Specific energy use in Swedish and Norwegian shopping malls

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Abstract

The prevalence of shopping malls is growing worldwide. Internationally, there are differences in energy use and system solutions due to local outdoor climate, available energy resources, prices, national building regulations, traditions etc. On the other hand, tenants are usually international chains and they often have the same demands regarding indoor climate, system solutions etc. irrespective of the national differences. Shopping malls overall tends to have large lighting loads, high population density and, hence, a large air conditioning demand. There is also an apparent trend towards increasing glass surfaces and such design feature affects the energy balance of the building. For those interested in the energy efficiency of the building and its installations, it is interesting to know how different system solutions affect the energy use. Benchmarking between buildings gives valuable insight to energy efficient design and operation. However, available information on energy use for such benchmarking in shopping malls is still rather limited.

This study investigates shopping malls in Sweden and Norway. Available national statistical data on retail and shopping malls are reviewed. Further building statistical data were collected from building owners and managers, covering energy use in 41 shopping malls. Additional energy use data for 115 shops, within three of these shopping malls were also collected.

The building statistical data shows that the average energy use in Norwegian and Swedish shopping malls are approximately 291 and 279 kWh/m^2/year respectively. The highest energy use exceeds the lowest figure by approximately 50 percent, indicating a significant potential for improvement. Results also show a wide deviation in energy use of the different shops in a shopping mall. The paper further provides a discussion concerning alternative benchmarking methods and necessary improvements to make valid conclusions regarding energy use in shopping malls.

Introduction

This paper investigates the energy use in Swedish and Norwegian shopping malls. A shopping mall, as it is referred to in this paper, is a large shopping centre entirely within a roofed structure, controlled by a limited number of entrances. Stores and other services are usually only accessible via interior corridors.

In Swedish and Norwegian shopping malls, the building owner is usually responsible for space heating, space cooling, ventilation and general lighting in the building. The tenants, on the other hand, controls the lighting in the shops and, if the tenant is a supermarket the refrigeration of frozen and chilled food. The tenant electricity is often excluded in the statistics. However the tenant electricity can be a significant part of a building's energy balance as indicated by **Figure 1**. Therefore shopping malls where the total energy us known is included in this study.

One of the major regulations concerning building energy use is the European Energy Performance of Building Directive (EPBD) (European Union, 2003). Even though Norway is not a member state of EU the Norwegian Parliament has decided to implement the EPBD as part of their European Economic Area agreement with EU (Rode and Isachsen 2008).

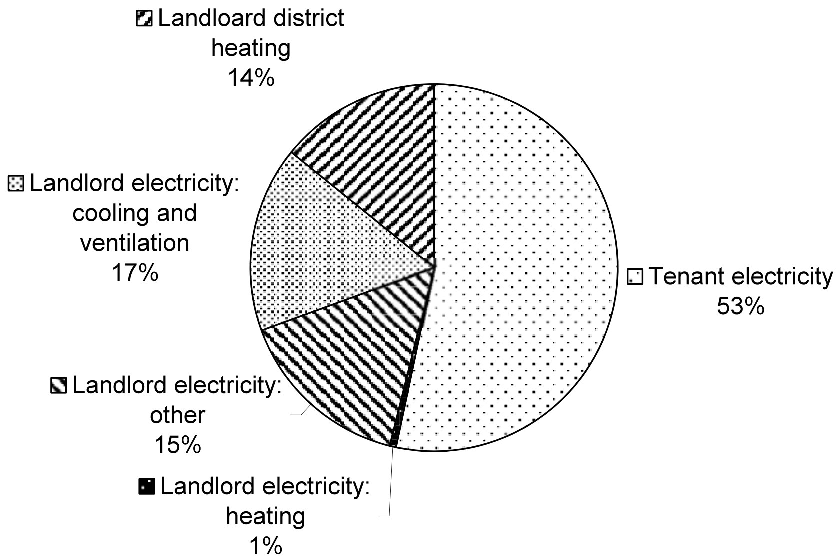

Figure 1. A breakdown of energy use in seven shopping malls in Sweden.

Benchmarking is an important tool to promote the energy efficiency of commercial buildings (Chung, Hui et al. 2006; Bohdanowicz and Martinac 2007). In order to create a successful and reliable benchmarking tool it is important to identify the parameters crucial to the energy use and the use patterns. Detailed and reliable information is required on the energy use in the shopping mall as a whole, as well as on the various end-users.

