owners and managers. This was because economic models associated with energy efficiency are primarily associated with the physical structure of shopping centres, there are economic models associated with sustainable products which could have been included in this analysis. However the literature review did not provide us with sufficient information to allow a productive analysis. The same applies to models associated with the reduction of consumption, encouraging consumers to recycle and buy less.

Retailing is a vital part of our society whether we approve of it or not. Retailing is a major employer, between the year 2000 and 2005, retail employment increased by 1.4 million jobs and it is expected to increase by 1.2 million by 2016 (ICSC, 2006). Retail is, for example, the single largest employer of women in Britain. In spite of this enormous economic activity there has previously been a general lack of interest in studying the economic implications of retail activity in shopping centres. This may be related to the fact that retailing has been seen as a reactive (non-productive) sector of the economy whose behaviour responds to consumer needs, tastes and fashion rather than helping to form them in the first place, implying that retailing does not qualify as a key social and economic process underlying capitalism which needs to be analysed. Mechanisms of national and international distribution have led to a greater acceptance and new way of valuing retailing as an industry, being both reactive and proactive (productive) able to generate wealth on its own creating tastes and fashions which also affect other parts of the economy (O'Brien et al., 2013).

When considering the economic aspects associated with energy investment, it is the physical structure of the shopping centre which is in focus. An investor/user dilemma which in shopping centres is primarily the problem of sharing the expenses among shopping centre building owners and tenants, and leads to the difficulties in energy –efficiency investments. There are a number of other barriers stopping investments in the energy efficiency. One of the barriers is the small share of energy costs within the total economic expenditures. In Germany, in the commercial and service sector, the share of energy costs is under three percent of the total costs and investments in energy efficiency do not affect the core production processes (Schleich, 2009). The motivations for energy investment or the

reasons for not investing in the commercial sector may be primarily understood in relation to a number of categories (Jasinski, 2011):

- Financial Gain/economic benefits
- Comfort in the shopping centre
- Emerging technologies, which influence the energy consumption either positively or negatively
- Social Concerns (building codes, etc.)
- Environmental Concerns
- Certifications enhancing the green branding

The most important motivation is the financial gain or economic viability. The most crucial parameters of the economic motivation are the unstable and growing energy prices and opportunity of cost-effective investments in the energy efficiency measures (Jasinski, 2011). Cost-effective investments will be analysed in the forthcoming CommONEnergy "Report on impact scenarios for the energy demand and uptake of renovation activities in the EU commercial building sector". The cost-effectiveness of different renovation measures is calculated by using the discounted cash flow (DCF) method. The method is indicated by net present value (NPV), the internal rate of return (IRR) and the payback period (PBP). The investment in to the different energy-efficiency measures will be analysed in this forthcoming report in line with the following parameters:

- Different energy price expectations
- Policy instruments (building codes, economic incentives, income tax deduction, etc.)
- Cost regression of the investigated energy efficiency measures

6.4. Green Leasing Programmes

The problem of the distribution of expenses among commercial building owners and tenants leads to difficulties around energy efficiency investments. In order to solve this problem, green leases have been applied by some companies. Green leases (also known as aligned leases, high performance leases, or energy efficient leases) align the financial and energy incentives of building owners and tenants so they can work together to save money, conserve resources and ensure the efficient operation of buildings (Green Lease, 2014). A very typical situation describing the "split incentive" is when one party (commercial building owner or tenant) pays for upgrading, but another party uses the financial benefit of the energy savings. A typical situation is when building owners pay the capital expenses for the energy retrofits and tenants receive the financial benefits of energy savings through the reduction of the running and operation costs. Tenants, on the other hand, pay back owners for performing retrofits (plaNYC, 2011).

Green leases have been used in for example Norway in office buildings, but they have up until now not been applied in shopping centres. In the cases where green leases are in use the intention is to motivate the tenant and landlord to participate in an ongoing discussion about environmental improvements. They offer a reasonable balance between investment costs, operating savings and environmental benefits. The landlord can write off any

additional costs incurred by environmental improvements and tenants have documented lower operating costs related to energy, cleaning and water conservation. Leading Norwegian real-estate investors have prepared a template for green leases consisting of a green voucher and a voluntary green usage agreement, which states requirements for how the building/ premises may be said to be energy efficient and environmentally conscious. Green vouchers mean a change in the principle that a lease means handing back a building when the lease has expired in exactly the same condition as it was when the agreement was entered into. Instead, the landlord and tenant, in cooperation, help to reduce the building or premises' negative environmental impact and promote sustainable development (Bramslev, 2014).

Green usage agreements specify the requirements for both tenants and landlords in energy use, materials, indoor air quality, recycling, water supply, transport and the care and provision of outdoor spaces so that both parties contribute to an environmentally sound use and management of the premises. The requirements should be printable, making it possible to continuously check that agreements are followed. Such agreements require commitment from both parties and can be particularly difficult if there are multiple tenants in the building (Bramslev, 2014).

6.5. Sustainable Building and Certificates

Since energy costs make up only small share of the total costs in commercial buildings, financial and economic benefits does not always ensure investments in the energy efficiency measures. However, certifications enhancing Green branding play an important role in the decision about investments in the energy efficiency measures. The Implementation of this type of model or program does not obligate the companies to invest in the energy efficiency measures. However, these models and programmes encourage energy-efficiency investments indirectly. In this section, the following two assessment tools will be briefly introduced: BREEM and EMAS.

In the past decade, several assessment tools worldwide have been developed to evaluate and certify the effectiveness of the buildings or the organisation (Sharifi and Murayama, 2014).

The most famous method of assessing, rating and certifying the sustainability of buildings is BREEAM (Building Research Establishment Environmental Assessment Methodology). BREEAM is an environmental assessment method and rating system for buildings. Over 250,000 buildings have been certified since its inception in 1990, and the scheme is now used in more than 50 countries. BREEAM has grown steadily since its launch, and the rate of growth continues although of the challenging economic climate (BREEAM, 2014). Fornebu shopping centre, outside Oslo, which opened in October 2014, will be built according to passive house principles and will be certified as BREEAM outstanding.[12]

[12] http://fornebusblogg.skanska.no/om-prosjektet/

Another BREEAM certified shopping centre is Donauzentrum in Vienna. However, BREEAM is not very common in today's shopping centres. When this report was written only 25-30 centres worldwide[13] were certified according to this standard.

The European Union's Eco-Management and Audit Scheme, or EMAS, has been in existence since 1995, with over 3,000 sites registered to the Scheme. EMAS is a voluntary tool available for any kind of organisation aiming to improve its environmental and financial performance and communicate its environmental achievements to stakeholders and society in general. In the sectorial and cross-sectorial reference document, which is established by the European Commission, the retail sector is defined as the priority sector (Schönberger, 2013). However, as shown by the results of the questionnaire these certificates are rarely used in the retail sector (see below).

6.5.1. Cost of sustainable refurbishment

When considering making a cost-benefit analysis of refurbishment projects in shopping centres and other kinds of buildings it is important to consider what should be included in order to achieve the level of ambitions set for the project, both comprehensive and long-term perspectives. For example in Norway the calculation of the design and construction costs for the refurbishment of a building that live up to the minimum requirements set by current regulations versus a more ambitious upgrade are commonly based on the necessary measures following the current building codes which set a minimum standard both for energy efficiency and for example universal design which is also require of all new builds, and the calculation of costs for additional measures to achieve a sustainable building.

The extent of additional measures will vary with a project's ambition. Energy Class A, passive or BREEAM Excellent NOR will require different measures, including the building envelope as well as the technical systems. Such a calculation can typically provide additional expenses around 1000 - 1500 -kr/m^2 (approx. 120-190 EUR/m^2) to reach a passive house standard. These types of calculations, however, rarely give an adequate picture of the actual additional costs. To achieve a clear picture of the actual costs it is essential for the additional costs to include savings related to technical installations. Reduced heating and cooling needs because of insulated building envelope and exterior shading will usually result in a need for simplified solutions for heating and cooling systems. Traditional pricing of installations per m^2 can cause the builder not being credited with the savings. In this case the builder should require documentation of both cost increases and savings (Bramslev, 2014). It may be difficult to obtain the correct price of a zero option, i.e. that measures need to be done because of technical wear. If a builder asks for price alternatives in relation to green versus building refurbishment, it is also important to be aware that contractors often charge tactically. Costs may be determined when contractors compete for the bid based on the ambitions associated with current regulations[14].

[13] http://www.greenbooklive.com/search/scheme.jsp?id=202

[14] This data comes from the SINTEF project UPGRADE which will be published in Autumn 2014.

6.5.2. Profitability

When calculating the profitability of upgrading to a green building standard, there are several parameters that must be included in the calculation than the project cost, in addition to saving energy costs. It is important to include parameters such as rental income, cost of ownership and return, which in turn affects the sales value. For example the data from the questionnaire shows that shopping centre tenants are not automatically willing to agree to upgrades if this means an increase in overheads (see the results of the survey below).
International research in the United States, Europe and Canada documents an increase in the value of green building. There are reports of 5-20 % higher rental income and 10-25 % higher sales price for green building in surveys which also considered the location, size and age of the buildings. It is suggested that higher rental income is achieved because the premises have lower operating costs and improve the reputation of the tenant. Higher selling prices are achieved because the expected return is lower. This suggests an increased environmental focus amongst investors. In Norway, there is a similar trend although Norway is lagging somewhat behind its North American counterparts. Norwegian real estate companies report a 2-6 % higher rental income, 1% lower cost of ownership and 0.2 % lower rate of return for green buildings (Bramslev, 2014). This trend does not so far apply to the whole of Norwegian shopping centre industry. Steen og Strøm who contributed data to the survey from all 38 shopping centres within their portfolio, are actively using the BREEAM certification system when developing and redeveloping their shopping centres and they are also using green leasing as shown by the survey results (see below). Storebrand, who owns eight shopping centres in Norway and is a partner of the CommONEnergy projectalso acted as informant during the data collection. They have not applied BREEAM to their portfolio and are not using green leases in shopping centres, but green leases are being used in other kinds of buildings in their real-estate portfolio.

6.6. An Analysis of the answers from the questionnaires

6.6.1. Shopping Centre Owners and Managers

98 shopping centre owners and managers participated in the survey. Around two-thirds answered the questions related to economic models. As shown in Figure 64 most of the shopping centres have programmes for increasing energy awareness among tenants and customers. According to the feedbacks, these programmes comprise ISO 14001 standardisation and energy consumption checks. Building owners and managers from Norway additionally mentioned ecobuilding-certification. These programmes are communicated mainly among internal channels to tenants as well as customers. During interviews informants amongst both owners/managers and tenants asked what the question about customer programmes was referring to. Few had a clear idea about what was implied. Interviews did not suggest information on displays in shopping centres. However information is provided on websites and the kind of shopping bag being offered to customers was also considered a customer programme. At Fornebu S, a shopping centre in Norway the intention is to actively inform customers about the shopping centres daily energy use on interactive displays in common areas. However this system had not been tested when the

CommON*Energy* data collection was taking place. Therefore although questionnaire data suggests the wide use of customer programmes, interviews do not support this finding.

