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Energy consumption of the tertiary sector (trade, commerce and services) in Germany for the years 2011 to 2013

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Summary

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1 Starting point and objective

In 2013, the tertiary sector (made up of trade, commerce and services) accounted for around 15.2 % of the total final energy consumption in Germany with 1,413 PJ or 392.5 TWh (AGEB 2014). There are gaps in the official energy statistics for this sector, which complicates reporting on energy consumption at national and international levels and also limits the basis for energy-economic assessments and forecasts and for energy policy decisions. The German government's Energy Concept that was adopted in September 2010 and the decisions of June/July 2011 to transform Germany's energy system, the so called "Energiewende", have further increased the requirements concerning reliable records in all energy consumption sectors, because of the need to regularly monitor the progress made towards the targets for expanding renewable energies and increasing energy efficiency. The German government established the corresponding monitoring process "Energy of the Future" in the autumn of 2011. The first two monitoring reports and the first progress report have already been submitted and statements have been published in parallel by the German government's appointed expert commission (BMW i and BMU 2012; BMW i 2014b,c; Expertenkommission 2012, 2014a,b). These reports also contain important information about data gaps in the tertiary sector that are currently hindering the regular monitoring of the Energiewende's progress. The EU's Energy Efficiency Directive (2012/27/EU) and its predecessor (2006/32/EC) also provide for comprehensive annual reporting obligations on energy consumption on the part of the Member States. These obligations go hand in hand with an increased demand for statistical data on energy consumption (BMW i 2011; BMW i 2014a). Greater efforts have been made recently in Germany and in other countries to document the energy consumption in the very heterogeneous sector of "trade, commerce and services" or parts of its energy consumption more precisely and in greater detail (IEA 2014). The project partners themselves have already conducted several surveys of energy consumption in the tertiary sector for Germany.¹ The objective of these surveys is to breakdown and extrapolate the energy consumption by sectoral group, energy carrier and end-use. This should further improve the statistical basis for this sector and satisfy the requirements for energy-economic information. This report presents the results of the current survey for the calendar year 2012 and the extrapolations for the years 2006 to 2013.

¹ Geiger et al. 1999; Fraunhofer ISI et al. 2004; Fraunhofer ISI et al. 2009, 2013 ; Schломann et al. 2014.

2 Methodology

The main basis for determining energy consumption in the tertiary sector is a broad survey of around 2,000 workplaces that is conducted every two years. The results presented here are based on the company surveys for the years 2006, 2008, 2010 and 2012. The tertiary sector was divided into 14 groups for the survey, which are then further subdivided into more detailed splits (see Table 1 for how groups and splits are defined). To extrapolate the energy consumption to Germany, first of all the average electricity and fuel consumption at the level of groups and splits was determined from the surveys for the respective year and related to the average number of employees in the surveyed companies. For the years not covered by a survey (2007, 2009, 2011 and 2013), the specific consumption values were interpolated or extrapolated. The electricity or fuel consumption is calculated in absolute terms by multiplying the survey value by the actual number of employees in the respective year in Germany – or by other statistically available reference units for individual groups. The projected results for 2013 are to be regarded as preliminary because of still incomplete statistical databases.

Secondary statistical data are also used for individual groups (agriculture and horticulture, airports). In addition, certain energy consumption components that are not covered by the survey, such as the energy consumption of the military or that for street lighting, jointly used installations in multi-family houses, water supply and wastewater disposal, cold storage and data centres are determined externally and added to the survey result. The energy consumption of the last three categories is ascertained for the first time in this study. This substantially reduced the biggest discrepancies between the electricity consumption determined on the basis of the survey and that featured in the national energy balance that were present in the previous surveys.

Another element in the survey is to gather information about energy end-uses in the individual groups of the tertiary sector. The survey also collected information about the energy-relevant stock of installations. Based on these data, the electricity and fuel consumption determined here were divided into the following end-uses: space heating, process heat, air conditioning, process cold, mechanical energy (power), lighting, information and communication technologies (ICT). Furthermore, the data collected on the energy consumption structure in the companies were evaluated and analysed for each sector specifically. Energy management in the enterprises of the tertiary sector was also included in the survey.

When evaluating the respective surveys in the previous studies up to 2010, it applied in principle that the frequency distributions of specific energy consumption were not able

to provide statistically sound information about the confidence interval of the mean values, because of the large deviation from a normal distribution and the associated extreme skewness. A supplementary analysis method now enables statements to be made about the confidence interval of the obtained results: It distinguishes workplaces within one group into those with strongly below average and those with strongly above average specific energy consumption and splits the originally highly skewed frequency distribution into two frequency distributions, in which only minor skewness now occurs close to a normal distribution. For these two sub-groups, statistical statements can now be made about the confidence interval. Of particular interest is the common standard deviation of both sub-samples that allows a common confidence interval to be calculated that corresponds to a weighted confidence interval from both sub-samples. These deviations lie between $\pm 5\%$ and $\pm 10\%$ when calculating the specific electricity consumption for the majority of the groups – including those with the dominant shares of electricity consumption like offices, the retail trade and hotels/restaurants. For several smaller groups like hospitals/schools/public baths, agriculture/horticulture or laundries, the deviations are above this with $\pm 15\%$ to 25% . For the specific fuel and district heat consumption, the corresponding deviations are even smaller. This applies to the groups with the highest consumption shares (again offices, the retail trade and hotels/restaurants) with deviations between $\pm 3.5\%$ to 5.2% and to the remaining groups (with the exception of public baths) with deviations between $\pm 5\%$ and almost 15% .

3 Extrapolation of energy consumption in the tertiary sector for the years 2006 to 2013

Energy consumption by consumer group in the tertiary sector

Table 1 shows the extrapolated fuel and electricity consumption in the tertiary sector for the period 2006 to 2013 for the 14 different groups and selected splits. The total energy consumption determined here in the tertiary sector amounted to around 396 TWh in 2013. Electricity accounted for 131 TWh and fuel and transport fuel including district heat for 266 TWh. The biggest energy consumers in the tertiary sector are office-like enterprises (Group 2), the retail trade (Group 4), hotels/restaurants (Group 6) and agriculture (Group 9).

Overall, the extrapolations over the analysed period of 2006 to 2013 reveal a slightly increasing trend for electricity and a constant one for fuels. However, it must be taken into account that the results should illustrate the actual energy consumption in the tertiary sector in each year, analogous to the national energy balance (AGEB 2014), and were therefore not temperature-adjusted. There were similar climatic conditions in the period 2006 to 2013, with the exception of 2010, so that it is possible to make reliable statements about trends based on the available figures. Only the year 2010 probably has significant additional temperature-related consumption, as there were significantly below average temperatures during the heating period in this year.

