SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Building Stock Distribution and Electricity Use for Lighting

T50.D1

A Technical Report of IEA SHC Task 50

February 2016

IEA Solar Heating and Cooling Programme

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Building Stock Distribution and Electricity Use for Lighting

A Technical Report of Subtask D (Case Studies), T50.D1

IEA SHC Task 50: Advanced Lighting Solutions for Retrofitting Buildings

February 2016

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KEYWORDS

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PREFACE

Lighting accounts for approximately 19 % (~3000 TWh) of the global electric energy consumption. Without essential changes in policies, markets and practical implementations it is expected to continuously grow despite significant and rapid technical improvements like solid-state lighting, new façade and light management techniques.
With a small volume of new buildings, major lighting energy savings can only be realized by retrofitting the existing building stock. Many countries face the same situation: The majority of the lighting installations are considered to be out of date (older than 25 years). Compared to existing installations, new solutions allow a significant increase in efficiency – easily by a factor of three or more – very often going along with highly interesting payback times. However, lighting refurbishments are still lagging behind compared to what is economically and technically possible and feasible.

“IEA SHC Task 50: Advanced Lighting Solutions for Retrofitting Buildings” therefore pursues the goal to accelerate retrofitting of daylighting and electric lighting solutions in the non-residential sector using cost-effective, best practice approaches.
This includes the following activities:

- Develop a sound overview of the lighting retrofit market
- Trigger discussion, initiate revision and enhancement of local and national regulations, certifications and loan programs
- Increase robustness of daylight and electric lighting retrofit approaches technically, ecologically and economically
- Increase understanding of lighting retrofit processes by providing adequate tools for different stakeholders
- Demonstrate state-of-the-art lighting retrofits
- Develop as a joint activity an electronic interactive source book (“Lighting Retrofit Adviser”) including design inspirations, design advice, decision tools and design tools

To achieve this goal, the work plan of IEA-Task 50 is organized according to the following four main subtasks, which are interconnected by a joint working group:
Subtask A: Market and Policies
Subtask B: Daylighting and Electric Lighting Solutions
Subtask C: Methods and Tools
Subtask D: Case Studies
Joint Working Group (JWG): Lighting Retrofit Adviser

ABSTRACT

This report presents an analysis of the current distribution of the building stock in the non-residential sector, which allows identifying the most important building types. The report also presents the current average energy intensity for electric lighting for each building type as well as characteristics of existing lighting installations in these buildings. The analysis concludes that five building types cover the largest floor space area:

1. Offices,
2. Educational buildings,
3. Wholesale and retail trade,
4. Industrial buildings,
5. Agriculture buildings.

Three other non-residential building types should be given a second priority:

1. Hotels and restaurants,
2. Hospitals and healthcare,
3. Sports buildings.

Data from Sweden, the Netherlands and the United States indicate that fluorescent lighting is clearly the dominant light source in non-residential premises, that LED lighting is still very scarce and that there are still many incandescent light sources installed in non-residential buildings.

EXECUTIVE SUMMARY

The International Energy Agency (IEA) “Task 50: Advanced Lighting Solutions for Retrofitting Buildings” pursues the goal to accelerate retrofitting of daylighting and electric lighting solutions in the non-residential sector using cost - effective, best practice approaches. The aim of this report is to analyze the current distribution of the building stock in the non-residential sector in order to identify the most important building types while generally providing a structure for this IEA Task 50. Another objective is to analyze the current average energy intensity for electric lighting for each building type as well as the characteristics of the existing lighting installations in these buildings.

The data used in this analysis is solely based on a review of available literature and data retrieved from:

- Building Performance Institute of Europe’s (BPIE) data hub;
- European projects (TABULA, DATAMINE, ENPER-EXIST, ETC);
- National documents (in original language) consulted by the experts involved in IEA Task 50.

This report mainly shows that five building types should be given priority in IEA-Task 50 since they cover the largest floor space area:

6. Offices,
7. Educational buildings,
8. Wholesale and retail trade,
9. Industrial buildings,
10. Agriculture buildings.

The first three building types each cover roughly 20-30% of the total floor area of the non-residential building sector. For industrial and agriculture buildings, the data is incomplete but when available, it indicates that these building types may cover a very large floor area, sometimes twice as large as the area covered by office buildings. Agriculture buildings could be excluded from the Task on the basis that these buildings mostly house animals and not human beings and thus entail different lighting issues and solutions.

Three other non-residential building types, which cover 2-10% of the total floor area, should be given a second priority within the IEA Task 50:

4. Hotels and restaurants,
5. Hospitals and healthcare,
6. Sports buildings.

In addition, higher energy intensity for electric lighting was found for “wholesale and retail trade”, “hotels and restaurants”, “hospitals and healthcare” and “sports buildings”. These building types should thus be considered as very important for this IEA Task 50 due to their high energy intensity for electric lighting. Lower lighting energy intensity is found for “offices” and “educational buildings”. Educational buildings are often used only a part of the year, which may explain the low annual energy intensity values found.

The report also indicates that for most non-residential buildings, data about the typical lighting installations is really scarce. However, some data found for Sweden, The Netherlands and the United States indicate that fluorescent lighting is clearly the dominant light source, that LED lighting is still very rare and that there are still many incandescent light sources installed. Data available about type of fluorescent lighting indicate that roughly half of the currently installed fluorescent lighting is of the older type i.e. T8 or T12 with conventional ballasts and thus, large energy savings could be achieved by simply upgrading these outdated light sources.

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LIST OF ABBREVIATIONS

BPIE Building Performance Institute Europe
CFL Compact fluorescent lamps
LPD Lighting power density
HF High frequency (ballasts)

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1. Introduction

Lighting accounts for approximately 19%, i.e. 2900 TWh, of the global electric energy consumption. Projections by the International Energy Agency (IEA, 2006) show that if governments only rely on current policies, global electricity use for lighting will grow to around 4250 TWh by 2030, an increase of more than 40%. Due to the world's growing population and the increasing demand for electrically driven services in emerging economies, the increase will occur despite constant improvements in energy efficiency of lighting systems. One recent study (Enkvist, Naucler, & Rosander, 2007) indicated that investment in energy-efficient lighting represent one of the most cost-effective ways to reduce CO2 emissions. In the United States, lighting was one of the three dominant end uses in 2010 together with space heating, space cooling, accounting for close to half of all energy consumed in the buildings sector (DOE, 2013).

Research and developments in the field of energy efficient lighting techniques encompassing daylighting, artificial lighting and lighting controls combined with activities employing and bringing these techniques to the market can contribute significantly to reduce worldwide electricity consumption and C02 emissions. These activities will therefore be in line with several different governmental energy efficiency and sustainability targets.

1.1. Objectives of building stock analysis

This report is part of the activities under Subtask D (Case Studies) of the International Energy Agency Task 50: Advanced Lighting Solutions for Retrofitting Buildings. Subtask D concerns the collection of Case Studies of lighting or daylighting retrofit projects, which includes the following sub activities:
D.1 Building stock analysis
D.2 State-of-the-art literature review
D.3 Assessment and monitoring protocol
D.4 Case study assessment
D.5 Lessons learned
D.6 Case study book / e-documentation

This report aims to fulfill the objectives of D.1: Building stock analysis. The objective of this report is to analyze the current distribution of the building stock in the non-residential sector in order to:

- Define the most important building types to include in IEA Task 50.
- Harmonize the name of each building type and generally provide a structure for IEA Task 50.

A secondary aim is also to investigate the current average electricity use for lighting by building type and obtain some knowledge about the typical characteristics of the electric lighting installations. This report will thus provide a general overview of the non-residential building stock distribution with specific information about the electric lighting intensity by building type and characteristics of lighting technology currently installed in these building types.

One problem encountered in trying to summarize data about building types is the fact that the same type of building is called by different names in different countries. For example, agricultural buildings are under "agriculture" in Germany and "farm houses" in Denmark.

Thus, one objective of this report is also to develop a common vocabulary (harmonize the name of each building type) to use throughout the IEA Task 50 in order to avoid misunderstanding.

1.2. Benchmark values of lighting electricity consumption for different building types according to EN 15 193

For of all, it is useful to consider the information which can be found in lighting standards. The Standard EN 15193 Energy performance of buildings – Energy requirements for lighting (Swedish Standards Institute, 2007) provides some energy intensity figures, which should be applied in the future (see Table 1). This can also serves as a guide to structure the present IEA Task50. The main sectors addressed in this standard are:

- Office,
- Education,
- Hospital,
- Hotel,
- Restaurant,
- Sport,
- Retail,
- Manufacture.

Table 1: EN 15193 Energy performance of buildings – Energy requirements for lighting.

Annex F
(informative)
Benchmark values and lighting design criteria
Table F.1 — Bench mark default value

				PN	t_D	t_N	F_c		F_o		F_D		No cte illuminance		Cte illuminance	
													LENI	*LENI*	*LENI*	*LENI*
	Quality class	Parasitic Emergency P_{ee}, kWh/(m²xyear)	Parasitic Control P_{pc} kWh/(m²xyear)	W/m²	h	h	no cte illuminanc	cte illuminanc	Manual	Auto	Manual	Auto	Limiting value Manual kWh/(m²xyear)	Auto	Limiting value Manu	Auto
Office	*	1	5	15	2250	250	1	0,9	1	0,9	1	0,9	42,1	35,3	38,3	32,2
	**	1	5	20	2250	250	1	0,9	1	0,9	1	0,9	54,6	45,5	49,6	41,4
	***	1	5	25	2250	250	1	0,9	1	0,9	1	0,9	67,1	55,8	60,8	50,6
Education	*	1	5	15	1800	200	1	0,9	1	0,9	1	0,8	34,9	27,0	31,9	24,8
	**	1	5	20	1800	200	1	0,9	1	0,9	1	0,8	44,9	34,4	40,9	31,4
	***	1	5	25	1800	200	1	0,9	1	0,9	1	0,8	54,9	41,8	49,9	38,1
Hospital	*	1	5	15	3000	200	1	0,9	0,9	0,8	1	0,8	70,6	55,9	63,9	50,7
	**	1	5	25	3000	200	1	0,9	0,9	0,8	1	0,8	115,6	91,1	104,4	82,3
	***	1	5	35	3000	200	1	0,9	0,9	0,8	1	0,8	160,6	126,3	144,9	114,0
Hotel	*	1	5	10	3000	200	1	0,9	0,7	0,7	1	1	38,1	38,1	34,6	34,6
	**		5	20	3000	200	1	0,9	0,7	0,7	1	1	72,1	72,1	65,1	65,1
	***	1	5	30	3000	200	1	0,9	0,7	0,7	1	1	108,1	108,1	97,6	97,6
Restaurant	*	1	5	10	1250	125	1	0,9	1	1	1	-	29,6	-	27,1	-
	**	1	5	25	1250	125		0,9	1	1	1	-	67,1	-	60,8	-
	***	1	5	35	1250	125	1	0,9	1	1	1	-	92,1	-	83,3	-
Sport	*	1	5	10	2000	200	1	0,9	1	1	1	0,9	43,7	41,7	39,7	37,9
	**	1	5	20	2000	200	1	0,9	1	1	1	0,9	83,7	79,7	75,7	72,1
	***	1	5	30	2000	200	1	0,9	1	1	1	0,9	123,7	117,7	111,7	106,3
Retail	*	1	5	15	3000	200	1	0,9	1	1	1	-	78,1	-	70,6	-
	**	1	5	25	3000	200	1	0,9	1	1	1	-	128,1	-	115,6	-
	***	1	5	35	3000	200	1	0,9	1	1	1	-	178,1	-	160,6	-
Manufactur	*	1	5	10	2500	150	1	0,9	1	1	1	0,9	43,7	41,2	39,7	37,5
	**	1	5	20	2500	150	1	0,9	1	1	1	0,9	83,7	78,7	75,7	71,2

2. Literature review

Unlike the residential building stock, most countries have limited information about their non-domestic building stock (Isaacs & Hills, 2013). Previous analysis of building stock has been

made in Europe by the Building Performance Institute Europe (BPIE) and indirectly in various European projects. The following sections summarize the information found.

2.1. Previous surveys for Europe's non-residential buildings

2.1.1. BPIE

In Europe, the Building Performance Institute Europe (BPIE) has undertaken an extensive survey across all EU member States, Switzerland and Norway reviewing the situation in terms of the building stock characteristics and policies in place. The BPIE has estimated that there are 25 billion m^2 of useful floor space in the EU27, Switzerland and Norway. The gross floor space could be concentrated in a land area equivalent to that of Belgium (30 528 km^2). Half of the total estimated floor space is located in the North and West regions of Europe while the remaining 36% and 14% are contained in the South and Centre& East regions, respectively, see Figure 1 (BPIE, 2013).

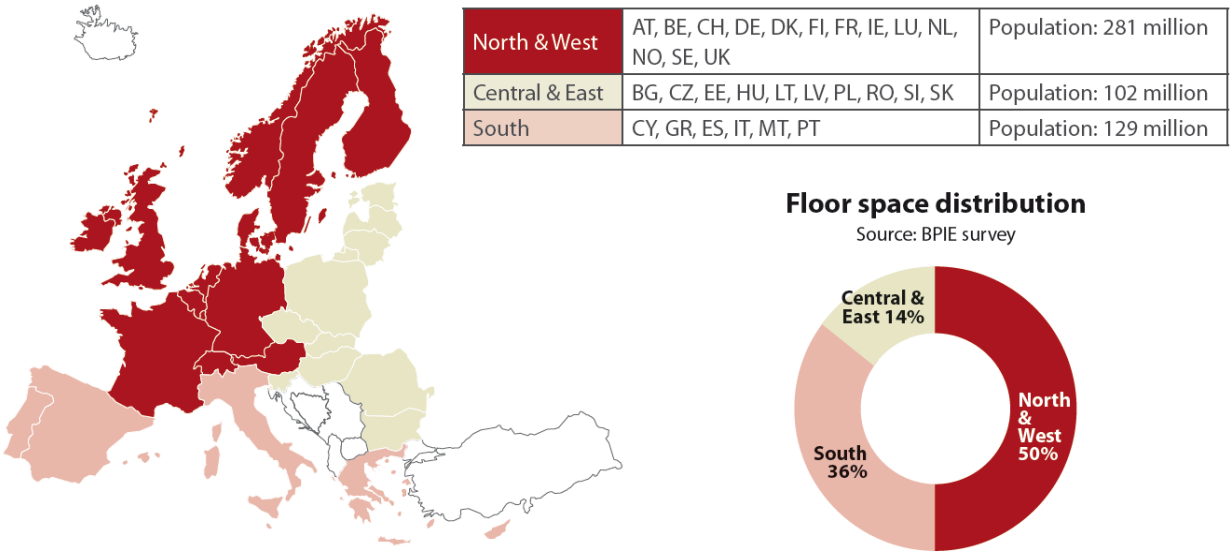


Figure 1: Distribution of useful floor space according to region in Europe.

Non-residential buildings account of 25% of the total stock in Europe and comprise a more complex and heterogeneous sector than the residential sector. According to (BPIE, 2013), the retail and wholesale buildings comprise the largest portion of the non-residential stock while the office buildings are the second biggest category with a floor space corresponding to one quarter of the total non-residential floor space, see Figure 2 (BPIE, 2013).

The average specific energy consumption in the non-residential sector is 280 kWh/m2 (covering all end-uses), which is at least 40% greater than the equivalent or the residential sector. In the non-residential sector, electricity use over the last 20 years has increased by a remarkable 74%.

According to (BPIE, 2013), the data from the survey indicates that policy measures applied only to on-residential buildings over 1000 m^2 in floor area would miss a substantial portion of buildings in many countries, especially in educational buildings, hospitals and offices. The structure of ownership and occupancy has also a significant relevance on the ability to renovate. The ownership profile in the non-residential sector is more heterogeneous and private ownership can span from as low as 20% to 90% from country to country.

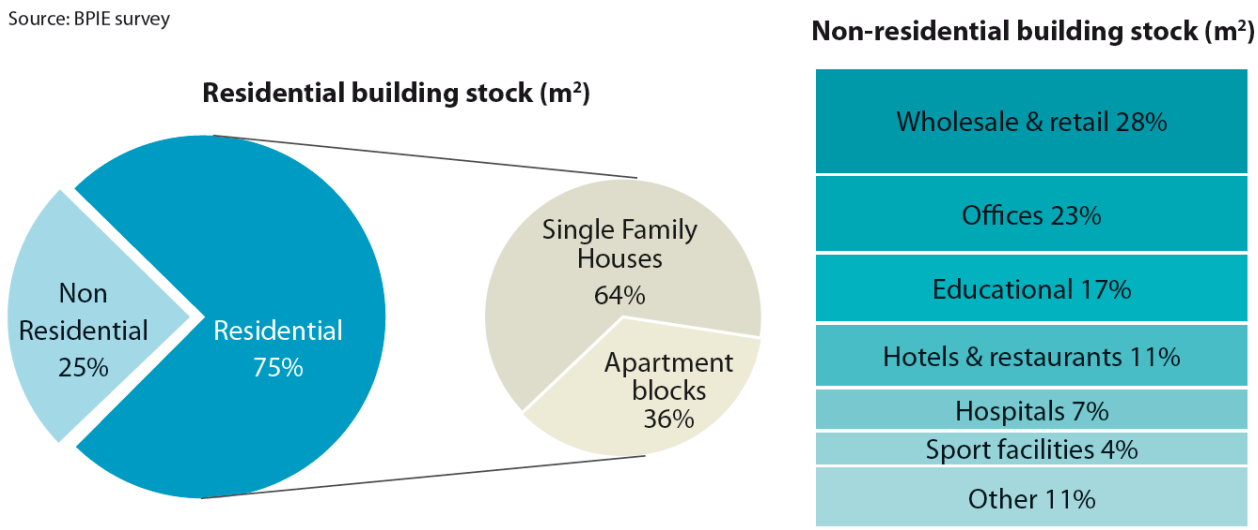


Figure 2: Distribution of building types in the European non-residential building stock.

The BPIE has also created a publicly accessible data hub, which is accessible at http://www.buildingsdata.eu. This data hub can show, for example, the total area of the main building types of the non-residential building sector, as shown in Figure 3 (BPIE, 2013). Figure 3 shows that Germany (DE) is the country with the largest non-residential building area, followed by France (FR), Great Britain (GB), Italy (IT), and Poland (PL). The dominating building types vary according to country but the figure clearly shows that the types “wholesale and retail trade” (yellow), “offices” (dark blue), “educational buildings” (light blue), and “hotels and restaurants” (orange) are the four most important types. Apart from France (FR), the categories “hospitals” and “sports facilities” account for a smaller total area. The BPIE also presents comprehensive data about energy use for electric lighting according to building type but only for some countries (Bulgaria, Czech republic, Finland, Greece, Latvia, Norway, Slovakia). Since this information is key to understanding the significance of the building types for this project, these countries have been included in the present report although some of them do not officially participate in this IEA Task 50.

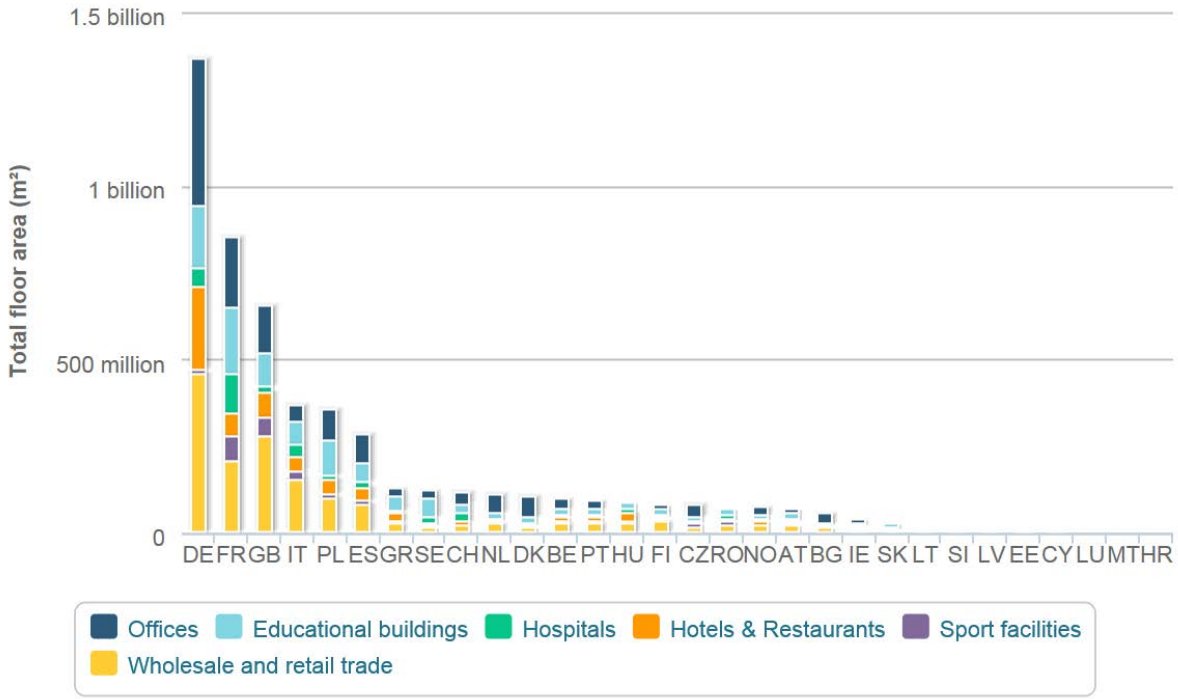


Figure 3: Breakdown of the building stock by building types in the non-residential sector.

