Improving the database of electricity efficiency in tertiary buildings by monitoring and surveying

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Abstract

Detailed and reliable information about electricity consumption is needed as a basis to identify efficiency improvement options – in individual buildings as well as in the sector as a whole – in order to develop suitable policies. To obtain this objective, a combination of two methodological approaches is useful: case studies for detailed analysis, and surveys to establish a broad statistical basis.

Two recent studies in the tertiary sector demonstrate this idea: the multi-country monitoring project EL-TERTIARY – funded by the Intelligent Energy Europe Programme – with 123 energy audits, and a regular survey in Germany of more than 2,000 companies in the tertiary sector, funded by the German Government.

EL-TERTIARY developed a web-based tool for data collection, documentation and evaluation of individual buildings concentrating on electricity. It provides benchmarks for various types of rooms and end-uses. Substantial energy-saving potentials, which are easy to implement, were identified for all types of buildings and end-uses. The database is open to interested building managers. The survey in Germany focuses on energy consumption and the features of energy-related equipment. As the sample is representative, the results can be extrapolated to the whole country on the basis of employees.

Against the background of the EU Directive on “Energy End-use Efficiency and Energy Services” (ESD) (2006/32/EC), the availability of reliable data on energy consumption is becoming more and more important. The data resulting from these studies form an essential basis for the definition of policy recommendations and the calculation of energy savings under the ESD.

This paper concentrates on electricity because of its increasing relevance in the tertiary sector, although the German study covers all types of energy. It shows that a combination of audits and surveys can create a useful database for multiple purposes.

Introduction

The share of electricity in final energy use continues to increase share of in the EU countries. Electricity use places an extra burden on both the energy economy and the environment. In the period 1999–2004, electricity consumption increased by 15.6 % (Bertoldi and Atanasiu 2007) and a further increase of more than 2% per year is expected during the next 15 years (European Commission 2006). This long-term development makes it necessary to initiate increased measures to save electricity and to use it efficiently. Southern EU countries tend to show a much higher increase in electricity consumption and an alarming occurrence of summer peaks with negative impacts on the stability of electricity grids. Together with the overall increase in the tertiary sector due to structural changes, the diffusion of innovative appliances, e.g. information and communication technologies, and increased cooled area represents a key factor in the increase in electricity consumption. The reported experiences of consultants show that they were able to find high potentials for a more efficient electricity use in most companies and buildings (Jochem and Gruber 2005).

For these reasons the current paper concentrates on electricity consumption and uses such as lighting, office equipment, ventilation, air conditioning, refrigeration, freezing and electric hot water production. Two recent studies are used to show the results of case studies and surveys with regard to the structure of electricity consumption and the identification of saving potentials: The EL-TERTIARY project generally focused on electricity, whereas the energy surveys in Germany include all types of energy carriers and uses (Fraunhofer ISI et al. 2009) because they are mainly intended for a nation-wide extrapolation of the total energy consumption in the trade, commerce and services sector (which in Germany also includes agriculture and the building industry). Due to the fact that most electricity uses involve cross-cutting technologies for most of the sectors concerned, electric equipment is also dealt with in great detail in these surveys.

A large untapped saving potential exists. Energy saving is not a priority in tertiary buildings for company or building managers and a high level of barriers was found in many studies in the past. Especially public organisations and companies which are not profit-oriented are characterised by a high level of barriers (Schleich and Gruber 2008). In individual companies energy costs absorb only a small part of the total budget or income of the companies and institutions in this sector. Above all decision makers and buildings managers are often not sufficiently informed about main electricity uses and efficiency potentials. Furthermore, the associated transaction costs, including the costs of collecting, assessing and applying information on energy saving potentials, investments and organisational measures, as well as the costs of negotiations with potential suppliers, consultants or installers, are often prohibitive (Ostertag 2003).

Energy policy making is dependent on detailed information about this heterogeneous sector in order to implement suitable policy measures. An overview of existing studies and data in Europe, which was part of the EL-TERTIARY project, revealed a lack of aggregated data at national level in the European countries. Various problems occurred with respect to the available data, mainly due to a lack of comparability between countries, types of companies, or electricity end-uses:

- There is a wide range of results from individual audits to extrapolations for a whole country,
- there are considerable differences between countries with regard to specific consumption, e.g. per m^2 or employee, and
- the definitions and the accuracy of the analysis of the end-uses vary from country to country.

The conclusion was that there is a need for more measured data, a clear methodology, reference values, and a very precise definition of the scope of buildings or companies included corresponding to the NACE classification. The reason is that exhaustive statistics must be available which allow the calculation of specific consumption values for all types of companies or types of buildings.

Efforts have been made for several years now by Germany and other countries as well as at the level of the EU and the IEA to record the energy consumption of this very heterogeneous sector or parts of its energy consumption more precisely and in more detail. The EU Directive on energy end-use efficiency and energy services (2006/32/EC; ESD directive) places high demands on the availability of energy statistics. Public institutions, which make up a subsector of the tertiary sector, are assigned an exemplary role in improving energy efficiency in the ESD.

The recent survey project in Germany offered the chance to further develop an efficient survey and evaluation method which actually motivates those affected and gets them involved. This method makes it possible to illustrate the main consumption and structural data in the tertiary sector by consumer group and application and to compare these data with the results of previous surveys (Geiger et al. 1999; Fraunhofer ISI et al. 2004). This should further improve the energy statistics for this sector and satisfy the requirements for information about energy.

The current paper aims at demonstrating that a combination of audits and surveys– shown here for the case of electricity use – can create a useful database. These data can be used for the analysis of consumption time series, forecasting, benchmarking purposes, and the identification of saving potentials.

Main findings from case studies in 12 EU countries

Within the EL-TERTIARY project (www.eu.fhg.de/el-tertiary) IGS (Institute of Building Services and Energy Design, Technical University of Braunschweig, Germany) – one of 18 partners in the consortium – developed a common internet-based tool to record data collected in electricity audits. The methodology provides an input mask for all the information needed for evaluation. The tool is characterised by the following features:

- It is very easy to handle and can be used during the audit on site.
- It is broadly applicable under different frame conditions, for various types of buildings, appliances, and technical standards and can be used to register calculated, assessed or metered values gained by all types of metering equipment.
- It is flexible with regard to administration, number of buildings and systems, amount of data, users, countries, etc., and can be used by many persons at the same time.
- Results are available immediately.

The tool distinguishes between two types of information: description of the building, and metering values. The description is handled top-down from general information (type, geometry, age, climate conditions, etc.) to specific electrical systems, e.g. ventilation or lighting, and operational data (size, power installed, number of systems, time of use, etc.). For each type of system appropriate characteristics are defined and listed. If complete information is given, the plausibility of the input can be checked immediately.