Figure 1 shows a compilation of the energy use for seven shopping malls in Sweden. The result shows that the main energy user in these shopping malls is the tenants' electricity use with 53%.

PURPOSE

The purpose of this study is to analyse energy use in Swedish and Norwegian shopping malls. The paper includes an analysis of existing and collected data that can be used for benchmarking. Also, the paper discusses existing benchmarking methods. Consequently, the paper gives an overview of information that is available for conducting benchmarking, but also what information that is missing.

METHODOLOGY

This study has been done through the following procedures:

1. Literature review of available information and methods that can be used for *benchmarking* of energy use in shopping malls.
2. Investigation of available *national statistical data* on energy use in buildings.
3. Collection of *building statistical data* through questionnaires and personal communication with managers, service staff and energy advisors.
4. Presentation and analysis of national and building statistical data on energy use in *Swedish and Norwegian shopping malls*.

Benchmarking methods

Benchmarking, as it is referred to in this paper, is a process of comparing a building's energy use with that of other buildings. It is supposed to be a tool for making changes that improve the energy performance. The *European Energy Performance of the Building Directive (EPBD)* provides a very general tool for comparing energy use between buildings. For a more thorough investigation, there are predefined *energy use assessment programmes*.

EUROPEAN ENERGY PERFORMANCE OF BUILDING DIRECTIVE (EPBD)

EPBD (European Union, 2002) is the main legislative instrument affecting energy use and efficiency in the building sector in the EU. EPBD lays down a framework for the calculation of an integrated energy performance measure in buildings. EPBD also requires that an energy performance certificate is made available when buildings are constructed, sold or leased. This certificate has to express the energy performance as a numeric indicator that facilitates benchmarking. It shall also be accompanied with recommendations for cost effective improvements of the energy performance. Buildings for public service, such as shopping malls, need to display the energy performance visible to the public.

EPBD IN SWEDEN

In order to follow the part of EPBD that demands energy declarations of buildings, one law, one ordinance and two regulations has been founded in Sweden. The Swedish energy performance measure for non-residential buildings includes building service energy but excludes tenant electricity. According to guidelines by the National Board of Housing - Building and Planning (in Swedish: Boverket) the following definitions are given (translated from Swedish):

- **Building service energy** is the energy used for operation of the central systems. It is needed for the building to be used for its intended purpose. Examples are, electricity use for fans, pumps, elevators, permanently installed lighting, and suchlike.

- **Tenant electricity** is the electricity used for the activities in premises. Examples are, lighting, computers, copying machines, TV, dishwashers, washing machine and other household machines and suchlike.

In shopping malls, this generally means that the energy purchased by the manager of the shopping mall corresponds to the building service energy and it is mainly used for the heating, ventilation and air-conditioning (HVAC) system. Tenant electricity is what it implies, electricity purchased by the tenants and used for lighting and other installations in the shops. Even though the tenant electricity is not considered in the energy declaration, it still highly affects the total energy use and the energy balance of the building.

ENERGY USE ASSESSMENT PROGRAMS

There are several benchmarking tools on the market, for example Building Research Establishment Environmental Assessment Method (BREEAM) (UK), Leadership in Energy and Environmental Design (LEED) (USA), Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) (Japan), and Green Star (Australia), Hong Kong Building Environmental Assessment Method (HK-BEAM) (China), to name a few. BREEAM and LEED are probably two of the most widely used building environmental assessment schemes worldwide. The International Council of Shopping Centers's European Sustainability Working Group has agreed to use BREEAM standards for measuring the efficiency of new retail developments across Europe. The group chose BREEAM rather then LEED or any other of the sustainability assessment programs, because of its European roots and adaptability to local markets.

The study by Lee and Burnett (2008) compared three assessment methods; BREEAM, LEED and HK-BEAM. The three schemes differ significantly in scope and assessment criteria. However, they include performance-based assessment, together with features that are intended to enhance energy performance. For new buildings, performance assessments are based on simulation and/or calculations. BREAM assess the 'absolute' performance to minimize the overall emission of CO_2, while HK-BEAM and LEED seek to determine the improvement in design as a percentage. HK-BEAM and LEED compares the assessed building with a baseline building, assuming similar weather data, occupancy patterns, installed equipment etc. There is no baseline building for BREAM. The study concludes among other things that; the certified buildings are in the top 25% of the market standard in energy performance. It is most difficult to score credits under BREEAM.

Another tool on the market is the Energy Star (USA), which offers free evaluation of energy performance. Building owners and managers are encouraged to benchmark their own buildings using Energy Star's Portfolio Manager online. Energy Star benchmark ratings are available for retail stores. Enclosed shopping malls are on the other hand excluded from Energy star, due to their complexity.