2.1.2. TABULA project

In Europe, the 'Typology Approach for Building Stock Assessment (TABULA)' has brought together experts from five countries (Austria, Bulgaria, Germany, Greece, Poland) to review existing national data and explore opportunities to develop a European typology (TABULA, 2012). The experts concluded that the available data source and knowledge about the non-residential building stock differ from country to country. Their analysis showed that the European non-residential building stock and on-going retrofit processes are not very well known and concluded that further research on various issues is needed to be able to set up national non-residential building typologies at the same level as those for residential buildings.

2.1.3. DATAMINE

Another European project called DATAMINE (IEE, 2012) has included the following non-residential building categories:

- offices
- education
- higher education
- hospitals
- hotels and restaurants
- others.

2.1.4. ENPER-EXIST

The European project ENPER-EXIST (Thomsen, Wittchen, Jensen, & Aggerholm, 2007), an acronym for "Applying the EPBD to improve the energy performance requirements to existing buildings" terminated in 2007 and aimed, among other things, at achieving a better knowledge of the European building stock. Therefore, the project included a work package that analyzed the level of information available in each country regarding the existing building stock both in the residential and non-residential building sectors. This project also

developed a procedure (in the form of a questionnaire) enabling to refine this information and develop ways to use the certification procedure as a tool to collect data regarding the building stock. The project involved only seven countries (Belgium, Denmark, France, Germany, Greece, The Netherlands, United Kingdom). The final report includes one chapter presenting existing building stock knowledge. The project also provided a building stock knowledge tool where all gathered data about the existing building stock is registered and readily accessible on an Excel sheet. The report also contains general data about energy consumption in the non-residential building stock. The building stock is divided into the following categories:

- Offices
- Education
- Hospitals/healthcare
- Hotels/restaurants
- Farm houses
- Factories/workshop
- Retail store
- Other production
- Transport and garage
- Sports facilities.

The report presents a graph showing the non-residential areas per person in the ENPER-EXIST countries, see Figure 4, as well as a graph showing electricity consumption in the non-residential building sector per floor area, see Figure 5. Although incomplete, Figure 4 shows qualitatively that, four sectors present high areas per person: Offices, Education, Farm houses (only reported in Denmark), Factories/workshops, and to a lesser extent, Retail sector, Hospitals/health, Hotels/restaurants and Sports (only in the Netherlands). These are also the dominant sectors identified in the present report. Figure 5 is also generally in line with the overall findings of the present report i.e. offices are more energy intensive than the education sector, retail and factories/workshops can be very energy intensive. Otherwise, the data is very limited or incomplete and does not allow clear conclusions.

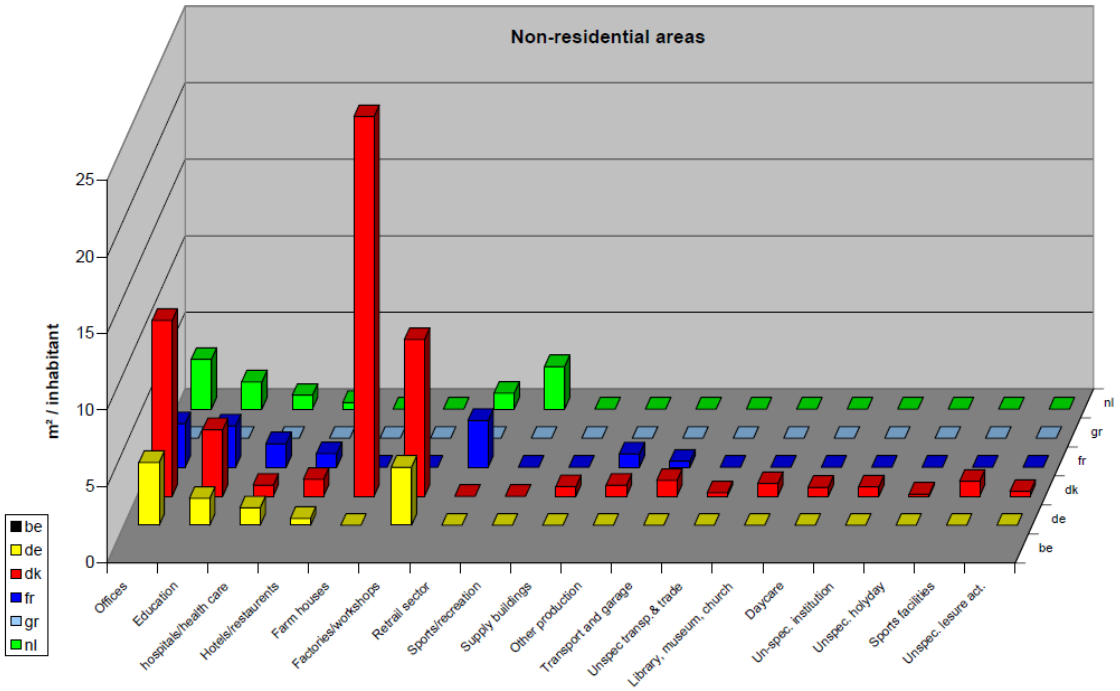


Figure 4: Non-residential areas per person in the ENPER-EXIST countries.

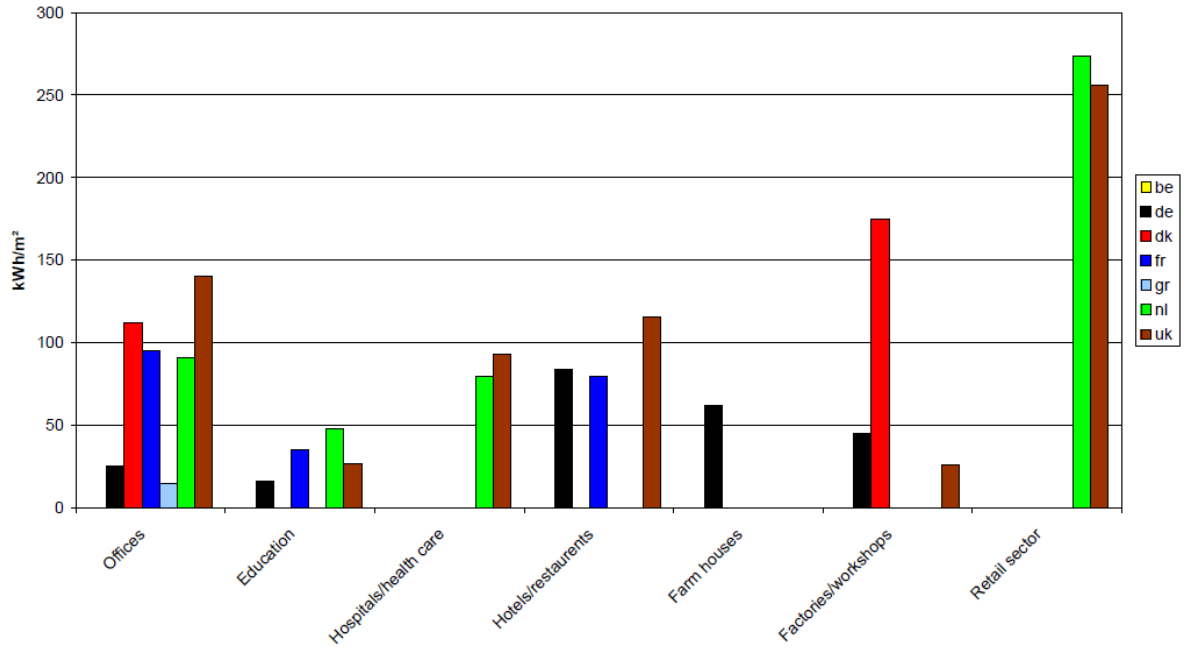


Figure 5: Electricity consumption in the non-residential building sector per floor area for the ENPER-EXIST countries.

2.2. By country data

The following sections present data found by task experts for only 18 countries totally. The priority was been given to data from countries officially involved in IEA Task 50. However, when data was found “by chance” through examination of European or international documents, it was collected in the sections below even though the countries are not officially involved in IEA Task 50. This data is unfortunately incomplete as it only represents a small sample of the total building stock on Earth. One great limitation is of course that it mostly covers the building stock in industrialized nations. Developing countries are not represented at all.

2.2.1. Austria

According to data from the Federal Ministry of Economy, Family and Youth, the overall energy consumption in Austria 2010 is distributed as shown in Figure 6 (BMWFJ, 2012).

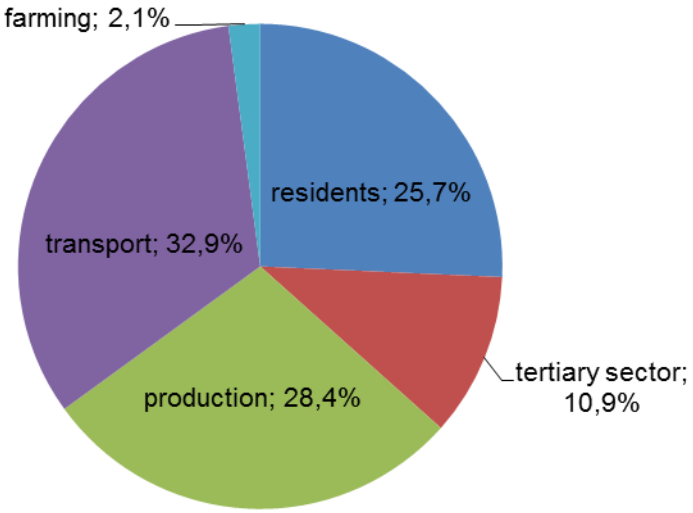


Figure 6: Percentage share of overall energy consumption by sectors in Austria.

Concerning overall electric energy consumption, the sectors and percentages in Figure 6 are distributed as shown in Figure 7 (BMWFJ, 2012). The three sectors 'industry, residents and stores', together account for 85% of 63 TWh overall electric energy consumption in Austria. Dividing this number by the number of inhabitants (8,36 million) gives an average annual electric energy consumption of 7535 kWh/capita. Accounting only for the 21% residential electric energy use, the mean annual electric energy consumption is 1583kWh/capita.

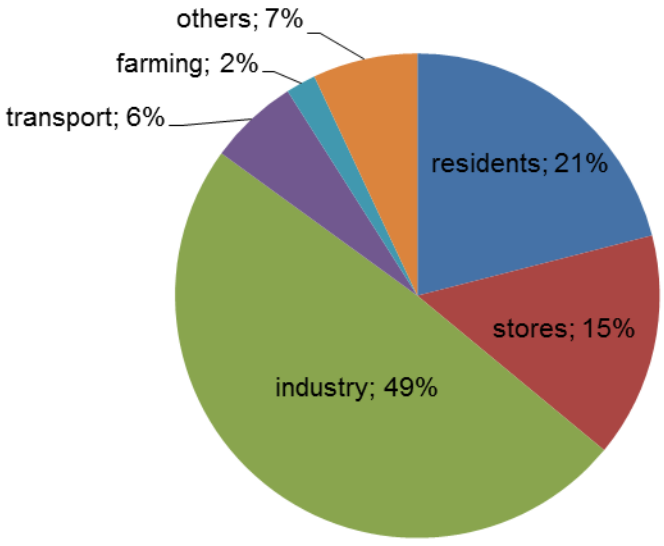


Figure 7: Percent share of electric energy consumption by sectors in Austria.

The overall distribution of building types is as illustrated in Figure 8 (Statistik Austria, Statistik Austria: Die informationsmanager, 2011). According to the Federal Bureau of Statistics, there were 2 046 712 buildings in Austria in 2001, of which 86,2% were residential buildings, and the remaining 13,8% were non-residential buildings. The non-residential buildings were distributed as shown in Figure 9 (Statistik Austria, Statistik Austria: Die informationsmanager, 2011). In 2006, there were 2 073 603 buildings in Austria, which is

only slightly more than in 2001. As no fractional data is available for 2006, it is reasonable to assume that the percentage of residential and non-residential buildings did not change significantly for this period.

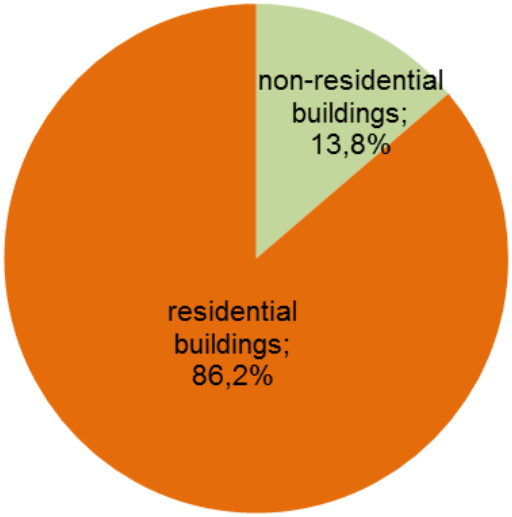


Figure 8: Buildings in Austria.

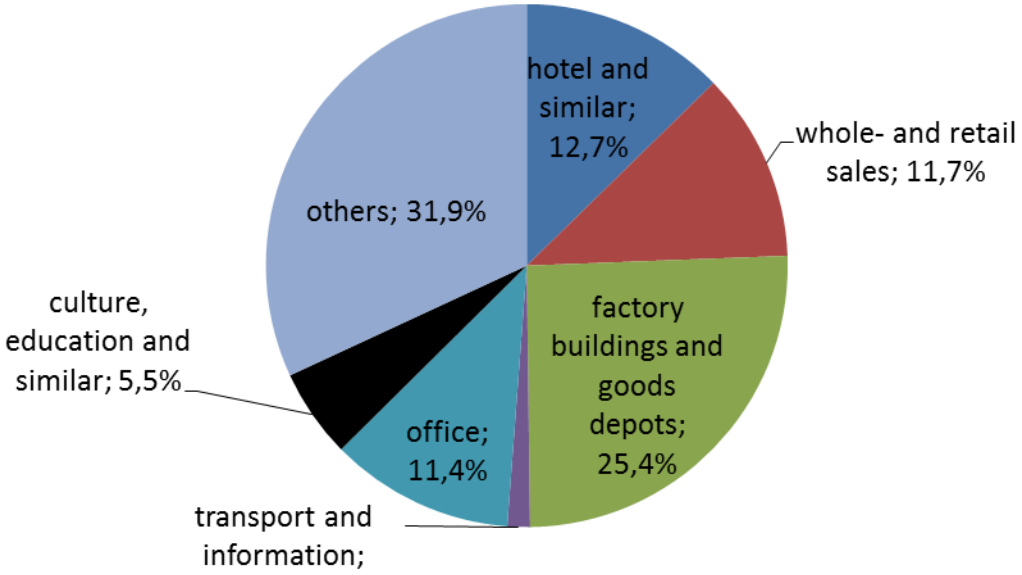


Figure 9: Percentage share of Austria's non-residential buildings as a function of their main usage.

Other data for Austria can be retrieved from a report of the TABULA project (TABULA, 2012), which shows the gross floor area of some main building types:

- Trade/office 104 896 999 m^2 (13,5% of total building stock)
- Factory/operational 101 212 175 m^2 (13,0% of total building stock)
- Tourism 24 499 175 m^2 (3,2% of total building stock)
- Public 46 108 784 m^2 (5,9% of total building stock)

The report also mentions that there exist energy benchmarks in Austria, for the following types of buildings: office buildings, tourism (restaurants, hotels), schools (including kindergartens), event centres (club house, sport facilities, indoor swimming pools, etc), home buildings (student housing, youth recreation children's home, youth hostel, nursing home), trade (outlets, grocery stores, sales locations, retail facility, etc), parking garages.

The BPIE also provides some data about the non-residential building stock distribution in Austria, see Figure 10 (BPIE, 2013). This figure shows that the type “wholesale and retail trade” is dominant, followed by “offices” and “educational buildings”. “Hotels and restaurants” is in the fourth place.

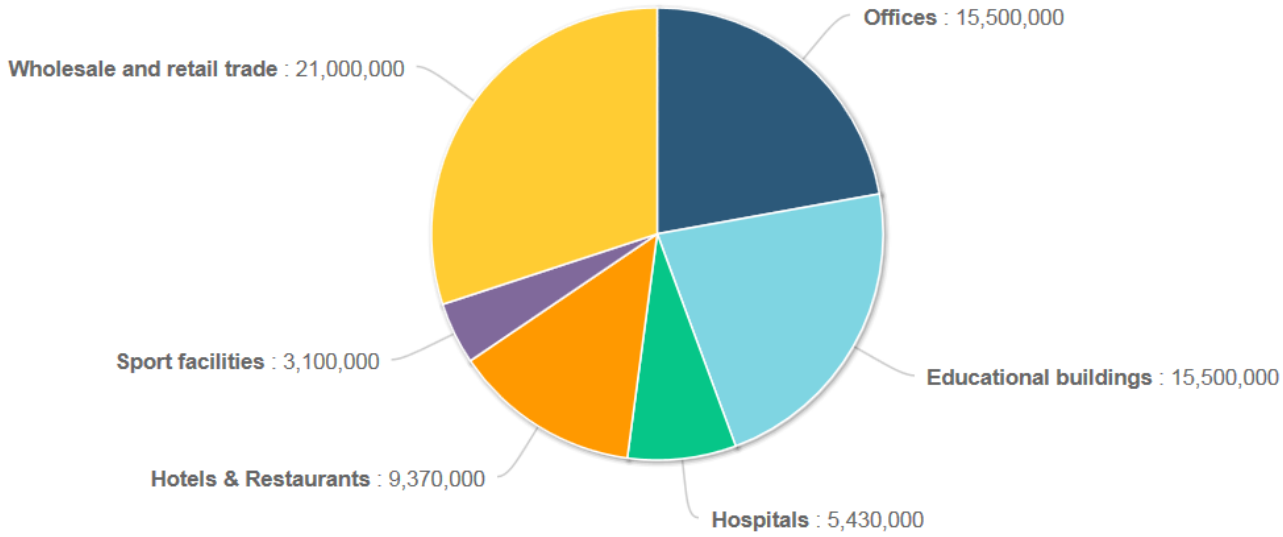


Figure 10: Breakdown of the building stock (in m^2) by building types, Austria.

Detailed data about electricity consumption is available for the tertiary sector, which accounts for a fraction of the non-residential buildings. The consumption of this sector can be divided as shown in Figure 11 (Statistic Austria, 2012) (Statistik Austria, BMWFJ, Lebensministerium, & E-control, 2011). The numbers are based on a study in 12 000 companies, corresponding to 9,6% of the tertiary sector.