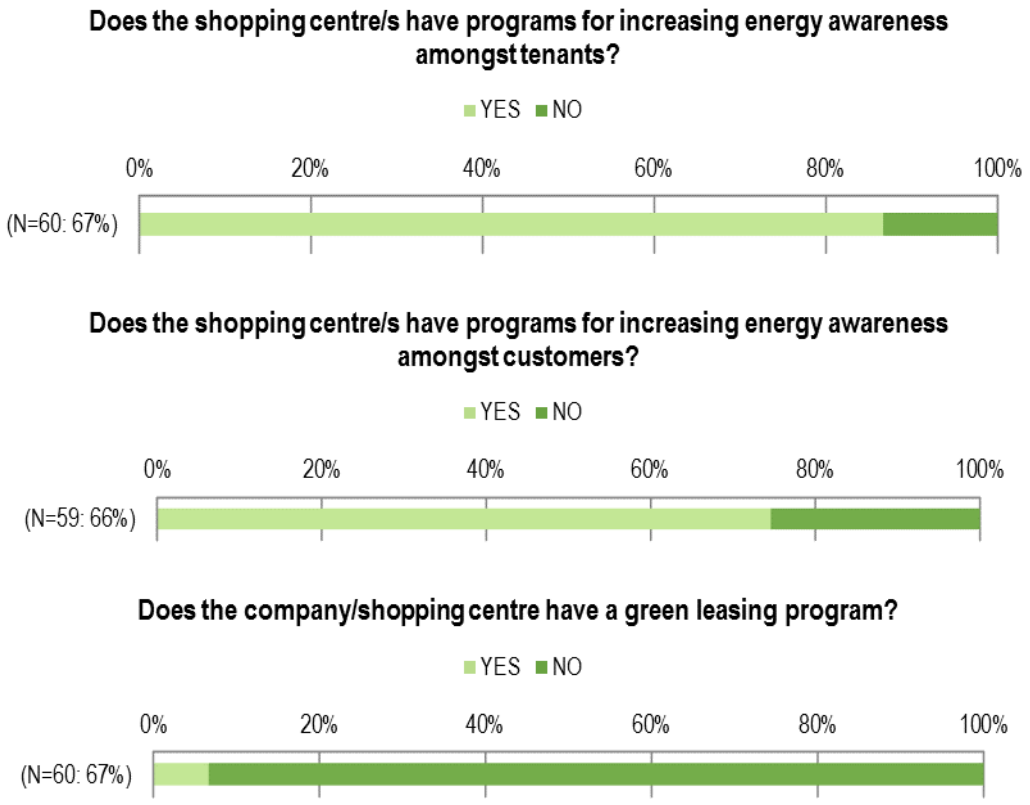


Figure 64 –Owners questionnaire. Answers to the questions "Does the shopping centre/s have programs for increasing awareness amongst tenants?", "Does the shopping centre/s have programs for increasing energy awareness amongst customers", and "Does the company/shopping centre have green leasing programmes?"

Only 7% of the shopping centres who participated in the questionnaire have a green leasing programme. The interviews gave an insight into these results. While most of the shopping centres are aware of energy efficiency, it is a minor topic in day-to-day management because the energy costs account only for around 5-7% of the overall cost as stated by some interviewees. Further, according to the interviews, most of today's shopping centres have all-in or revenue-based rents. Both rental systems do not support additional efforts on increasing energy efficiency. However, as stated by an interviewee, in highly competitive mature markets shopping centre owners may benefit from energy efficiency via lower costs. This allows them to offer cheaper rents than other shopping centres or to benefit from higher profit margins than their competitors. Influence of the rental system on energy efficiency is mentioned in earlier studies by Schneider (2012).

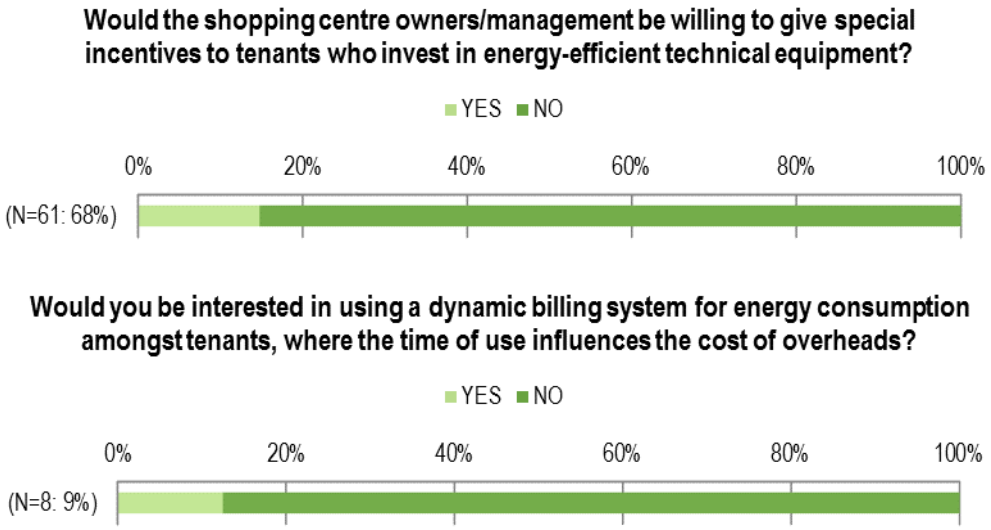


Figure 65 – Owners questionnaire. Answers to the questions "Would the shopping centre owner/management be willing to give special incentives to tenants who invest in energy efficient technical equipment?" and "Would you be interested in using dynamic billing systems for energy consumption amongst tenants?

As shown by the answers to the survey in Figure 65 only a small portion of shopping centre owners and managers are willing to offer incentives to tenants, who would be willing to invest in energy-efficient equipment. Also a dynamic billing system, with variable prices for the tenants is not appreciated. These results indicate a strong resistance to new pricing instruments for increasing energy efficiency among tenants. However, only eight people answering this question (see Figure 65). Owners and managers see energy efficient stores and investments in energy efficient technologies as very important issues to achieve a sustainable retail environment (see Figure 65). Further important topics are energy efficient shopping centres in general, an efficient building envelope, recycling systems as well as recycling rooms and energy efficiency schemes of the company. This is in line with the abovementioned high agreement on energy efficiency programmes for tenants and customers. Moreover, and also in line with the findings presented in Figure 66, in the managers opinion, green leasing schemes do not contribute to more sustainability in the retail sector. Quite interesting is the fact that neither communication between managers and tenants nor policy measures is considered as a measure for increasing energy efficiency. If the first answer holds true, it thwarts the efforts of having programmes for increasing energy awareness amongst tenants. These somewhat contradictory answers call a) for further investigations about manager-tenants interaction and b) from an overall energy efficiency perspective for programmes to strengthen communication between both groups.

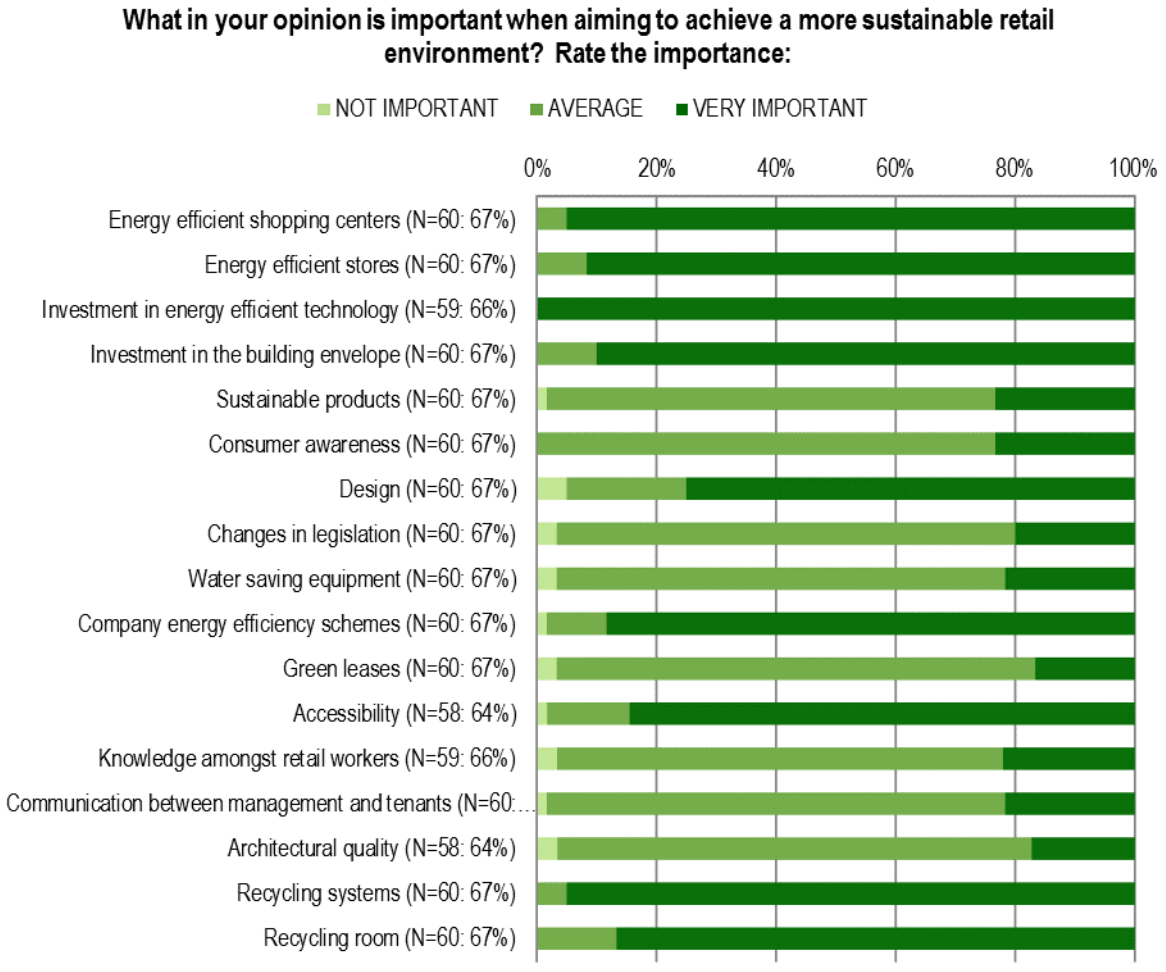


Figure 66 – Owners' questionnaire. Answers to the question "What in your opinion is important when aiming to achieve a more sustainable retail environment?"

6.6.2. Results from Tenants

40 shopping centre tenants answered the questionnaire (Figure 67). Less than 50% of the tenants have a monthly or annual review of the energy consumption of the store. On the other hand, 37% of the respondents do not know, if such review is in place. This means that energy consumption is not an issue for most of the tenants, which may be associated with the all-in and revenue-based rents mentioned earlier. Under these circumstances tenants see no differentiation between running costs and rents. Therefore, it is not surprising that energy management systems are not an important topic for most tenants as shown in Figure 68.

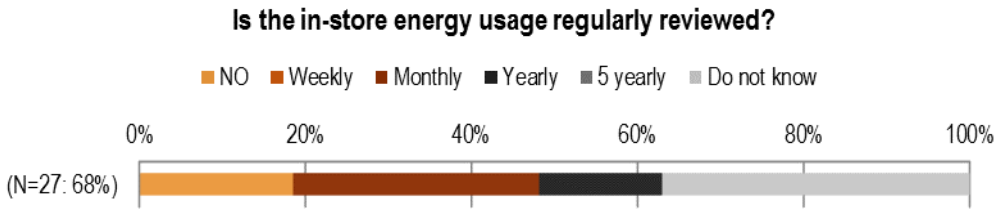


Figure 67 – Tenants questionnaire. Answers to the question "Is the in-store energy usage regularly reviewed?"

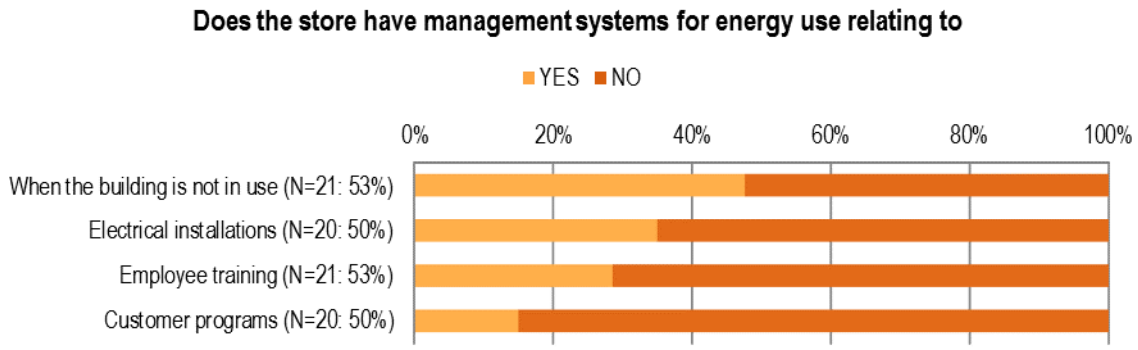


Figure 68 – Tenants questionnaire. Answers to the question "Does the store have management systems for energy use relating to?"