National statistical data

General statistic about energy use in Swedish and Norwegian building are found in reports from SCB and Enova, respectively. The statistics in these documents are useful for rough estimates for building owners, technical consultants and energy companies. However, the statistics is probably more useful for national accounts then for building benchmarking. These statistics are important for estimates of the total energy use in buildings. For detailed planning and energy efficiency measures more detailed information is needed in order to achieve a useful benchmark.

NATIONAL STATISTICAL DATA IN SWEDEN

Statistics Sweden (SCB) is a central government authority for official statistics and other government statistics. The energy data from SCB are provided in delivered energy. "This means energy paid for by the consumers and supplied to the buildings, which includes losses within the buildings but not external conversion and transformation losses. As an example, changing from decentralised oil furnaces to centralised oil-fired district heating production may thus increase the efficiency at the point of delivery whereas the total use of oil could remain unchanged. Also, the existing data does not support a separation of space heating from heating of water. All energy use for heating is adjusted for annual changes in climate, using degree-day statistics from the Swedish Meteorological and Hydrological Institute (SMHI).

According to SCB (Statistics Sweden 2007b) the electricity use is difficult to measure and analyse because it is used for different purposes: heating, warm water, tenant electricity and operational electricity. In non-residential buildings, there are most often more then one electricity meter, but the information that SCB receives usually only covers one of these electricity meters and it is often uncertain what the data covers.

NATIONAL STATISTICAL DATA IN NORWAY

Enova is a public enterprise owned by the Royal Norwegian Ministry of Petroleum and Energy. The energy data from Enova is also, as for Statistics Sweden, provided in delivered energy. The total delivered energy is not corrected for the efficiency of various installations in the buildings.

In order to compare the energy use from one year to the other, climate corrections are applied with respect to normal year according to the methodology of Statistics Norway. The climate adjustment is done through the method of degree-day normalization. In order to compensate differences in energy use due to geographical reasons, the data is also adjusted so that the figures represent the climate in Oslo. It is only the temperature dependent portion of energy use that is adjusted. For shopping malls and shops this temperature dependant portion is assumed to be 25% of the total energy.

The buildings in the statistics from Enova are classified into different building categories according to the Norwegian standard NS 3457 "Bygningstypetabell". It is the building's main area of use that determines which category it is classified into. As an example a school with a swimming bath will be classified as a school and not a swimming bath. For calculations of the average energy use for groups of buildings, the average specific energy use for individual buildings have been used, and not the sum of energy uses divided by the sum of the areas.

According to Ettestøl (2005) the statistics have become an essential tool for many actors in the building industry and authorities. Building owners use them in benchmarking their buildings. Technical consultants use them in planning new

Table 1. Average specific energy use in 2006 in Norwegian shopping malls and retail/shops. Data are from table 3.1 and figure 3.5 in the report by Enova (Enova 2007:2).

Type of building	**Shopping malls**	**Other retail (Shops)**
Number of buildings included in the statistics	184	338
Total heated area [m^2]	1 700 271	392 161
	Energy use [kWh/m^2/year]	
Average temperature and geographically normalized specific energy use	**391**	**509**
Average measured specific energy use	**379**	**493**

Table 2. Average specific energy energy use in 2006 in Swedish supermarkets and retail/shops. Data are from table 1, 4, 11, 12a, 12b in the report by Sweden Statistics. All data are given with standard error. (Statistics Sweden 2007b)

Type of building	**Supermarkets**	**Other retail (Shops)**
Number of premises	3 339 ± 258	7644 ± 352
Area of premises [million of m^2]	4,9 ± 0,3	11,1 ± 0,4
	Energy use [kWh/m^2/year]	
Average district heating used for heating and hot water per square metre heated area of premises (only genuinely district heated premises are included)	**108 ± 6**	**109 ± 3**
Average energy used (incl. district cooling and electricity for climate cooling) for heating and hot water per square metre heated area of premises	**146 ± 5**	**142 ± 3**
Average energy used (excl. district cooling and climate cooling) for heating and hot water per square metre heated area of premises	**142 ± 5**	**120 ± 3**

buildings. Energy companies use the statistics when making estimates of the power requirements of new installations, etc.