Depending on the year, discrepancies of between one and ten percent (Table 1) result from comparing the fuel and electricity consumption extrapolated from the surveys with the corresponding statistics of the German Working Group Energy Balances (AGEB 2014). For most years there is a good match between the extrapolated energy consumption and the figures from the energy balance with regard to the level of consumption and the trend. The biggest discrepancies are in 2012. Especially with regard to electricity consumption, the deviations were able to be significantly reduced compared to the previous studies by considering additional electricity consumption components that could not be covered by the survey (see Chapter 2).

Table 1: Projected energy consumption in the tertiary sector by consumer group 2006 to 2013

Energy unit: TWh		2006			2007			2008			2009			2010			2011			2012			2013		
Group/ Split	Definition	Elec- tricity	Fuels	Total	Elec- tricity	Fuels	Total	Elec- tricity	Fuels	Total	Elec- tricity	Fuels	Total	Elec- tricity	Fuels	Total	Elec- tricity	Fuels	Total	Elec- tricity	Fuels	Total			
1	Construction industry	3.9	12.9	16.8	3.6	11.8	15.4	3.4	11.8	15.2	3.3	11.6	14.9	3.4	12.9	16.3	3.5	11.8	15.3	3.7	12.9	16.6	3.8	13.4	17.2
2	Office-like enterprises	29.2	85.8	115.0	30.1	78.1	108.2	30.7	73.5	104.2	28.8	67.9	96.7	27.4	70.7	98.1	28.1	62.9	91.0	29.2	70.6	99.8	29.5	74.0	103.5
3	Manufacturing enterprises	5.0	7.2	12.2	4.2	7.2	11.4	3.5	7.7	11.2	4.0	7.4	11.4	4.5	7.9	12.4	4.2	7.2	11.4	3.9	7.8	11.7	3.9	8.1	12.0
4	Retail trade	28.4	39.2	67.6	26.1	38.4	64.5	23.5	38.6	62.1	23.7	38.7	62.4	23.6	42.3	65.9	22.8	36.3	59.1	22.3	38.8	61.1	22.5	40.5	63.0
5/1	Hospitals	7.0	12.6	19.6	6.6	11.4	18.0	6.1	10.8	16.9	6.0	11.0	17.0	5.8	12.0	17.8	5.9	10.9	16.8	6.1	11.6	17.7	6.1	12.0	18.1
5/2	Schools	3.8	19.3	23.1	3.6	19.0	22.6	3.4	19.8	23.2	3.8	18.9	22.7	4.2	19.7	23.9	3.9	15.9	19.8	3.9	15.9	19.8	3.9	16.5	20.4
5/3	Public baths	1.9	3.8	5.7	2.0	4.4	6.4	2.0	5.2	7.2	2.1	4.6	6.7	2.2	3.9	6.1	1.8	3.4	5.2	1.4	2.9	4.3	1.4	2.9	4.3
6	Hotels, restaurants, homes	15.9	46.2	62.1	15.5	44.3	59.8	15.2	44.5	59.7	16.9	44.8	61.7	18.6	47.9	66.5	18.3	42.8	61.1	18.1	44.0	62.1	18.5	46.2	64.7
7/1	Bakers	0.6	1.4	2.0	0.6	1.3	1.9	0.5	1.3	1.8	0.5	1.0	1.5	0.4	0.9	1.3	0.4	0.8	1.2	0.4	0.8	1.2	0.4	0.8	1.2
7/2	Butchers	0.6	0.6	1.2	0.6	0.6	1.2	0.5	0.6	1.1	0.5	0.5	1.0	0.4	0.5	0.9	0.3	0.5	0.8	0.3	0.4	0.7	0.3	0.4	0.7
7/3	Other food	0.1	0.3	0.4	0.2	0.2	0.4	0.2	0.2	0.4	0.2	0.2	0.4	0.2	0.2	0.4	0.2	0.1	0.3	0.2	0.1	0.3	0.2	0.1	0.3
8	Laundries	0.5	0.5	1.0	0.4	0.5	0.9	0.3	0.6	0.9	0.3	0.7	1.0	0.4	0.6	1.0	0.4	0.5	0.9	0.3	0.5	0.8	0.3	0.5	0.8
9	Agriculture	4.2	34.0	38.2	4.0	34.1	38.1	4.9	37.9	42.8	4.3	34.9	39.2	4.3	32.5	36.8	4.2	33.8	38.0	4.3	36.0	40.3	4.3	35.7	40.0
10	Horticulture	0.2	3.6	3.8	0.3	4.2	4.5	0.4	4.8	5.2	0.4	4.3	4.7	0.4	2.5	2.9	0.4	2.2	2.6	0.4	1.4	1.8	0.4	1.5	1.9
11	Airports	1.4	2.1	3.5	1.4	2.1	3.5	1.4	2.2	3.6	1.4	2.3	3.7	1.4	2.4	3.8	1.4	2.1	3.5	1.3	2.2	3.5	1.3	2.2	3.5
12	Textile, clothing, leather	0.7	2.1	2.8	1.5	2.8	4.3	1.5	3.0	4.5	1.2	3.0	4.2	0.9	3.5	4.4	1.0	3.5	4.5	1.1	4.2	5.3	1.1	4.4	5.5
13	Remaining groups (not covered by questionnaire)*	16.6	1.6	18.2	17.4	1.5	18.9	18.2	1.5	19.7	18.1	1.5	19.6	17.8	1.5	19.3	17.3	1.3	18.6	17.0	1.5	18.5	16.8	1.5	18.3
14	Others**	16.5	7.0	23.5	16.4	6.1	22.5	16.4	6.2	22.6	16.3	6.3	22.6	16.3	6.2	22.5	16.1	5.8	21.9	16.0	5.0	21.0	15.9	5.2	21.1
Total tertiary from extrapolation		136.7	280.0	416.7	134.4	268.2	402.6	132.4	269.6	402.0	131.5	259.9	391.4	132.0	268.4	400.4	130.1	241.9	372.0	129.9	256.7	386.6	130.6	265.8	396.4
Total tertiary from energy balance***		136.8	289.6	426.4	133.3	230.1	363.4	135.7	265.1	400.8	140.3	236.2	376.5	147.1	264.7	411.8	140.9	233.0	373.9	148.0	225.7	373.7	136.6	255.9	392.5

* Non-ferrous metals/plastic/rubber, water supply and wastewater disposal, cold storage and data centres

** Street lighting, jointly used installations in multi-family houses, military, others

*** As of September 2014 (AGEB 2014)

Energy consumption by energy carrier in the tertiary sector

In a second step, the extrapolated consumption for fuels and district heat was differentiated by energy carrier for all consumer groups. Table 2 shows the relevant results for the final reporting year 2013. Consumption of gases clearly dominates here, followed by heating oil. Fuels are only used in the tertiary sector for agriculture, the building sector and the military (included in Group 14). Only the energy consumption of those sector-specific vehicles is recorded here that are used as part of the production process (e.g. diggers in the construction industry or tractors in agriculture). The energy consumption of all other vehicles in enterprises of the tertiary sector is allocated to the transport sector in the German energy balance (AGEB 2014) and is therefore not included in the extrapolations. There is, however, a difference to the energy balance in that the consumption figures projected here include both traded and non-traded amounts of energy, whereas the energy balances only include traded energy sources to the largest extent. This particularly concerns the energy source wood, which is widely used, primarily in agriculture, although smaller amounts of wood are also used by most of the other consumer groups (Table 2).