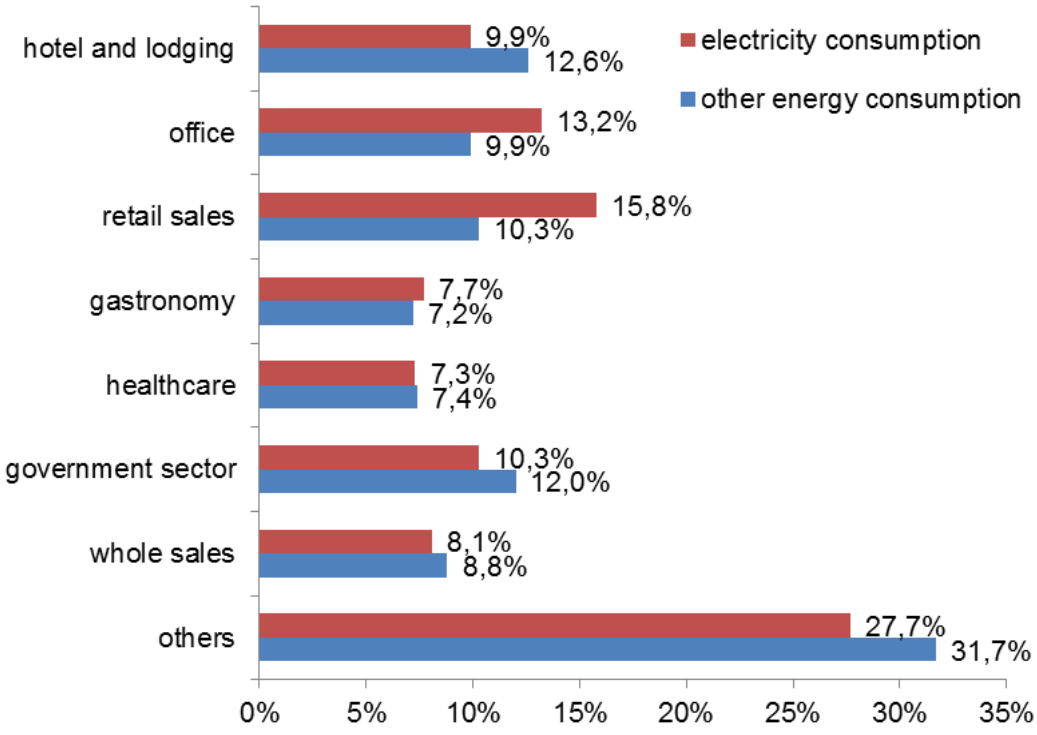


Figure 11: Electric and other energy use for different building types in Austria.

When comparing normalized lighting electricity consumption values per square meter, food stores and gastronomy are the highest consuming types in the tertiary sector, see Figure 12 (Kapusta, Jandrokovic, & Mandl, 2012). These data are based on a small study with sample sizes between 71 and 225 companies.

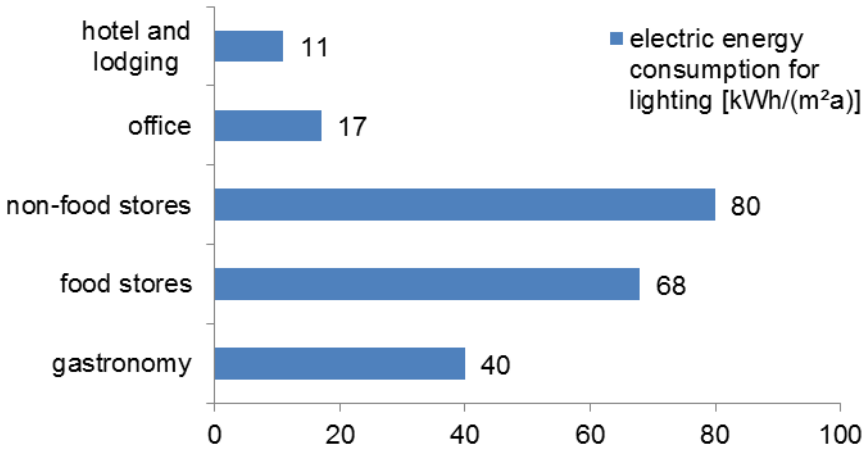


Figure 12: Average electric energy consumption for lighting in the tertiary sector in Austria.

Figure 13 shows the electricity consumption according to building types in the non-residential building sector. Overall, lighting is an important energy end-use in all types of buildings. Lighting accounts for 18% (gastronomy) to 53% (non-food stores) of the electric energy consumption. Non-food stores, food stores and gastronomy use 86, 58 and 54 kWh/m²a, respectively, only for lighting.

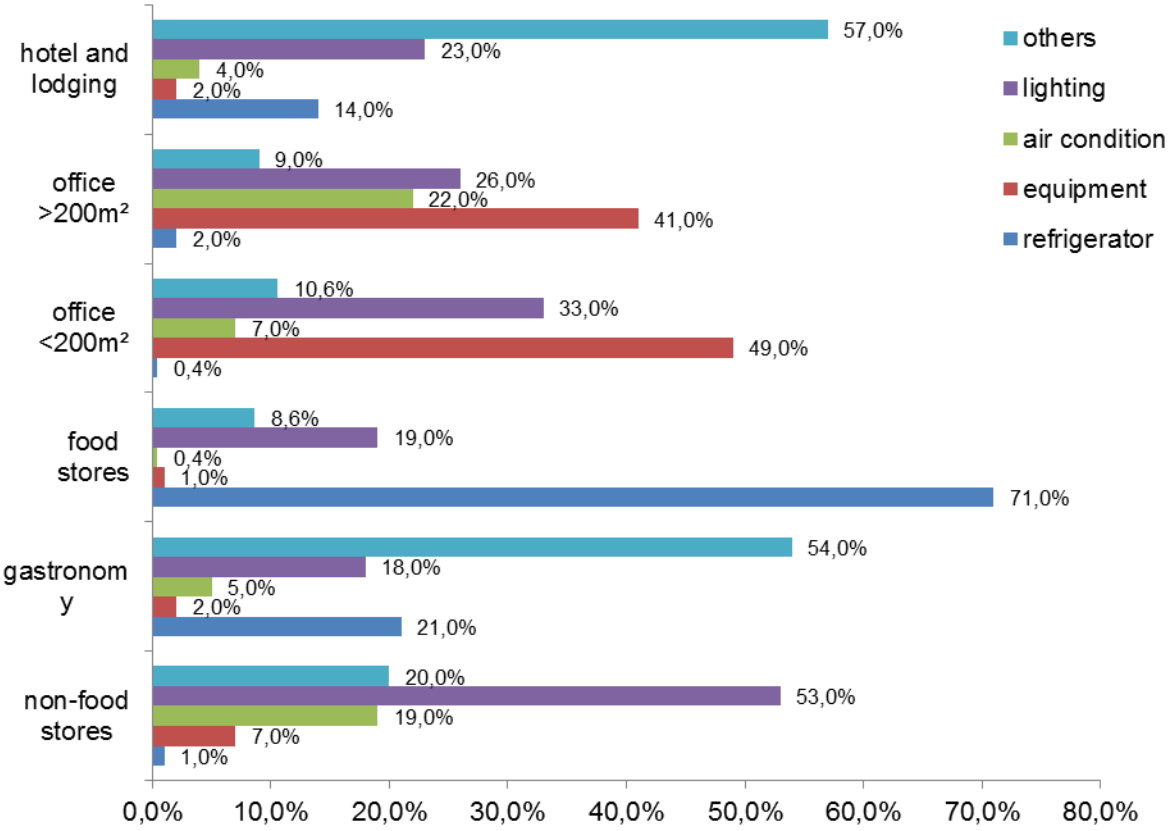


Figure 13: Electricity use per building type in the non-residential sector in Austria.

In residential buildings,10,7% of the electric energy consumption is used for lighting (Statistik Austria, Energiestatistik: Strom- und Gastagebuch, 2012) compared to 18 -53% in the tertiary sector. This shows the enormous potential for lighting retrofits in non-residential buildings.

2.2.2. Belgium

According to the ENPER-EXIST project (Thomsen, Wittchen, Jensen, & Aggerholm, 2007), statistics for non-residential buildings exist in Belgium about the following types:

- Commercial buildings
- Hotels and restaurants
- Offices and administrations
- Education
- Health and related services
- Other types of services
- Swimming pools (only for some regions).

The BPIE presents data concerning the total floor area in the non-residential sector for Belgium, see Figure 14 (BPIE, 2013). This figure indicates that the type “wholesale and retail trade” is dominant in Belgium, closely followed by “offices” and “educational buildings”.

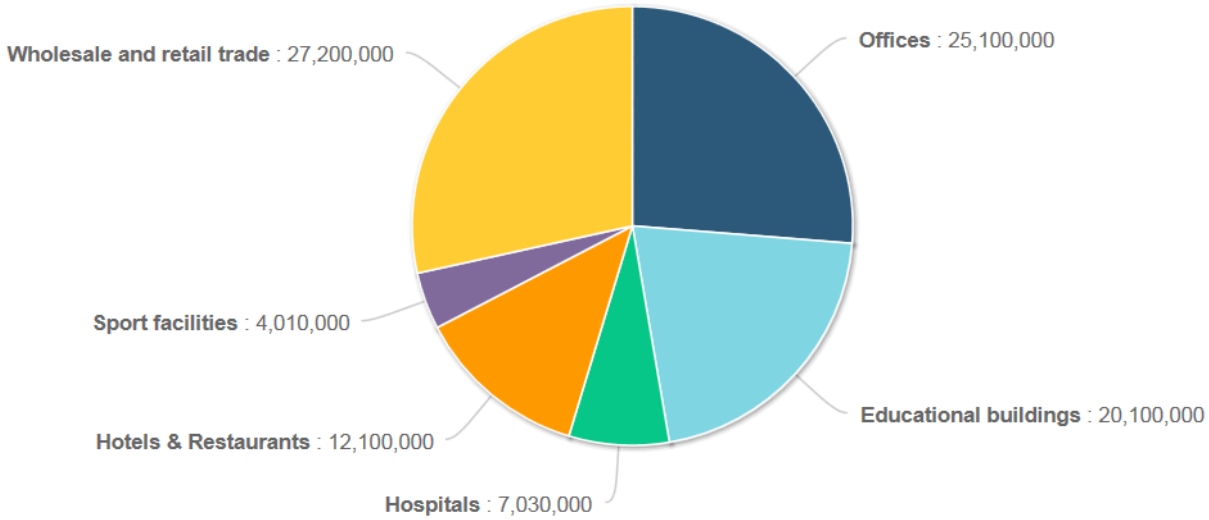


Figure 14: Breakdown of the building stock (in m2) by building types, Belgium.

National documentation also presents data about energy use for lighting by building type, see Figure 15 and Table 2 (LABORELEC, 2007). Figure 15 shows, that a large portion of energy use is devoted to lighting in schools compared with most other building types, where the proportion of energy use for lighting varies from 37-47%. Surprisingly, electric lighting in industry only represents about 10% of total energy use. Note that these numbers are difficult to interpret since energy use is presented in relative terms.

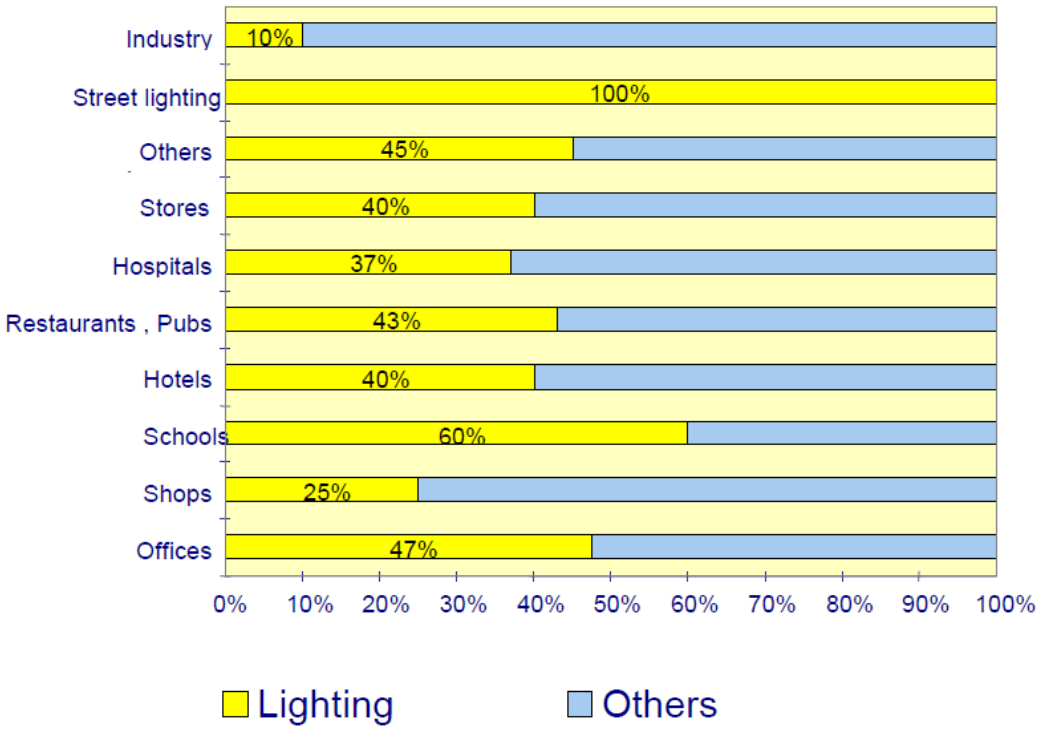


Figure 15: Relative energy use for lighting in Belgium.

Table 2: Energy use for lighting and other end-uses in Belgium.

Use of electrical energy in Belgium [%]						
	Lighting	Airconditioning	Refrigeration	Pumps	Warm water	Others
Hotels and restaurants	40,7	11,2	16,9	5,5	3,4	22,2
Hospitals	37,4	32,3	7,8	5,8	3,6	13,1
Schools	59,1	19,7	1	9,8	3,3	7,1
Services To people	68,5	4,5	6,5	3,4	3,7	13,4
Offices Administrations	47,2	19,3	1	4,5	3,9	24,1
Shops	39,8	19,9	23,5	5,5	5,1	6,2
Totaal tertiaire sector	**45,8**	**18,7**	**11**	**5,3**	**4,2**	**15**

2.2.3. Bulgaria

Bulgaria is not officially involved in the IEA Task50 but some data from the TABULA project (TABULA, 2012) can be presented here. According to one report of the TABULA project, the

following types have been considered separately in Bulgaria due to specific use, type of construction and installations:

- Industrial buildings (production buildings, energy buildings, warehouses, etc)
- Office buildings
- Commercial buildings (shopping centres and malls, retail centres, chains)
- Educational buildings (including kindergartens, schools, universities)
- Hotels
- Health buildings (hospitals, clinics, sanatoriums)
- Other buildings (agricultural, religious, sport, transport, catering)

Moreover, the BPIE presents data about the building stock distribution (Figure 16) as well as energy intensity for electric lighting (Figure 16). Figure 16 shows that “offices” are clearly dominant in Bulgaria, followed by “wholesale and retail trade” and “educational buildings”. Furthermore, Figure 17 shows that the energy intensity for electric lighting is highest for “hospitals”, followed by “wholesale and retail trade” and “offices”.

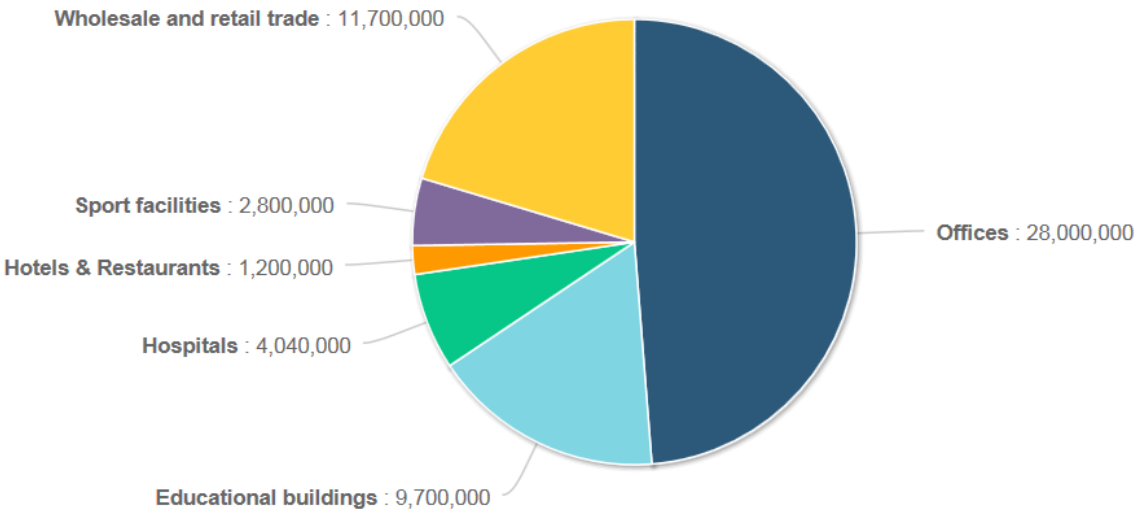


Figure 16: Breakdown of the building stock (in total m2) by building types, Bulgaria.

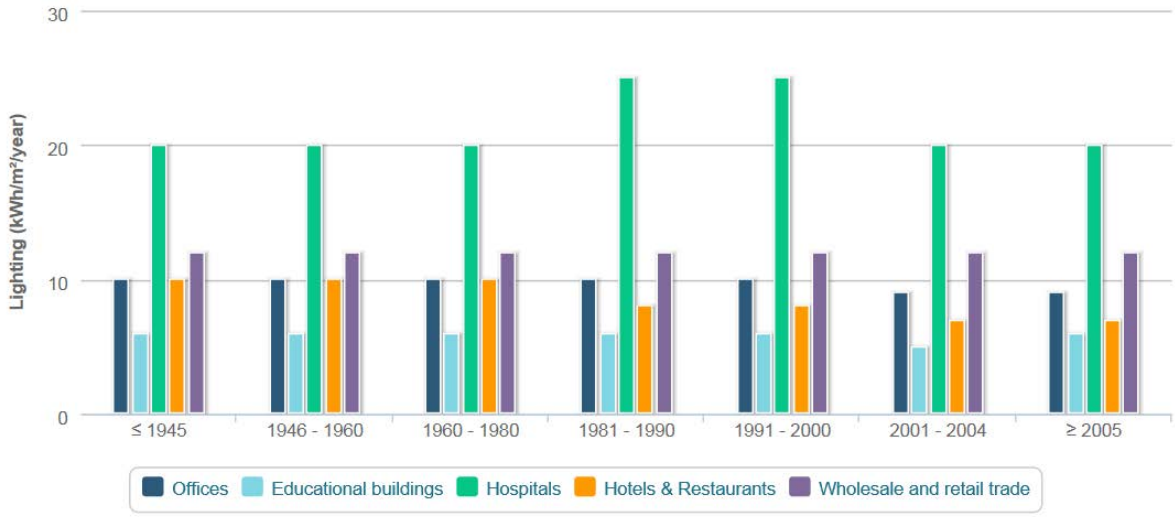


Figure 17: Energy intensity for electric lighting according to building type and age group, Bulgaria.

2.2.4. Canada

Statistics Canada has undertaken annual energy use surveys of the commercial and institutional building stock since 2000, with the latest published data in 2013 covering the 2009 year. These statistics are based on an indirect sample approach using existing lists of establishments and selected buildings (Isaacs & Hills, 2013).

The data on energy use available via Natural Resources Canada website is condensed in Figure 18 (Natural Resources Canada, 2010). This figure, which presents the energy consumption for year 2010 by building type, shows that energy use is highest for “offices”, followed by “retail trade”, “educational services”, “health care and social assistance”, etc. According to information found on the website, the building type called “offices” includes activities related to finance and insurance; real estate and rental and leasing; professional, scientific and technical services; public administration; and others.