The metering strategy should always be applied, as this provides the best quality, but is also the most cost-efficient in terms of time and money spent on the metering procedure. For this reason, long-term metering should be used for dynamic systems (e.g. cooling), short-term metering for cyclic systems (e.g. lighting, ventilation), and spot-metering for continuous or

Figure 1. EL-TERTIARY tool for electricity audits in buildings

on/off systems (e.g. office equipment). Figure 1 shows a typical page of the programme and a laptop for data input on-site.

The tool was tested during the project in selected case studies covering buildings such as office buildings, schools, universities, kindergartens, supermarkets, hotels, hospitals, and old people's residences. Currently the database contains information on 123 buildings from 12 EU countries. Technical "systems" were defined according to the electricity end-uses of lighting, ventilation, refrigeration, etc. Very important input data for calculating reference values are the total floor area of the building and the areas supplied by the systems identified. If there are rooms which are similarly equipped, e.g. school classrooms, or offices in a bank, it is sufficient to fill in the data for one lighting system, which describes the situation in this room. Later, it is then possible to multiply specific values such as installed power or electricity consumption by the total number of rooms equipped with the same system.

The specific annual electricity consumption per m^2 gives a first impression of the performance of a building. Three levels were introduced as benchmark:

- low consumption ("best" 25% of cases): technically feasible to reach this level
- medium consumption (50% of cases): technically and economically feasible
- highest consumption ("worst" 25% of cases): high saving potential

The results of the audits are summarised in Table 1 for the overall electricity consumption.

However, for a more detailed picture, installed power, operating hours and electricity consumption were analysed on a system level (lighting, ventilation, etc.) per type of room, e.g. lighting in classrooms in schools, ventilation in office rooms, or cooling in supermarket salesrooms. All interested

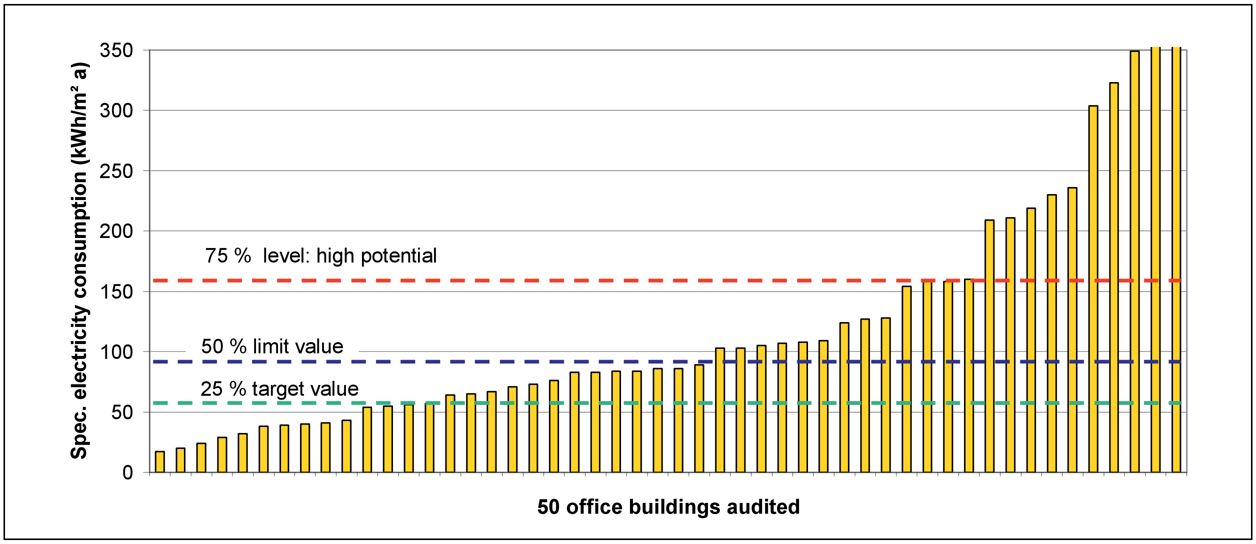

Figure 2. Electricity consumption in office buildings

users of the database can make their own evaluations of this kind, e.g. operating hours of ventilation in office rooms (Figure 3). It shows that 25% of the systems analysed are operated all year for 24 hours per day – definitely a starting point for saving measures.

The illumination level in classrooms should be 300 lux if the classroom has adequate daylight levels and 500 lux if natural lighting is poor. This means that the benchmark lies between 7.5 W/m² and 11 W/m² (Figure 4). Compared to a classroom in a school building, the installed lighting power of a standard office room in an office building is almost twice as high.

Provided there is adequate information available about the type of lamps (incandescent, fluorescent, compact, metal halide, etc.), daylight quality, location of light source (desk, ceiling, suspended lamp), direction of the light, ballasts, installation of daylight or motion sensors, time of use, and metering strategy, a very detailed evaluation and benchmarking is possible. However a larger sample of buildings is required for this type of comparison.

After the audits, the results were presented to the facility owners or managers together with recommendations for **energy-efficiency measures**. These recommendations were collected and evaluated. Together with specific electricity consumption data and the consumption structure per end-use, the efficiency gaps are an important basis for policy conclusions.

- Almost all auditors found potentials in lighting. Most frequently, a replacement of lamps was recommended: incandescent and halogen lamps by CFLs and T12, or T8 by T5 lamps.
- Motion control systems should be installed, at least in infrequently used rooms (sanitary rooms, corridors, staircases, garages). In other cases, daylight sensors are considered the best solution.
- In some cases too much power per m² was installed, lamps were left on at night or insufficient use was made of daylight (dark wall colours, window shading). Some of the lamps or their covers were dirty and lighting therefore inefficient. Finally, managers should motivate employees to switch off lamps when not used.
- The second main area of potentials was office equipment. The large majority of recommendations refer to user behaviour: Computer equipment should be switched off completely when leaving the office after work, which means that this measure is by no means common practice in offices. Another recommendation was to replace CRT with LCD monitors.
- If air conditioning is installed in a building, energy-saving potentials were found in almost all cases. These covered a variety of measures: externally protecting rooms from overheating, tolerating higher room temperatures, lower fan speeds, using fresh air, better control of equipment, switching systems off overnight, replacing old equipment, insulating pipes, heat recovery, and behavioural measures (closing windows and doors). For ventilation systems, mainly heat recovery, replacing old and inefficient equipment, switching them off in unused rooms and automatic control were mentioned.
- In office buildings and schools, refrigeration is mainly used in small units. In many cases these refrigerators are old and should be replaced by at least A class equipment. Some are also too large or simply unnecessary. Another recommendation was to inform the staff about energy-saving possibilities.
- In the case of electric motor drives, mainly heat circulation pumps with low energy efficiency were found. Some are operated all year 24 hours per day and could at least be turned off at night. Others are oversized. Another recommendation in a number of cases was to install automatic control equipment.
- Electric hot water production is used in some buildings. The main suggestions for improvement were to replace old equipment, install or repair boilers or pipe insulation, install