Table 2 also shows the respective reference units used for the extrapolation of energy consumption by consumer group and energy carrier (see Chapter 2 for the extrapolation methodology).

Table 2: Projected energy consumption in the tertiary sector by energy carrier in 2013

Reference year: 2013		Reference units*	Fuels						Electricity	Total final energy	
Group / Split	Definition		Coal	Gases	Wood	Oil	Liquid	District heat			Total fuels
		in 1000	TWh						TWh	TWh	
1	Construction industry	2,430	0.0	5.6	1.4	3.9	2.5	0.0	13.4	3.8	17.2
2	Office-like enterprises	13,543	0.0	52.5	1.0	12.9	0.0	7.6	74.0	29.5	103.5
3	Manufacturing enterprises	939	0.0	4.9	0.3	2.5	0.0	0.3	8.0	3.9	11.9
4	Retail trade	5,615	0.2	26.6	0.6	11.9	0.0	1.3	40.6	22.5	63.1
5/1	Hospitals	670	0.0	9.5	0.0	0.5	0.0	2.0	12.0	6.1	18.1
5/2	Schools	13,762	0.0	9.7	0.3	1.3	0.0	5.3	16.6	3.9	20.5
5/3	Public baths	4,650	0.0	0.9	0.3	0.0	0.0	1.6	2.8	1.4	4.2
6	Hotels, restaurants, homes	4,172	0.1	27.9	1.3	14.3	0.0	2.6	46.1	18.5	64.7
7/1	Bakers	69	0.0	0.4	0.1	0.3	0.0	0.0	0.8	0.4	1.2
7/2	Butchers	56	0.0	0.3	0.0	0.1	0.0	0.0	0.4	0.3	0.7
7/3	Other food	21	0.0	0.1	0.0	0.1	0.0	0.0	0.2	0.2	0.4
8	Laundries	53	0.0	0.3	0.0	0.2	0.0	0.0	0.5	0.3	0.8
9	Agriculture	632	0.1	1.2	11.9	3.5	18.6	0.3	35.7	4.3	39.9
10	Horticulture	192	0.0	0.4	0.1	1.0	0.0	0.0	1.5	0.4	1.9
11	Airports	245,071	0.0	0.4	0.0	0.4	0.7	0.7	2.1	1.3	3.5
12	Textile, clothing, leather	922	0.0	3.1	0.2	1.0	0.0	0.2	4.4	1.1	5.6
13	Remaining groups (not covered by questionnaire)	2,089	0.0	1.0	0.1	0.4	0.0	0.1	1.5	16.8	18.4
14	Others	–	0.0	2.2	0.0	0.6	2.0	0.4	5.2	15.9	21.1
Total tertiary from extrapolation		33,490	0.4	146.7	17.6	54.9	23.8	22.3	265.8	130.6	396.4

* Group 1-4, 6-9 and 12: employees; group 5 hospitals: number of beds, schools/universities: number of pupils/students, Public baths: water volume; group 11 airports: traffic units (1 passenger / 100 kg freight)

Energy consumption by end-use in the tertiary sector

The energy consumed for lighting dominates electricity consumption with almost 36 % (Table 3), followed by the electricity used for motor drives (power). The share of air conditioning (cooling) in electricity consumption is still low at present in most sectors. It reaches a share of about 8 % only at airports and in agriculture and about 5 % in hospitals. Process cooling plays a bigger role in the tertiary sector, especially in the retail trade, in hotels and restaurants and in parts of the food industry.

The application structure is less differentiated for fuels: more than 70 % of the energy demand in the tertiary sector is accounted for by space heating followed by process heat (hot water and other process heat) with around 15 %.

Table 3: Projected energy consumption in the tertiary sector by end-use in 2013

Reference year: 2013		Consumption		Shares															
Group / Split	Definition	Electricity	Fuels	Electricity							Fuels (incl. district heat)								
		Total [TWh]	Total [TWh]	Lighting	Power	Hot water	Other process heat	Process cold	AC	ICT	Space heating	Lighting	Power	Hot water	Other process heat	Process cold	AC	ICT	Space heating
		[%]																	
1	Construction industry	3.8	13.4	47.4	18.4	13.2	2.6	0.0	2.6	7.9	7.9	0.0	18.7	3.7	0.0	0.0	0.0	0.0	76.9
2	Office-like enterprises	29.5	74.0	45.1	4.4	3.1	1.4	2.4	3.1	36.9	3.7	0.0	0.0	3.5	0.0	0.0	0.0	0.0	96.5
3	Manufacturing enterprises	3.9	8.0	38.5	41.0	5.1	0.0	0.0	0.0	10.3	5.1	0.0	1.2	2.5	26.1	0.0	0.0	0.0	69.6
4	Retail trade	22.5	40.6	48.9	9.3	3.1	2.7	18.7	2.2	8.4	6.2	0.0	0.0	3.2	0.0	0.0	0.5	0.0	96.1
5/1	Hospitals	6.1	12.0	19.7	27.9	4.9	27.9	1.6	4.9	9.8	1.6	0.0	0.0	15.8	4.2	0.0	2.5	0.0	78.3
5/2	Schools	3.9	16.6	74.4	2.6	2.6	2.6	0.0	0.0	10.3	2.6	0.0	0.0	1.2	1.2	0.0	0.0	0.0	97.0
5/3	Public baths	1.4	2.8	14.3	78.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.1	92.9	0.0	0.0	0.0	0.0
6	Hotels, restaurants, homes	18.5	46.1	28.6	25.9	7.0	11.4	13.5	1.1	5.4	7.6	0.0	0.0	5.9	20.8	0.0	0.2	0.0	73.1
7/1	Bakers	0.4	0.8	0.0	0.0	0.0	75.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	86.2	0.0	0.0	0.0	12.3
7/2	Butchers	0.3	0.4	33.3	0.0	0.0	33.3	33.3	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	74.9
7/3	Other food	0.2	0.2	50.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0
8	Laundries	0.3	0.5	33.3	0.0	0.0	66.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	80.0	0.0	0.0	0.0	20.0
9	Agriculture	4.3	35.7	25.6	41.9	11.6	0.0	2.3	9.3	4.7	4.7	0.0	52.7	5.6	7.3	0.0	0.0	0.0	34.5
10	Horticulture	0.4	1.5	50.0	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.7	80.0	0.0	0.0	0.0	13.3
11	Airports	1.3	2.1	38.5	30.8	7.7	7.7	0.0	7.7	7.7	7.7	0.0	33.3	4.8	4.8	0.0	9.5	0.0	47.6
12	Textile, clothing, leather	1.1	4.4	54.5	9.1	0.0	0.0	0.0	0.0	18.2	18.2	0.0	0.0	2.3	18.2	0.0	0.0	0.0	79.5
13	Remaining groups (not covered by questionnaire)	16.8	1.5	6.5	47.0	0.6	2.4	17.3	0.0	24.4	1.2	0.0	0.0	0.0	26.7	0.0	0.0	0.0	66.7
14	Others	15.9	5.2	36.5	54.1	1.3	1.3	0.6	0.6	6.3	0.0	0.0	38.5	5.8	5.8	0.0	0.0	0.0	48.1
Total tertiary from extrapolation		130.6	265.8	35.8	24.7	3.8	4.8	8.2	2.0	16.2	4.1	0.0	9.1	4.6	8.1	0.0	0.3	0.0	77.7