AREA DEFINITIONS IN THE NATIONAL STATISTICAL DATA

One of the differences in the energy statistics from SCB and Enova is the way that floor area is measured. Enova uses the heated area defined as: The gross floor area (BTA according to NS 3940 "Areal-og volumberegning av bygninger") where the air temperature is kept at 15˚C or above and measured from the outside walls (Enova 2007:2).

SCB uses the 'premise area', LOA (in Swedish: lokalarea). Staircases and accessory spaces are not included in LOA, which means that heated area is larger in reality then in the statistics. Consequently this gives a slightly higher specific energy use compared to a case where the real heated area had been used. (Andreasson, Borgström et al. 2008) For more information on area definitions see standard SS 021053. Since the energy is divided by a smaller area in Swedish then in Norwegian shopping malls, Swedish malls will appear to have relatively higher energy use than the reality.

Atemp, a temperate area, is another area definition that is worth mentioning. It is used for energy declarations in Sweden and also by the Swedish building regulations. Atemp is defined as the floor area in temperature regulated spaces that is supposed to be heated above 10˚C and that is enclosed by the building envelope.

PRESENTATION OF THE NATIONAL STATISTICAL DATA IN SWEDEN AND NORWAY

Shopping malls in Sweden and Norway usually have centralised heating, ventilation and air conditioning (HVAC) plants. The HVAC systems consist of central air handling units.

Table 1 shows the average specific energy use in 2006 in Norwegian shopping malls and shops. Figures are extracted from the building statistics from Enova. Enova points out that there might be some inconstancies in the categorisation between shopping malls, department stores and shops. The 62 shopping malls/departments stores with the highest energy use are all grocery stores that can be part of a larger shopping mall or because of its size or product range have been classified as independent shopping malls. The 13 with the lowest energy use are furniture stores within the same chain. Also for the shops it is grocery stores that have the highest energy use. The energy use in shops seams rather high, but the report does not comment on why that could be. Table 2 shows Swedish energy statistics from SCB for supermarkets and retail. *However, there is no separate presentation on the energy use for shopping malls.*

Building statistical data

The building statistical data in this study covers energy use of 41 different shopping malls. It was of interest to analyse the total energy use, why only premises with known tenant electricity have been included in this presentation. Since the sample of shopping malls participating in this study is not random, the statistics that emerge from the statistics cannot simply be extrapolated to the overall shopping mall population.

For the Norwegian shopping malls included in the study, information was extracted from the internet based energy monitoring system EnergiNet and complementary information was given from the shopping malls' energy advisor according to the shopping mall survey. EnergiNet is used by 2 of the major estate owners in Norway that hold 48 shopping malls representing a heated area of 1.1 million square meters, consequently providing a unique database. Of these, 34 were selected and included in the study. The shopping malls that were excluded from the study were so because of missing data, reconstruction, or other uncertainties.

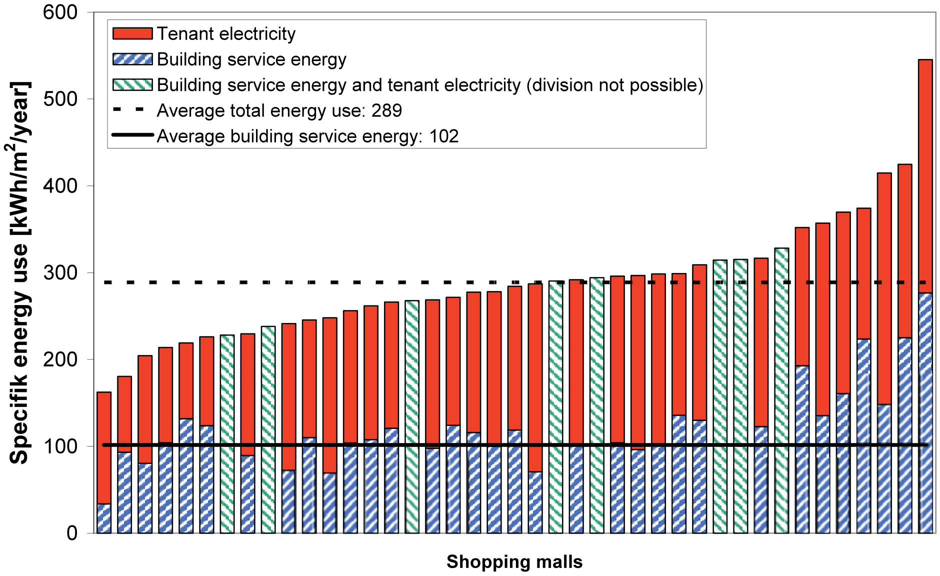

Figure 2. Specific energy use in participating shopping malls.