6.7. Summary

Additional costs for a refurbishment change over time. Increased demand for components and labour may satisfy new environmental standards, increased knowledge, better technology and competition. The ambition level can result in lower prices and reduced construction costs for the effort due to achieving a better environmental performance. In a transition phase project related demands that require specific training and energy and environmental specialists contribute to increased engineering costs for green building. As architects and consultants increase their experience, additional costs will be reduced and even eliminated over time. Several real estate companies have stated that designing and building green buildings does not result in increased building costs. Additional costs associated with green building are caused by ongoing pilot projects that require extra training and quality assurance. Effort is placed on achieving precise execution, and efficient planning of critical details during the early phase of the project.

As shown by the questionnaire and the interviews, there are some energy efficiency programmes in place. For example, green leasing programmes play a minor role and economic models for increasing energy efficiency and related investments among tenants are hardly known. However, current business models in shopping centres do not offer many incentives to increase energy efficiency and no standardised economic models to increase energy efficiency in shopping centres have been identified by the survey or the interviews.

The easiest way would be to move from all-in and revenue-based rents towards a clear pricing of running costs, which are mainly based on energy consumption, and thereof independent rents. However there was no interest during interviews amongst owners and managers in changing the system. For example in the UK there is a strong focus on the independence of tenants, they run their own cooling systems but receive a set price in relation to energy needs. There is no sufficient data to explain why this is the case, but streamlining management activity may be an influential issue. Individual billing based on actual running costs, is more time consuming and would require the installation of new management systems and possibly also supply systems.

7. Shopping Mall Inefficiencies: Conclusions

The CommON*Energy* project aims to "re-conceptualize shopping malls through energy efficient renovation, developing a systemic approach made of innovative technologies and solution sets as well as methods and tools to support implementation and to assess the environmental and social impact in a life cycle approach." This report is part of Work package 2, which has as its main focus the defining of retrofitting drivers for shopping centres. The drivers will provide the basis for developing energy retrofitting concepts, offering amongst other things, constructive technology, an understanding of typical function patterns and socio-cultural aspects and an understanding of potentials associated with interaction with local energy grids.

The aim of this report is to identify the main inefficiencies regarding energy, comfort, operations (maintenance) and logistics. It is within these areas that the main drivers are located. The report presents an analysis of systematic efficiencies and inefficiencies associated with both built and social environments found in shopping centres today. Six main fields have been considered:

- Facilities
- Functions
- Management
- Ergonomics
- Logistics
- Economic models

The intention, by providing an overview of the inefficiencies in shopping centres in relation to these six fields, has been to encourage effective energy investments, by providing necessary information about the challenges faced in shopping centres today. The analysis has been guided by the understanding that inefficiencies in shopping centres are not just found within the physical environment in shopping centres but are also associated with decision making practices and user behaviour. The systemic analysis therefore considers behavioural, managerial, technical and physical systems in shopping centres.

The six fields have not been considered individually but as required in relation to the report's four main sections:

1. The methodology used to collect the data used and presented in the report.
2. User behaviour, primarily customers and decision making structures associated with owners/managers and tenants.
3. The systemic inefficiencies associated with the function and use of a shopping centre building.
4. Economic models that are used to sell energy investment to tenants.

Each chapter is concluded with a summary of the main results and areas covered, and conclusions based on the results. A more detail overview of the results from the report may therefore be found in connection with these four sections.

The aim of this report is to identify the main inefficiencies regarding energy, comfort, operations (maintenance) and logistics by collecting and analysing data about the social and technical systems found in shopping centres. When considering the causes of energy inefficiencies in shopping centres an aspect which comes across through the results from the CommON*Energy* survey is the difference in the level of knowledge about and interest in energy efficiency amongst the three main stakeholder groups. The customer has low awareness of energy efficiency in shopping centres, but customers were found to care about the energy efficiency of the centres, although it did not influence their choice of shopping centre. Tenants showed interest in energy efficient shopping centres, but it is not of primary importance to them. The results from the different stakeholder groups vary, they have different roles and interests in shopping centres. The report therefore proposes promoting increased knowledge and communication between the three stakeholder groups, thereby reducing inefficiencies associated with user behaviour in shopping centres.

CommON*Energy*'s primary objective is to develop breakthrough methods which promote optimal selections of energy-efficient solutions that will in the future benefit shopping centre's owners, managers, tenants and customers, as well as the community as a whole. Questionnaires and interviews have been used to collection empirical data which targets user-behaviour and perceptions amongst the three main stakeholder groups. The resulting analysis provides the reader with general knowledge as well as shedding light on issues that require special attention in relation to the various actors' journey towards making well justified decisions about optimal energy efficient solutions that benefit all three main stakeholder groups.

In a transitional phase, project related demands that require specific training and energy and environmental specialists can contribute to increased engineering costs for buildings. However, as architects and consultants increase their experience and knowledge about designing shopping centres with low energy consumption, additional costs will be reduced and even eliminated over time. Effort should therefore be placed on achieving the precise execution, and efficient planning of critical details during the early phase of the retrofitting process. Inefficiencies exist in relation to all the technical systems which both use and control the use of energy in the centres, however a main focus in this report is the lighting source and how it is used because it causes major inefficiencies in shopping centres. It is essential to extend the use of daylight in shopping centres, but at the same time avoid overlit areas caused by daylight in common areas. Good planning in order to establish sufficient lighting levels, the use of efficient light sources and quality control of the whole energy system is necessary throughout the entire building if optimal energy reductions are to be achieved.

Within this report systemic inefficiencies have been considered within social and managerial systems, because users and operators have the potential to influence efficient operation. Inefficiencies that are grounded within the technical system are mainly based around the improper design, operation and maintenance of the various technical systems in shopping centres. Inefficiencies are defined here as:

(1) Energy inefficiencies, e.g. building physics and technical solutions.

(2) Comfort inefficiencies and inefficiencies in providing an effective retail environment.

(3) Other inefficiencies, e.g. maintenance.

In addition there are four main areas of energy use inefficiencies in shopping centres these are: lighting, HVAC, refrigeration, and architecture and design. These all have implications for an effective retail environment, according to comfort levels and energy use both of which are important for human well-being and health. In addition they contribute to a successful retail environment, offering the customer satisfaction so important to the main stakeholder groups.

Shopping centres have room for improvement. This is a suggestion which is supported by the comments made by a customer interviewed at the City Syd shopping centre, who when asked what he thought were the most important actions to be taken when trying to reduce energy use in shopping centres, effectively summed up the problems faced, "*it is not something an old man goes around thinking about all the time, but we certainly have the potential for improvement. We live beyond our means; the only way forward is to improve*." We should therefore increase our efforts to improve energy inefficiency in shopping centres, and if all the stakeholder groups start thinking about reducing energy use in shopping centres, this will increase knowledge about the problems and solutions. The more we know about the social and technical systems within the shopping centres and the greater the communication between the systems, the more efficient the everyday running of shopping centres will become.

Literature

Amann, C. (2012) *Energieeffiziente Beleuchtung für Shops – Grundlagen, Technologien, Anwendungen*, FFG Endbericht, 2012

Atkin, B. and Brooks, A. (2009) *Total Facilities Management.* 3rd edition. Wiley-Blackwell. UK.

Bassa, D., Canazei, M., Hinterhuber, H., & Weiss, E. M. (2013) *Lichttherapie : Zum Stand der aktuellen Forschung*, 1–8. doi:10.1007/S40211-013-0067-5

Bauer, M., Mösle, P., Schwarz, M. (2013) *Green Building: Leitfaden für nachhaltiges Bauen*, Springer Verlag, ISBN-10: 3642382967

Blakstad, S., Kjølle, K. H. and Arge, K. (2010) *KPIs for Space Management. Barriers for benchmarking in Norwegian Municipalities*. Paper at conference 12th EuroFM.

Bointner, R., Toleikyte, A. (2015) *Shopping malls features in EU-28 + Norway.* Deliverable Draft 2.1 for CommONEnergy, 2014

BREEAM (2014) *About BREEAM*, http://www.breeam.org/index.jsp

Colt (2012) *Smoke Control in Shopping Centres*, report, Colt International Limited.

Custers P.J.M. (2010) Lighting in retail environments : *Atmosphere perception in the real world*. Lighting Research Technology, *42*, 331–343.

Coleman, P. (2006) *Shopping Environments: Evolution, Planning and Design*. Elsevier, Oxford, UK.

Cresswell, J.W. (2009) *Research Desgin: Qualitative, Quantitative and Mix Method Approaches*. Third Edition. Sage. London.

Dawson, J. A. (1983) *Shopping centre development.* Longman. London

Denk, E., Jimenez, P., & Schulz, B. (2014) *The impact of light source technology and colour temperature on the well-being, mental state and concentration of shop assistants.* Lighting Research and Technology.

Eichholz, P., Kok, N. and Quigley, J.M. (2009) *Why companies rent green: CSR and the role of real estate*. Working paper.

EN 15193 (2007) *Energy performance of buildings — Energy requirements for lighting*, *3*.

ESPADELADA Project (Spanish) *Manual de ergonomía*.
Fleschner, F. (2011) Fit durch Licht. *Focus*.

Freathy, P. (2003) *The Retailing Book: Principle and Applications*. Pearson Education Limited. Harlow, UK.

Gibalova, A., McKinnon, K., Serikstad, G.L. (2010) *Flaskehalser i grønt sektoren*. Økologisk landbruk. Nr. 1. 2010. www.bioforsk.no/ikbViewer/.../flaskehalser%20i%20grøntsektoren

Gilje, N., Grimen, H. (2002) *Samfunnsvitenskapenes forutsetninger: Innføring i samfunnsvitenskapenes vitenskapsfilosofi*. Oslo. Universitetsforlaget.

Haasl, T., and K. Heinemeier (2006) *California Commissioning Guide: New Buildings California Commissioning Collaborative.*

Halonen Liisa. (2010) *EFFICIENT ELECTRIC LIGHTING FOR BUILDINGS*. IEA ECBCS ANNEX 45 Energy Efficient Electric Lighting for Buildings*,* Aalto University School of Science and Technology.

Heschong Lisa. (2003) *Daylight and Retail Sales*.

ICSC (2005) *Towards a Pan-European Shopping Centre Standard: A Framework for International Comparison*. International Council of Shopping Centres. New York.

ICSC (2008) *The Importance of Shopping Centres to the European Economy*. The European Shopping centre Trust and International council of Shopping centres.

Illuminating Engineering Society. (2011) *The Lighting Handbook*. (Di Laura David L., Ed.) (10th ed.) New York.

Jasinski, S. (2011) *How to Sell Energy Efficiency*, The smart energy design assistance center (SEDAC) of the University of Illinois, ChicaGO Green 2011 Conference.

Jensen, P. A. (2008) *Facilities management for students and practitioners*. Centre for Facilities Management – Real Dania research. Denmark.

Klingmann, A. (2007) *Brandscapes. Architecture in the Experience Economy*. MIT Press Books: Cambridge Massachusetts

Kyoung-Non, K. and D. W. Schumann (2001) ,*The Influence of Consumer=S Price Expectations on Value Perception and Purchase Intention*, in *NA - Advances in Consumer Research Volume 28,* eds. Mary C. Gilly and Joan Meyers-Levy, Pages: 316-322*.*

Licht.de (2010) *LED: The light of the future*. Licht Wissen 17 2010.

Licht.de (2011) *Shop Lighting - Attractive and Efficient*. Licht Wissen 06 2011.

Loosmore, M. and Hsin, Y. Y. (2001) *Customer-focused benchmarking for facilities management*. Facililities 19 (13/14) pp 464 -476

Luxmagazine (2011a) *Talking Shop*, Luxmagazine 1–10 2011.

Luxmagazine (2011b) *Within limits*, Luxmagazine 10–13 2011.

Malaspina, P. (2008) “Centri commerciali, una nuova prospettiva” in Consiglio Nazionale dei Centri Commerciali, CNCC Italy “*L’industria dei centri commerciali in Italia”,* Milano

Massheder, G. and Finch, E. (1998) *Benchmarking metrics used in UK facilities Management*. Facilities. **16** (5/6) pp 138 – 142

Miller, D. (1998) *A Theory of Shopping*. Polity Press. Cambridge, UK.

McGregor, W., Then, D. S. (1999) *Facilities Management and the business of space.* Arnold. UK.

Morgan H. P., Gardner J. P. (1990) *Design principles for smoke ventilation in enclosed shopping centres*, Colt International Ltd, Fire Research, BR186.