4 Sector-specific analyses

In addition to the extrapolation, the data collected in the broad surveys for the individual groups of the tertiary sector for the calendar years 2006, 2008, 2010 and most recently for 2012 can be used to examine the enterprises' energy consumption structures in greater detail. The analyses concentrate on cross-cutting technologies and sector-specific, energy-relevant equipment features like lighting, office appliances, air conditioning, common rooms (used during work breaks etc.) and canteens. Furthermore, company structural data and questions concerning energy management, i.e. how the topic of energy is managed, the implementation of energy-saving measures and estimates of energy costs were analysed. Unlike the extrapolation, these analyses are based on unweighted raw data of the questioned companies. In view of the partially low case numbers in individual groups, the information is not strictly representative; however, since the quota was fulfilled even in the sub-groups, the results are very useful for a more detailed insight into the sectors.

Energy technology equipment by sector

Some examples from the wide range of data collected are presented below of major energy-relevant features of tertiary sector branches. The results of the four broad surveys conducted between 2006 and 2012 serve as the basis for this. Any relevant differences between the most recent broad survey for 2012 and the earlier surveys are pointed out.

The *construction industry* is a very heterogeneous sector with regard to company size and structure. The main focus in the construction industry is on structural and civil engineering and prefabricated building; plumbers/fitters and painters/varnishers are the biggest lines of business in the finishing trade. Energy consumption is divided into space heating and production in the enterprises' own facilities as well as numerous machines and appliances on building sites and building site traffic. As expected, companies in the main construction industry operate many more energy-intensive appliances themselves and on building sites than is the case in the finishing trade. Almost all the appliances are electrically powered apart from forklift trucks and dump trucks. There are considerable problems with recording energy consumption in the construction industry, especially on building sites, e.g. for the power on site and container heating systems, because the client (building owner) bears these costs.

The branches grouped together here as "*office-like enterprises*" cover a wide range of public and private services: banks and insurance companies, public enterprises, non-profit organisations and other business services. Some have a more obvious office

character such as lawyers or tax advisors, others feature relevant energy technologies like waste disposal services, hairdressers, cleaning businesses or doctors. From an energy perspective, however, most of these enterprises have similar structures. Space heating dominates followed by electrical applications for lighting, ventilation and air conditioning, information and communication technologies. Air conditioning is used more frequently than the average in these office-like enterprises: Related to the office area, 3.7 % of all office enterprises are air conditioned on average (with dehumidification), 11.1 % are cooled (without dehumidification) and 6.1 % are ventilated mechanically. Air conditioning is mainly used in banks (26 %), most often as central air-conditioning systems, followed by small offices (16 %). As expected, office enterprises have more office equipment and appliances than other branches of the tertiary sector; this is the case above all in banks and insurance companies and public institutions.

Metalworking, the automobile trade, wood, paper and printing businesses all count as *manufacturing enterprises*. Alongside general equipment such as heating, lights, office appliances, ventilation and air conditioning, sector-specific process technologies play a bigger role here, especially for electricity. Fuels, on the other hand, are predominantly used for space heating. The *metal trade* covers industrial branches with heterogeneous operating technologies and varying energy intensity. Mechanical engineering, electrical engineering, locksmiths/metalworking and welding shops, and the production of medical and orthopedic appliances account for the largest relative shares in the tertiary sector. The variety of production technologies is correspondingly large; most of them use electricity, e.g. to produce compressed air to form and separate. Alongside space heating, fuels are also used for heat treatment processes such as, e.g. hardening, tempering, annealing, welding etc. The *automobile trade* is made up of car repair shops, car dealers and mixed service firms. Car mechanics is the main field of activity for repair shops, followed by bodywork and paintwork jobs. There are offices and sales rooms on top of this. Electricity in these enterprises is mainly used for lighting, powering pumps and appliances/instruments as well as for compressed air in the repair and service areas. *Wood and wood products* covers the manufacture of furniture and building components, each with relatively little energy-intensive equipment; the other enterprises are sawmills. Extraction systems usually have the highest electricity consumption in carpentry/joinery. In the *paper and printing trade*, small firms include printers, copying services, paper/cardboard processing. Electricity is mainly used for printing machines following by cutting, folding and stapling devices. Digital printing machines, compressed air, lighting, air conditioning and the operation of devices in standby mode also play a role.

Besides offices, the *wholesale and retail trade* is the largest branch in the tertiary sector with almost 5.5 million workers. The distinction between food and non-food busi-

nesses is relevant for energy use. The retail food trade has a high demand for refrigeration and freezing foodstuffs. The dominant share of electricity consumption is used for these applications followed by lighting. It should be noted that huge cold storage units are being covered more often – both over night and during the day. In the non-food retail trade, halogen lamps are being used more often than in other sectors, primarily in shop windows. There has been a significant increase in the share of LED bulbs compared to the previous survey, from 4 % (2010) to 8 % (2012) of all lights used. 19 % of the surveyed companies use air conditioning systems or devices. Other electricity consumers are the ovens used to bake or heat bread, meat and processed meat products in food stores equipped with baked goods departments or snack areas. 28 % of the surveyed businesses have one or more of these ovens for baked goods and 14 % have one for meat and processed meat products. The energy demand of modern cash registers is not insignificant. 99 % of enterprises have cash registers, 1.6 on average per firm. Space heating demand is the main energy and fuel consumer across the whole of the retail trade.