When premises are leased in Sweden the tenants usually have their own electricity subscription, which means that the premise owners only have insight in the estate electricity. Therefore it has been difficult to gather information on the total energy use including the tenants' electricity use. Therefore, only seven Swedish shopping malls have been included in the study.

QUESTIONNAIRE FOR COLLECTION OF BUILDING STATISTICAL DATA

Information concerning the following topics was gathered through questionnaires and personal communication with managers, service staff and energy advisors.

- Total delivered electricity
- Total delivered district heat
- Total delivered district cooling
- The tenants' electricity ratio to the total delivered electricity.
- Distribution of energy use between heating, cooling/ventilation and other.
- Distribution of tenant electricity between grocery shops and other shops.
- Floor area

Energy use is measured as total delivered energy to a building in a year. The energy use is thus not corrected for efficiency losses in installations etc. During the data collection it was found that the electricity used for space cooling is most often unknown. Further, when there is a supermarket within the shopping mall there are inconsistencies whether or not the supermarket's electricity is included in the tenant electricity or not. This means that in Figure 2 the tenant energy use might in some cases include electricity for supermarkets' refrigeration of food.

Tenant electricity

There have been three different methods for buying and distribution of the tenant electricity in the studied shopping malls:

- *The shops have their own electricity agreements and buy their own electricity.* When this has been the case it has not been possible to gather information about the tenant's electricity use, since this would have meant that each tenant in each shopping mall should have reported their energy use and that was not possible within the scope of this study.
- *The shopping mall's building owner buys electricity and distribute to the tenants with separate electricity meters for each tenant.* The building owner charges each shop/tenant for the actual electricity used. For shopping malls where this has been the case the total electricity use has been divided between the building owner and the tenant.
- *The shopping mall's building owner buys electricity and distribute to the tenants without separate electricity meters for each tenant.* The tenant electricity is in this case included indirectly in the tenant rent. In this case the tenant electricity is included in the total electricity use but there is no possibility to separate the electricity use between the tenants and the building owner.

PRESENTATION OF THE BUILDING STATISTICAL DATA IN SWEDISH AND NORWEGIAN SHOPPING MALLS

Figure 2 shows a comparison of 41 shopping malls, gathered in this study, situated in Sweden and Norway. The total heated area (per shopping mall) ranges from 4000 m^2 to 66 000 m^2. When possible the total energy use has been divided between the building service energy and the tenant electricity. As discussed earlier the tenant electricity is not encompassed by the EPBD. Where the tenant electricity has been separated, it accounts for between 40 to 80% of the total energy used. The average specific energy use for all shopping malls is 290 kWh/m^2. While the average specific energy uses for Swedish and Norwegian shopping malls are 279 and 291 kWh/m^2, respectively. The

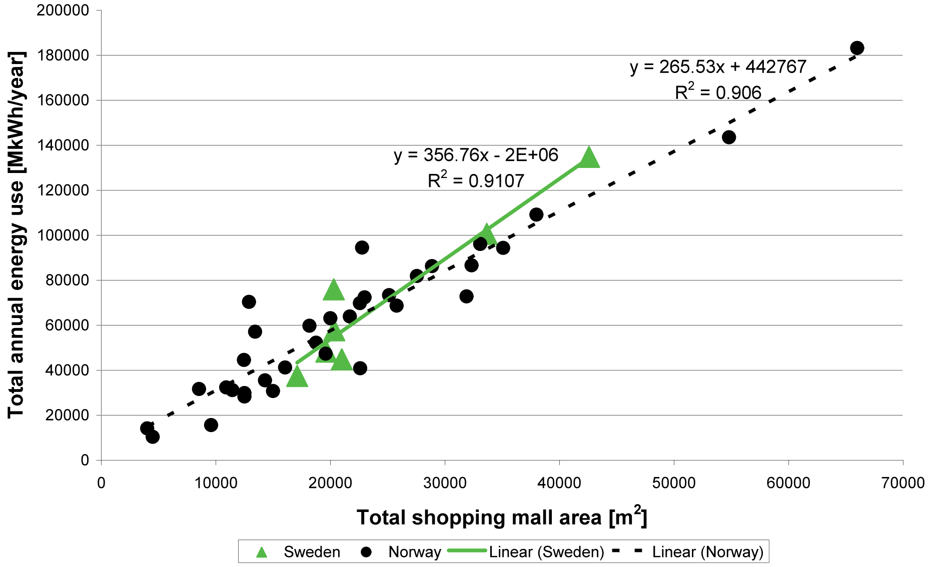

Figure 3. Total annual energy use for shopping malls in Sweden and Norway vs. total shopping mall area.