MSA 2013, *Ergonomic Considerations*. Overview presentation 2012, Facilities safety and health inspection program, Department of Energy (Hanford).

Musa, Z.N and Pitt, M. (2009) Defining fasilities management service delivery in UK shopping centres. *Journal of Retail & Leisure Property,* **8** (3) pp 193-205.

Nolte, I., & Strong, D. (2011) *Europe ’ s buildings under the microscope*.

NRCAN Archive, *Cherry Picking Versus Multiple Measures*, NRCAN Archive, Natural Resources Canada, Office of Energy Efficiency. Retrieved 1.4.2014, Available online at: https://www.nrcan.gc.ca/energy/publications/efficiency/buildings/6565

NRPF (2000) Maintenance. In: *Shopping Centre Management.* New York: international Council of Shopping Centres, pp.21-50.

O'Brien, L. G., Harris, F.W. (2013) *Retailing Shopping, Society, Space.* Published for the Routledge in Enlgand, USA, Canada simultaneously 2013.

Offer, F. (2012) *LED for retail*. Bartenbach GmbH.

Olsson, H., Sörensen, S. (2003) *Forskningsprosessen: Kvalitative and kvantitative perspektiver*. Oslo. Gyldendal norsk forlag AS.

OSHA (2004) *Ergonomics for the Prevention of Musculoskeletal Disorders*, OSHA Occupational Safety and Health Administration.

EU-OSHA (2006) *Hazards and Risks in the Retail Trade: advice for young workers*, E-fact 5, European Agency for Safety and Health at Work.

OSHA (2011) *Indoor Air Quality in Commercial and Institutional Buildings*, OSHA 3430-04.

Oxford Properties Group. (2010) *Sustainable Intelligence - Operations guide for retail*. Toronto, Ontario.

Philips Lighting Division (2014) *Retail Scene 2014*.

plaNYC (2011) New York City Energy Alignet Clause, Available online at: http://www.nyc.gov/html/gbee/html/initiatives/clause.shtml

Pless S. (ed.), et. al. (2011) *Advanced Energy Design Guide for Medium to Big Box Retail Buildings: Achieving 50% Energy Savings Toward a Net Zero Energy Building*. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), Atlanta, Ga.

Pohl, W. (2009) *Energy efficient electric lighting*. Lux Europa. Bartenbach GmbH.

Pohl, W. (2010) *Technology forecast in Lighting regarding Energy Efficiency*. In Conference On Energy Efficiancy In Commercial Buildings (Vol. 12) Bartenbach GmbH.

Pohl, W. (2013) Beleuchtung und Energieeffizienz. Clima Design Compact.

RICS (2013) Going for Green: *Sustainable Building Certification Statistics Europe*. Available online at: http://www.breeam.org/filelibrary/Grun_kommt!_2013.pdf

Sääf, A. S. and Alvebro, B. (2008) *Fastighetsförvaltning*. In Fastighetsnytt (ed) Fastighetsekonomisk analys og fastighetsrätt. Fastighetsnytt Förlag AB. Sweden.

Schleich J. (2009) *Barriers to energy efficiency: A comparison across the German commercial and services sector*, Ecol. Econ., Bd. 68, Nr. 7, S. 2150–2159, Mai 2009.

Schneider, K., Steinmann, H., Bügelmayer, B., Carbonaro, S. and C. Votava (2012) *Wenn Konsum aus dem Zirkus der Emotionen ausbricht, first edition*, Ekazent Immobilien Management, ISBN 978-3-200-02810-4, Wien, October 2014

Schönberger, H., D. Styles, et al. (2013). *Best Environmental Management Practice in the Retail Trade Sector*, Institute for Prospective and Technological Studies, Joint Research Centre.

Sharifi A., Murayama A. (2014) *Neighborhood sustainability assessment in action: Cross-evaluation of three assessment systems and their cases from the US, the UK, and Japan*, Build. Environ., Bd. 72, S. 243–258, Feb. 2014.

Teller, C. 2014 *Shopping streets versus shopping malls – Determinants of agglomeration format attractiveness from the consumers' point of view*. The International Review of Retail, Distribution and Consumer Research; article.

Thomsen, J., Eikemo, T.A. (2010) *Aspects of Student Housing Satisfaction: A quantitative Study*. Journal of Housing and the Built Environment. Vol. 25 No. 3 September 2010.

Ticleanu Cosmic C. , Littlefair Paul J., H. G. J. (2013) *The essential guide to retail lighting*. Garston, Watford: BRE Press.

Tronconi O. (2010) *I centri commerciali, progetti architettonici investimenti e modelli gestionali*, Maggioli ed

U.S. Department Of Energy. (2013) *Life-Cycle Assessment of Energy and Environmental Impacts of LED Lighting Products*.

Zhao, Y. (2007) *A decision-support framework for design of natural ventilation in non-residential buildings*, Virginia Polytechnic Institute and State University.

Woods, R. (2012) *Shopping with Art: How Art Creates its Role in Public Places.* Doktoravhandlinger ved NTNU, ISSN 1503-8181; 2012:32

Yates, S.J. (2004) *Doing Social Science Research*. Sage. London.

Woods, R., Mellegård, S., Homolka, S., Stenerud Skeie, K., Haase, M. (2015) *Functional Patterns and Socio-Cultural Aspects*. Deliverable 2.3 for CommONEnergy, 2014

Appendix 1: Case studies of inefficiencies

Within the project pilot buildings were identified and analysed. Further details can be studied in D2.1 and D2.3. The historic market hall in Valladolid that provided examples of systemic inefficiencies with regard to lighting and ventilation provides an interesting case study.

Appendix 1.1. Case Study: Market hall – Lighting situation

The “historic market hall” is a special typology and provides a case study to analyse typical lighting inefficiencies in shopping centres. The market hall buildings have succumbed to change to a much lesser extent than other types of retail architecture (Morrison, 2003). The halls are divided into long aisles, connected by cross aisles, often with shops and stalls around the periphery. Similarities to this kind of organization can be found in galleries and arcades/streets with glass roofs.

The "Mercado del val" houses 114 stalls for retail in a total building area of 2230 m^2 on one single floor. Stalls are organized in a simple form with 2 parallel main (horizontal) circulation pathways (width 3.2m) along the longitudinal axis of the building on the ground floor. The stalls are closed boxed with a depth of 3.2m with a counter orientated towards one of the main pathways. There are 4 main entrance areas, 2 at the top end of the building and 2 in the middle of the longitudinal façade. Some minor areas have a second floor above the stalls, probably for administration purposes.

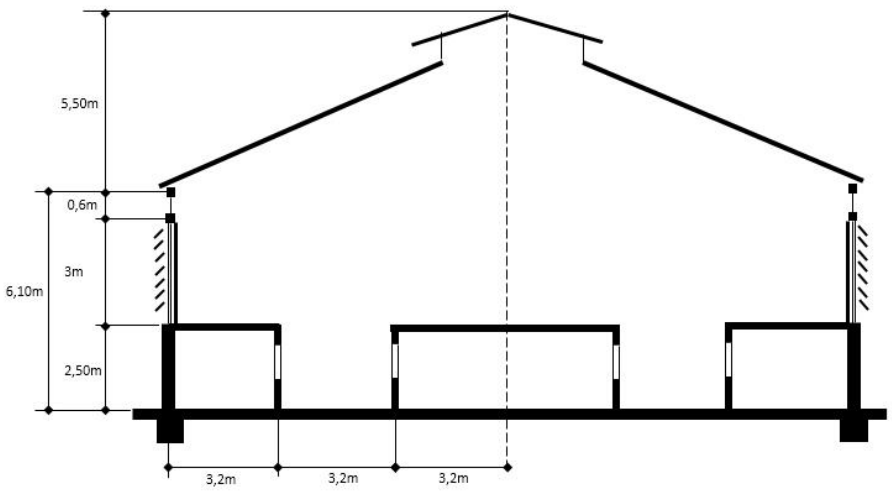


Figure 69 – Section of historic markethall. Current state (after refurbisment in the year 1983).

The market hall consists of a façade with an opaque brick parapet (height 2.5m), followed by a section which is at the exterior covered by fixed lamellas. While inside, this area is covered up by opaque panels. The facade element is completed at the top by a cast iron bow which has a perforated decorative structure, furnished by transparent glazing. The pitched roof comprises of a narrow elevated space with a 0.6m high vertical glazing area at both sides,

which probably is intended to be used for ventilation and daylighting. However, the narrow strip cannot significantly contribute to the supply of daylight.

Figure 70 – Impressions of the Market Hall in Valladolid.

Figure 70 shows some impressions of the market hall. Note that that the current dark interior areas of the market hall are due to the combination of a fixed shading system, and the mounted opaque panels behind the lamella system, the horizontal lighting strip brings little light into the space.

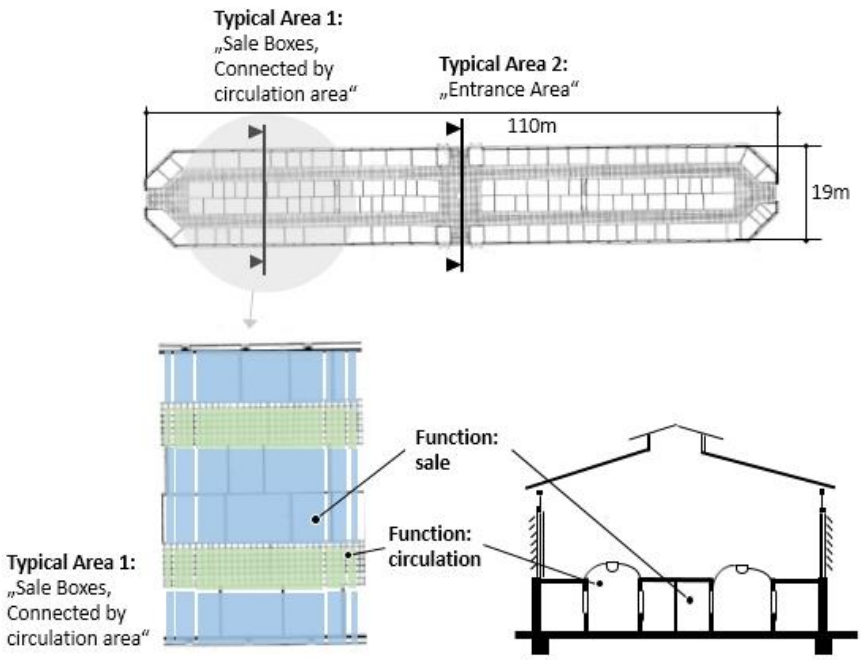


Figure 71 – Typical areas for old market hall layout and condition (state after refurbishment in year 1983), typical area 1 will be discussed in detail.

Within the market hall (in its current state after refurbishment in the year 1983), there are two typical areas defined along a cross-section of the building. One area includes the sale boxes with the main circulation path, the other area shows the entrance area (e.g. at the middle of the longitudinal façade). The entrance situation as typical situation will be not analysed here (see Figure 71).

Figure 72 – Visualization of the proposed new design of the market Mercado del Val

There exists a new design proposal for the market hall by a local architectural design team. Figure 72 to Figure 73 shows some visualizations of the new design proposal for the market hall as well as typical areas within the design proposal.

Figure 73 – Typical areas for new design proposal of market hall

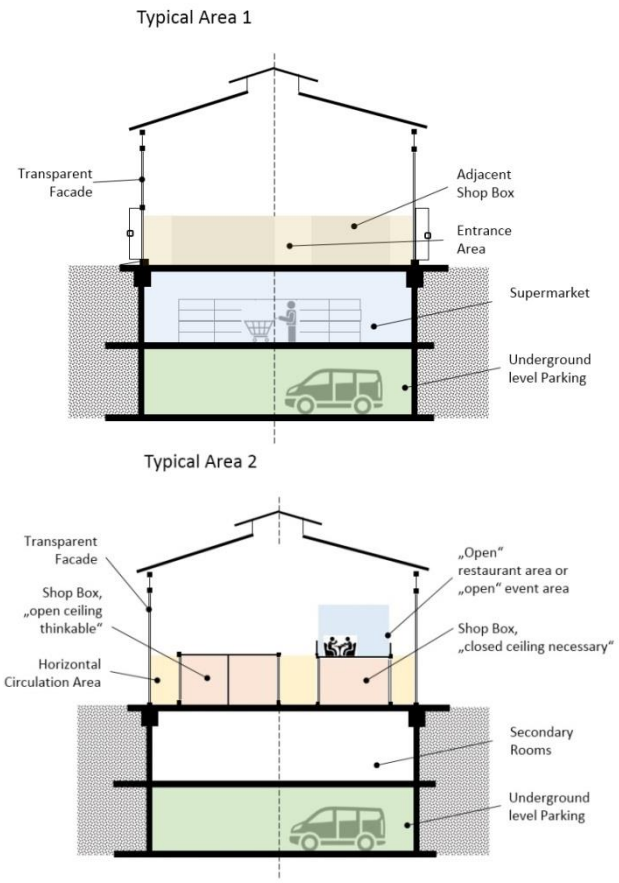


Figure 74 – Cross section of typical areas 1, and 2.