Table 1. Benchmarks for types of buildings (consumption in kWh/m² a)

	Number of buildings audited	Lowest 25 % "Target"	Medium 50 % "Limit"	Highest 75 % "High potential"
Offices	51	41	84	154
Schools	26	13	19	35
Supermarkets	10	388	626	769
Hotels	10	60	76	118
Hospitals	5	29	35	44
Old people's homes	4	67	108	141

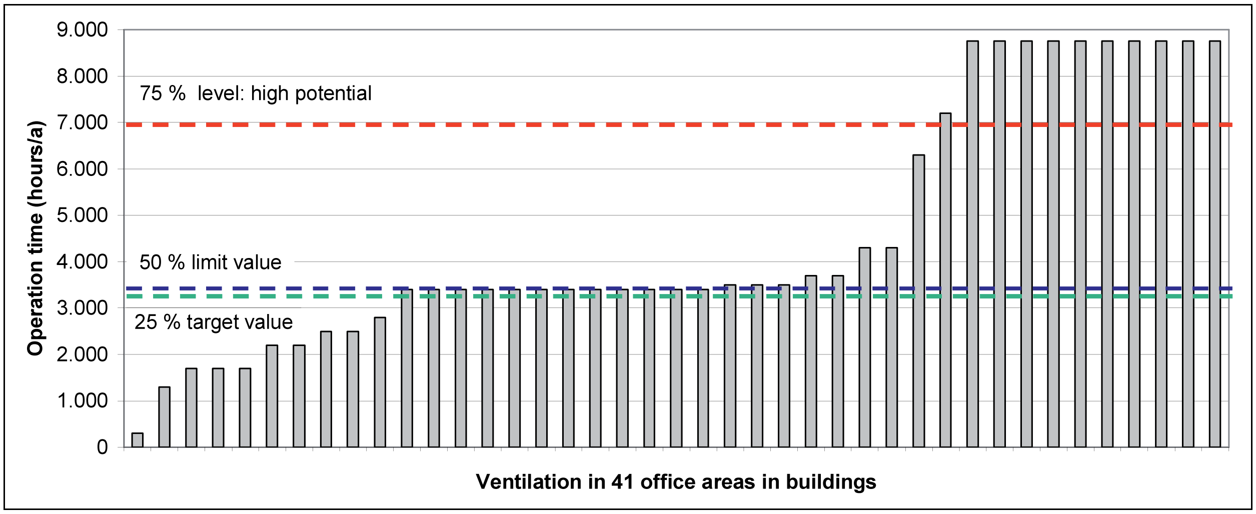

Figure 3. Ventilation in offices – operating hours per year

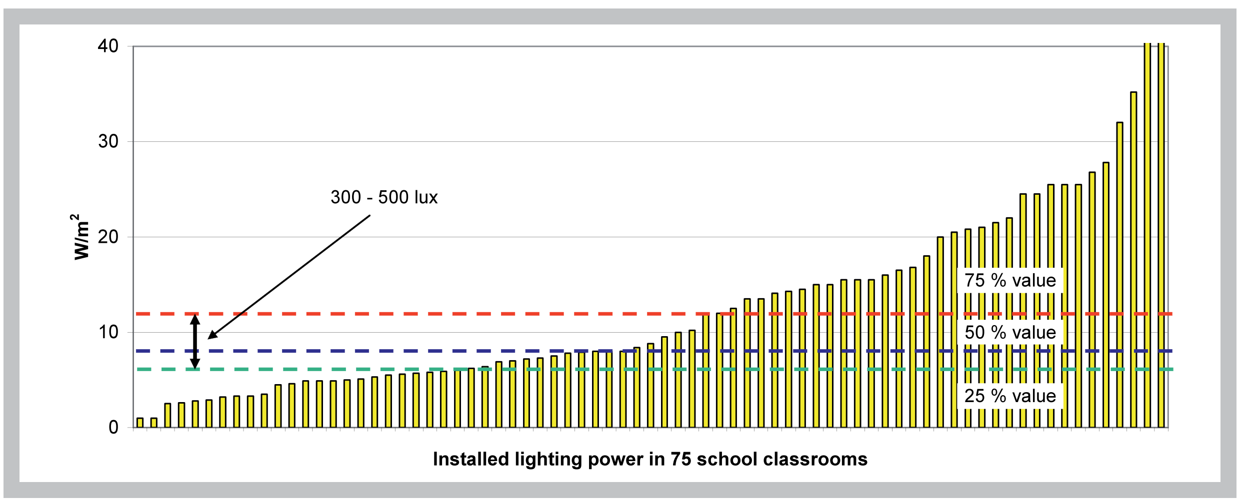

Figure 4. Lighting in classrooms – installed power

timers or thermostats, and use gas or solar energy instead of electricity.

- Various other electricity uses and saving measures were mentioned, e.g. switching off vending machines, replacing old kitchen or laundry equipment or using it more efficiently, disconnecting the power factor compensation at night, checking the efficiency and use of small appliances such as water heaters and coffee machines. Finally, the installation of photovoltaic systems was recommended.
- Generally, many auditors recommended informing and motivating employees about energy-saving possibilities. Another often mentioned measure is the installation of electricity meters to enable control of consumption and improved energy management.

To summarise these findings it can be said that substantial electricity saving potentials were identified in all types of buildings and end-uses which are easy to implement. A survey of building managers showed that, in their opinion, their energy

Table 2: Differentiation of the tertiary sector by groups, splits and subsplits

	Groups	Splits (examples)	Subsplits (examples)
1	Construction	Construction	Structural and civil engineering, plumbers, varnishers
2	Offices	Financial services, public administrations	Banks, insurances, city halls, social security, cultural buildings, lawyers, doctors
3	Manufacturing	Metal working, wood, car trade & repair, paper & printing	Mechanical and electrical engineering, locksmiths, welding shops, medical and orthopaedic products, carpentry, copy shops
4	Trade	Retail trade, wholesale trade	Various categories of food and non-food
5	Hospitals, schools, public baths	Hospitals, schools, public baths	Universities, high schools, kindergartens; indoor/outdoor pools
6	Hotels, restaurants	Hotels, restaurants	Hotels with restaurant, hotels with breakfast only, restaurants, bars, cafés
7	Food Industry	Bakers, butchers	Bakers, cake shops, breweries
8	Laundries	Laundries, dry-cleaning	Laundries, dry-cleaning, textile rental services, dyeing works
9	Agriculture	Agriculture	Crops, livestock
10	Horticulture	Horticulture	With and without greenhouses
11	Airports	Airports	Airports
12	Others	Textile, transport activities	Textile, clothing, freight forwarders, storage

management is quite good (measures taken, control of consumption, information, etc.). However in the audits, as well as through the technical evaluation of the data, still untapped potentials were found. Some of these are "no-regret" measures, e.g. organisational ones, low-cost measures with short payback times, or measures to be taken into account in the next purchasing decision.