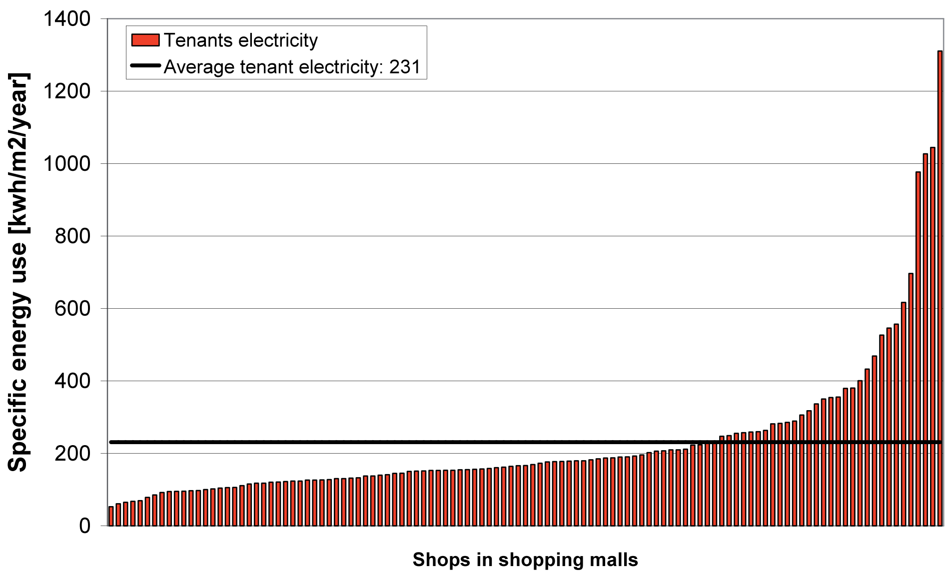

Figure 4. Specific energy use in shops.

minimum and maximum specific energy uses for all shopping malls are 162 and 545 kWh/m²/year, respectively.

The average specific electricity uses for the tenants were 144 kWh/m² in Sweden and 175 kWh/m² in Norway, based on the total area of the shopping mall. For Swedish shopping malls, the total rentable area was known and if the specific energy use is based on this area instead of the total floor area then the tenants' energy use is 180 kWh/m².

The total energy use in individual shopping malls and the variation in energy use correlate significantly with shopping mall area, as indicated in Figure 3. The obtained value for the correlation between energy use and shopping mall area is $R^2 > 0.9$ both for shopping malls in Sweden and Norway.

Shops in the shopping malls

Figure 4 shows the energy use in 116 shops that are situated within three of the Norwegian shopping malls, included in this study. The average specific energy use in these shops is 231 kWh/m²/year. The difference in energy use ranges from 53 to 1311 kWh/m²/year. The shop with the highest energy use is a kiosk with a specific energy use of 1311 kWh/m²/year. This is quite high compared to the other shops. A kiosk is usually a small shop that sells magazines, sweets, tobacco, drinks, ice cream and such like. This particular kiosk has a floor area of 52 m². The small floor area might somewhat explain the high energy use.

Figure 5 shows the specific energy use in shops in relation to the shops' floor area. There is a large deviation between the spe-

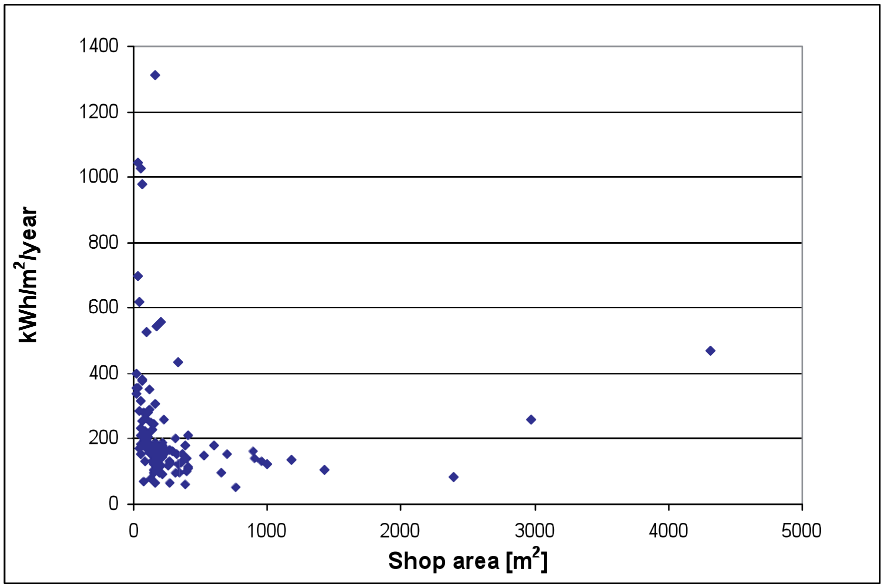

Figure 5. Specific energy use vs. total shop area.