In the section below lighting inefficiencies regarding several topics are discussed in four diagrams which consider a representative building section. The analysis is divided in four topics: visual performance, visual comfort, visual ambience and the energy efficiency of artificial lighting. Important parameters are outlined, which is described in detail in the lighting section (Chapter 5.3).

Artificial lighting inefficiencies

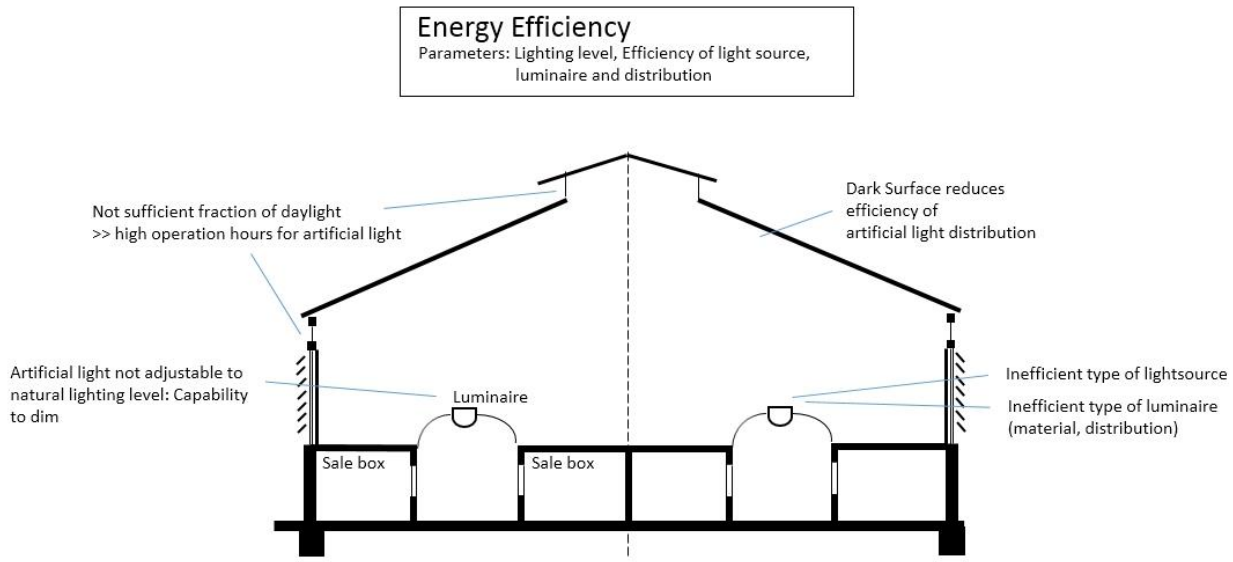


Figure 75 – Artificial light & energy efficiency for old market hall layout, typical area 1

Visual performance inefficiencies

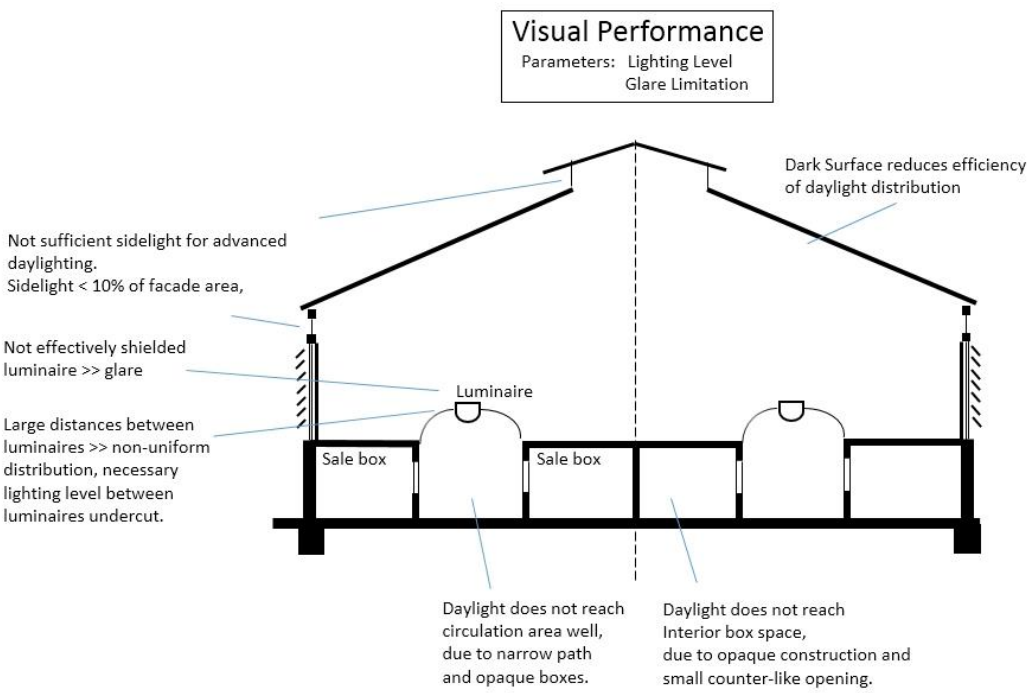


Figure 76 – Visual performance inefficiencies for old market hall layout, typical area 1

Visual comfort inefficiencies

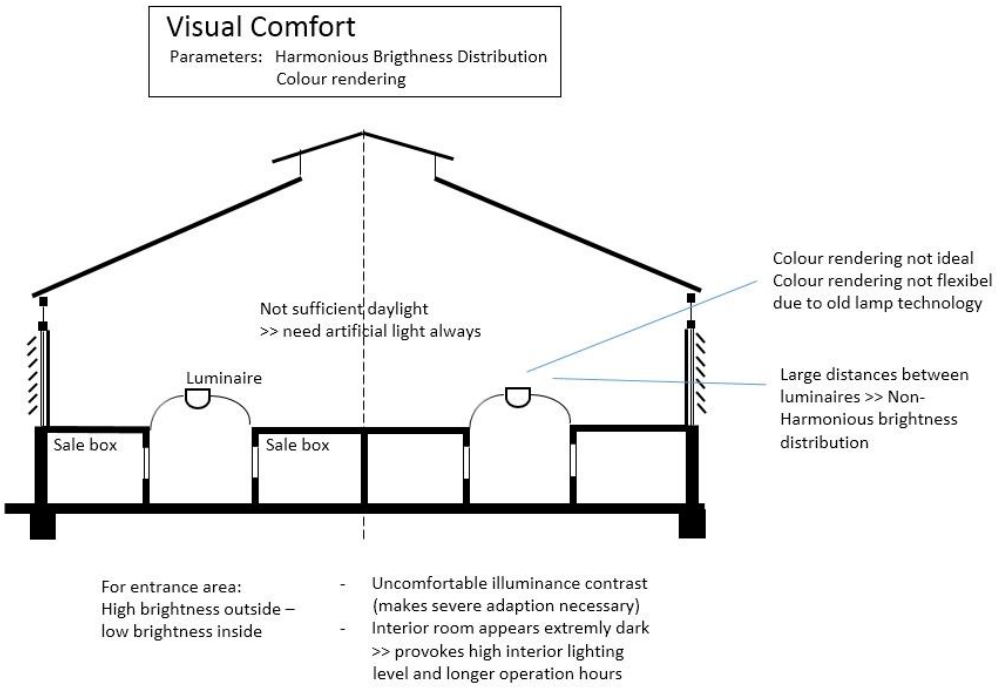


Figure 77 – Visual comfort inefficiencies for old market hall layout, typical area 1

Visual ambience inefficiencies

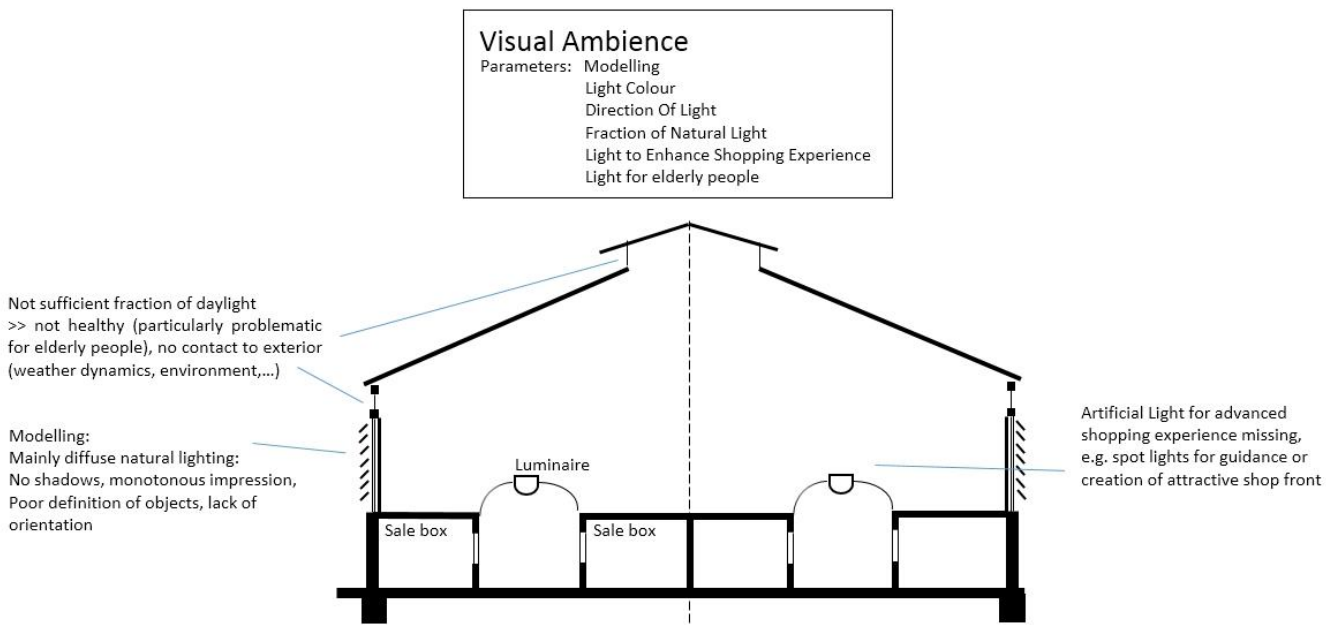


Figure 78 – Visual Ambience Inefficiencies for old market hall layout, typical area 1

Appendix 1.1. Case Study: Market hall – HVAC situation

Mercado del Val was built in the nineteenth century and was renovated in 1983. Since then, the building and HVAC installations have remained practically unchanged. Due to the age of the technical installations and overall the deterioration of the building components, the potential to increase energy efficiency is strikingly apparent. Moreover, the market hall is in much need of a complete redesign to increase its attractiveness for customers and vendors. Consequently, an evaluation of the systemic inefficiencies related to HVAC is focused on the characteristics and constraints associated with the building typology "historic market hall", and the need for new HVAC-system designs to deliver energy efficient operation and maintenance, but also on improving comfort and well-being for customers and tenants.

Inefficiencies in the building form

The large volume compared to exterior surfaces (volume to external surface ratio), and relative to the retail area, make up a large heat loss. These are features that follow the particular building form, but through improving thermal properties of windows and better insulation of facades, roofs and the ground floor, transmission losses can be overcome. Lower thermal losses would lead to a decrease in space heating and cooling demand, and limit the required peak heating power in winter.