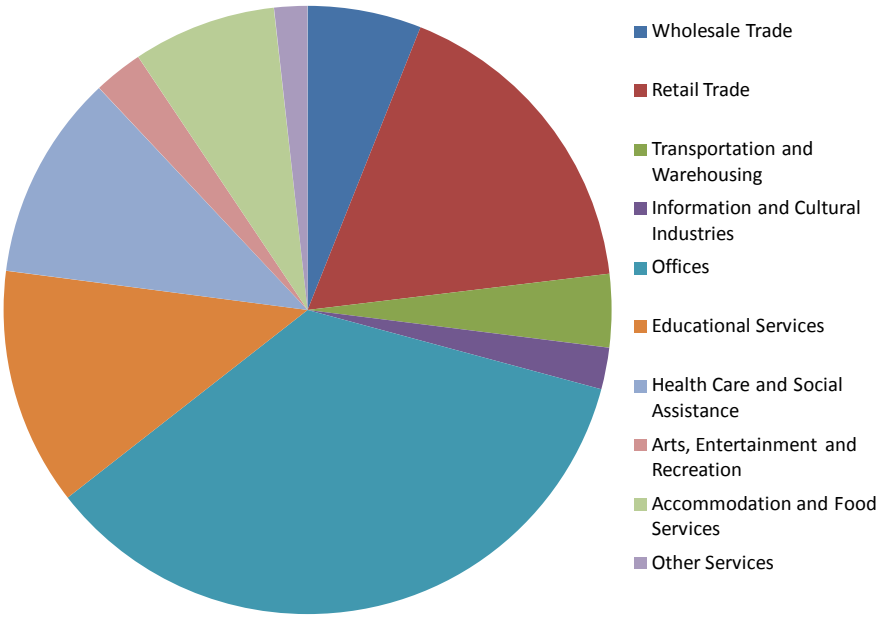


Figure 18: Energy use by building type, Canada.

2.2.5. Czech republic

Although the Czech Republic is not officially involved in this IEA Task 50, data about the non-residential building stock distribution is available in the BPIE data hub, see Figure 19 (BPIE, 2013). This figure shows that “offices” are clearly dominant, followed by “wholesale and retail trade” and “educational buildings”.

Data about energy intensity of electric lighting is also available on the BPIE data hub, see Figure 20 (BPIE, 2013). This figure shows that “hospital” have the highest energy intensity for lighting, followed by “wholesale and retail trade”. The type “educational buildings” generally have the lowest energy intensity for lighting, which is line with similar data from other countries.

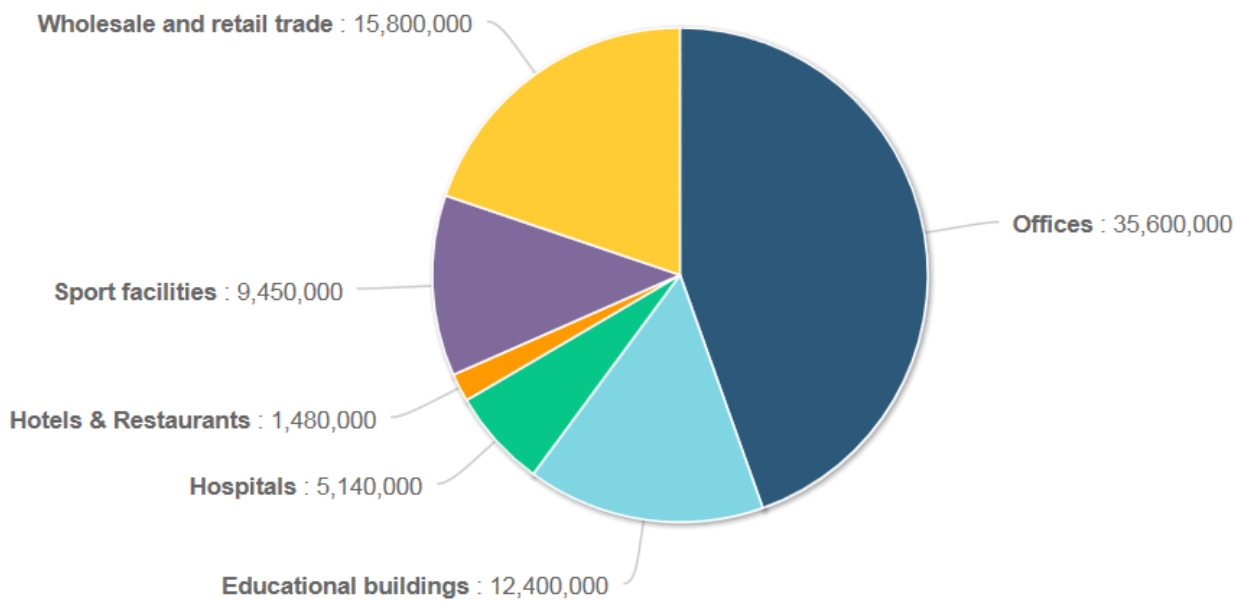


Figure 19: Breakdown of the building stock (in total m2) by building type, Czech Republic.

Figure 20: Energy consumption for lighting according to building type and age group.

2.2.6. Denmark

Figure 21 and Figure 22 present the distribution of the total floor area for the main building types in Denmark, according to publicly available statistical data (Danmarks statistik, 2012). These figures show that agriculture buildings represent a very large share of buildings in Denmark i.e. they cover 42,8% of the total non-residential building stock, followed by industrial buildings and offices with 19,3% and 17,3%, respectively. The remaining 20% of the non-residential building sector is distributed between the remaining building types, i.e. schools, trade buildings, hotels, hospitals, etc.

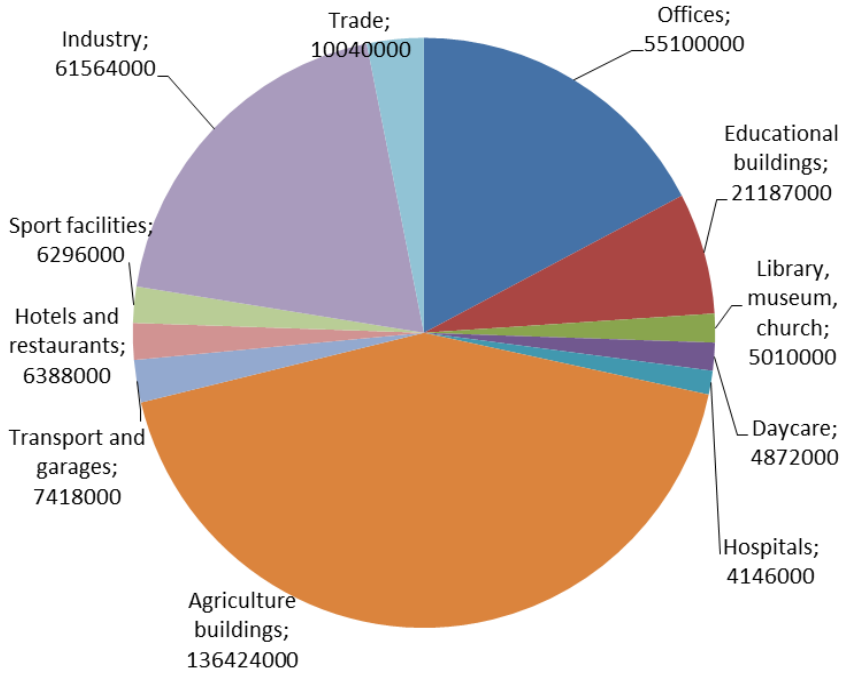


Figure 21: Breakdown of the building stock (in total m^2) by building types in Denmark 2013.

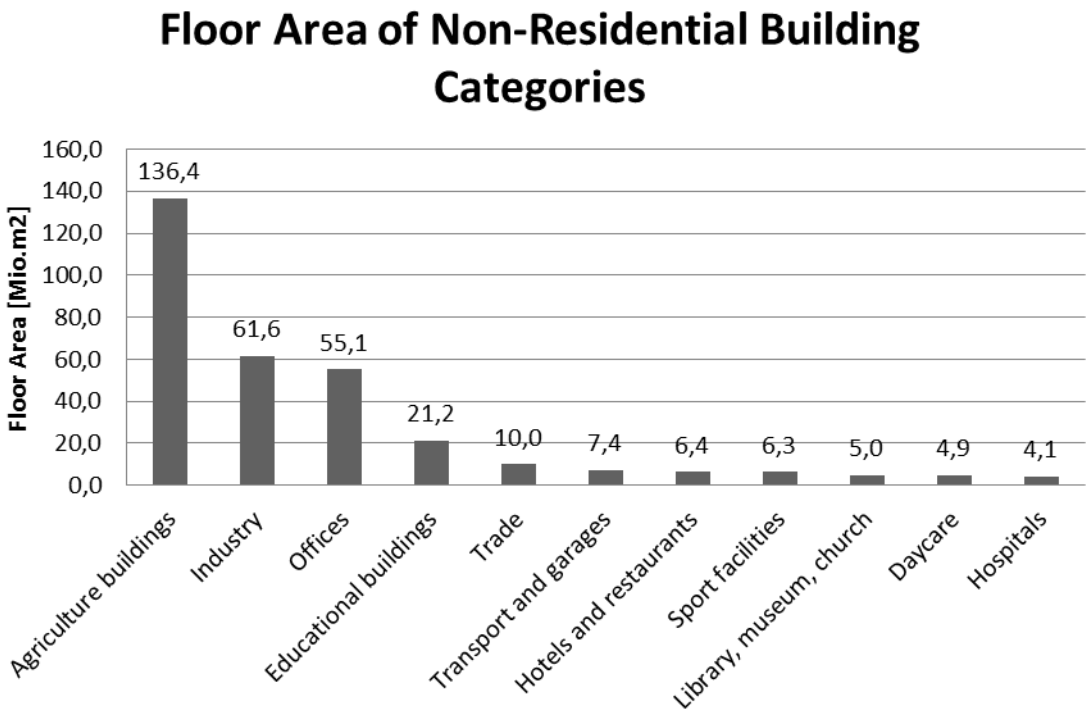


Figure 22: Distribution of floor area among the non-residential building sector in Denmark 2013.

Table 3 (Danmarks statistik, 2011) shows the total floor area in m^2 and their percentage in the different categories, while Table 4 shows the number of buildings in the various categories (Danmarks statistik, 2011). This table shows that office buildings are more numerous than industrial buildings. The data indicates that industrial buildings are generally larger than office buildings since a larger area is covered with fewer buildings.

Table 3: Distribution of floor area for non-residential buildings in Denmark 2013.

Categories of Non-Residential buildings	**Floor Area 2013**	
	[Mio. m²]	[%]
Agriculture buildings	136.4	42.8%
Industry	61.5	19.3%
Office/administrative buildings	55.1	17.3%
Educational Buildings	21.2	6.7%
Trade	10.0	3.2%
Transport and garages	7.4	2.3%
Hotels and restaurants	6.4	2.0%
Sport facilities	6.3	2.0%
Library, museum, church	5.0	1.6%
Daycare	4.90	1.5%
Hospitals	4.1	1.3%
Total	318.4	100%

Table 4: Number of buildings in the non-residential sector in Denmark.

Categories of Non-Residential buildings	**Number of buildings 2013**	
	[Number]	[%]
Agriculture buildings	452 701	73.6%
Office/administrative buildings	75 673	12.3%
Industry	67 875	11%
Educational Buildings	18 769	3.1%
Total	615018	100%

Figure 23 presents the total floor space for the main building types in Denmark, according to another source (BPIE, 2013). This figure does not include agriculture and industrial buildings. It shows that the category “offices” is clearly dominant, followed by “educational buildings”, which is in line with the previous data. The type “whole sale and retail trade” comes in the third place, as in previous figures but the shares seem to be somewhat different. Other categories represent a smaller share of the total floor area of the non-residential building sector in Denmark.

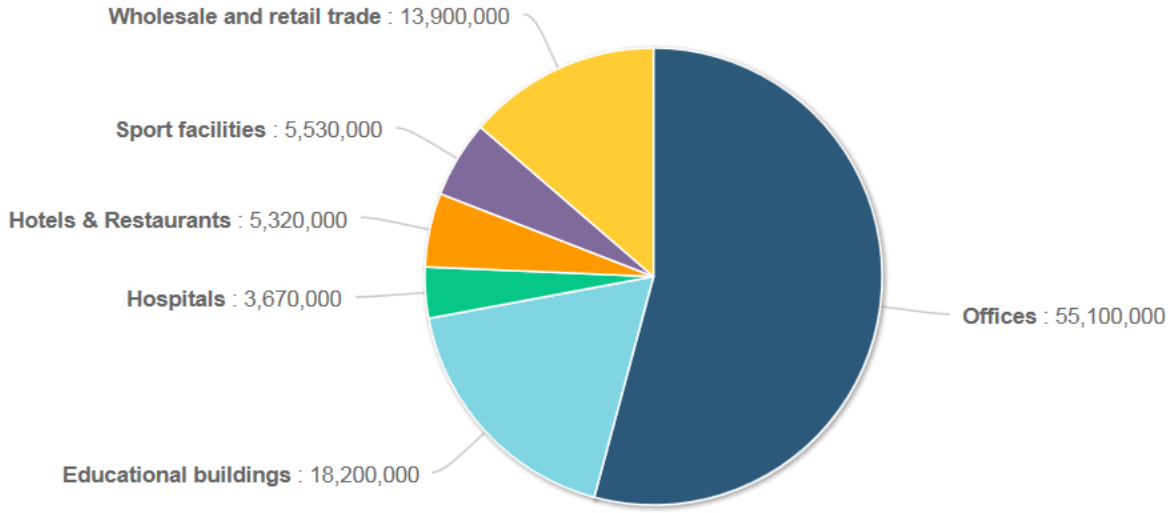


Figure 23: Breakdown of the building stock by building types, Denmark.

Data for the non-residential building stock in Denmark can also be found in the report of the ENPER-EXIST project see Table 5 (Thomsen, Wittchen, Jensen, & Aggerholm, 2007). The areas reported are slightly different but generally in line with data presented in Figure 23. Data from the ENPER-EXIST project are from before 2007. Note that the area reported for “factories/workshops” is about as large as the area for “offices” while the area for “farm houses” is more than twice larger than the area for “offices”. This shows that agricultural buildings occupy a very large area and should perhaps be considered.

Figure 24 shows the total electricity consumption for different building types, with industrial buildings using the biggest amount of electricity followed by trade and services (Danmarks statistik, 2011).

Figure 25 shows the percent share of energy used for lighting, according to building type (Energiwiki, 2013). This figure shows that education buildings and offices and administration use proportionately large amounts of energy for lights. In Figure 26, the total energy use (in TJ) for lighting is presented, showing that trade and services use a high amount of energy for lighting in absolute values (Danmarks statistik, 2011). Finally, Figure 27 shows the energy intensity for lighting according to building type (Danmarks statistik, 2011) (Energiwiki, 2013) (Munck & Clausen, 2008) (Energi styrelsen, 2011). In this figure, trade and services are also a dominant sector.

Table 5: Building stock characteristics, energy consumption and potential savings for the non-residential building stock in Denmark.

		Building stock characteristics				Energy consumption					Potential energy savings	
		number of 1000*buildings	area * 1000 m²	% of total area	Information source	Heating [kWh/m²]	Cooling [kWh/m²]	Domestic hot water [kWh/m²]	Electricity [kWh/m²]	Information source	Savings [PJ]	Information source
dk	**Non residential**											
	Offices	73.5	62171	18.2	statistikba	277			112	ENS		
	Education	18.2	23519	6.5	statistikbanken							
	Hospitals/health care		3829	1.2	statistikbanken							
	Hotels/restaurents		5946	1.9	statistikbanken							
	Farm houses		134175	43.3	statistikbanken							
	Factories/workshops	70.9	55420	17.1	statistikba	584			175	ENS		
	Other											
	Supply buildings		3415	1.1	statistikbanken							
	Other production		3900	1.3	statistikbanken							
	Transport and garage		5522	1.8	statistikbanken							
	Unspec transp.& trade		1208	0.4	statistikbanken							
	Library, museum, church		4490	1.4	statistikbanken							
	Daycare		3163	1	statistikbanken							
	Un-spec. institution		3299	1.1	statistikbanken							
	Unspec. holyday		746	0.2	statistikbanken							
	Sports facilities		5277	1.7	statistikbanken							
	Unspec. lesure act.		1668	0.5	statistikbanken							
	Total non-residential		**317848**									

BBR	Extract of residential buildings from the Danish Building register for to investigate the composition of Danish residential buildings to be able to evaluate the potential energy savings by refurbishment.
Statiskikbanken	www.statistikbanken.dk free of charge on-line information from Statistics Denmark.
EM	Energy labelling scheme for small buildings. Have been running in Denmark from 1996 to 2005. A building should be labelled when is was sold if a current label was more than 5 years old or not existing.
ENS	Free information source on www.ens.dk about energy consumption on different sectors.
SBi 057	SBi 057: Ananysis of the heating saving potential in exiting dwellings (In Danish). Danish Building Research Institute. By og Byg Documentation 057.

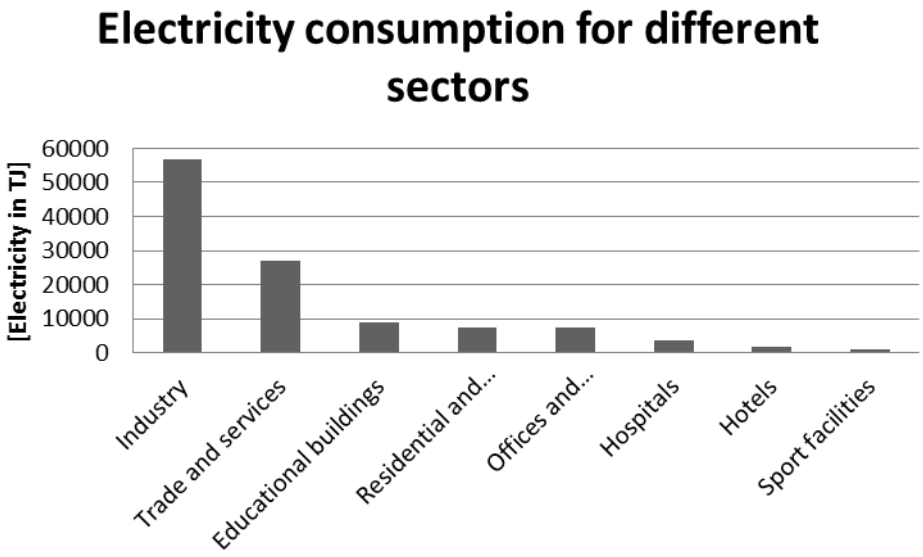


Figure 24: Distribution of Electricity consumption in various sectors in 2011.

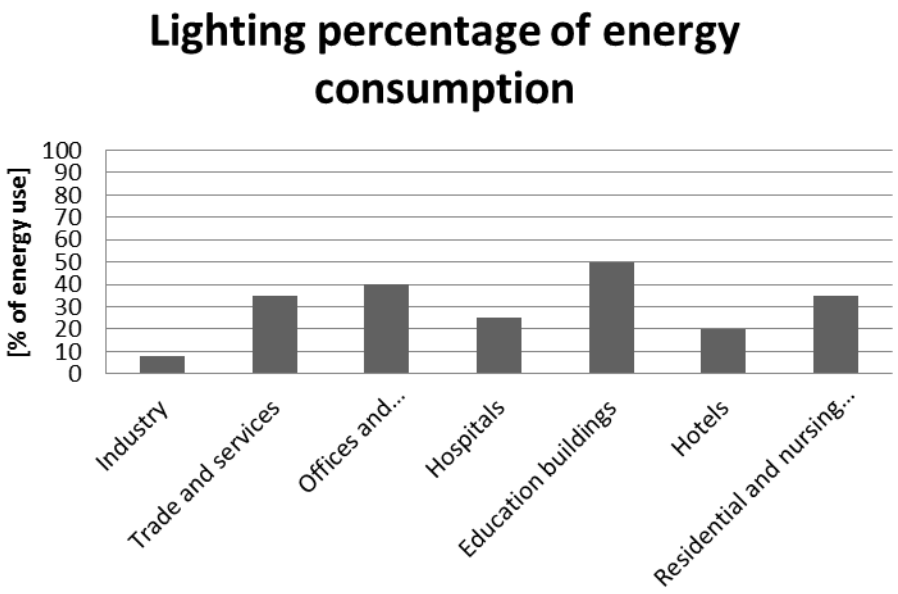


Figure 25: Distribution of light consumption share in various sectors.