Table 3. Maximum, minimum and mean specific energy use in different shop categories.

	Clothing	Hobby	Home	Supermarket	Other service	Other everyday stores	Not categorized
Number of shops	56	8	15	3	11	10	12
Min [kWh/m^2/year]	65	53	95	260	105	158	68
Max [kWh/m^2/year]	380	283	401	1027	336	1311	697
Mean [kWh/m^2/year]	164	156	161	585	311	522	276
Standard deviation	62.5	79.4	84.8	396.6	257.0	371.6	197.0

Table 4. Description of shop categories

Shop categories	Description
Clothing	Clothing, shoes, jewellery
Hobby	Sports equipment, bookshop, toys, music, games
Home	Furniture, decoration, telephony, hardware
Supermarket	Supermarket
Service	Hairdresser, travel agency, drugstore, optician, photography
Other everyday stores	Beauty care, kiosk, bakery, health food, flowers, perfume
Not categorised	Shop category is unknown to the author

cific energy used in different shops. As can be seen it is among the small shops that the highest specific energy use is found. The lack of linear correlation in this case points to other factors playing a significant role in determining energy use rather then just floor area. Building owners, interviewed in this study have expressed that there is a trend where 'more fashionable' shops have relatively more lighting installed. Also, it tends to be the small shops that are more high fashion. This might be part of the explanation to the wide deviation. In Table 3 the specific energy for different shop categories are illustrated. Table 4 gives a description of the different shop categories.

Discussion

EPBD AND SHOPPING MALLS

One driver for improved energy efficiency in shopping malls is the EPBD and its requirement for an energy certificate. For the first time, shopping malls are required to have a standard energy assessment and a certificate that allows comparison of performance between premises. It is believed that the existence of certificates, and more importantly their public display, will cause organisations to seek improvements in order to retain their reputation, especially those who already have a high environmental profile.

Although EPBD is supposed to be a strong driver for energy efficiency, it is questionable if this integrated energy performance measure is appropriate for some building types, such as shopping malls, because the tenant electricity is excluded. Since the tenant electricity constitutes 40–80% of the total energy use this exclusion affects the measure significantly.

The fact that the tenant electricity is not included in the integrated energy performance can cause misleading results. A building could actually be very poor concerning energy efficiency, but still be rated well in the energy performance measure. This would for example be the case when a building is heated through an inefficient lighting plant if the light is provided through tenant electricity.

EPBD is supposed to be reported in a harmonised way. The integrated energy performance measure is only one numerical value reflecting the specific annual primary energy use, but the input data for it will inevitably reflect different climatic and social conditions. Therefore, it can only give vague information if used for benchmarking of shopping malls in different countries.

The complexity of shopping malls makes it difficult to use statistics from the EPBD for benchmarking purposes. EPBD probably has its largest impact for dwellings where both the physical and operational parameters are more standardized throughout a larger population. However, even though the integrated energy performance value might not be the best measure for comparison between shopping malls, there is still a value in that the building owners go through their property, gain awareness of its energy performance, and receive relevant energy efficiency measures. For some building owners, who already have high awareness, this might be superfluous while it might be a wake up call for others.

LARGE POTENTIAL FOR IMPROVED ENERGY EFFICIENCY IN SHOPPING MALLS

So why are shopping malls so energy intensive? There might be many reasons. One reason is that for shops the cost of energy use is a very small percentage of their total cost. Among other candidates is the desire to build prestige buildings that seem, by definition, to require more air conditioning. It is difficult to develop energy efficient solutions due to the complexity of the buildings. A possible reason could be that both heating and cooling systems in shopping malls are over-specified and not designed for a specific user in mind. Instead, it is designed to be flexible and serve any possible tenant. One way to reach improved energy efficiency is though better guidelines for both design of installation, and energy measurements in shopping malls.