Figure 79 – Examples of British market halls, Wakefield's covered market and Huddersfield market hall (Woods 2012).

The physical environment of a large open market hall

In relation to heat losses, the other major inefficiency is air exchange and infiltration with the outside due to a large volume and the overall poor state of the building envelope. Today, drafts and uncontrolled air flows causes uncomfortable conditions for vendors and customers. Since market halls usually consist of a single open space with little separation, there can be challenges with thermal stratification and uneven temperature distribution, besides unwanted airflows.

Since each facade is differently exposed to the wind and solar gains from the outside, it is also challenging to achieve optimal conditions in the entire space. Furthermore, requirements and internal gains vary according to activities that take place. Around the entrance areas, temperatures are expected to be lower. In the current situation, without double doors, or air curtains that prevent conditioned air from escaping, a considerable energy loss occurs in the colder months through the entrance areas.

Figure 80 – Some impressions of the old refrigeration units and roof light of the old market hall.

Uncontrolled air flow in the entrance areas may also affect the conditions negatively in the summers. The open building plan, high internal room height and central openings provides an opportunity for natural ventilation, but the upwards airflow needs to be effectively controlled according to climatic conditions and user requirements during different seasons, and during the day and night.

Inside a large market hall, noise from HVAC equipment is another important issue.

Centralized, or decentralized HVAC systems?

Within the redesign the developer can take advantage of the possibility of design coherent systems for heating, ventilation and refrigeration, to prevent each vendor from installing small separate systems. Today, small refrigeration units on top of the stalls spill out heat in the common area (Figure 80). With individual systems additional punctuations through the building envelope are necessary, which makes it more difficult to prevent unwanted air leakages. With central systems, it is generally easier to utilize heat surpluses from cooling plants, or other refrigeration systems. Using mechanical ventilation, exhaust air which is warmer, or colder than the outside air, can be recovered in an air handling unit. Larger HVAC systems can encompass more efficient fans and pumps, but the trade-off is longer distribution routes, potentially taking up more space, or higher distribution losses.

Another important aspect is the joint operation with multiple systems in place. Another recently renovated market hall in Spain has portable gas heaters placed around the hall to provide additional heating to the radiative panels in the ceiling. With multiple systems, heating and cooling may occur at the same time. This is more likely to occur when supplementary systems are installed, i.e. tenants bringing in their own equipment. Often these are signs that the existing systems are not meeting the requirements for comfort, reliability, or operating efficiency.

Since the market hall typology can be composed of anything from temporary vendors to permanent tenants, HVAC systems need to be flexible. Therefore, it may be highly dependent on the market type, whether central or decentralized systems for lighting, heating, cooling and refrigeration are more effective.

Appendix 2: Shopping Centre Definition and terminology

CommONEnergy Shopping Centre Definition

From Bointner, R., Toleikyte, A., (2015) Shopping malls features in EU-28 + Norway, Deliverable 2.1 for CommONEnergy, 2015.

Location	Type of development	Size	GLA [m²]	Anchor store	Trip purpose
Town Centre Shopping/ urban	Neighbourhood centre/ community centre	Small shopping centres	5,000 – 19,999 m²	Supermarket or hypermarket	Convenience shopping
	Speciality centre (market halls, historical buildings, other)		Usually 5,000 m² and above	Traditional markets, tourist shops	Leisure, convenience shopping
Out-of-Town Shopping/ suburban	Retail Park and Factory Outlets		5,000 – 30,000 m²	None	Household shopping, Comparison shopping, leisure
	Regional centre	Medium/ large shopping centres	20,000 – 79,999 m²	One or more department stores	Comparison shopping
	Super-regional centre	Very large shopping centres	80,000 m² and above	Several department stores, entertainment centres	Comparison shopping, leisure

CommONEnergy Shopping Centre terminology

From Bointner, R., Toleikyte, A., (2015) Shopping malls features in EU-28 + Norway, Deliverable 2.1 for CommONEnergy, 2015.

Enclosed shopping centres

Enclosed shopping centres provide retail opportunities within one environmentally controlled/ air conditioned building. Enclosed shopping centres protect customers, workers and merchandise from the out-door climate. Victor Gruen the architect, who pioneered the enclosed shopping centre during the 1950's, suggested that customers who feel comfortable will shop longer and spend more (Coleman, 2006).

Open shopping centres

Open shopping centres such as strip malls and shopping precincts include more than one retail unit which are attached to each other, but customers cannot go from store to store without going outside. Retail units are often in a row or a U-form with a central open

courtyard. The first 1950's shopping centres had an open design. Contemporary shopping centre developments often offer more open designs. Examples are Oracle in Reading, UK and Beursplein in Rotterdam, The Netherlands.

Convenience shopping
Convenience shopping provides articles which are purchased regularly and often frequently (Dawson, 1983). Convenience goods are perishable goods provided by supermarkets or smaller grocery stores. It may be understood as daily shopping done at smaller neighbourhood centres, but convenience shopping may also be bulk shopping done at convenient intervals (Coleman, 2006).

Comparison shopping
Comparison shopping provides articles which are long term purchases usually bought at irregular intervals. Quality, price and style are important factors in the selection (Dawson, 1983).

Anchor stores
A key tenant or larger store, usually a department store in a shopping centre. In larger regional or super-regional centres containing more than one anchor store, they are commonly located as far as possible from each other to maximise the amount of exposure of smaller units. The Mall of the Emirates in Dubai has 10 anchor stores.

Leisure
Shopping may be understood to be a leisure activity, if it is not directly connected to a specific aim, such as purchasing long term or perishable merchandise. This kind of shopping has its fair share of negative associations. It is often seen as extreme shopping, an over the top activity devoted to indulgence. Shopping in these terms is associated with materialism, hedonism and self-indulgence (Miller, 1998). Leisure in shopping centres may also be related to other activities not directly related to shopping, often found in larger regional and super-regional centres, such as going to the cinema, ice skating and bowling, but also visiting cafes and restaurants are leisure activities.

Hypermarket
A hypermarket is a store usually larger than 5,000 m^2, combining a supermarket and a department store including grocery and general merchandise, which allow customers to satisfy all their daily shopping needs in one place. A hypermarket often has a parking area and a restaurant.

A **market hall** is a covered space in which to buy and/or sell groceries, provisions or livestock is held. Historic market halls from the 19th or early 20th century, often a one- or two-story buildings, are usually covered by a cast iron or steel structure, varying from several hundred up to more than 10.000 square meters. A famous example is the Great Market Hall in Budapest.

Appendix 3: Questionnaire for Owners and Managers

Information introducing the questionnaire to be presented on an introductory (web) page

The questionnaire is for the managers and owners of European shopping centres. The aim is to collect information about the efficiencies and inefficiencies associated with the everyday management, operation and use of shopping centres. The primary focus is energy use, but there are also general questions related to the fields of facilities, functions, management, ergonomics, safety and logistics.

The information gathered will help us to identify drivers, barriers and potential associated with the operation of shopping centres which will be used to define the specifications necessary to achieve effective energy investments within European shopping centres. The CommON*Energy* project will provide shopping centres with practical support, tools and solutions which will transform them into lighthouses of energy efficient systems and architecture.

Please select your language
Norway ☐ Sweden ☐ Italy ☐ Germany ☐ Austria ☐ Spain ☐ Other ☐

Please enter your email address if you wish to receive further information about the CommON*Energy* project.

_____

1. **What is your role? (Tick more than one box if necessary)**
   Owner ☐ manager ☐ developer ☐ other ☐_____

2. **How would you rate your knowledge about energy efficiency in shopping centres?**
   Limited 1☐ 2☐ 3☐ 4☐ 5☐ 6☐Extensive

3. **Do you plan to further develop your knowledge/ skills in energy efficiency?**
   Yes☐ No☐

BACKGROUND INFORMATION

4. **Where is/are the shopping centre/s located?**
   Town centre ☐

Suburbs ☐
Urban perimeter ☐
Commercial zone ☐

5. **What is the approx. net floor area of the shopping centre in m^2**
   _____

6. **When was the shopping centre/s built?**
   1950's ☐ 1960s ☐ 1970s ☐ 1980s ☐ 1990s ☐ 2000s☐
   2010s ☐ Historical building ☐

7. **Has the shopping centre/s been rehabilitated/ upgraded?**

   No ☐ (continue to the next question**)**
   Yes ☐ in what year/s _____
   If yes, describe the actions taken _____

8. **How many customers visited the shopping centre/s in 2013?**
   _____

9. **How many tenants does the shopping centre/s have?**
   _____

10. **a. Shopping centre opening hours per day**_____

    b. number of opening days per week ____

11. **Does the building have unused roof space that can be used to generate energy with renewable sources?**

No ☐ (continue to the next question)

Yes ☐ , size m^2 < 10 000 ☐ 10 000 – 40 000 ☐ 40 000 – 70 000☐
70 000 – 100 000☐ 100 000 – 130 000 ☐ 130 000 > ☐
other ☐_____

12. **Does the building have empty areas or empty stores?**

No ☐ (continue on to the next question)
Yes ☐ approx. m^2_____

13. **Approximately how much is the total energy use in kWh per year in the shopping centre/s <u>including</u> rental space?** _____

14. **Approximately how much is the total energy use in kWh per year in the shopping centre/s <u>not</u> including rental space?** _____

15. **Approximately what are the main energy sources in the shopping centre?**
Approx. 0% ☐ 10 % ☐ 20% ☐ 30% ☐ 40% ☐ 50% ☐ 70% ☐ 80%☐ 90%☐ 100%☐

Electricity
District heating
Gas
Oil
Solar power
Other _____

16. Approximately what are the main causes of energy consumption?

Approx. 0%☐ 10 % ☐ 20% ☐ 30% ☐ 40% ☐ 50% ☐ 70% ☐ 80%☐ 90%☐ 100%☐

Heating
Cooling
Lighting
Ventilation
Other _____

17. Does the shopping centre produce an energy surplus which could be utilized?
No ☐ (continue on to the next question)
Yes ☐ describe _____

FACILITIES

18. What in your opinion are the main reasons for an energy efficient upgrade?

	Irrelevant				High importance
	0☐	1☐	2☐	3☐	4☐	5☐
Green image						
Improved indoor environment quality for workers and customers						
To give the shopping centre a facelift						
Improved energy efficiency						
The need for rehabilitation of the shopping centre						
The need for in-store rehabilitation						
A carbon reduction commitment energy efficiency scheme						
To be competitive within the retail market						
Consumer energy awareness						
To become more attractive to customers						
Taxation						
Environmental responsibility						
Reducing expenses associated with energy use						
Reducing overheads						

Reducing operational costs
Expectations from store owners/managers
Expectations from the planning authorities
Meeting law and regulation requirements
Government funding
Participating in research projects

19. **What in your opinion are the main barriers against an energy efficient upgrade of shopping centre facilities?**

	Not important 0	1	2	3	4	Important 5
The need for rehabilitation of the shopping centre						
Rental/overhead costs						
Upgrade costs						
Expectations from store owners						
Communication between tenants and managers						
Personal knowledge about energy efficiency						
Information about energy efficiency within the public realm						

20. **Which systems are <u>already</u> implemented in the shopping centre/s?** (tick more than one box if necessary)

Natural day lighting	☐
Natural day light control systems (shading)	☐
Artificial lighting control systems	☐
Low-energy light (LED)	☐
Waste recycling programs	☐
Water saving systems	☐
Energy storage	☐
Solar - thermal	☐
Photovoltaic	☐
Heat pumps	☐
Wind turbines	☐
Energy efficiency strategy for tenants	☐
Energy efficiency strategy for customers	☐
Energy efficient elevators and escalators	☐
Improved building envelop (insulation, doors/windows)	☐
AMS/ BEMS systems	
Others	_____

21. **Has an energy efficiency study been commissioned?** yes ☐ no ☐

22. **Which systems are <u>planned</u> installed within the next 12-18 months?** (tick more than one box if necessary)

Natural day lighting	☐
Natural day light control systems (shading)	☐
Artificial lighting control systems	☐

Low-energy light (LED) ☐
Waste recycling programs ☐
Water saving systems ☐
Energy storage ☐
Solar - thermal ☐
Photovoltaic ☐
Heat pumps ☐
Geothermal (wind) ☐
Energy efficiency strategy for tenants ☐
Energy efficiency strategy for customers ☐
Energy efficient elevators and escalators ☐
Improved building envelop (insulation, doors/windows) ☐
AMS/ BEMS systems ☐
Others _____