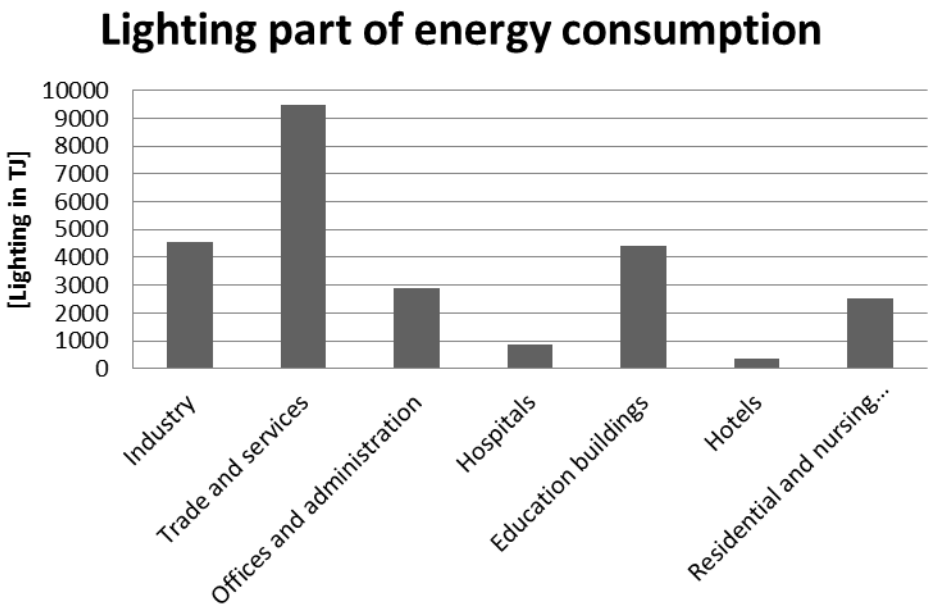


Figure 26: Energy used for light in various sector in 2011.

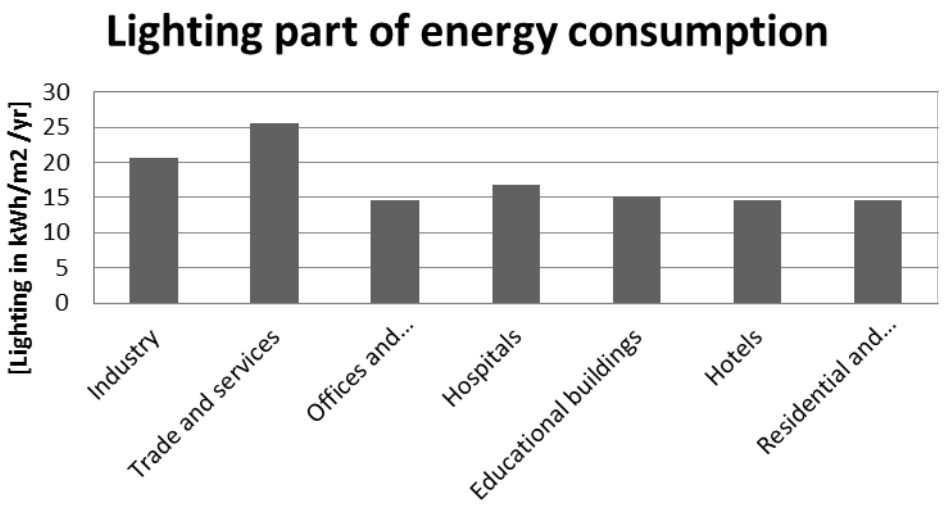


Figure 27: Energy use intensity for lighting in various sectors in 2000.

2.2.7. Finland

Figure 28 presents data about the non-residential building stock distribution for Finland, from the BPIE data hub (BPIE, 2013). This figure shows that the category “wholesale and retail trade” is clearly dominant in Finland, followed by “offices” and “educational buildings”.

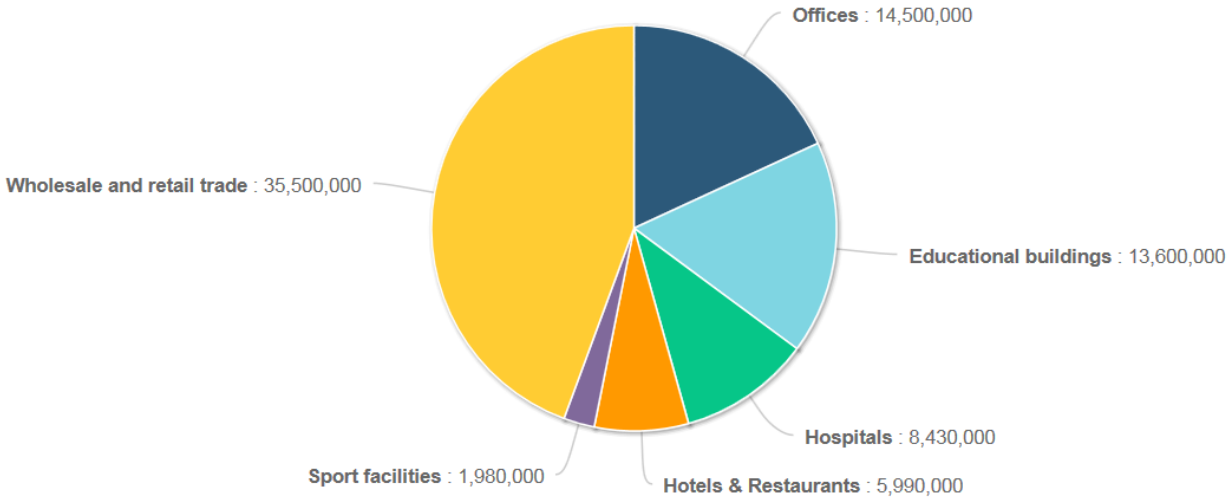


Figure 28: Breakdown of the building stock (in total m2) by building type, Finland.

In addition, another source (Official statistics Finland, 2012) provides data about the number and areas of the Finnish building stock for year 2012, see Table 6. Although the numbers differ, the wholesale and retail trade sector is still dominant.

Regarding energy use for electric lighting, the BPIE data hub presents incomplete data, see Figure 29 (BPIE, 2013). This figure, although incomplete, shows that energy intensity for electric lighting is higher for “offices” than for “educational buildings”, which is generally in line with data found for other countries. Note that the lower values obtained for educational buildings might be due to the fact that many schools are not used during the summer.

Table 6: Finnish building stock distribution in 2012.

Building type	Number of buildings	Floor space (m^2)
One family houses	1 122 315	156 380 401
Raw house	77 931	33 187 176
Block of flats	57 849	92 514 761
Commercial	42 580	28 320 836
Offices	10 907	19 229 947
Traffic related buildings	55 915	12 159 931
Hospital, caring	8 414	11 677 272
Meeting places	13 826	9 140 984
Education	8 916	18 104 779
Industry	41 799	47 958 684
Warehouses	28 582	18 946 162
Others	5 619	1 898 009
Total	1 474 653	449 518 942

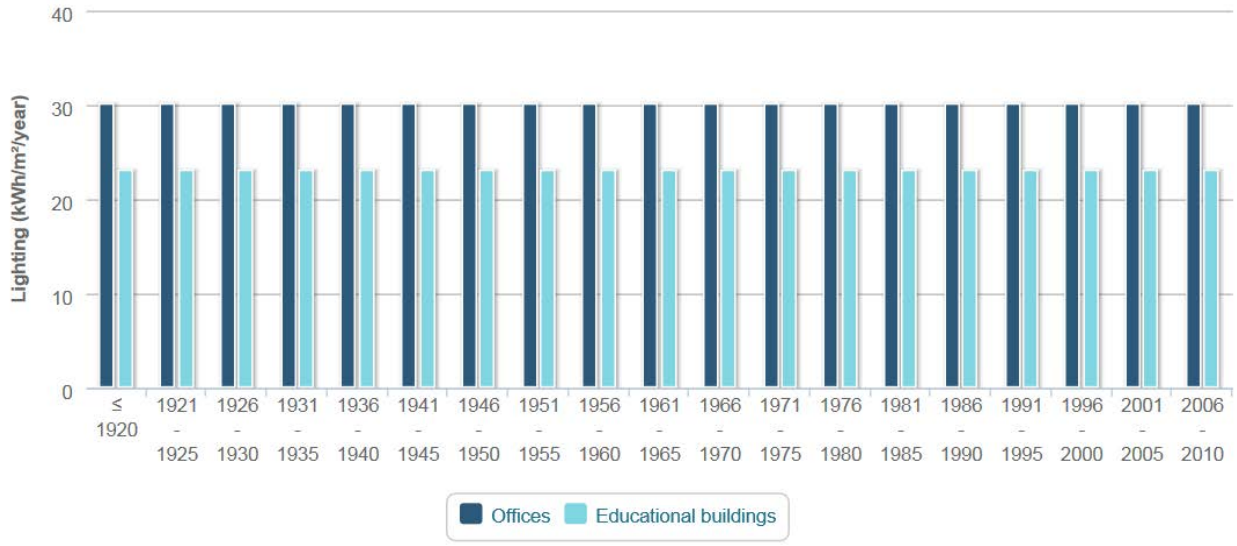


Figure 29: Energy intensity for electric lighting for the non-residential Finnish building stock.

Other information can be found in the Finnish energy performance of buildings calculation method as presented in Table 7 (Ministry of the Environment, 2007). This table generally gives an overview of how Finland structures the residential and non-residential buildings sectors. Note that these figures can be used in the calculation of energy consumption of a building, if no other information is available. Also, the values given for energy intensity (kWh/brutto m^2 yr) are generally in line with data obtained for the existing building stock in other countries. For example, educational buildings have generally lower energy intensity than offices; hospitals and sports buildings generally have a high energy intensity, which is higher than offices, etc. The last column shows the number of hours of use, which are used in the calculation in different buildings.

Table 7: Energy consumption of buildings according to Finnish energy performance of buildings calculation method.

Building type	Total (kWh/br m^2/yr)	Lighting (kWh/br m^2/yr)	Air conditioning (kWh/br m^2/yr)	Equipment (kWh/br m^2/yr)	Usage (h/yr)
Single family house	50	7	10	33	550
Row houses	50	7	7	36	550
Block of flats	50	7	7	36	550
Office	70	30	12	28	2 500
Education	60	23	12	25	1 900
Commercial	80	48	17	15	4 000
Hotel	110	60	17	33	5 000
Restaurant	110	42	36	32	3 500
Sports	180	60	41	79	5 000
Hospital	100	60	28	12	5 000
Others	100	30	11	59	500

2.2.8. France

Data for France can be found from the BPIE data hub see Figure 30 (BPIE, 2013). This figure shows that the “offices”, “educational buildings” and “wholesale and retail trade” are the three dominant building types in France, each taking about a quarter of the non-residential stock, followed by “hospitals”.

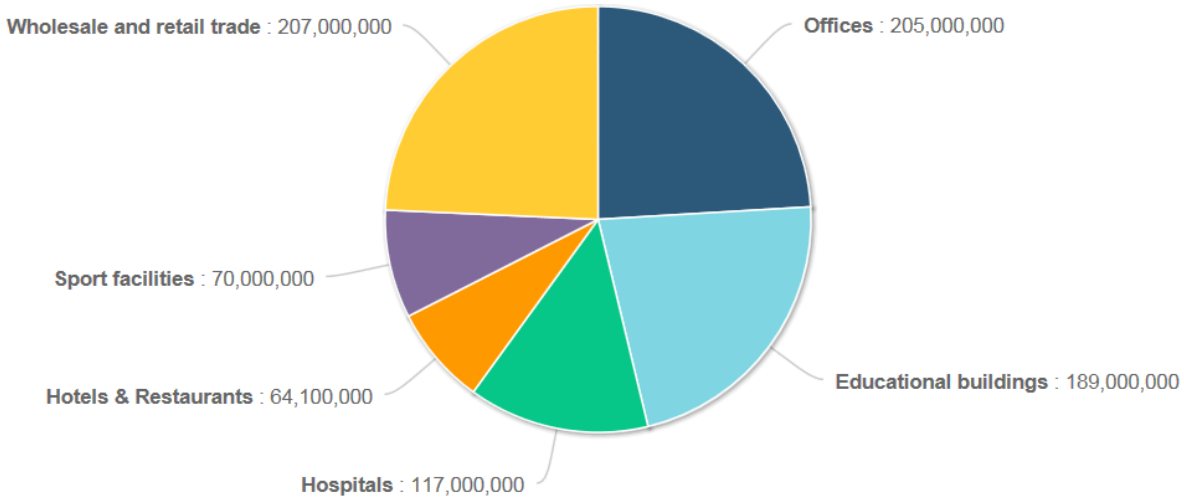


Figure 30: Breakdown of the building stock (in total m2) by building type, France.

Data for France can be also found from the ENPER-EXIST project (Thomsen, Wittchen, Jensen, & Aggerholm, 2007), see Table 8. This table shows slightly different numbers compared to the ones presented in Figure 30 but the “offices”, “education” and “commercial” building types are still dominant, each covering about an equivalent floor area.

Table 8: Building stock characteristics, energy consumption and potential savings for the non-residential building stock, France.

		Building stock characteristics				Energy consumption					Potential energy savings	
		number of 1000*buildings	area * 1000 m²	% of total area	Information source	Heating [kWh/m²]	Cooling [kWh/m²]	Domestic hot water [kWh/m²]	Electricity [kWh/m²]	Information source	Savings [PJ]	Information source
fr	**Non residential**											
	Offices		176912		1	166						
	Education		168148		1	118						
	Hospitals/health care		95983		1	155						
	Hotels/restaurents		55191		1	179						
	Farm houses											
	Factories/workshops											
	Other											
	commercial		190625			119						
	Transport		24477			167			126			
	Other		54145			128			159			
	sport					146			61			
	Total non-residential		**190625**			**141**			**83**			

1 CEREN (in Chiffres clés du bâtiment 2nergie - Environnement, édition 2004-ADEME)

2.2.9. Germany

In Germany, there is no elaborate monitoring of the non-residential building stock and no statistical data is available about the total number of non-residential buildings (TABULA, 2012). The data about the existing building stock is quite different in quality and availability in the residential and non-residential sectors. Whereas extensive information about the residential building stock exists, the non-residential building stock is not covered very well yet.

The BPIE data hub presents some data about the non-residential building stock distribution, see Figure 31 (BPIE, 2013). This figure shows that the types “wholesale and retail trade” and “offices” are clearly dominant, followed by “hotels and restaurants” and “educational buildings”. Unfortunately, no data about electric lighting is available in BPIE data hub for Germany.

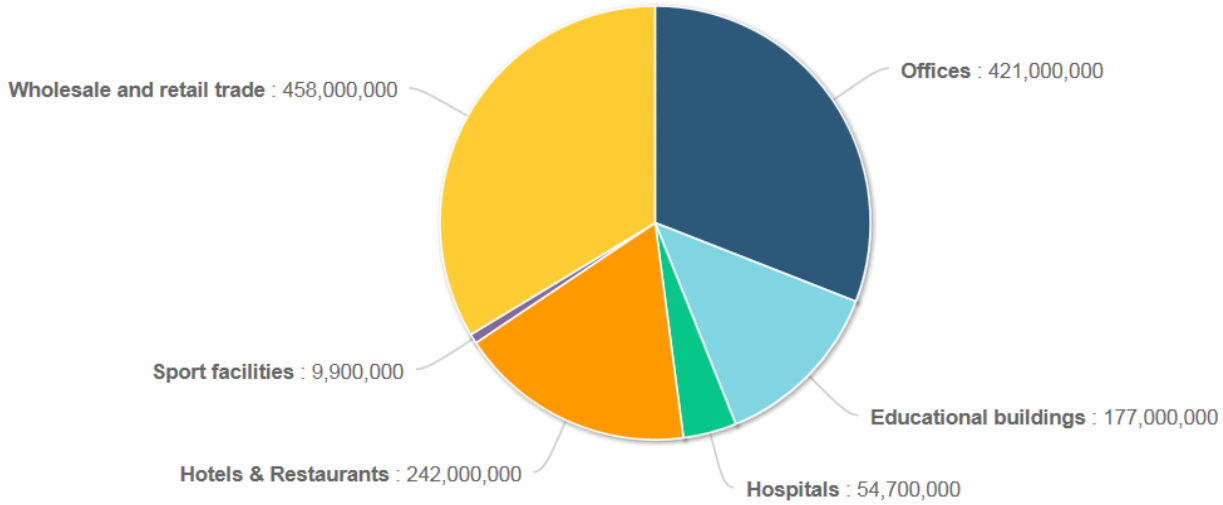


Figure 31: Breakdown of the building stock (in total m2) by building type, Germany.

Some data can also be found from the ENPER-EXIST project (Thomsen, Wittchen, Jensen, & Aggerholm, 2007). The data about floor area for different types of non-residential buildings differ from the numbers presented by BPIE (BPIE, 2013), compare data in Figure 31 and Table 22. In particular, the numbers for “Hotels and restaurants” is much smaller in Table 9 than in the BPIE data, see Figure 31. Note also that the area reported for “Factories /workshops” is approximately as large as the area reported for “offices”, which is missing in the BPIE data.

Table 9: Building stock characteristics, energy consumption and potential savings for the non-residential building stock, Germany.

		Building stock characteristics				Energy consumption					Potential energy savings	
		number of 1000*buildings	area * 1000 m²	% of total area	Information source	Heating [kWh/m²]	Cooling [kWh/m²]	Domestic hot water [kWh/m²]	Electricity [kWh/m²]	Information source	Savings [PJ]	Information source
de	**Non residential**											
	Offices	678	338800	36%	3 + 2	120	0		25	4		
	Education	40	144500	16%	3 + 2	160	0		16	4		
	Hospitals/health care	31	93800	10%	3 + 2	22880	0		5100	5		
	Hotels/restaurents	11	37300	4%	3 + 2	222	0		84	4		
	Farm houses	N/A	N/A			372	0		62	4		
	Factories/workshops	793	313200	34%	3 + 2	170	0		45	4		
	Other											
	Swimming halls					2223			597	4		
	Total non-residential	**1553**	**926600**									

1 Reiß, J. and Erhorn, H.: Stand und Tendenzen der Neubautätigkeit in Deutschland - Analyse und Ent-wicklung energierelevanter Gebäudekenndaten". gi - Gesundheits-Ingenieur 115 (1994), Heft 5, Seite 233-246.
2 Clausnitzer, D.: Potenzial and Fachleuten zur Umsetzung der GebäudeRL. Bremer Energie Institut ITB, 2005.
3 Gierga, M. and Erhorn, H.: Bestand und Typologie beheizter Nichtwohngebäude in Westdeutschland. IKARUS-Bericht 5-14. Forschungszentrum Jülich GmbH, Jülich (1994).
4 Richtlinie zur Ermittlung von Vergleichswerten für den Energieverbrauch von Nichtwohngebäuden im Rahmen des Feldversuchs der Deutschen Energie-Agentur. Herausgeber: Bundesministerium für Ver-kehr, Bau- und Wohnungswesen. Berlin (2005)
5 VDI-Richtlinie 3807-2: Energieverbrauchskennwerte für Gebäude. Heizenergie- und Strom-verbrauchskennwerte. Beuth-Verlag, Berlin (1998).

In addition, the Federal Bureau of Statistics provides detailed information on an annual basis about the number of existing buildings or businesses, but not including information about the floor area covered. In addition, yearly information about newly built and demolished buildings is published. All this information goes back several years, but rarely before the 1990’s. Besides, statistical information about the total areas of open space and estate are available. According to these statistics, 3.3 billion square meters of floor area were used within the non-residential building sector in 2011 (Federal Bureau of Statistics, ????) (Statistics, 2012).

Furthermore, some estimates about floor area and distribution of different building categories exist, though covering different scopes, applying various definitions and presenting different years (from 1991 to 2010) (BPIE, 2011) (Federal Ministry of Transport, 2011) (Kohler, Hassler, & Paschen, 1999).

All the information mentioned above was combined in Figure 32, giving an overview of the building stock distribution for the non-residential sector in Germany. Besides the existing data, the respective mean values thereof are presented.