CATEGORISATION OF SHOPPING MALLS INTO SUBGROUPS

What constitutes a low energy shopping mall is not easily defined because of the widely variable shopping mall typology. This paper suggests that there are significant differences in the energy use between different shopping malls, ranging between 162-545 kWh/m^2/year. This indicates that establishing realistic energy use benchmarks or models requires classifying shopping malls into sufficiently specialised sub-groups representing facilities with comparable properties. Profile data could be used to classify shopping malls into sub-groups having similar characteristics. Such sample diversification is expected to help in developing more precise energy use models, as well as establishing adequate and reliable benchmarks.

DIVIDING SHOPPING MALLS INTO DIFFERENT MODULES

It is well known that shopping malls are complex systems with individual modules such as shops, supermarkets, restaurants, corridors etc combined into a greater whole. Due to varied service requirements, the acceptable energy uses for e.g. shops are quite different from that of restaurants or other areas. An example on how energy use can differ between different modules was shown in Table 3. Due to the difference in distribution (proportion of the overall area) of these modules in different shopping malls, having one benchmark value for an entire premise, based on absolute figures may appear too simplistic. Instead, it may be appropriate to disaggregate shopping malls into modules and develop energy use models and indicators for each particular module. The individual efficiencies/performance indicators should then be combined and weighted to provide a fair overall evaluation of a premise.

BENCHMARKING PARAMETERS

It would be interesting with further investigations on the development of the energy performance of the buildings based on year of construction. Are these buildings becoming more energy efficient or are they just becoming more complex in terms of architectural design and technical installation systems resulting in higher energy use? Another parameter that would be interesting to correlate the energy performance with is sales data. The number of customers is also another interesting parameter.

NEED FOR IMPROVED STATISTICS

In order to achieve efficient use of energy in shopping malls there is a need for more information and awareness of the energy use in this building sector. It is crucial to use the same area definition when comparing specific energy use. For the Swedish shopping malls both the premise area and the rentable area was known. Depending on which area that is being used specific energy uses vary significantly. The specific energy use for tenants in Swedish shopping malls was 144 kWh/m^2 based on premise area while 180 kWh/m^2 based on rentable area.

In order to benchmark buildings in different countries it is desired to have internationally harmonised definitions and methodology. Work to enhance the comparability of the statistics will have to continue in the future.

Conclusions and recommendations

The main conclusions from this study are;

- EPBD excludes the energy used by the tenants in shopping malls. It is questionable to compare energy use in buildings when a large portion of the electricity used, the portion that is assigned to the tenants, is excluded.
- There is a large potential for improved energy efficiency in shopping malls.
- Further work is needed for the creation of a useful benchmarking model.
- There is a need for improved statistics on energy use in shopping malls.

According to the statistics treated in this paper, the average energy use in shopping malls is approximately 290 kWh/m^2. Of this approximately 100 kWh/m^2 is assigned to the building owner. This is also the only energy use that will be reflected upon in the energy declaration of the building. This gives a misleading picture of the actual energy use in the building and it does not encourage the tenants, who use the most energy, to improve their energy performance.

There is a large deviation between the energy used in different shops. It is shown in the paper that small shops tend to use relatively more energy compared to larger ones. There is a also a wide deviation between the shopping malls that use the most energy compared to the one that use the least energy, indicating that there is a large potential for energy efficiency improvements in this type of commercial buildings. However, buildings included in the shopping mall category have varying types of establishments. Further subgroups are needed to make accurate conclusions about the energy saving potential.

The tenant's electricity use constitutes 40-75% of the total energy used in shopping malls. In regular shops, the main lighting for exposure of products is the main installation, consequently contributing significantly to the internal heat loads that have to be removed by the space cooling system.

It was further found that the high heterogeneity of shopping mall characteristics might require a sub-classification of shopping mall into specialised groups or even disaggregating shopping malls into modules, in order to enable development of reliable benchmarks.

There is a need for better documentation and statistics on energy use in shopping malls. Such statistics would be useful both to the building owners who would like to compare energy use from building to building and from one year to the other. Technical advisors require key figures for their planning. Energy suppliers can also use the energy statistics for dimensioning net capacity. Without a careful consideration of the accuracy of the statistics there are great risks of making false assumptions. The statistics would benefit a great deal if individual measurement of the tenant electricity were included. It is also indicated by SCB that it is difficult to analyse the electricity use because of inadequate measurements. The division of measurements is too rough. This causes the problem that it is difficult to understand what is included or not and difficult to use the statistics for making improvements. EPBD will make a large impact on what data that will be measured in buildings.

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