A survey of office employees in Belgium – which was also part of the project – showed that comfort aspects which are relevant for electricity consumption are not given sufficient consideration and offer additional saving potentials (Coolen and Martens 2008). The survey covered temperature, air circulation (automatically controlled ventilation or ventilation via windows), lighting comfort and noise, and revealed that sufficient daylight is by far the most important comfort parameter. In addition, the respondents were satisfied with a level of 300 lux, a level of 500 lux did not increase the level of lighting comfort. For temperature and ventilation, the most important factor is that employees can influence the room conditions themselves. "Modern" buildings have a higher energy consumption (cooling, much glazing, low thermal mass, complex HVAC systems), but lower comfort levels for their users than "conventional" buildings (windows can be opened, more thermal mass, simple systems).

Results of broad surveys in Germany

The German study (Fraunhofer ISI, GfK, TUM-IfE 2009) consists of various components: two surveys in 2005 and 2007 of 2,157 and 2,239 respondents respectively, in-depth interviews in selected companies – all based on a face-to-face approach. In addition, telephone interviews about the use of renewable energy sources were carried out starting with a sample of 20,000 companies in order to obtain a reasonable number of respondents actually using renewable energies. A final step was to carry out more detailed interviews with this subgroup.

The sample was constructed according to a fixed quota: For this purpose, the sector was divided into 12 groups which were then each differentiated even further into 23 splits (Table 2). These splits are considered relatively homogenous. The interviewers were also supposed to make sure that subsplits and different company sizes were represented according to the defined sample structure because representativeness is a crucial precondition for extrapolation on a national level.

The resulting consumption values refer to the years 2004 and 2006. The interviews were only carried out if the respondents were able to report the complete amount of energy consumed in the respective year differentiated for all energy carriers. Former comparable data exist for 2001. For the interim years not covered by a survey (2002, 2003 and 2005), the specific consumption values were interpolated. The absolute electricity or fuel consumption was calculated by multiplying the survey value by the actual number of employees in the subgroups, except in three splits – hospitals, schools, and public baths – where other indicators were considered more appropriate, and are available. For all other splits the number of employees is the only indicator for which national statistics are available throughout.

The **total electricity consumption** in the tertiary sector in 2006 determined by the survey results and extrapolation was around 434 PJ or 118 TWh. Overall, the projected results over the period 2001 to 2006 show a stagnating trend for electricity (see Figure 5) and a slightly declining one for fuels. Several components of electricity consumption which were not documented in the surveys were added to the consumption value (mainly electricity for street lighting, for shared appliances in larger buildings and for supply and disposal functions), which make up a good 10% of the total electricity consumption in the tertiary sector. Compared to the figures of the German Working Group Energy Balances (AG Energiebilanzen 2008), it can be seen that the extrapolated figures are between 7 and 15% below those of the energy balances depending on the year. On the one hand, this may be due to electricity consumption com-

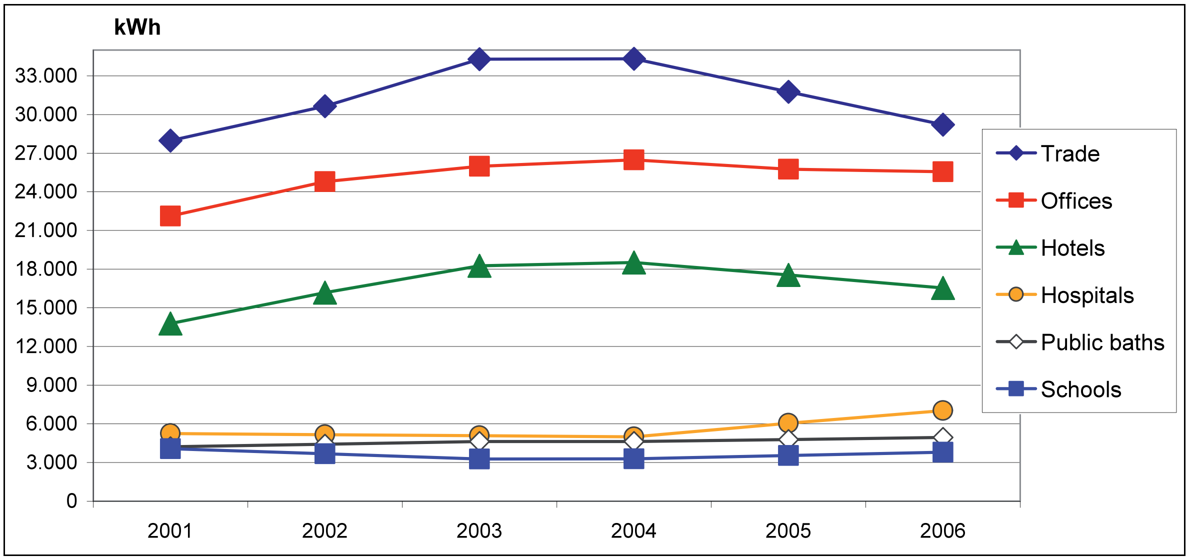

Figure 5. Electricity consumption in selected subgroups of the tertiary sector in Germany