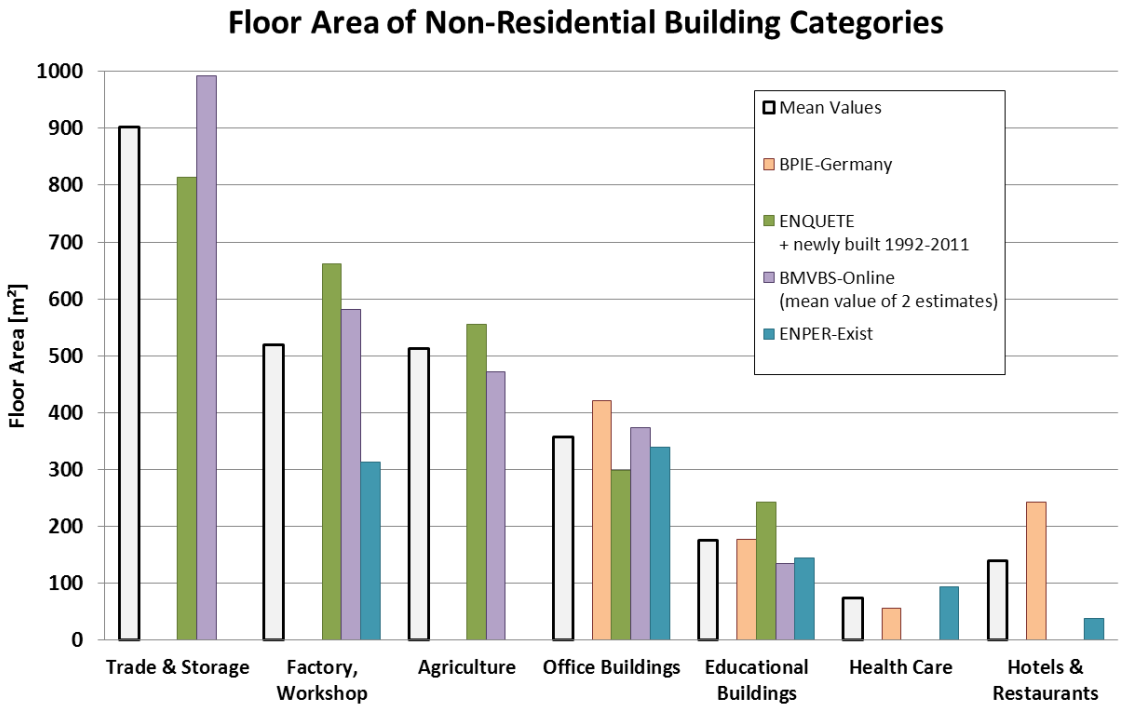


Figure 32: Bar chart illustrating the distribution of floor area in the non-residential building sector according to each category, as given by different sources and the mean value thereof.

These mean values are presented in Table 10, which describes the distribution of non-residential buildings in Germany, when referring to a floor area, altogether covering 3.3 bn. m². The numbers are quite different from the ones published by the BPIE data hub the "trade and storage" and "office" sectors are still quite dominant. Data for agriculture and industrial buildings also show that these building types represent very large and important building areas, as was the case for Denmark.

Table 10: Distribution of non-residential buildings in Germany.

Categories of Non-Residential Buildings	**Floor Area**	
	(Mio.m²)	**(%)**
Trade and Storage	902	27
Industry (Factory, Workshop)	518	16
Agriculture	513	16
Office Buildings	358	11
Educational Buildings	175	5
Health Care	74	2
Hotels and Restaurants	140	4
Other	620	19
SUM	3 300	100

Figure 33 illustrates the resulting percentage distribution of the German non-residential building stock.

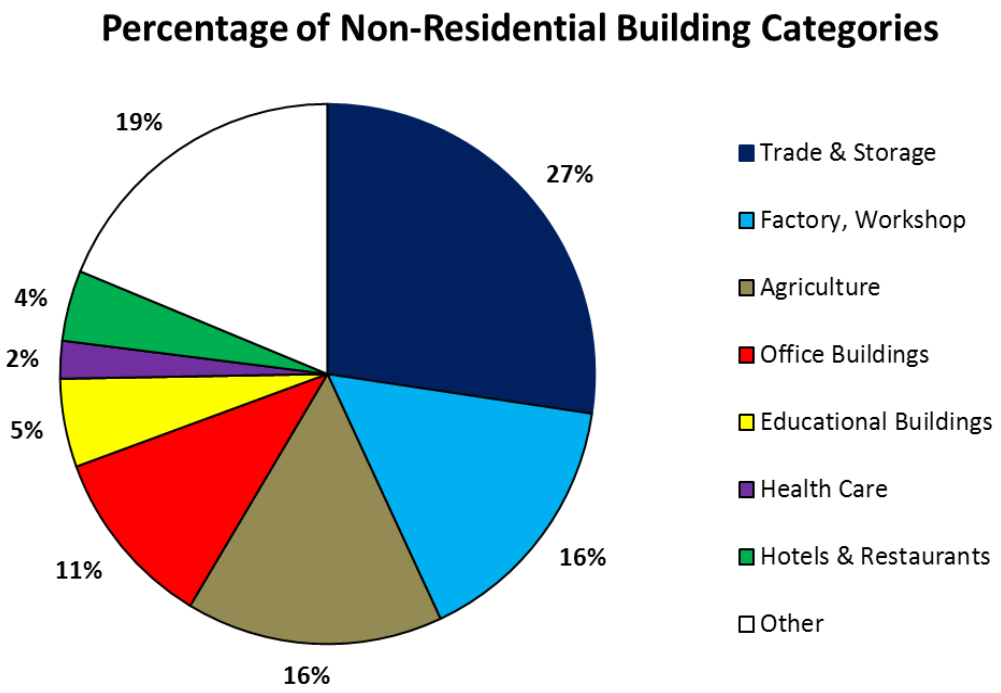


Figure 33: Pie chart illustrating the building stock distribution on a percentage basis.

Data about relative electricity consumption is also available; see Figure 34 and Figure 35 (Ziesing, 2013). These figures generally show that electricity use for lighting is relatively less important in the industrial sector, as shown by the Belgian data, see Figure 15. Lighting is however very significant in the trade and services sector.

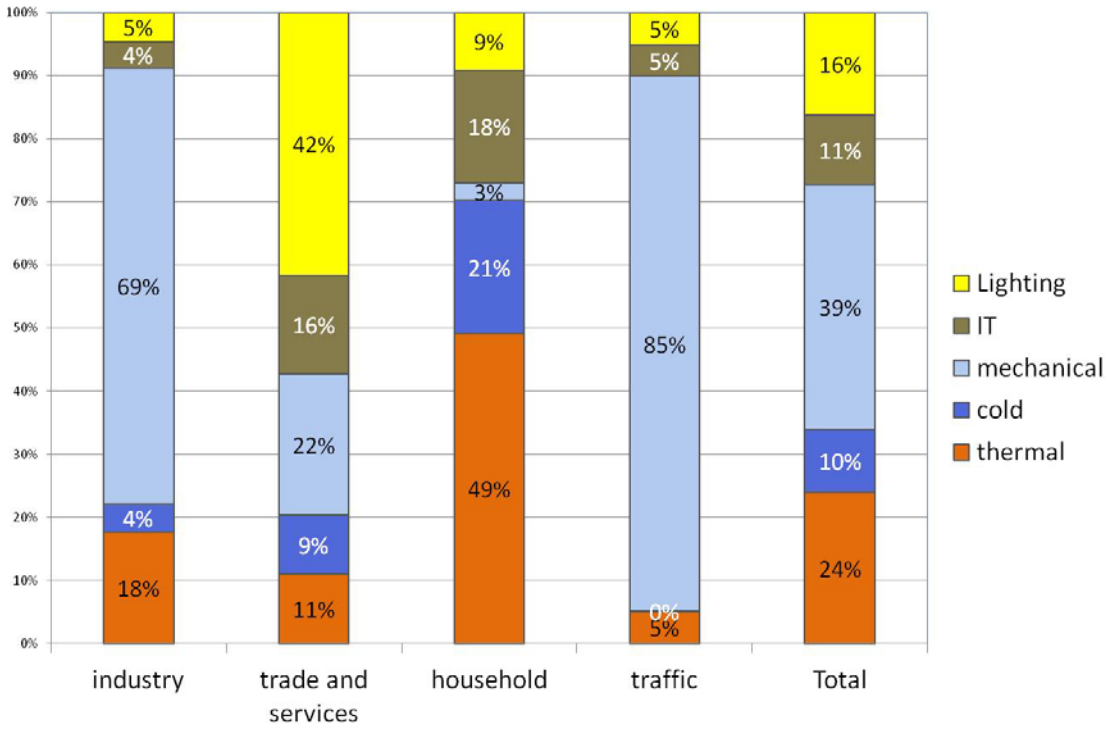


Figure 34: Electricity consumption in Germany.

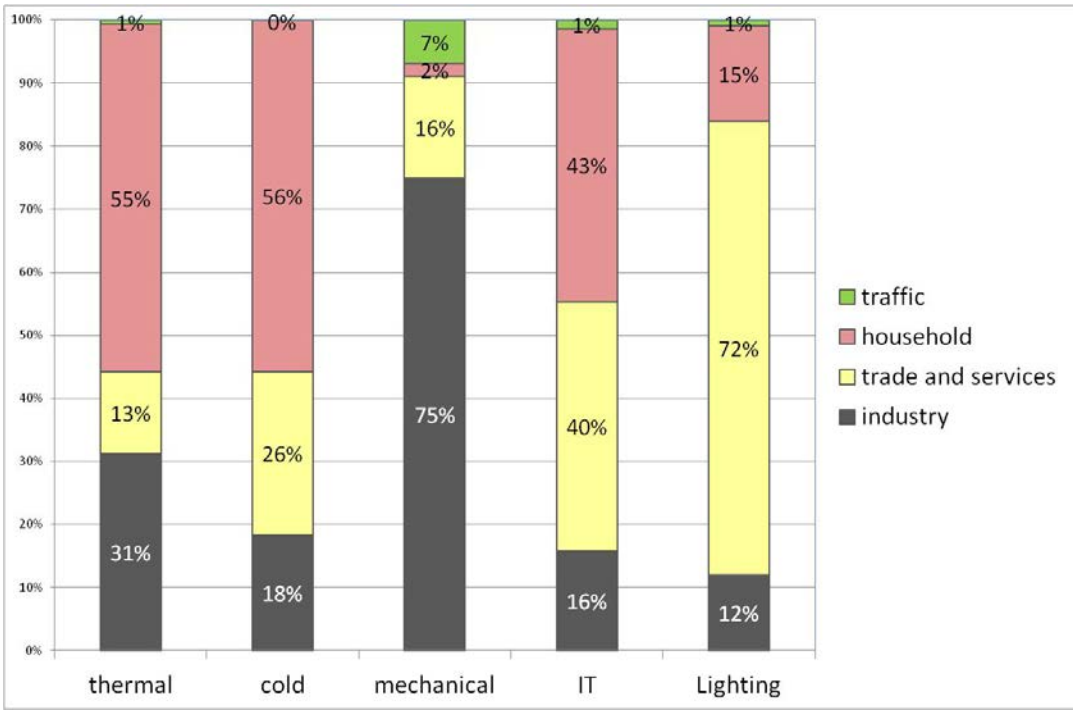


Figure 35: End-uses according to economic sectors in Germany.

2.2.10. Greece

According to the report from the ENPER-EXIST project (Thomsen, Wittchen, Jensen, & Aggerholm, 2007), there is no available data on the total area per type for the non-residential building sector in Greece. The available data for the area of non-residential buildings is based on the average area per type delivered through research reports of all kinds. The building types listed in this report are:

- Offices
- Education
- Healthcare buildings
- Hotels/restaurants
- Farm houses
- Factories

Although Greece is not officially involved in this IEA Task 50, some data from the TABULA project report (TABULA, 2012) can be retrieved. This report states that the non-residential building stock is rather limited but that it is the fastest growing energy demand sector in Greece. According to this report, non-residential buildings represent about 25% of the total number of Hellenic buildings for 1990, which is in line with general numbers for the whole EU, see Figure 2 (TABULA, 2012). The main categories of the Hellenic non-residential building stock are represented in Table 11.

Table 11: Number of buildings and total floor area for the main categories of the Hellenic tertiary sector.

	Offices/Commercial		Schools		Hotels		Hospitals	
	# bldgs	Floor area (m^2)	# bldgs	Floor area (m^2)	# bldgs	Floor area (m^2)	# bldgs	Floor area (m^2)
pre 1980	89,352	34,176,657	14,126	20,966,906	3,015	6,524,219	1,566	3,394,400
1981-2000	39,348	32,361,389	700	1,164,145	2,580	9,380,098	117	1,004,400
2001-2010	23,850	25,544,135	750	1,322,299	1,214	5,430,632	59	580,041

The category with the largest total floor area is thus offices/commercial, followed by (in order) schools, hotels and hospitals. Another figure of the TABULA project reports that the electricity consumption is highest for hospitals (84-124 kWh/m^{2}yr), followed by hotels (73-122 kWh/m^{2}yr), offices/commercial (48-67 kWh/m^{2}yr) and schools (17-23 kWh/m^{2}yr), which is generally in line with data obtained from other countries. Data about total floor space and electric lighting can also be found for Greece in the BPIE data hub, see Figure 36 and Figure 37 (BPIE, 2013). Figure 36 shows that the type “educational buildings” is clearly dominant in Greece, followed by “wholesale and retail trade” and “hotels and restaurants”. The category “Offices” comes in the fourth place. This data is not completely in agreement with data presented in Table 24 but still generally indicates that educational buildings do cover a large floor space in Greece. Although incomplete, Figure 38 shows that “hospitals” generally has a higher energy intensity that “offices” and “educational buildings”, which is in line with the data found for other countries.

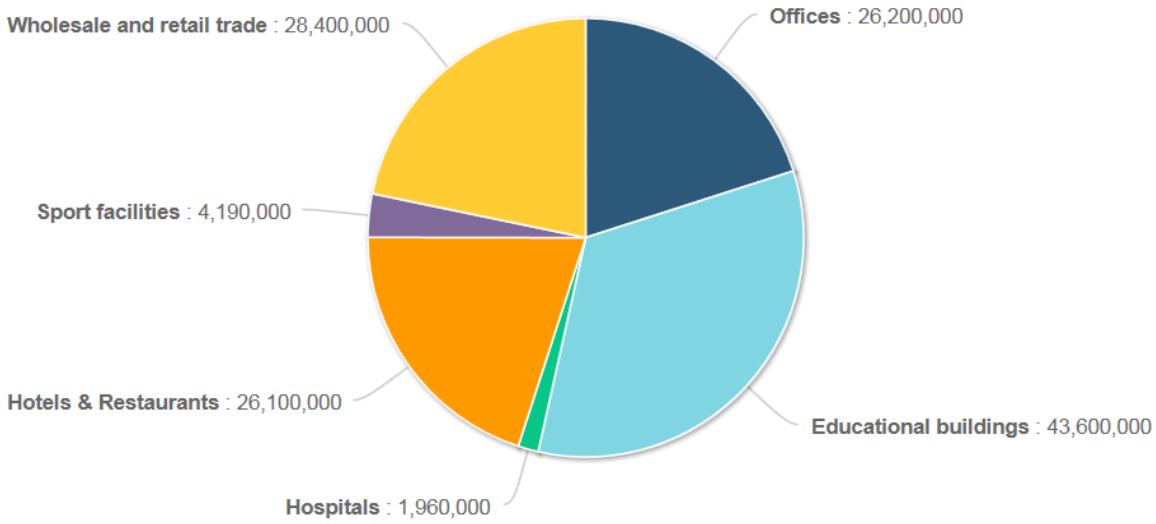


Figure 36: Breakdown of building stock (in total m2) by building type, Greece.

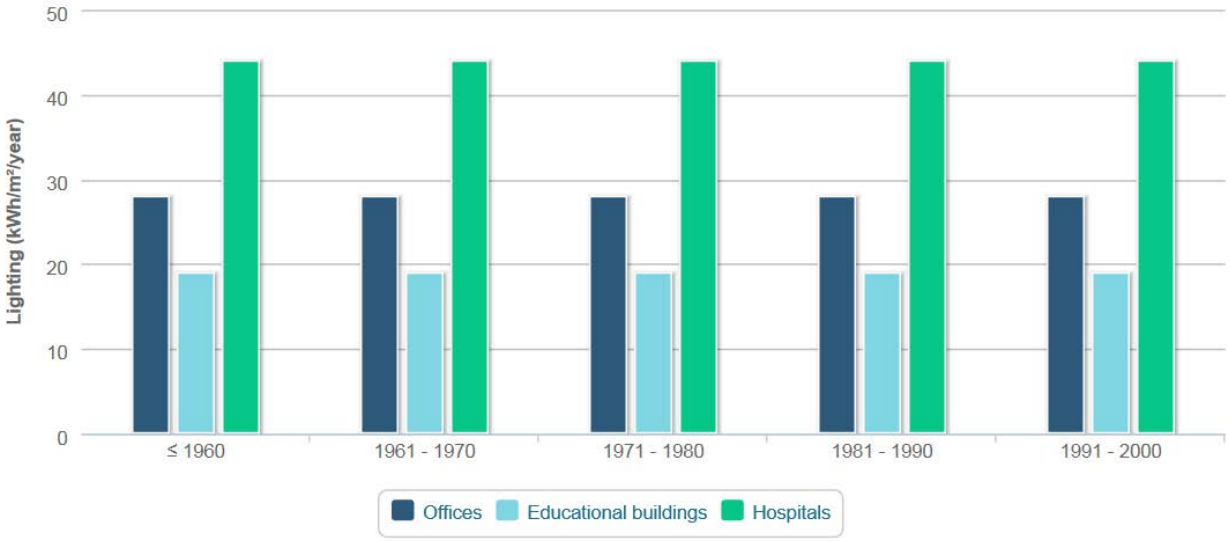


Figure 37: Energy consumption for lighting according to building type and age group.

2.2.11. Japan

The statistical building stock data published by the Ministry of Land, Infrastructure, Transport and Tourism in Japan is classified into the following categories (the total floor space as of 1 January 2013 is shown for each category (Ministry of Land, Infrastructure, Transport and Tourism, 2013)):

1. Residential buildings

1-1. Wooden structure

- Detached houses and so-called "nagaya" (a kind of terrace houses)	356 928 x 10^4 m^2
- Apartment hoses	11 821 x 10^4 m^2
- Others	645 x 10^4 m^2

1-2. Other structures

- Detached houses and so-called "nagaya" (a kind of terrace houses)	32 875 x 10^4 m^2
- Apartment houses	140 063 x 10^4 m^2
- Others	848 x 10^4 m^2

2. Non-residential buildings

2-1. Public non-residential buildings

- Offices	2 457 x 10^4 m^2
- Medical and healthcare facilities	67 x 10^4 m^2
- Educational facilities	63 x 10^4 m^2
- Others	1 007 x 10^4 m^2

2-2. Private non-residential buildings

2-2-1. Wooden structures

- Offices and shops	2 389 x 10^4 m^2
- Factories and storehouses	2 925 x 10^4 m^2
- Others	5 234 x 10^4 m^2

2-2-2. Non-wooden structures

- Offices and shops	55 996 x 10^4 m^2
- Factories and storehouses	75 498 x 10^4 m^2
- Others	38 464 x 10^4 m^2

2-2-3. Unidentified structures

- Offices and shops	901 x 10^4 m^2
- Factories and storehouses	970 x 10^4 m^2
- Others	271 x 10^4 m^2

The Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry publishes annual energy reports. FY2011 Annual Energy Report shows a trend in energy consumption in Japan (Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry, 2010). Energy consumption is classified into three sectors: the industrial sector, the commercial and residential sector (civil sector), and the transport sector. For the industrial sector, the amount of energy consumption has remained roughly around the same level after the oil crisis. In contrast, it has increased for the commercial and residential sector as well as the transport sector. Figure 38 shows the evolution of the final energy consumption and real GDP. The civil sector can be divided into the home and commercial sectors. The final energy consumption for the civil sector accounted for 33.2% of the total final energy consumption in the fiscal year 2010, see Figure 39.

In Japan, the commercial sector includes nine business sectors, i.e.:

- Office buildings
- Department stores
- Whole sales and retails
- Restaurants
- Schools
- Hotels and ryokans (Japanese-style hotels)
- Hospitals
- Theaters
- Places of amusement
- Other services

In recent years, energy consumption in office buildings has accounted for a large percentage of the total energy consumption for the commercial sector. Figure 40 shows the evolution of the energy consumption by business sector for the non-residential building sector in Japan. This figure shows that the most important energy consumers are: offices, wholesale and retail, hotels and ryokans (although going down significantly in the last year), schools, other services, hospitals.

For office buildings, the energy consumption for heating and cooling accounted on average for about 31% of the total energy consumption, about 21% for lighting and about 21% for electric power from outlets. In Japan, the energy consumption for the commercial sector is classified into five end-uses i.e. heating, cooling, hot-water supply, cooking, lighting and other power. The energy consumption for lighting and other power has been increasing due to the spread of automated systems and information technology.