FUNCTIONS

23. **Approximately what percentage of the net floor area is used for**

0% ☐ 10% ☐ 20% ☐30% ☐ 40% ☐ 50% ☐ 60% ☐ 70% ☐ 80% ☐ 90% ☐ 100% ☐

Food sales
Clothing sales
Other sales categories _____
Rooftop car parking
Entertainment
Food consumption and production
Storage
Service/maintenance
Access between stores
Communal areas
Toilet facilities
Indoor car parking
Store rental
Other _____

24. What in your opinion are the most important areas to be addressed when considering upgrading the shopping centre?

Select the 5 most important areas:

Thermal comfort/ indoor climate ☐
Improved day lighting ☐
Improved artificial lighting ☐
Architectural quality ☐
Customer satisfaction ☐
Worker satisfaction ☐
Improved pedestrian access ☐
Green leases ☐
Durability ☐
Functionality ☐

More parking spaces ☐
Improved orientation within the building ☐
Energy efficient storage and loading areas ☐
Reduced energy demand ☐
Cost ☐
More meeting places ☐
Improved toilet facilities ☐
Acoustic comfort ☐
Entertainment ☐

MANAGEMENT

25. Is energy saving and environmental awareness important to the brand image?

Irrelevant					High importance
0☐	1☐	2☐	3☐	4☐	5☐

26. Are tenants required to have an environmental profile?

Irrelevant					High importance
0☐	1☐	2☐	3☐	4☐	5☐

27. Does the shopping centre/s have recycling programs for:

Paper ☐
Plastic ☐
Glass ☐
Food ☐
Metal ☐
Water ☐
Dangerous substances ☐
Batteries ☐
Wooden materials ☐
Fluorescent tubes/ light bulbs ☐
Other waste materials ☐
describe_____

28. Do the operative and maintenance personnel have good knowledge about energy efficiency?

Limited 1☐ 2☐ 3☐ 4☐ 5☐ 6☐Extensive

ECONOMIC MODELS

29. Does the shopping centre/s have programs for increasing energy awareness amongst tenants?

No ☐ **(**continue to the next question)
Yes ☐ Describe the program and dissemination channels used
_____

30. Does the shopping centre/s have programs for increasing energy awareness amongst customers?

No ☐ **(**continue to the next question)
Yes ☐ Describe the program and dissemination channels used
_____

31. **Does the company/shopping centre have a green leasing program?**
Yes☐ No ☐

32. Would the shopping centre owners/management be willing to give special incentives to tenants who invest in energy-efficient technical equipment?
No ☐ (continue to the question 34)
Yes ☐ describe incentives _____

33. Would you be interested in using a dynamic billing system for energy consumption amongst tenants, where the time of use influences the cost of overheads?
Yes ☐ No ☐

34. **What in your opinion is important when aiming to achieve a more sustainable retail environment?** Rate the importance from 0 (not very important) to 5 (very important)

Not important					Very important
0☐	1☐	2☐	3☐	4☐	5☐

Energy efficient shopping centers
Energy efficient stores
Investment in energy efficient technology
Investment in the building envelop
Sustainable products
Consumer awareness
Design
Changes in legislation
Water saving equipment
Company energy efficiency schemes
Green leases
Knowledge amongst retail workers
Accessibility
Communication between management and tenants
Architectural quality
Recycling systems
Recycling room

ERGONOMICS

35. Rate the shopping centre's accessibility in terms of (Rate from 1, not very good to 6 very good):

1 ☐ 2☐ 3☐ 4☐ 5☐ 6 ☐

Legibility
Information and signage
The location of elevators
The location of escalators
Wheelchair and pushchair access
For the visually impaired
For the hearing impaired
For the physically handicapped
Allergy-free
Outdoor meeting places
Indoor meeting areas
Children's facilities – changing areas, play areas
Barrier-free access for customers
Paths between stores and communal areas
Seating and resting areas
Cleaning and maintenance
Barrier free delivery of goods
Access to storage areas
Staff rooms
Valeting zones

SAFETY

36. How would you rate the shopping centre/s in terms of safety (Rate from 1, not very good to 6 very good):

1 ☐ 2☐ 3☐ 4☐ 5☐ 6 ☐

Customer safety
Staff safety
Fire safety
First aid
Keeping escape paths clear

Maintenance of fire protection sensors and devices

Personnel training in fire and safety protocol
An emergency evacuation plan
Security services
Signposting dangerous areas

A preventive management system for fire protection
A preventive management system for electrical installations

LOGISTICS

37. When locating a shopping centre what is in your opinion is logistically important?

Irrelevant				High importance	
0☐	1☐	2☐	3☐	4☐	5 ☐

Access to public transport
Access to parking spaces
The relationship with the urban environment (housing, offices, industry)
Pedestrian access
Access to loading areas
An effective road network
Cycle paths and cycle parking

38. What is most important when planning internal logistics/ communication?

Irrelevant				High importance	
0☐	1☐	2☐	3☐	4☐	5 ☐

Loading docks for goods
The connection between loading docks, stores and sales areas
Elevators exclusively for logistical tasks
Energy efficient entrance zones
The location of customer elevators
The location of customer escalators
Information and signage
Wheelchair and pushchair access
Universal design for everyone (sight, hearing, physical, handicap, allergy, young, elderly and infirm)
The location of valeting zones

GENERAL QUESTIONS

39. a. How would you rate the shopping centre/s in terms of (Rate from 1, not very good to 6 very good):

1 ☐ 2☐ 3☐ 4☐ 5☐ 6 ☐

- Energy efficiency (heating, cooling, ventilation)
- The building envelop
- Social quality
- Safety
- Visual experience
- User friendly design/ ergonomics
- Accessibility (Logistics)
- Architecture
- Management
- Aesthetic quality

- Recycling
- Customer satisfaction

b. What would you improve? (tick more than one box if necessary)

- Energy efficiency (heating, cooling, ventilation): ☐
- The building envelop ☐
- Social quality ☐
- Safety ☐
- Visual experience ☐
- User friendly design/ ergonomics ☐
- Accessibility and organisation (Logistics) ☐
- Architecture and design ☐
- Management ☐
- Aesthetic quality ☐
- Recycling ☐

40. What in your opinion are the most important actions when aiming to reduce energy use in shopping centres?
Please give a short description, using examples if possible

_____
_____

41. When doing your own shopping how important is it to you that a shopping centre is energy efficient?
Rate the importance from 1 (not very important) to 6 (very important)

Not important					Very important
1☐	2☐	3☐	4☐	5☐	6 ☐

Your answers been saved!
THANK YOU VERY MUCH FOR YOUR CONTRIBUTION!

Appendix 4: Questionnaire for Tenants

Information introducing the questionnaire to be presented on an introductory (web) page

The questionnaire is for tenants in European shopping centres. The aim is to collect data from 2013 about the efficiencies and inefficiencies associated with the everyday management, operation and use of shopping centres. The primary focus is energy use, but there are also general questions related to the fields of facilities, functions, management, ergonomics, safety and logistics.

The information gathered will help us to identify drivers, barriers and potentials associated with the operation of shopping centres which will be used to define the specifications necessary to achieve effective energy investments within European shopping centres. The CommON*Energy* project will provide shopping centres with practical support, tools and solutions which will transform them into lighthouses of energy efficient systems and architecture.

Please select your language
Norway ☐ Sweden ☐ Italy ☐ Germany ☐ Austria ☐ Spain ☐ Other ☐

Gender
Male ☐ Female ☐

Please enter your email address if you wish to receive further information about the CommON*Energy* project.
_____

1. **What is your role? (if necessary, tick more than one box)**
   Shop owner ☐ Shop manager ☐ Shop employee ☐ Other ☐

2. **How would you rate your knowledge about energy efficiency in commercial buildings?**
   Limited 1☐ 2☐ 3☐ 4☐ 5☐ 6 ☐Extensive

BACKGROUND INFORMATION

1. **What kind of retail establishment do you work in?**
   (Tick more than one box if necessary)

   Sale of food and beverages ☐
   Sale of alcoholic beverages ☐
   Sale of health foods ☐
   Dispensing chemists ☐
   Sale of cosmetic and toiletry articles ☐

Sale of textiles and clothing	☐
Sale of children's clothing and equipment	☐
Sale of footwear and leather goods	☐
Sale of lighting equipment	☐
Sale of china and glassware	☐
Sale of furniture	☐
Sale of electrical household appliances	☐
Sale of music (cd's etc.), games and DVD's	☐
Sale of hardware, paint, wood, glass	☐
Sale of books, newspapers and stationary	☐
Sale of gold and silver ware	☐
Sale of photographic and optical goods	☐
Sale of sporting goods, games and toys	☐
Sale of flowers and plants	☐
Sale of wallpaper, carpet and floor coverings	☐
Sale of second-hand goods	☐
Repair of personal and household goods	☐
Repair of watches, clocks and jewellery	☐
Operation of restaurants and cafés	☐
Operation of snack bars	☐
Other	☐ _____

3. **How many paying customers visited the store in 2013?**
   _____

4. **What is the approx. net retail floor area in m^2?**
   Under 40 ☐ 40-100 ☐ 100-500 ☐ 500-1000 ☐ 1000-5000 ☐
   5000-10 000 ☐ Over 10 000 ☐

5. **How long has the store been a tenant in the shopping centre?**
   Less than a year ☐ 1-2 years ☐ 2-5 years ☐ 5-10 years ☐
   more than 10 years ☐

6. **How long is the lease?**

Short term	☐	how long _____
Long term	☐	how long _____
Green lease	☐	

7. **When choosing a location for a new store, how important is it that a shopping centre has an,**
   a. **energy efficient profile**

Irrelevant				High importance	
0☐	1☐	2☐	3☐	4☐	5 ☐

   b. **a green building certificate (LEED, BREEAM, DGNG)?**

Irrelevant				High importance	
0☐	1☐	2☐	3☐	4☐	5 ☐

8. Would you accept an increase in overheads because of

	Yes	No
Shopping centre rehabilitation	☐	☐
In-store rehabilitation	☐	☐
Introduction of energy efficient heating systems	☐	☐
Introduction of energy efficient cooling systems	☐	☐
Introduction of energy efficient lighting systems	☐	☐
Introduction of energy efficient ventilation systems	☐	☐
Installation of roof-top solar thermal systems	☐	☐
Other _____	☐	☐

9. Has the store been rehabilitated/ upgraded?

No (continue to the next question)

Yes ☐ in what year/s _____

If yes, describe the actions taken _____

10. Approximately how much of the total energy use in kWh per year provides

Heating _____ kWh
Cooling _____ kWh
Lighting _____ kWh
Ventilation _____ kWh
Other _____ kWh
Total in-store energy use _____ kWh

11. **Would you expect a decrease in overheads due to reduced energy use/costs within the shopping centre**? Yes ☐ No☐

FACILITIES

12. What in your opinion are the main reasons for an energy efficient upgrade of store facilities?

Irrelevant High importance
0☐ 1☐ 2☐ 3☐ 4☐ 5 ☐

Green image
Improved indoor environment quality for workers and customers
To give the store a facelift
Improved energy efficiency
The need for rehabilitation of the shopping centre
The need for rehabilitation of the store
A carbon reduction commitment energy efficiency scheme
To be competitive within the retail market
Consumer energy awareness
To become more attractive to customers
Taxation
Environmental responsibility

Reducing expenses associated with energy use
Reducing overheads
Expectations from shopping centre owners/managers
Expectations from the planning authorities
Meeting law and regulation requirements
Government funding
Participating in research projects

13. **What in your opinion are the main barriers against an energy efficient upgrade of the in-store facilities?**

	Not important 0☐	1☐	2☐	3☐	Important 4☐
Rental/overhead costs					
Upgrade costs					
Expectations from store owners					
Information from store owners					
In-store design					
Expectations from shopping centre owners/managers					
Communication between tenants and managers					
Personal knowledge about energy efficiency					
Information about energy efficiency within the public realm					

14. **Which of the following systems are <u>already</u> implemented in the store?** (tick more than one box if necessary)

Natural day lighting	☐
Natural day light control systems (shading)	☐
Artificial lighting control systems	☐
Low-energy light (LED)	☐
Waste recycling programs	☐
Water saving systems	☐
Energy storage	☐
Solar - thermal	☐
Photovoltaic	☐
Heat pumps	☐
Geothermal (wind)	☐
Energy efficiency strategy for tenants	☐
Energy efficiency strategy for customers	☐
Energy efficient elevators and escalators	☐
Improved building envelop (insulation, doors/windows)	☐
AMS/ BEMS systems	
Others	_____

15. Has an in-store energy efficiency study been
Commissioned Yes ☐ No ☐

16. **Which of the following systems are <u>planned</u> to be installed in the store within the next 12-18 months?** (tick more than one box if necessary)

Natural day lighting	☐
Natural day light control systems (shading)	☐
Artificial lighting control systems	☐
Low-energy light (LED)	☐
Waste recycling programs	☐
Water saving systems	☐
Energy storage	☐
Solar - thermal	☐
Photovoltaic	☐
Heat pumps	☐
Geothermal (wind)	☐
Energy efficiency strategy for tenants	☐
Energy efficiency strategy for customers	☐
Energy efficient elevators and escalators	☐
Improved building envelop (insulation, doors/windows)	☐
AMS/ BEMS systems	
Others	_____

17. How important is the influence of the heating-ventilation and air conditioning systems on your working conditions

Irrelevant High importance

0☐ 1☐ 2☐ 3☐ 4☐ 5 ☐

To customer satisfaction

Irrelevant High importance

0☐ 1☐ 2☐ 3☐ 4☐ 5 ☐

18. Would your store be willing to invest money in refurbishment of the shopping centre building if the store overheads were reduced?