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 here, more suitable reference units – the number of beds, number of pupils/students or pool surface area - were used here. *Hospitals* are characterized by a high demand for space heating and process heat. The latter is particularly relevant if the hospital operates its own laundry. Apart from lighting, electricity is required mainly for ventilation and air conditioning. *Schools* are a very heterogeneous group that ranges from kindergartens right up to universities. Space heating demand dominates the energy consumption here. Electricity is mainly used for lighting. 66 % of both hospitals and schools have a computer network. The main distinction with regard to *public baths* is between indoor swimming pools and outdoor ones. "Water parks" represent a combination of the two which is becoming more common. A large share of the energy consumption in public baths is for the process heat used to heat the water, but also for space heating in indoor pools. Public baths today are equipped with very complex building technologies, mainly for ventilation, electrical engineering and pool water technology that consume a lot of power. In addition, pools are also more often equipped with additional energy-intensive installations such as saunas, solariums, wellness and health-related areas, fitness rooms, restaurants, cafeterias etc.

The *hotel and restaurant trade* consists of catering and accommodation (hotels and carehomes). It is true that, as a service sector, there are businesses of every size in the tertiary sector, but small to very small enterprises dominate here. As far as energy consumption is concerned, space heating and therefore fuel consumption is the most

important in both branches. The second largest energy consumer after space heating is the process heat for kitchens, mainly for cooking food, but also for heating food and keeping it warm, preheating and cleaning crockery. Electricity is also mainly used for cooking, and secondly for fridges and freezers, but also for dishwashing, laundry and lighting. Refrigerators and freezers are becoming more significant because of the growing use of more frozen products on account of the greater flexibility offered. With regard to lighting, hotels and restaurants still have a high proportion of incandescent bulbs compared to other sectors (around 20 %), although the share of LED lights is also relatively high with 16 %.

Bakers and butchers are the main lines of business in the tertiary sector belonging to the *food industry*. The ovens are the biggest energy consumers in *bakers*. In the bakers included here, which tend to be quite small enterprises, mostly discontinuous processes are used, e.g. rack ovens or deck ovens. Today, outlets and production facilities including a retail outlet often have an electric oven directly in the salesroom to finish baking pre-made raw pastries and rolls. Electricity is additionally used mainly for cooling appliances. Comparatively low shares of electricity are used for power applications (machines, e. g. to sieve, mix, knead and stir as well as for ventilation), lighting and hot water production. The main energy consumption in *butchers* is for producing sausages and processed meat products. Different heat treatment processes are carried out in large cooking kettles and combi-ovens. Making raw sausages is done in maturing chambers and smokehouses. Production plants are mostly fuel-heated, fewer use electricity. The main electricity share is due to heating water, refrigerating and freezing. Electricity consumption for refrigeration and freezing is increasing because enterprises additionally use or sell an increasing number of refrigerated and frozen products. There are relatively few office appliances compared to other sectors.

The group of *laundries* covers the entire textile cleaning industry, i.e. laundries, dry cleaners, textile rental services, dyeing works, ironing and rotary iron services. This is a comparatively energy-intensive sector. Energy is mainly used for heat processes: washing, drying, hot pressing/mangling, cleaning and ironing. The energy demand for space heating is negligible. Due to the high demand for process heat, there is usually enough waste heat available to heat the production rooms. Space heating is predominantly needed for separate rooms, e.g. sales, offices and canteens. Electricity is mainly required for the electric motors used to drive machines and provide ventilation and for lighting to a lower extent.

Based on the number of workers, *agriculture* is quite an energy-intensive sector. This has to do with the low average number of employees per farm. The 105 agricultural enterprises surveyed in 2012 only have 4.3 workers on average; half of them actually

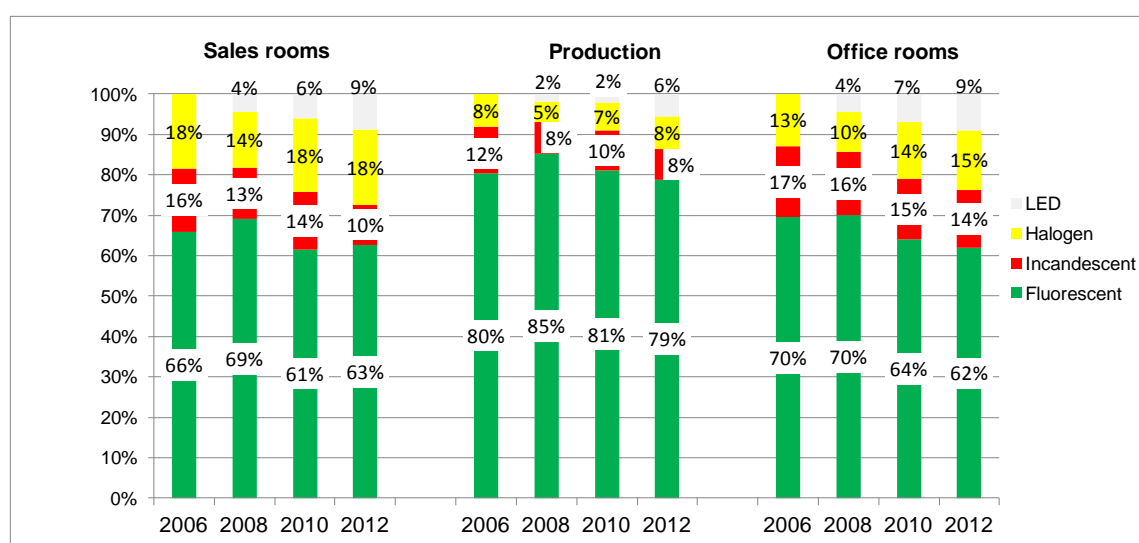
only have one or two employees. The biggest energy demand is for livestock. Farming crops is not as energy-intensive with a few exceptions (drying grain), if the fuel consumption for agricultural vehicles is disregarded. The main electricity end-uses are for power processes, primarily to air and ventilate animal pens in intensive livestock farming and for cooling milk. Process heat is needed for radiant heaters when rearing chicks and piglets. In *horticulture*, enterprises with heated under-glass areas are very energy-intensive. Fuels are used to heat greenhouses; electricity is needed for lighting, ventilation and heating small areas of plants as well as for controlling automatic ventilation and irrigation processes.