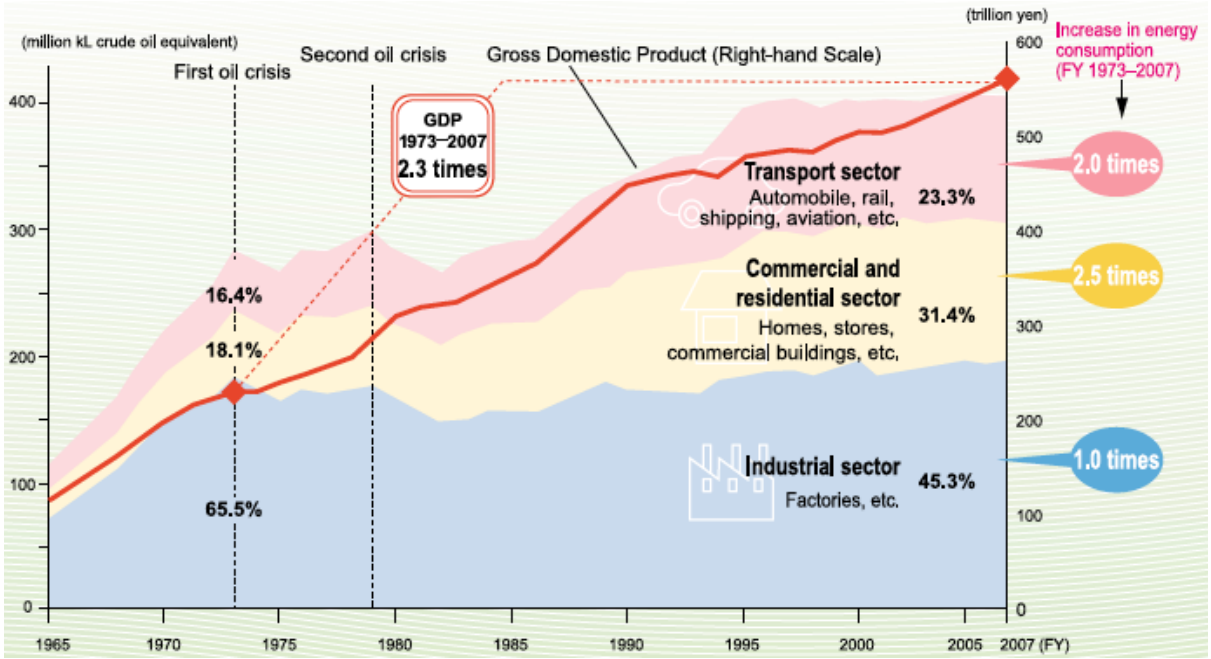


Figure 38: Changes of the final energy consumption and real GDP in Japan.

Note 1: For real GDP, the former SNA 1990 is the base year up to FY 1980, the new SNA 1995 is the base year from FY 1980 to FY 1993, and the chaining method SNA is adopted from FY 1994 on.
Note 2: Crude oil equivalent is a figure generated by converting units of different sources (coal, natural gas, etc.) to the amount of crude oil that would produce the same amount of energy.

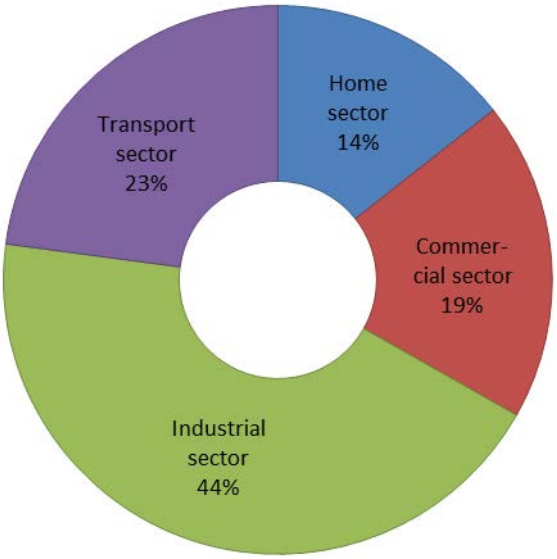


Figure 39: Proportions of the final energy consumptions in the fiscal year 2010, Japan.

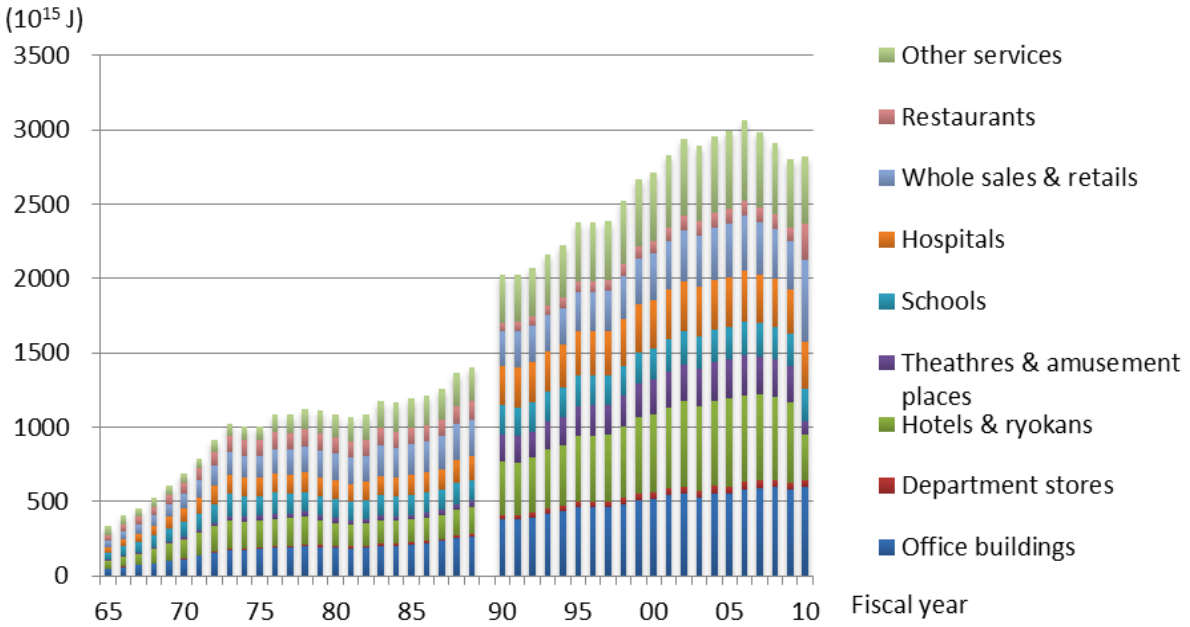


Figure 40: Evolution of the energy consumption by business sector for the commercial sector.

Appropriate data on typical installed light power density values has not been found but the lighting power density for general lighting in offices is 17,7 W/m^2 on average for the year 2002.

2.2.12. Latvia

The BPIE data hub provides some data for Latvia regarding the total floor space of different building types in the non-residential building sector, see Figure 41 (BPIE, 2013). This figure shows that the category “educational buildings” is dominating, followed by “offices” and “wholesale and retail trade”.

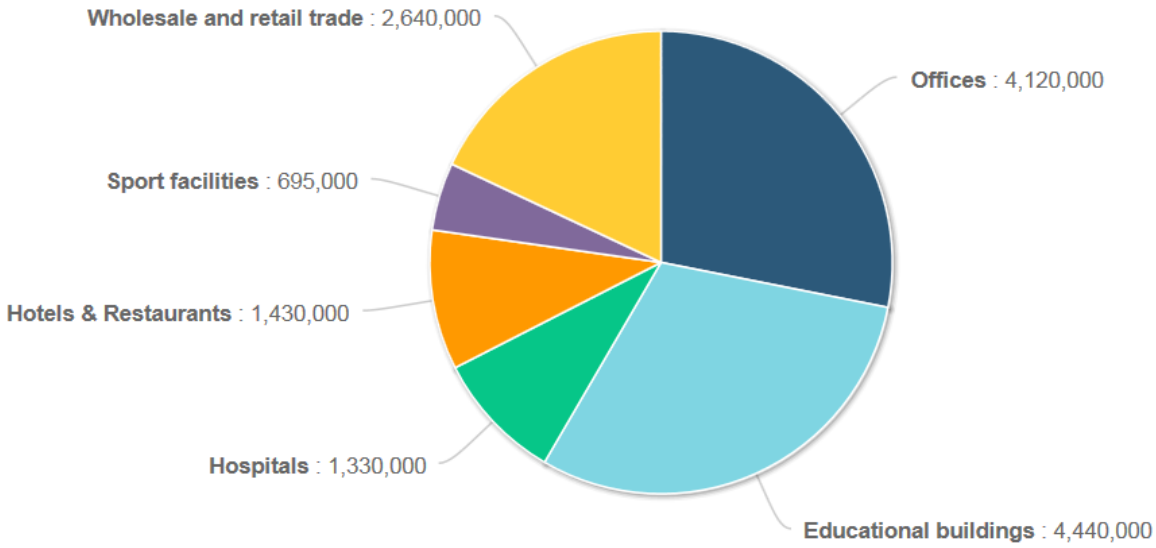


Figure 41: Breakdown of the building stock by building types in Latvia.

The BPIE also provides some data regarding the energy intensity for electric lighting, see Figure 42 (BPIE, 2013). This figure shows that the category “sports facilities” is dominating in the recent buildings, followed by “hospitals” “wholesale and retail trade” and “educational buildings”. However, in the older building stock, “hospitals” had higher energy intensity for lighting than other building types.

Figure 42: Energy intensity for electric lighting according to building type and age group, Latvia, source.

2.2.13. Norway

The BPIE data hub provides some data for Norway regarding the total floor space of different building types in the non-residential building sector, see Figure 43 (BPIE, 2013). This figure shows that the category “offices” is dominating, closely followed by “wholesale and retail trade” and “educational buildings”. The other three categories represent a somewhat lesser share of the total floor space in the non-residential sector.

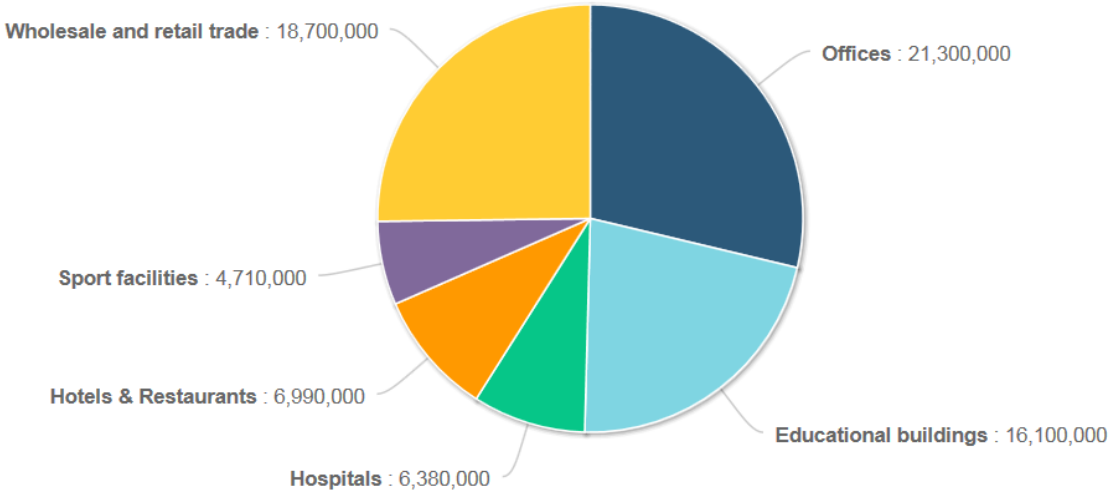


Figure 43: Breakdown of the building stock by building types in Norway.

The BPIE provides some data for Norway regarding the electricity consumption for lighting, see Figure 44 (BPIE, 2013). Although incomplete, this figure shows that the category "wholesale and retail trade" is the one with the highest energy intensity in the lighting sector, followed by "hospitals" and "hotels and restaurants".

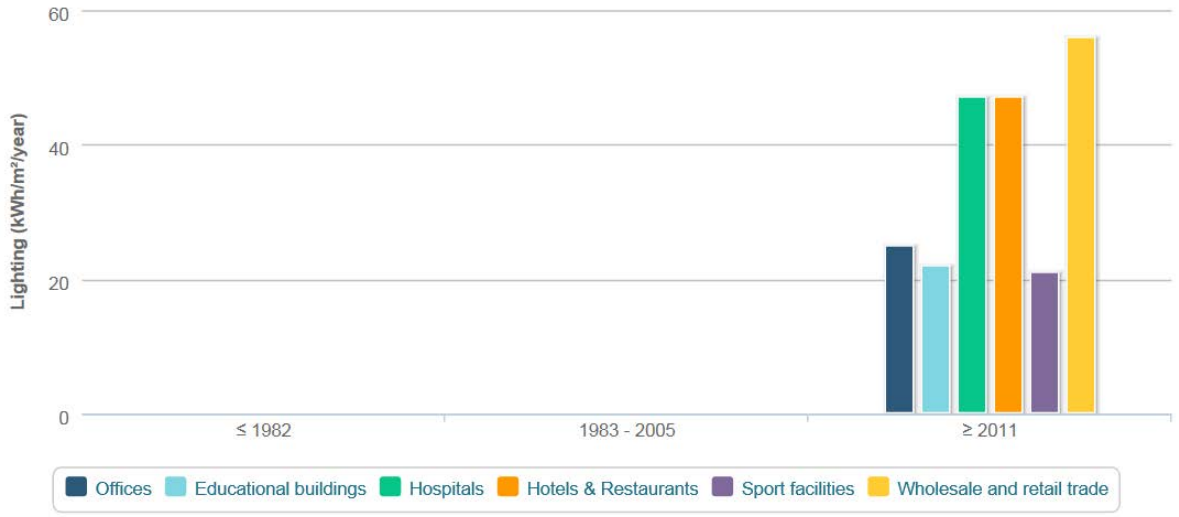


Figure 44: Energy consumption for lighting according to building type and age group (data missing for older buildings), Norway.

2.2.14. Poland

Although Poland is not officially involved in IEA Task 50, the TABULA project report provides some data about building stock distribution. According to this report (TABULA, 2012), a building is regarded in Poland as a non-residential building when the minor part of the building (i.e. less than half of its gross floor area) is used for dwelling purposes. Non-residential buildings in this country comprise:

- Industrial buildings
- Commercial buildings
- Educational buildings
- Health buildings
- Other buildings

Unfortunately, statistics related to these buildings is very poor, as shown in the report. The BPIE data hub contains some data about the Polish non-residential building stock distribution, see Figure 45 (BPIE, 2013). This figure shows that the dominating sectors in Poland are “educational buildings”, followed by “wholesale and retail trade”, “offices” and “hotels and restaurants”. No data is available about electricity use for lighting.

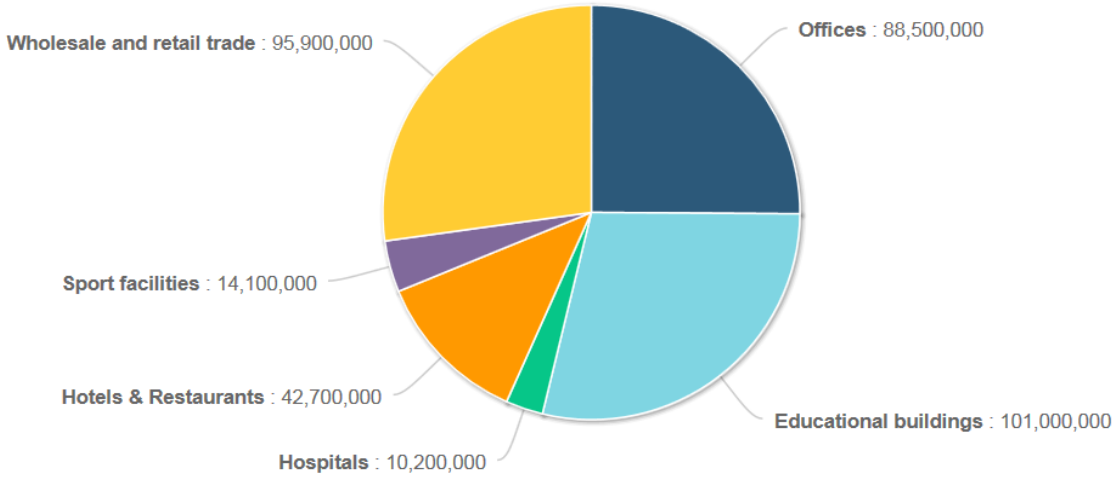


Figure 45: Breakdown of the building stock by building types in Poland.

2.2.15. Slovakia

The BPIE data hub presents data about the building stock distribution, Figure 46, as well as energy intensity for electric lighting, Figure 47 (BPIE, 2013). Figure 46 shows that the type “educational buildings” is dominant in Slovakia, followed by “hospitals”, “offices” and “hotels and restaurants”. Slovakia is the only country where “hospitals” occupy such a large share of the total non-residential floor space. In addition, Figure 47 shows that “hospitals” also have a high energy intensity for lighting.

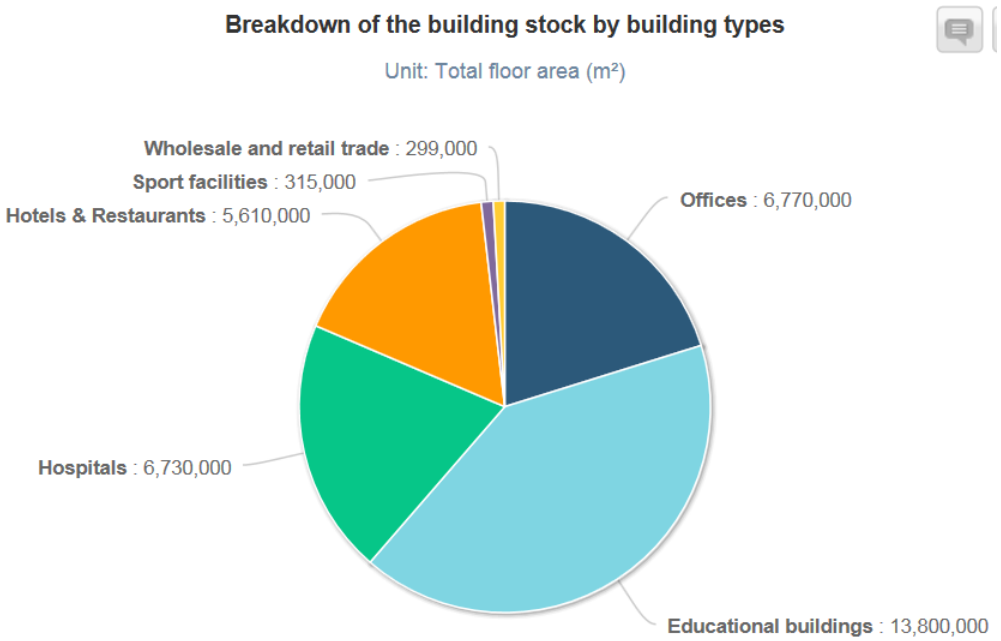


Figure 46: Breakdown of the building stock by building types in Slovakia.