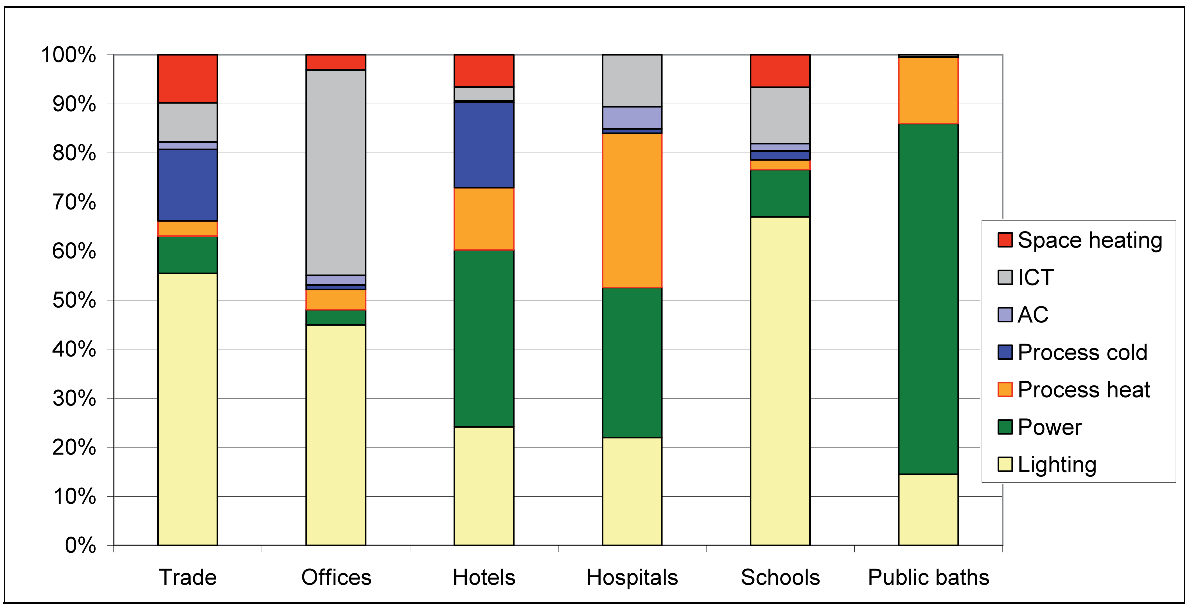

Figure 6: Electricity uses in selected subgroups of the tertiary sector in Germany

ponents which were not able to be determined via the survey. On the other hand, the tertiary electricity consumption figure from the energy balances contains statistical differences which do not enter the tertiary calculations made here. In general, the tertiary consumption figures given in the energy balances are determined to a large extent as the balance to other consumption sectors, i.e. as a remainder, with all the associated upstream uncertainties this implies. Despite this, there is still a generally good agreement between the extrapolated figures and the energy balance figures for fuel and district heat consumption with regard to consumption level and trend.

One of the main elements of the two broad surveys and especially of the in-depth interviews was to collect information about the **structure of energy use** within the individual groups or splits. The electricity consumption determined here for 2006 was divided into the following uses (Figure 6):

- Space heating: The electricity used for heating rooms as well as the amount of electricity resulting from the additional heat demand via fans and radiators.
- Process heat: Electricity used for hygiene (hot water) and for thermal processes (heating, boiling, frying, melting, welding, tempering, drying etc.).
- Cooling: The electricity consumption of stationary and mobile electrically-powered compressors for producing cold for central and decentral air conditioning systems and space cooling as well as the gas used to operate absorption chillers for air conditioning commercial areas.
- Process cooling: The power consumption of electrical chillers in cold stores, walk-in coolers of refrigerated display

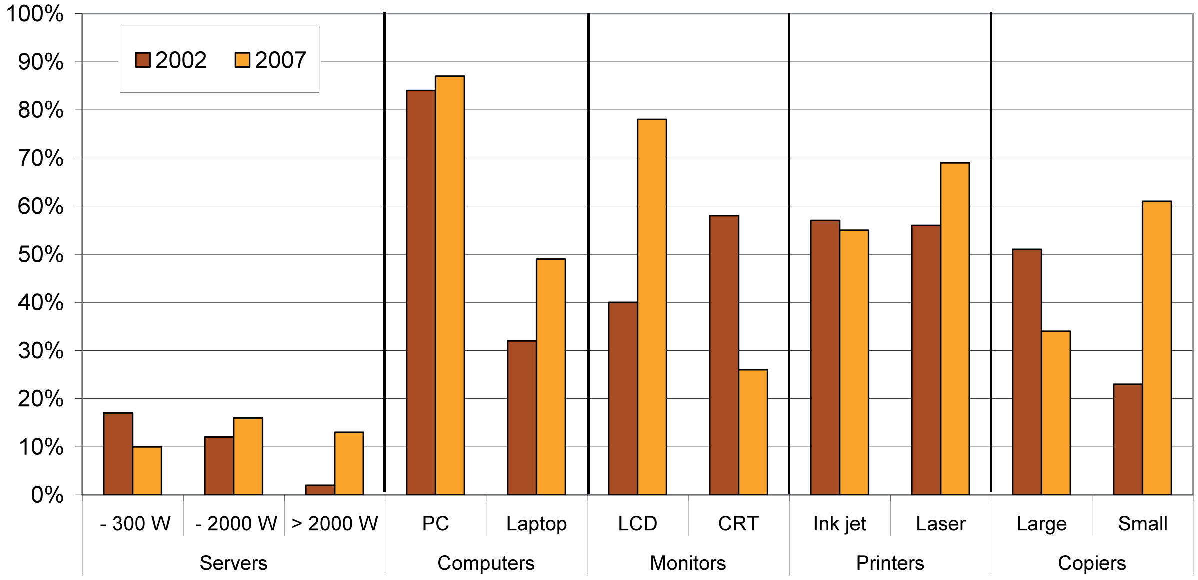

Figure 7. Office equipment in offices 2002 and 2007 in Germany

cases, freezers and fridges which are supplied by absorption chillers.

- Mechanical energy (power): Electricity used to power machines and appliances excluding the consumption of compressors used for process cooling and to produce cold for air conditioning and space cooling. On top of this, the fuel used to power combustion engines in agriculture (tractors etc.), in the construction industry (to generate electricity and compressed air, for diggers and wheel loaders etc.), at airports (airplane tractors, buses etc.) and used for stationary purposes in businesses.
- Lighting: Electricity used for all types of lamps inside and outside the building.
- Information and communication (ICT): The electricity consumption of appliances to obtain, process, disseminate, store and document information (computers, servers, printers, copiers etc.), for communications (telephones, mobile phone chargers etc.) as well as for cash registers etc.
- Even if there are boundaries to the depth of information desired because sound data on the technical installations and company processes can only be obtained to a limited extent given the duration of the interview, it was still possible to compile an approximate balance characteristic for tertiary sector applications based on the data from the broad and detailed surveys, secondary studies and expert knowledge. The differentiation of energy uses chosen here is more detailed than that of the German Working Group Energy Balances (2008) and other available sources. As well as the areas of process heat, space heat, power, lighting and ICT distinguished there, this study also treated air conditioning and cooling separately. This was done in order to take account of the growing importance of these energy applications and increase the international comparability of the data.

According to the results of the survey, in 2006, lighting is the dominant use with 40 %, followed by the electricity for motor drives (power). The share of air conditioning (cooling) in power consumption is still low today; only at airports does it reach a share of about 10%. Process cooling plays a larger role in the tertiary sector, especially in the retail trade, and in hotels and restaurants.