Cross-sectoral comparison of energy-relevant features

The following sections compare lighting, office appliances, ventilation and air conditioning as well as employee common rooms and canteens across the different sectors.

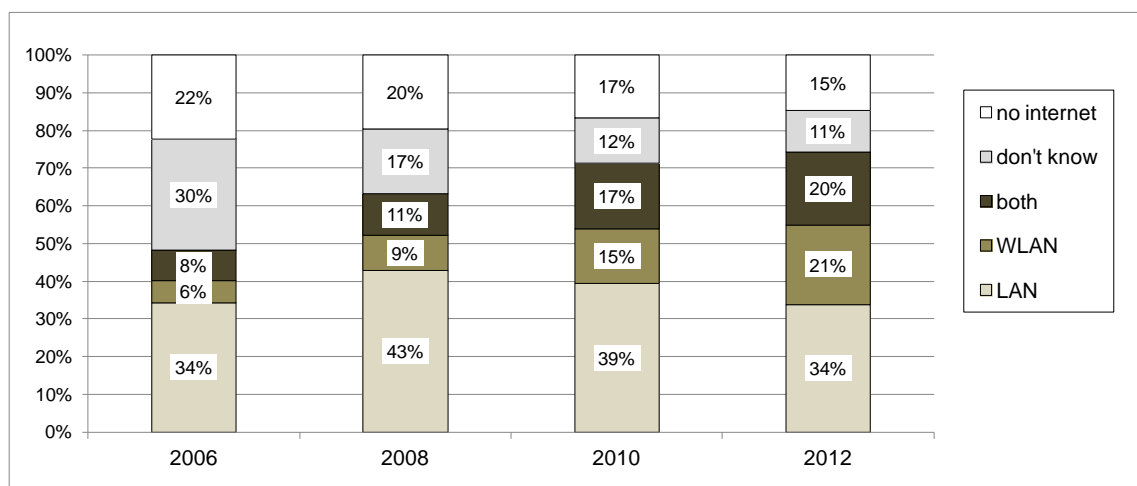
With regard to *lighting*, the rooms evaluated were those considered to be the most typical for each sector. The lighting in salesrooms was taken for the retail trade and in offices for office-like enterprises; otherwise the lighting in production was selected. In restaurants, this means the kitchens, for hotels and hospitals, the rooms, and in schools, the classrooms. The vast majority of lights in all sectors are fluorescent or energy-saving lamps (Figure 1); these make up almost 80 % in production, in storage rooms and canteens. LED lamps were recorded for the first time in 2008. These are presently mainly used in shop windows. In sales rooms and offices, LED lamps have replaced both fluorescent and incandescent lights and currently make up 9 % of all the types of lamps used.

Figure 1: Changes in types of lamps 2006 to 2012



Among the group of *office appliances*, the equipment with computers is particularly interesting in the cross-sectoral comparison. 21 % of the surveyed enterprises had one or several servers or mainframe computers in 2012, 85 % have PCs or notebooks, 84 % printers, which are mainly devices combined with copiers or fax machines. Almost all the monitors are now LCD flat screens. On average, 85 % of all the surveyed enterprises have an internet connection; restaurants and laundries are least likely to have one. 41 % of all enterprises have WLAN; this implies a marked increase of 14 % compared to 2006 (Figure 2).

Figure 2: Internet connection, LAN and WLAN 2006 to 2012



The equipment of office-like enterprises with office appliances can be compared based on a time series since 2002 (Figure 3). Compared to the previous surveys, the sample had slightly less office equipment. Over time, the use of cathode ray tube screens has declined from 60 % (2002) to almost 0 % (2012); the use of WLAN, in contrast, has risen from about 10 % (2006) to around 40 % (2012).

Air conditioning (with dehumidification) or *cooling* (without dehumidification) are found in 20 % of enterprises, whether this is done with small mobile devices, split air conditioners or a central air conditioning system. Hospitals stand out among all the different sectors as 75 % of them have air-conditioned rooms (Figure 4). The lowest share is in laundries (5%).