Yes ☐ No ☐

FUNCTIONS

19. What do you see as the most important areas to be addressed when considering upgrading the shopping centre?

Select the 5 most important areas:

Thermal comfort/ indoor quality	☐
Improved day lighting	☐
Improved artificial lighting	☐
Architectural quality	☐
Customer satisfaction	☐
Worker satisfaction	☐
Improved pedestrian access	☐
Green leases	☐
Durability	☐
Recycling facilities	☐
More parking spaces	☐

Improved orientation within the building ☐
Energy efficient storage and loading areas☐
Reduced energy demand ☐
Cost ☐
More meeting places ☐
Improved toilet facilities ☐
Acoustic comfort ☐
Entertainment ☐

20. What is the average in-store temperature
Summertime _____ do not know ☐
Wintertime _____ do not know ☐

21. **When aiming to achieve an energy use reduction would you accept**,
Lower indoor temperatures in common areas? (winter) Yes ☐ No ☐
Lower indoor temperatures in stores? (winter) Yes ☐ No ☐
Higher indoor temperatures in common areas? (summer) Yes ☐ No ☐
Higher indoor temperatures in stores? (summer) Yes ☐ No ☐
A reduced luminosity level in common areas? Yes ☐No ☐
A reduced luminosity level in stores? Yes ☐No ☐

22. Does the store have its own
Lighting system yes ☐ No ☐
Heating system yes ☐ No ☐
Air conditioning yes ☐ No ☐

23. **Do you know how the in-store systems work?** Yes ☐ No ☐
some of the systems ☐ describe _____

MANAGEMENT

24. Is the in-store energy usage regularly reviewed?
No ☐ Weekly ☐ Monthly ☐ yearly ☐ 5 yearly ☐
do not know ☐

25. Does the store have management systems for energy use relating to
When the building is not in use Yes ☐ No ☐
Electrical installations Yes ☐ No ☐
Employee training Yes ☐ No ☐
Customer programs Yes ☐ No ☐

26. How would you rate the store's operation manuals in terms of clarity and usability (Rate from 1, not very good to 6 very good):

1 ☐ 2☐ 3☐ 4☐ 5☐ 6 ☐

27. Are the manuals used regularly by staff?

Yes ☐ No ☐

28. Does the shopping centre have recycling programs for:

(tick more than one box if necessary)

Paper	☐
Plastic	☐
Glass	☐
Food	☐
Metal	☐
Dangerous substances	☐
Batteries	☐
Wooden materials	☐
Fluorescent tubes/ light bulbs	☐
Clothing	☐
Other waste materials	☐

describe_____

29. **What in your opinion is important when aiming to achieve a more sustainable retail environment?** Rate the importance from 1 (not very important) to 6 (very important)

Not important Very important

1☐ 2☐ 3☐ 4☐ 5☐ 6 ☐

Energy efficient shopping centres
Energy efficient stores
Investment in energy efficient technology
Investment in the building envelop
Sustainable products
Consumer awareness
Design
Changes in legislation
Water saving equipment
Company energy efficiency schemes
Green leases
Knowledge amongst retail workers
Accessibility
Communication between tenants and managers
Architectural quality
Recycling systems
Recycling room

ERGONOMICS

30. Within the shopping centre, is there in your opinion enough,

	Yes	No
Retail space	☐	☐
Communal space (corridors/ meeting areas)	☐	☐
Storage space	☐	☐
Staff meeting/private space	☐	☐
Recycling facilities	☐	☐

31. How would you rate the shopping centre's accessibility in terms of (Rate from 1, not very good to 6 very good):

1 ☐ 2☐ 3☐ 4☐ 5☐ 6 ☐

Legibility
Information and signage
The location of elevators
The location of escalators
Wheelchair and pushchair access
For the visually impaired
For the hearing impaired
For the physically handicapped
Allergy-free
Outdoor meeting places
Indoor meeting areas
Children's facilities – changing areas, play areas
Barrier-free access for customers
Paths between stores and communal areas
Seating and resting areas
Cleaning and maintenance
Barrier free delivery of goods
Access to storage areas
Staff rooms
Recycling rooms

SAFETY

32. How would you rate the shopping centre's in terms of safety (Rate from 1, not very good to 6 very good):

1 ☐ 2☐ 3☐ 4☐ 5☐ 6 ☐

Customer safety
Staff safety
Fire safety
First aid
Keeping escape paths clear

Maintenance of fire protection sensors and devices

Personnel training in fire and safety protocol
An emergency evacuation plan
Security services
Regular security checks
Signposting dangerous areas

A preventive management system for fire protection
A preventive management system for electrical installations

GENERAL QUESTIONS

33. Is energy saving and conservation important to the store image?

Irrelevant					High importance
0☐	1☐	2☐	3☐	4☐	5 ☐

34. a. How would you rate the shopping centre/s in terms of (Rate from 1, not very good to 6 very good):

1 ☐	2☐	3☐	4☐	5☐	6☐

Energy efficiency (heating, cooling, ventilation)
Meeting places
Safety
Visual experience
Lighting
Acoustic comfort
Environmentally friendly
Thermal comfort (heat and air quality)
Air conditioning
User friendly design/ ergonomics
Accessibility and organisation (Logistics)
Cleanliness
Architecture and design
Barrier-free accessibility
Aesthetic quality
Recycling
Management
Communication between management and stores
Customer satisfaction
Access to public transport
Bicycle comfort (enough bicycle stands, distance to main-entrance)
Car parking

b. What would you improve in the shopping centre? (tick more than one box if necessary)

Energy efficiency (heating, cooling, ventilation):	☐
Meeting places	☐
Safety	☐
Visual experience	☐
User friendly design/ ergonomics	☐
Accessibility and organisation (Logistics)	☐
Cleanliness	☐
Architecture and design	☐
Aesthetic quality	☐
Recycling	☐
Management	☐
Communication between management and stores	☐
Thermal comfort (heat and air quality)	☐
Public transport	☐
Car parking	☐

35. What in your opinion are the most important actions when aiming to reduce energy use in shopping centres?

Please give a short description, using examples if possible

_____

36. What in your opinion are the most important actions when aiming for an in-store reduction in energy use?

Please give a short description, using examples if possible

_____

37. When doing your own shopping how important is it to you that a shopping centre is energy efficient?

Rate the importance from 1 (not very important) to 5 (very important)

Not important				Very important
1☐	2☐	3☐	4☐	5☐

Your responses have been saved!
THANK YOU VERY MUCH FOR YOUR CONTRIBUTION!

Appendix 5: Questionnaire for Customers

Information introducing the questionnaire to be presented on an introductory (web) page

The questionnaire is for shopping centre customers. The aim is to collect information about the influence of energy use and environmental profile on customer behaviour.

The information gathered will help us to identify drivers, barriers and potentials associated with the operation of shopping centres which will be used to influence effective energy investments within European shopping centres. The CommON*Energy* project will provide shopping centres with practical support, tools and solutions which will transform them into lighthouses of energy efficient systems and architecture.

Please select your language
Norway ☐ Sweden ☐ Italy ☐ Germany ☐ Austria ☐ Spain ☐ Other ☐

Gender
Male ☐ Female ☐

Please enter your email address if you wish to receive further information.

_____

1. **How would you rate your knowledge about energy conservation?**

Extensive 1☐ 2☐ 3☐ 4☐ 5☐ 6☐ Limited

2. **How important is it to you that a shopping centre is energy efficient?**
   Rate the importance from 1 (not very important) to 6 (very important)

   Not important Very important
   1☐ 2☐ 3☐ 4☐ 5☐ 6☐

3. **How do you usually travel to the shopping centre?**
   Public transport ☐
   Car/ motorbike ☐
   Bicycle ☐
   Pedestrian ☐
   Other_____

4. **When choosing where to shop, what influences your choice of shopping centre?**
   Select the 5 most important areas:
   Location ☐
   Energy efficiency ☐

Green building certification ☐
Low prices ☐
A wide range of products ☐
A wide range of organic/bio or free trade products ☐
Free car parking ☐
Good cycle access and cycle parking ☐
Good access to public transport ☐
Access to battery charging for electric cars ☐
Architecture ☐
Aesthetic pleasure ☐
Indoor climate ☐
Pleasant meeting places ☐
Entertainment opportunities ☐
Legibility/ easy orientation ☐
Accessibility indoors ☐
Well-known brands ☐

5. **Would you accept a lower indoor temperature in the shopping centre during the winter?**
Yes ☐ No ☐
Would you accept a higher indoor temperature in the shopping centre during the summer?
Yes ☐ No ☐

6. **Would you be willing to pay a higher price for a product sold in an energy efficient store?**
Yes ☐ No ☐

7. **Would you be willing to shop in stores that are less brightly lit?** Yes ☐ No ☐

8. **When shopping in this shopping centre how important is the availability of "organic/bio" and "fair trade" products?**
Rate the importance from 1 (not very important) to 6 (very important)
Not important Very important
1☐ 2☐ 3☐ 4☐ 5☐ 6☐

9. **When shopping in this shopping centre how important is transparency concerning production of products and their origins?**
Rate the importance from 1 (not very important) to 6 (very important)
Not important Very important
1☐ 2☐ 3☐ 4☐ 5☐ 6☐

10. **a. How would you rate the shopping centre in terms of (Rate from 1, not very good to 6 very good):**
1 ☐ 2☐ 3☐ 4☐ 5☐ 6☐ Don't know ☐

Energy efficiency (heating, cooling, ventilation)
Safety
Lighting

Acoustic comfort
Environmentally friendly
Thermal comfort (heat and air quality)
User friendly design/ ergonomics
Accessibility and organisation (Logistics)
Meeting places
Cleanliness
Architecture and design
Aesthetic quality
The range of products
The range of organic/bio and free range products
Recycling
Customer satisfaction
Access to public transport
Bicycle comfort (enough bicycle stands, distance to main-entrance)
Car parking

b. What would you improve? (tick more than one box if necessary)

Energy efficiency (heating, cooling, ventilation): ☐
Safety ☐
Lighting ☐
Acoustic comfort ☐
Thermal comfort (heat and air quality) ☐
User friendly design/ ergonomics ☐
Accessibility and organisation (Logistics) ☐
Meeting places ☐
Cleanliness ☐
Architecture and design ☐
The range of products ☐
The range of organic/bio and free range products ☐
Recycling ☐
Access to public transport ☐
Bicycle comfort (enough bicycle stands, distance to main-entrance) ☐
Car parking ☐

11. What in your opinion are the most important actions to be taken when aiming to improve the shopping centre's environmental profile?
Please give a short description, using examples if possible

_____

Your responses have been saved!
THANK YOU VERY MUCH FOR YOUR CONTRIBUTION!