SECTOR-SPECIFIC ANALYSES

In addition to the extrapolation, the data collected can also be used to examine energy consumption in the businesses more closely. The analyses concentrate on general and sector-specific energy-relevant features as well as indicators and their correlation with energy consumption. Unlike the extrapolation, these evaluations are based on raw data, comprising the unweighted data of all the enterprises surveyed. In view of some low case numbers in individual groups, the statements are not strictly representative. However, since the quota was essentially fulfilled, even in the subgroups, the results are still very useful for obtaining a more detailed insight into the sectors. The examples illustrated here are mainly based on the results of the second broad survey in 2007 and reflect the situation at the time of the interviews.

The companies grouped together under the heading of "offices" cover a wide range of public and private services: banks and insurance offices, public utilities and other business services, some with an obvious office character such as lawyers, solicitors or tax advisors, but others with more energy-relevant aspects like waste disposal services, hairdressers, cleaning services or doctors. From the viewpoint of energy, however, most of these have similar structures. Space heating dominates followed by electricity applications for lighting, ventilation, air conditioning, and ICT. The share of air conditioned, cooled or ventilated rooms is around 10% on average in this group. About one third of the businesses with air conditioning or cooling have a central air conditioning system, two thirds have small units; mobile units are more common than split ones. The lighting system may be as old as 45 years; the average of 11.7 years is a bit lower here than in other splits. In office areas, the share of fluorescent lamps and CFLs is relatively high at around 70%;

halogen lamps are used especially in shop windows and open spaces. As expected, offices have more office equipment than other branches of the tertiary sector; this is especially valid for banks, insurances, and public institutions. A comparison between 2002 and 2007 can be made for the office sector. It shows that office equipment has increased considerably over these five years (Figure 7). A shift towards more powerful servers can be observed and a clear increase in the number of laptops. The number of laser printers has risen disproportionately and there has been a shift from large to smaller machines for copiers. With regard to monitors many CRTs were replaced by LCDs.

Alongside offices, the wholesale and retail trade is the largest branch in the tertiary sector with more than 5.5 million workers. There is a significant difference in electricity consumption between food and non-food companies. The food trade has a high demand for refrigeration and freezing, but space heating demand is also a main energy consumer. Lighting represents a large factor on the electricity side. The air conditioning of salesrooms also has a noticeable impact in food retailers. Although the number of retail trade businesses is declining as a result of the concentration process, the sales areas have been increasing for years, which will probably influence energy consumption. Since the last survey, shop opening hours in Germany have increased slightly from Mondays to Fridays and significantly on Saturdays (21% more than eight hours a day compared to 8% previously). More and more groceries and food stores have areas where baked products and small snacks are served, which are equipped with electric ovens to bake or heat bread, meat and processed meat products. One or several ovens of this type exist in 24% of the businesses questioned. The electricity demand of modern cash registers is also not negligible.

Hospitals, schools, and public baths vary greatly with regard to energy and should therefore be regarded separately. Since the specific energy consumption based on the number of employees is limited in its meaningfulness in this sector, more suitable reference units – the number of beds, number of students, water demand – were used here. Hospitals are characterized by high space and process heat demand. The latter is particularly relevant if the hospital runs its own laundry. Apart from lighting, electricity is required mainly for ventilation and air conditioning. Schools are a very heterogeneous group ranging from kindergartens right up to universities. Space heating demand dominates the energy consumption here. Electricity is mainly used for lighting. In public baths, electricity is used for ventilation, electrical engineering, pool technology and lighting. Modern baths are equipped with very complex building technology and additional installations (saunas, solariums, wellness and health-related areas, fitness rooms, restaurants, etc.), which cause considerable electricity consumption.

The hotel and restaurant sector consists of catering and accommodation. It is true that, as a service sector, there are businesses of every size in the tertiary sector, but this area is dominated by small to very small enterprises (restaurants have 4 and hotels 7 employees on average). Space heating and thus fuel consumption is the most important area in both sectors from the viewpoint of energy consumption. The second largest energy consumer after space heating is process heat for kitchens, mainly for cooking food, but also for heating food and keeping it warm, pre-heating and cleaning dishes. Electricity is also used mainly for cooking, followed by refrigerators/freezers, then for dishwashing, laundry and lighting. Refrigerators and freezers are becoming more significant because of the growing use of frozen products due to their greater flexibility. Lighting also plays a relatively important role for energy consumption.

CROSS-SECTORAL COMPARISON OF ENERGY-RELEVANT FEATURES

With regard to lighting, the rooms evaluated (Figure 8) were those considered to be the most typical for each sector, e.g. salesrooms for the retail trade, offices for the office sector, guest rooms in restaurants, hotel rooms, classrooms, etc. It is apparent that fluorescent lamps and CFLs are most often found in schools and least often in restaurants and hotels. With the exception of these two splits, the share of these lamps always exceeds 70%.

Among the group of office appliances, computers are particularly interesting (Figure 9). 25% of the respondents have one or more servers or mainframe computer, almost half of them in an average power range between 300 and 2,000 W, about 30% are smaller and 20% larger.

On average almost 80% of all companies have internet access; hospitals and schools are most likely to have this, restaurants and laundries least likely. There are similar differences between the splits with regard to LAN and WLAN connections; 14% have WLAN on average (Figure 10).

Air conditioning or cooling in any form, whether this be with small mobile units, split appliances or a central air conditioning system, is used by 13% of enterprises, usually however only in some of the rooms. Hospitals really stand out among the different splits, 75% of those considered have air conditioning, at least in some rooms (Figure 11).

In addition to technical issues, a short questionnaire on energy management – also used in the EL-TERTIARY project – was integrated in the second broad survey (Fraunhofer ISI et al. 2009). It gives a representative overview of measures taken in the tertiary sector, e.g. energy-efficiency measures, control and evaluation of energy consumption, information behaviour and sources, relevance of the energy issue in general for business decision making, etc. The results cannot be presented here in detail. For example, it shows that many companies are already addressing the relevant area of lighting: The energy-saving measures mentioned most are switching off unnecessary lights or optimizing the use of daylight (64% of the respondents), and the installation of more efficient bulbs or lighting systems (53%), followed by switching off electrical appliances not used. Generally, the study revealed large differences between companies with regard to energy management issues. The larger the company, the more active it is. The highest activity was found for the group of hospitals, schools and public baths. A hypothesis sometimes mentioned was not confirmed in the study: a contradiction between energy-saving measures on the one hand and productivity, product quality, comfort, and job satisfaction. 75% of the respondents do not see any relation, 23% stated that energy-saving has a positive and only 2% that it has a negative influence.