Figure 3: Comparison of office equipment in offices over time 2002-2012

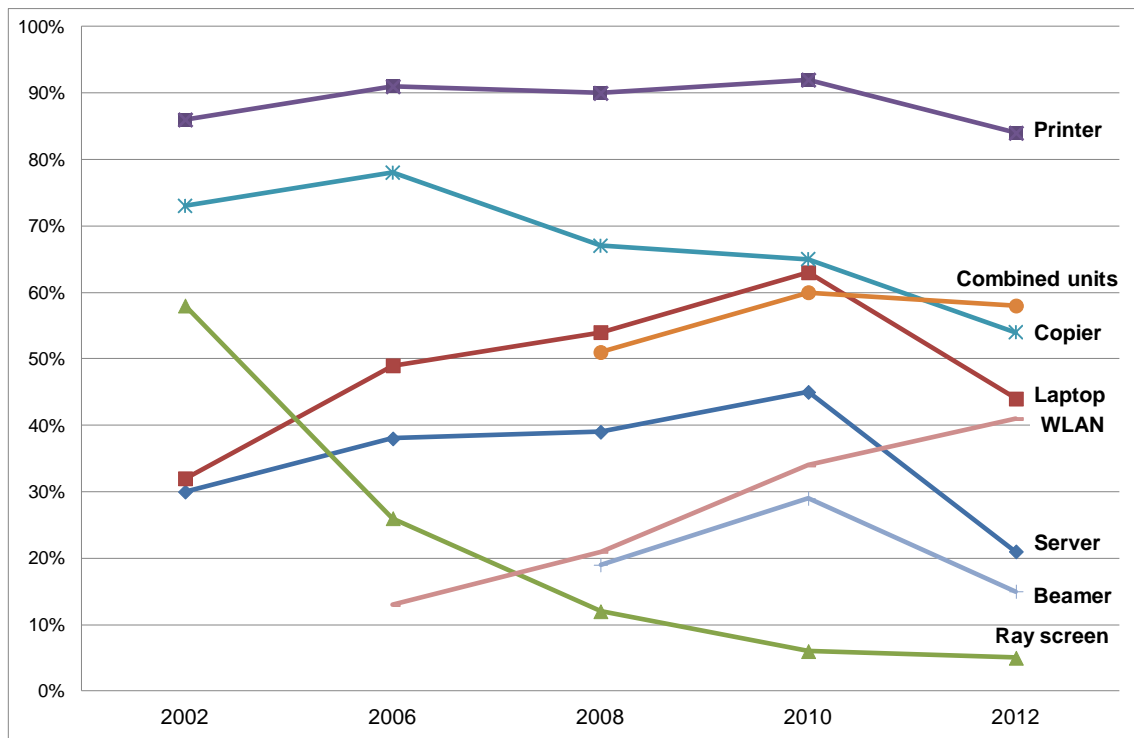
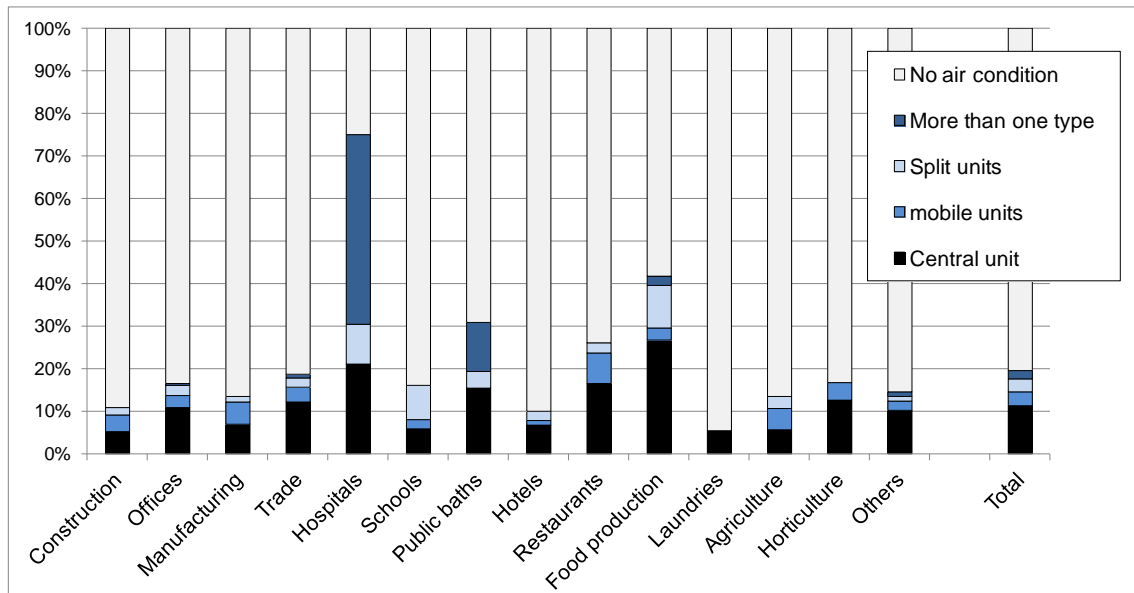


Figure 4: Use of air conditioning systems and devices (2012)



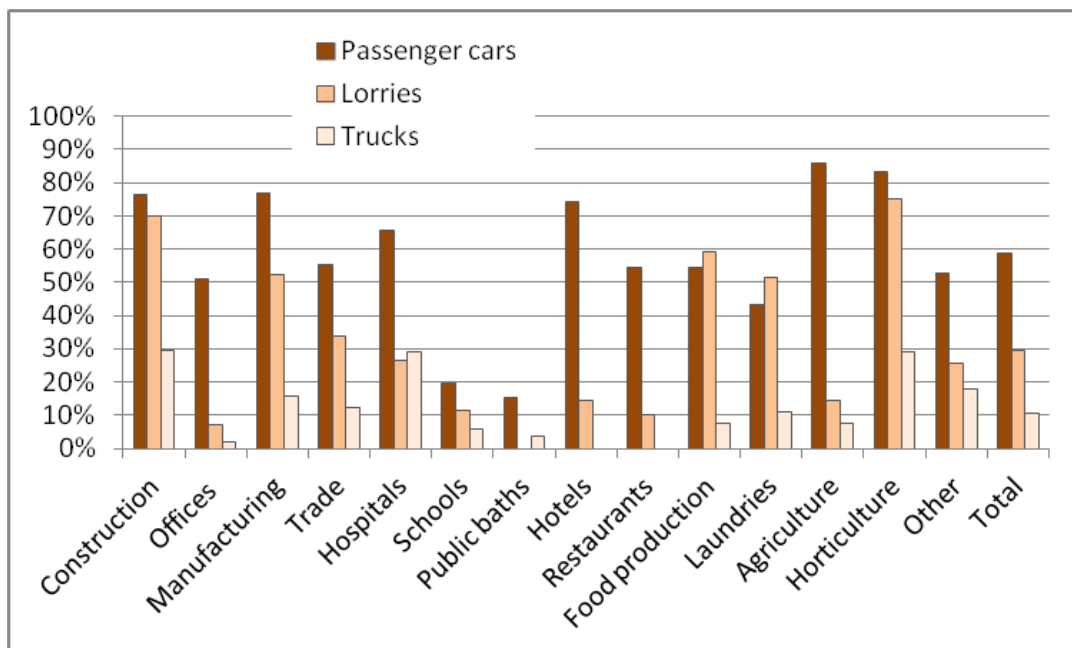
Company common rooms (for employee breaks) exist in 48 %, canteens in 4 % of the enterprises questioned in 2012. Canteens have a significant influence on company energy consumption, but common rooms are also often equipped with energy-relevant

devices: 44 % with fridges, 25 % with dishwashers, 5 % with freezers and 74 % with coffee machines, of which 20 % are fully automatic. This is equivalent to 7.8 coffee machines per enterprise on average in the tertiary sector. Drinks dispensing machines are relatively rare (11 %) as are vending machines for sweets or snacks (5 %).

Cogeneration (combined heat and power) is only used in 1.4 % of the enterprises, mainly in hospitals, office enterprises, schools and public baths. *Waste heat use* is more common, in 2.2 % of enterprises, mainly in laundries, in companies producing or processing foods and agriculture.

Recording the *enterprises' vehicle stock* of cars (including vans), delivery vehicles and trucks revealed that 59 % of the surveyed workplaces have at least one passenger car, 29 % have delivery vehicles and 10 % have trucks. The vehicle stock varies greatly by sectoral group (Figure 5). Cars drive 40,945 km on average per company, delivery vehicles 39,425 km and trucks 75,245 km. As an average of all firms that have company cars, private trips make up 21 % of the annual mileage. The private use of delivery vehicles and trucks is negligible.