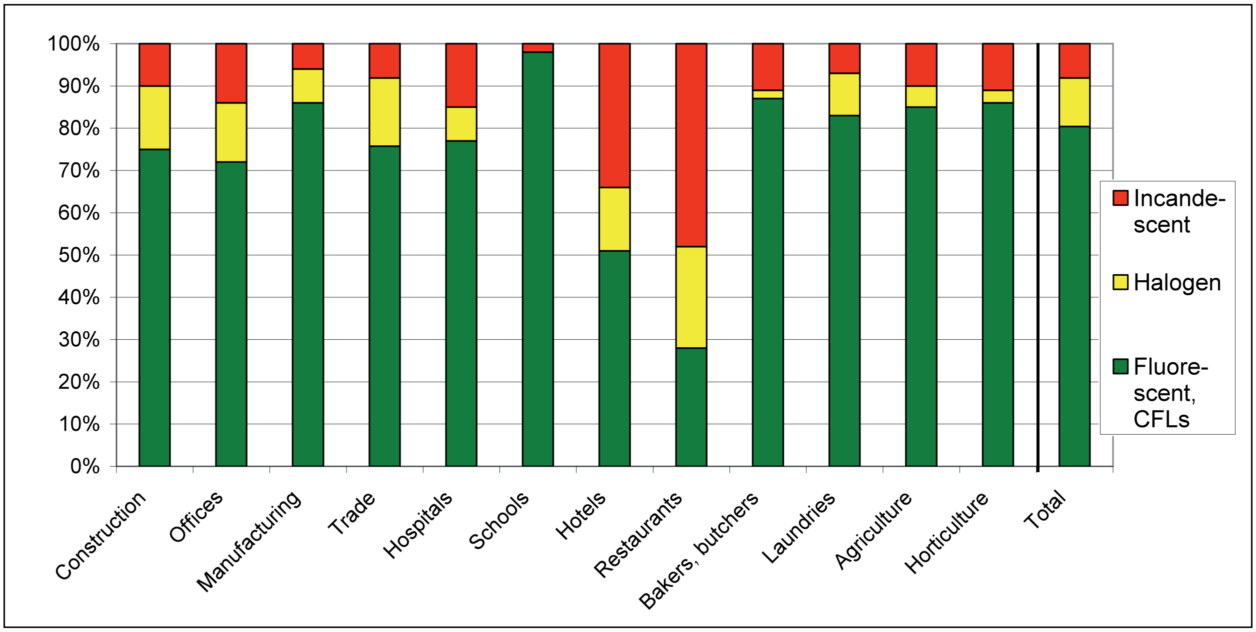

Figure 8. Types of lamps in typical business areas 2007 in Germany

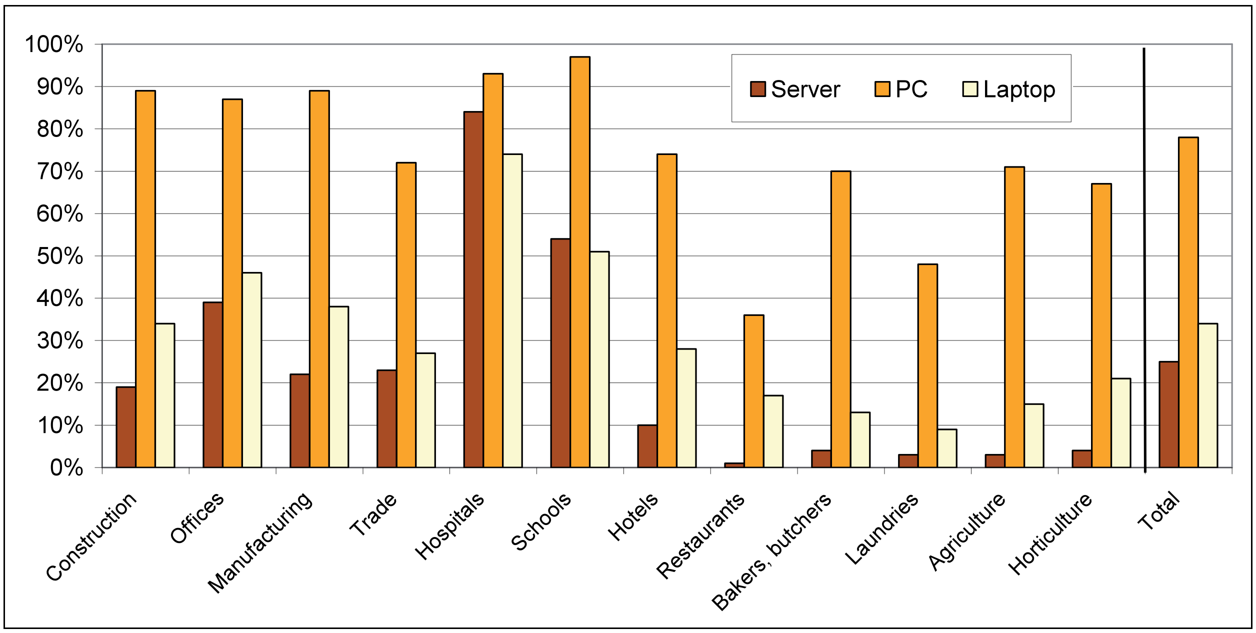

Figure 9. Equipment with servers, PCs and laptops 2007 in Germany

Conclusions and further perspectives

The collection and analysis of existing data of disaggregated electricity consumption at EU level was undertaken for the first time on this scale. It revealed the difficulties of defining and identifying reference values for electricity consumption. The work done in EL-TERTIARY should be seen as the initial step in a wider attempt and shows that more input is needed. It provides a basis on which future work can build. An accurate definition of the number and content of end-uses is needed to allow an EU-wide analysis on a common basis and to work towards common targets.

A very efficient and handy tool was developed in EL-TERTIARY, a methodology for data collection and documentation of the electricity consumption and the relevant equipment in a building in an audit. At the same time this is a database which allows further input to be added and the data to be evaluated. It includes data of the building as a whole and – even more important – on a more detailed level of well-defined systems which use electricity with their typical characteristics and electricity consumption. This enables the user to compare typical systems (e.g. lighting in office rooms) in different types of buildings and makes a larger number of cases available.