Figure 5: Vehicle stock of enterprises by sectoral group (2012)



Delivery vehicles and trucks almost always run on diesel as do 57 % of the company cars. Around 35 % of the cars use gasoline. All other fuels have negligible shares of less than 1 %. 24 enterprises (1.4 %) have electric or hybrid vehicles; three quarters of these are offices and manufacturing enterprises. These vehicles are not used very of-

ten: They have annual mileages between 0 and 54,700 km, around 10,800 km on average.

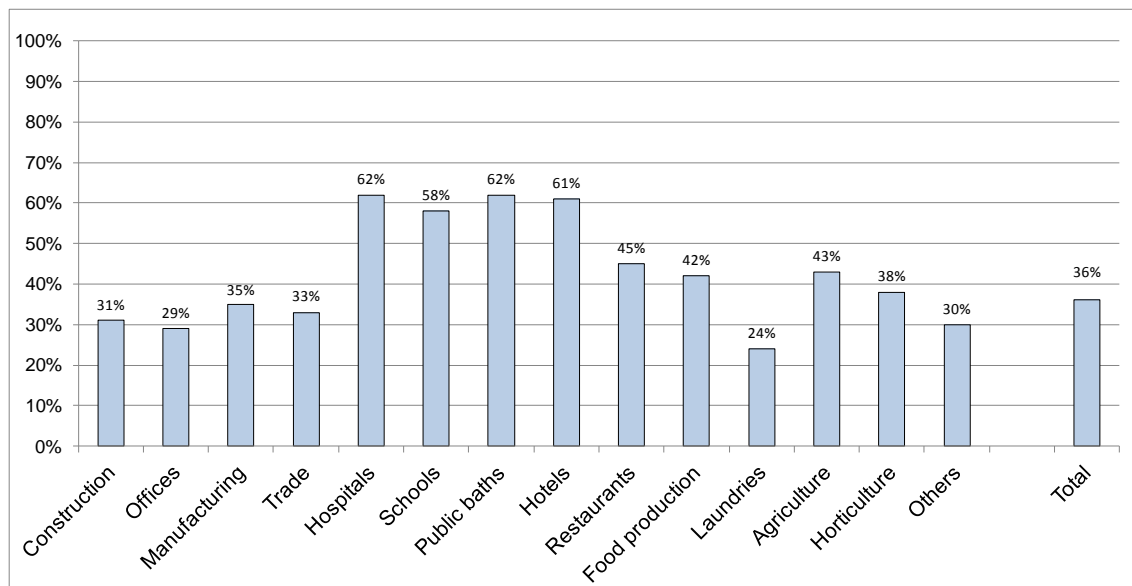
Energy management in the enterprises

Compared to the two previous surveys, the 2014 survey was expanded to include more questions on energy management (see Annex). Above all, individual energy management measures, experiences with energy consultation and the implementation of energy-saving measures were documented in more detail.

An important framework condition is what decision-making authority the managers have at each workplace. 46 % of the enterprises rent their property, 7 % lease it and 47 % own it. 16 % are branch companies. These two factors influence the company's activities to reduce energy consumption: Owners and branch companies are more active with regard to energy efficiency measures.

Overall, the following situation results for the tertiary sector with regard to energy management and the implementation of energy-saving measures: 11 % of enterprises practise energy management, mainly hospitals, public baths and schools. These have also made use of energy consultation more often. All the enterprises claim they at least check their energy consumption; 25% of them monthly. 36 % of all enterprises responded that they have implemented energy-saving measures in the last six years, i.e. since 2008. Larger enterprises have conducted more measures than smaller ones: Microfirms with up to nine employees have 2.6 measures on average; companies with 20 employees 4.3 measures (Figure 6). The measures focus on lighting, organization and space heating / hot water. Only very few companies have considered using load management.

Figure 6: Implementation of energy-saving measures by sectoral group (2012)



In connection with the questions on energy management, the subjective energy cost burden of the companies was also recorded. 57 % of the enterprises answered the question: “How high do you think the share of energy costs is related to turnover (in public organizations: related to total costs)?” The resulting overall average was 10.7 %. Restaurants and laundries estimate their energy cost share to be the highest with approx. 16 % on average; this is the lowest in hospitals. There are substantial deviations in the estimations even within the sectoral groups, roughly in a range from 1 % to 45 % in schools and hotels. Comparing the answers about energy cost shares between 2006, 2008, 2010 and 2012 does not show any clear trend for the majority of branches. Whereas energy costs tended to be estimated as lower – and more realistic - in 2010, there is a rising trend again in the 2012 survey.

If the energy costs stated are evaluated in connection with energy consumption, as expected, the average energy costs per employee are the highest by far in public baths (€26,224 per year), followed by agricultural enterprises, hotels, laundries and restaurants. They are the lowest in construction firms (€964) and offices (€1,287). Overall, the energy costs in hospitals and public baths are particularly high (on average €616,000 and €359,000 resp.), followed by schools (on average €85,562). Another question addressed the perception of energy costs. Overall, 19 % of all those who provided an answer here classed the share of energy costs as “high”, 40 % as “moderately high”, 31 % as “low” and 10 % as “negligible”. Across all the sectoral groups, the larger the enterprise and the higher its energy costs, the more often energy management is to be found.

5 Final Remarks

The analyses presented for the tertiary sector compiled data on energy consumption that can be differentiated by consumer group and energy source and that can be considered a base for the further refinement and examination of future consumption structures in trade, commerce and services. Of course the results on energy consumption in the tertiary sector cannot achieve the overall accuracy of the energy balances established by a series of conventions in mapping real consumption. However, they do provide differentiated results for areas where the energy balance only contains aggregated data with no structural information, and insights where conventional data sources fail to do so, for instance concerning biomass use or energy sources that are only traded to a limited extent.

Additional components of electricity consumption were determined for the first time here for water supply and wastewater disposal and for cold storage and computer centres that were not able to be documented up to now based only on the survey. This meant that the discrepancies ascertained in the earlier surveys between the extrapolated electricity consumption and that shown in the energy balance were able to be substantially reduced.

Because the survey has now been repeated several times, it was also possible to compile time series for a longer period – in this study 2006 to 2013 – of energy consumption in the tertiary sector by branch and energy source for Germany that are comparable, at least to a certain extent. This means there is an additional source of information on energy consumption in the tertiary sector that should be of interest for monitoring purposes on a national and international level. On top of this, compared to previous surveys, energy consumption was able to be determined more comprehensively by end-use at the level of individual consumer groups.

Above and beyond pure energy statistics, the comprehensive sector-specific knowledge gained in the surveys and company inspections about energy consumption structures, energy-relevant equipment features, economic framework conditions and energy management of the companies can also be used for a wide variety of other purposes, for example, designing energy policy measures or to structure the advice given by energy agencies, energy consumer associations and energy supply companies.

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