This database could be developed still further and should be used on a large scale especially in standard buildings like

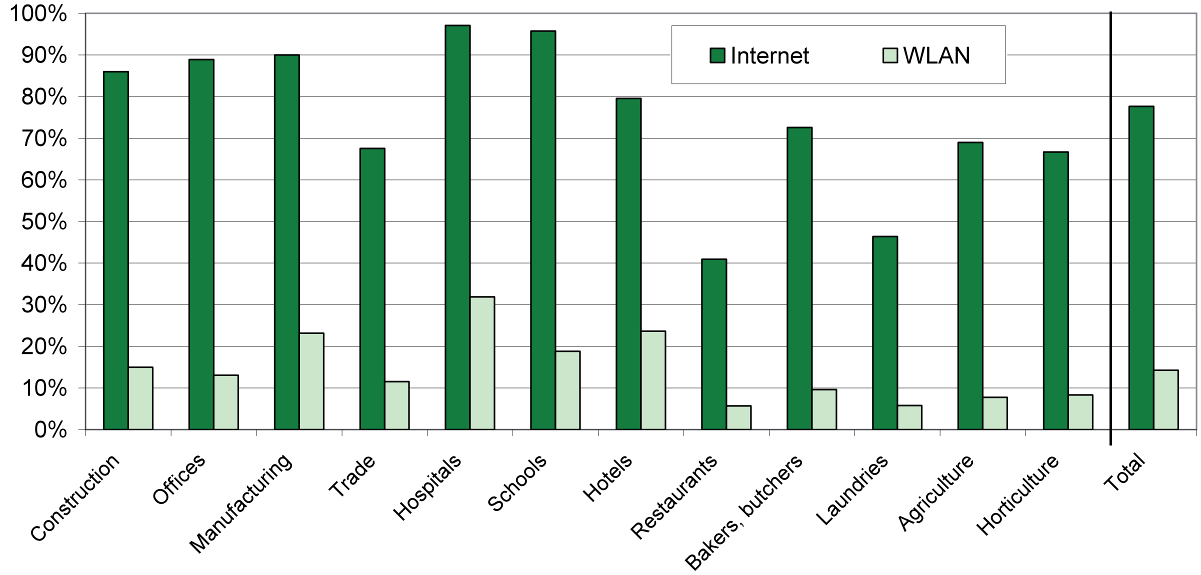

Figure 10. Internet access, LAN and WLAN 2007 in Germany

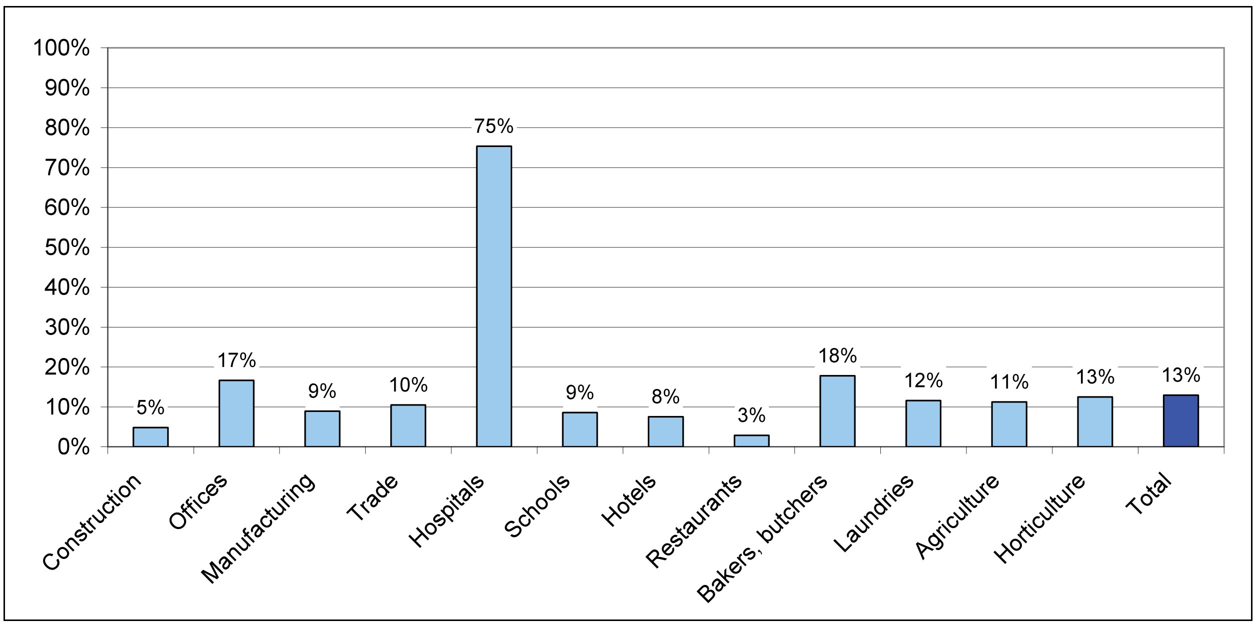

Figure 11: Share of enterprises with air conditioning in Germany

schools, supermarkets or public office buildings. Employees of public authorities who are in charge of building maintenance or management could be trained to use the tool themselves to reduce consulting costs. IGS is currently cooperating with public authorities and private companies to implement the suggested improvements in the tool and to apply it in every day building management. The tool could also be used to create a national data base on the German building stock and to integrate this in European and international activities.

Significant saving potentials were found in the case studies which can be realized using easy and cheap measures, above all operational and behavioural ones.

EU and national policies are headed in the right direction: The measures introduced for lighting, appliances, air conditioning (labels, minimum standards, transparency of electricity consumption, Green Buildings, Best Practice, etc.) are in line with the results found in the EL-TERTIARY project. In addition, it is recommended to take more account of users' needs and behaviour in planning and designing, to check norms and standards accordingly, to inform users, management and maintainance staff about the handling of equipment and their influence on energy consumption, and introduce electricity tariffs which motivate consumers to save electricity.

The study in Germany showed that surveys can be a complementary element to case studies in order to create a broad statistical basis for analyses. Energy consumption data differentiated by consumer groups and energy sources were obtained. The results can serve as the basis for further examination of future consumption patterns and trends and for improving energy efficiency in the tertiary sector. Of course the data cannot match the overall accuracy of the energy balances in mapping real consumption which is defined by a series of provisions. But they do provide differentiated results for areas where the energy balance is only able to present aggregated, unstructured information, and they give insights where conventional data sources fail to do so, e.g. into renewable energies or energy sources which are only traded to a limited extent. Because the survey has now been repeated, it was also possible for the first time to compile time series over a longer period – 2001 to 2006 – for energy consumption in the tertiary sector by subgroup and energy source for Germany which are comparable, at least to a certain extent. This provides another source of information on energy consumption in the tertiary sector which promises to be interesting for international comparisons. Above all, concerning electricity, consumption there is also differentiated by application at sectoral level for 2006. This is particularly valid for air conditioning, an application which is expected to continue to grow in importance in the future.

Above and beyond pure energy statistics, comprehensive sector-specific insights can also be gained from the survey regarding energy consumption structures, energy-relevant features, economic framework conditions and energy management in the businesses which can be used for numerous other purposes, for example, designing energy policy measures or forming agendas and awareness campaigns by energy agencies, energy consumer associations, and energy supply companies.

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