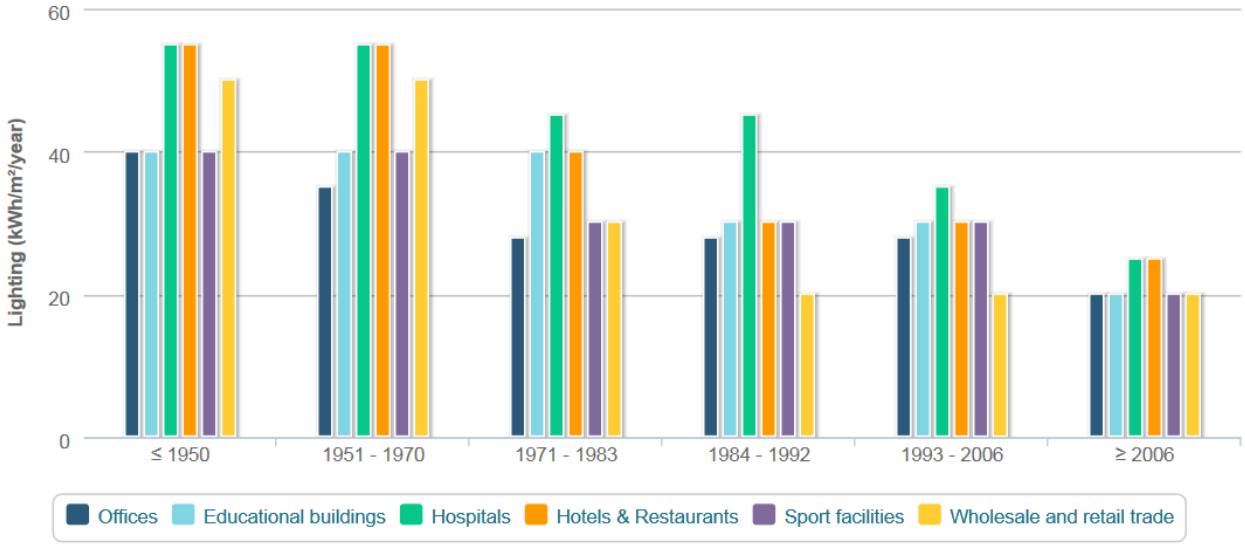


Figure 47: Energy consumption for lighting according to building type and age group.

2.2.16. Sweden

According to the BPIE data hub, the building stock distribution for Sweden is as presented in Figure 48 (BPIE, 2013). This figure shows that the category “educational buildings” is dominant in Sweden, followed by “offices” and “hospitals”. Surprisingly, the sector “wholesale and retail trade” is not as dominant as in other highly industrialized countries. Unfortunately, data concerning energy use is not available from the BPIE site.

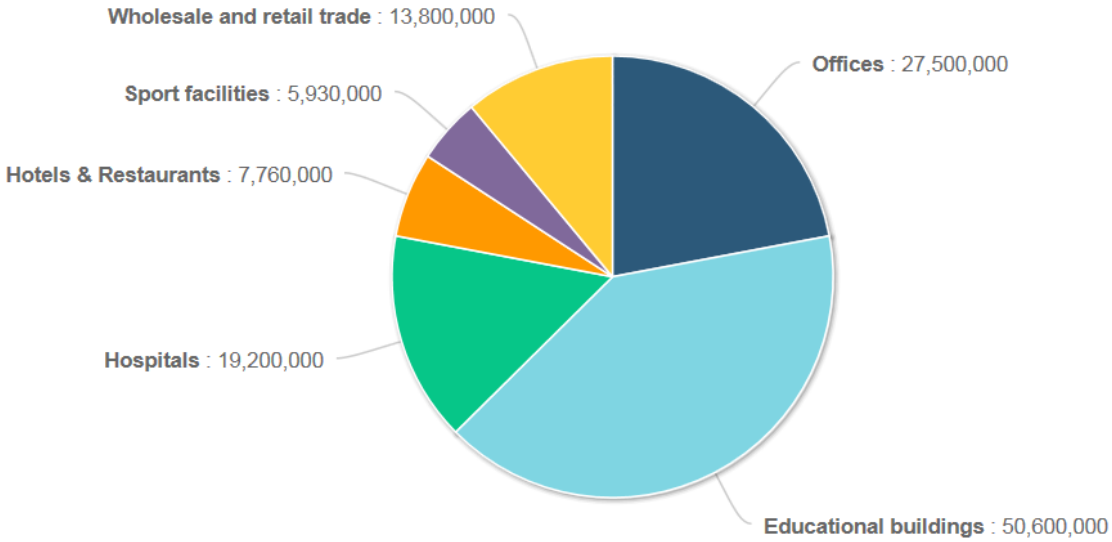


Figure 48: Breakdown of the building stock (in total m^2) by building types, Sweden.

According to another source (SCB), building types are organized according to eleven categories in Sweden. Many buildings contain operations from several different categories, such as offices and homes. The building types classification is determined by the activities that make up the greatest percentage of its area. The eleven building types categories are listed below:

1. Residential buildings
2. Hotels and restaurants
3. Offices

4. Stores and warehouses
5. Healthcare
6. Schools
7. Churches
8. Halls including theaters and cinemas
9. Sports and spas
10. Heated garages
11. Other premises

According to this data, the overall area of non-residential premises represents 144 million square meters in 2005, spread over approximately 53 000 properties. Offices and schools are the two major non-residential types, which is in line with the data presented in Figure 48, each with about a quarter of the total area (not in accordance exactly for educational buildings). The largest owners of facilities are insurance companies (41 percent) and local government (27 percent). Overall, taking the public sector (state and local government) into account, it covers about two-fifths of the total non-residential premises' area (Statens offentliga utredningar, 2008).

According to another source (Statens energimyndigheten, 2010), the different categories of premises in the non-residential building sector are:

- Offices
- Schools
- Healthcare
- Shops/Groceries/Stores
- Hotels/Restaurants/ Halls/theaters/cinemas
- Sports/Spa
- Churches

This report also provides floor areas according to building types, see Table 12 (Statens offentliga utredningar, 2008) (Statens energimyndighet, 2011). Note that although the absolute numbers differ, the relative proportions are similar. Educational buildings, offices and healthcare buildings are the most important building types in Sweden. The wholesale and retail sector is somewhat less dominant.

Table 12: Total areas according to different categories used in the STIL investigation and electricity use for lighting.

Type	Area (m^2)	Electricity (kWh/m^2yr)	Other	Comments
Public buildings	144 milj			Premises
STIL study				
Office premises	~44,9 milj	~21		
School premises	~36,0 milj	~21		Part of Municipality and Country council
Healthcare premises	~13,4 milj	~21,7		Country council
Commercial premises	~5,9 milj			Part of Investors and Developers
Hotel, Restaurant, Halls	~7,8 milj	~28		Venues
Sport facilities	~3,2 milj	~30		Part of Municipality
Churches	~2,6 milj			
Other	~30 milj			

Additional information can also be found from another source, see Figure 49 (SCB). This figure also shows that educational buildings represent a very significant share of the total non-residential building stock in Sweden.

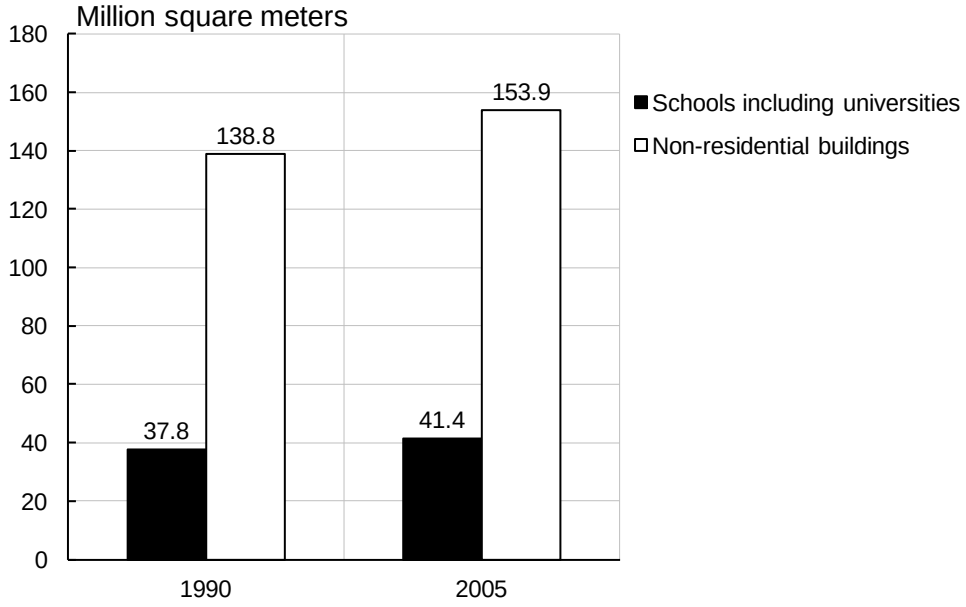


Figure 49: Heated areas in schools compared to other non-residential buildings 1990 and 2005, in Sweden.

Office buildings

The total area covered by office buildings is approximately 44,9 million m^2 in 2005. Although lighting technology has developed rapidly during the last decades, the electricity used for lighting in these building types is still very high. It is increasingly common to use CFLs and electrically efficient, flicker-free T5 fluorescent lamps with high frequency ballasts, which consume about half of what the old T8 lamps with conventional ballasts consumed. But still nearly 30 percent of all electricity is used for lighting in offices. One survey (Statens energimyndigheten, 2010) shows that a large portion of currently installed lighting is outdated with respect to today's technology, see Figure 50 (Statens energimyndigheten, 2006). This figure shows that light sources in offices consist of 46% older lamp types (probably T12 lamps with conventional ballasts), 10% T8 with HF ballasts, 17% T5 (with HF ballasts), 12% incandescent lamps, 7% halogen lamps, 7% CFL, 1% other types of lamps. Thus, over half of all lighting is of the older and conventional type, and therefore at least twenty years old. Lighting technology has evolved substantially since 1990. The specific use of electricity for lighting, overall, has decreased by 30% from 1990 to 2005, i.e. from 30 to 21 kWh/m^2yr.

The installed LPD has also decreased significantly, and the distribution of types of lighting systems has changed dramatically. Calculated over the entire building, the installed lighting power density (LPD) declined from 18.5 to 10.5 W/m^2, as shown in Table 13 (Statens energimyndigheten, 2006).

The use of incandescent lighting has diminished and the dominant fluorescent lighting has halved in terms of LPD. This is connected with the introduction of more electric efficient technology (e.g. more efficient light sources and high frequency ballasts), and probably better lighting design. One can assume that the offices have undergone quite a few renovations and changes during these 15 years, and this has led to good opportunities to improve the lighting placement and take the opportunity to switch to better and more electric

efficient fixtures (e.g. lighting solutions). Calculated on the office space (cellular offices and open plan offices, excluding corridors, etc.), the LPD decrease to 10.5 W/m^2. The use of electricity has decreased to 21 kWh/m^2 in 2010 (Statens energimyndigheten, 2010).
School premises

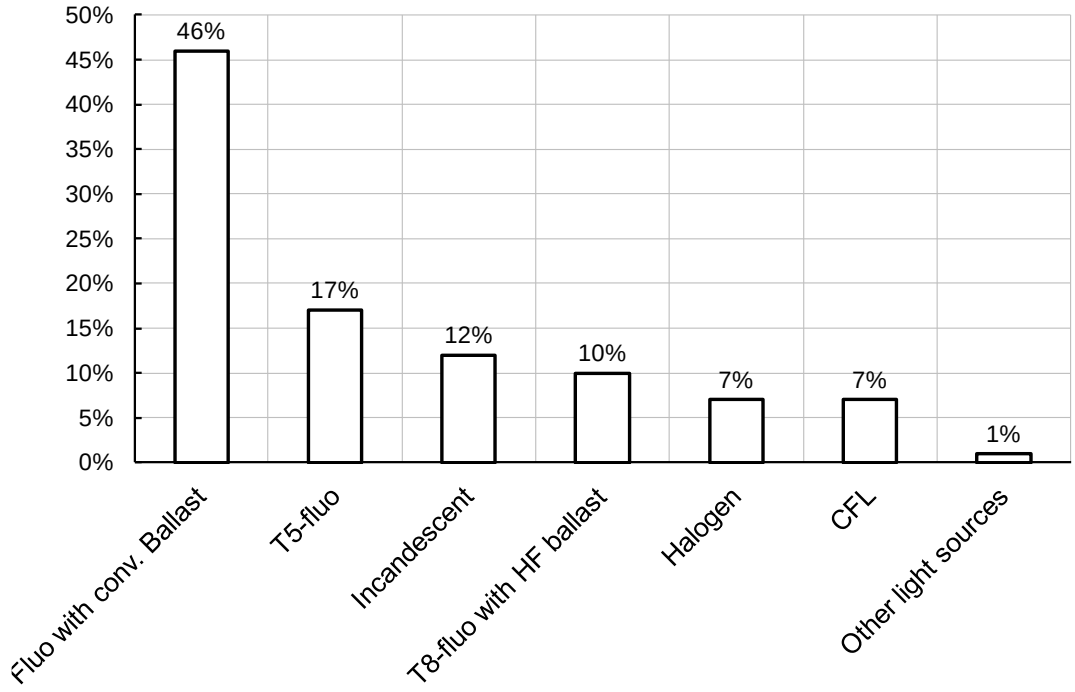


Figure 50: Distribution of lamp types in office buildings in Sweden.

Table 13: Installed electric lighting power density LPD, W/m^2 in Sweden.

Type of light source	Year 1990	Year 2005
Calculated for the whole building		
Incandescent	2.1	1.2
Fluorescent total	15.3	7.7
▪ With conventional ballast	Approx. 15.3	4.9
▪ T8 with HF ballast		1,1
▪ T5	Approx. 0	1.7
CFL	0.3	0.7
Other types	0.2	0.8
Light source not given	0.6	0
Sum whole building	18.5	10.5
Within office buildings	23	13.0

The total area of school buildings has increased from approximately 37.8 million m^2 in 1990 to 41.4 million m^2 in 2005. The increase of approximately 10 % of electricity use corresponds to the increase in floor area over the same period of time. These values differ from those presented in Table 12. This shows that there are problems between different investigations and the definition between different databases.

Some information about the distribution of light sources in school premises can be found in (Belysningsbranschen, 2008). This report shows that 59% of light sources are of the older

type (probably T12 lamps with conventional ballasts), 14% are T8 lamps with HF ballasts, 11% are incandescent lamps, 7% are modern T5 lamps (with HF ballasts), 5% are CFL, 3% other type and 1% halogen lamps, see Figure 51 (Belysningsbranschen, 2008).

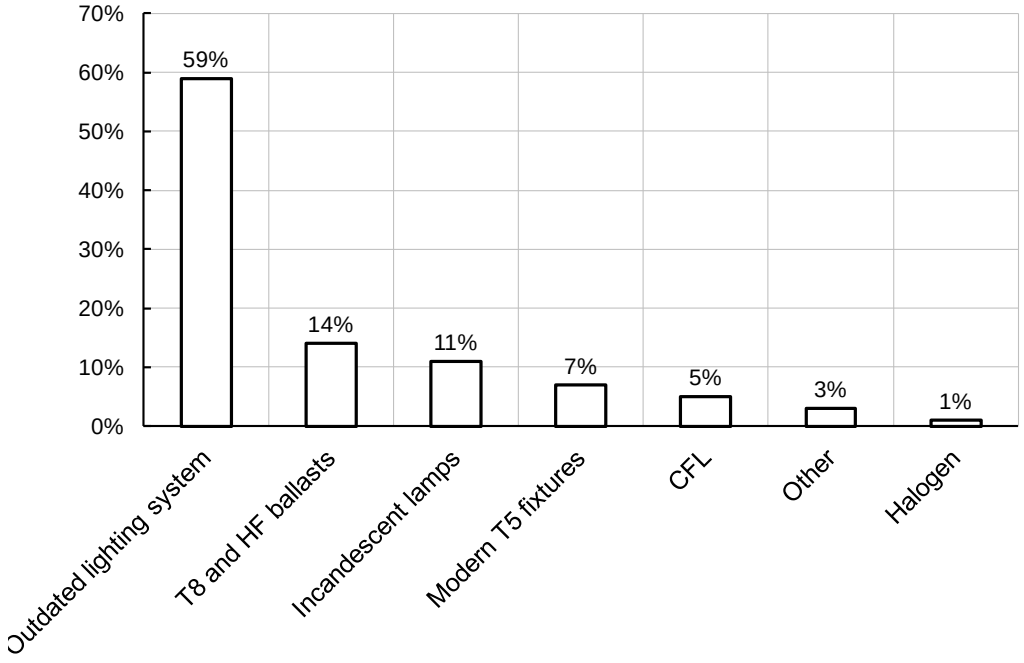


Figure 51: Distribution of lamp types in school premises in Sweden.

The large proportion of incandescence bulbs in preschools explains the high figures for LPD, 17.3 W/m^2, while primary and secondary schools have figures of 10.9 W/m^2 (Statens energimyndigheten, 2010). Lighting uses an average of 21 kWh/m^{2}yr and operating time is approximately 1650 hours/year in school premises (Statens energimyndigheten, 2010).

Healthcare premises
It is notable that almost all fluorescent lights are older fixtures with conventional ballasts, while the more efficient HF-ballasts are only found in 14 percent of cases. The total installed LPD, however, is still at reasonable levels, from 7.3 W/m^2 for health centers to 9.6 W/m^2 for centers for the elderly.

Overall, lighting uses an average of 21.7 kWh/m^{2}yr and operating time is approximately 2450 hours per year (Statens energimyndighet, 2008).
Figure 52 shows the distribution of light sources used in Swedish healthcare premises(Belysningsbranschen, 2008). This figure shows that 56% of light sources are of the older type (probably T12 fluorescent lamps with conventional ballasts), 2% are T8 lamps with HF ballasts, 7% are T5 lamps with HF ballasts, 26% are incandescent lamps, 1% are halogen lamps, 5% are CFLs, 3% are other types of light sources.

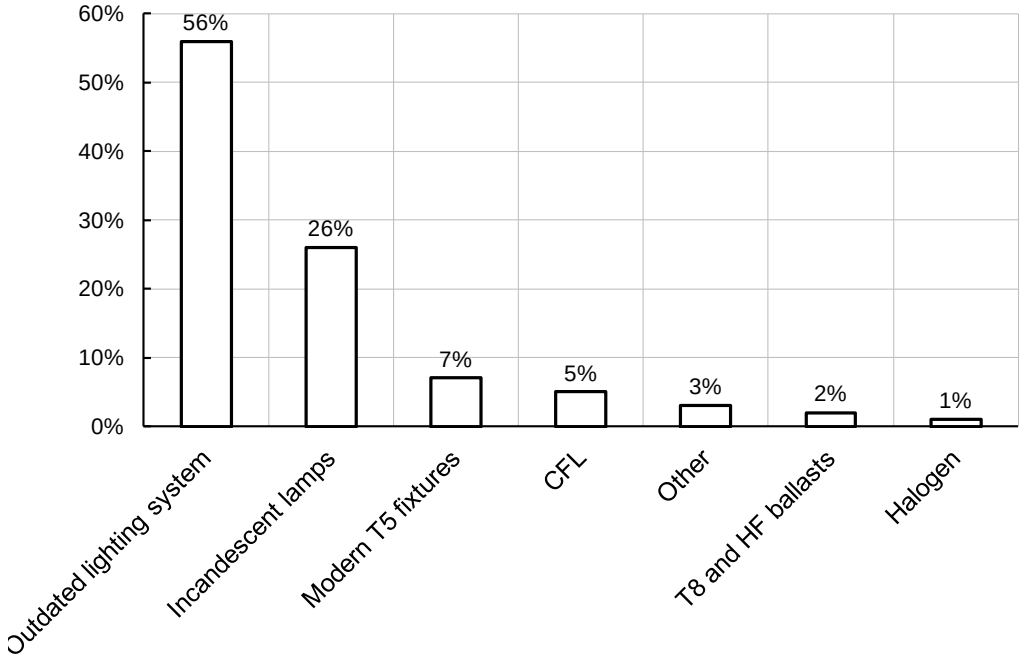


Figure 52: Distribution of lamp types in hospitals and healthcare premises in Sweden.

Commercial premises

The specific electricity consumption per square meter varies greatly between the different groups. Most electricity-intensive premises are the grocery trade while malls and other retail have a lower specific consumption of electricity. The largest items of electricity consumption, for all categories of commercial premises is the lighting, which accounts for 42 %, followed by food refrigeration and fans with 26 % and 12 % respectively.

Food refrigeration is the largest single item of food stores' specific use of electricity, 145 kWh/m^2. Lighting is responsible for 90 kWh/m^{2}yr and fans for 24 kWh/m^{2}yr. Other businesses and malls generally have a lower electricity use than supermarkets. Lighting is the dominant electricity usage within these categories by 59 kWh/m^2 yr and 85 kWh/m^{2}yr. Overall installed LPD is 17 W/m^2. The average operating time of lighting in commercial premises is 3552 h/year (Statens energimyndighet, 2010).

Hotels, Restaurants, Halls

According to the Energy Statistics (Statens energimyndighet, 2011), hotels and restaurants represent 4.2 percent of the total floor space of 135 million square meters. Of these, restaurants use 1.2 % of the space. Assembly rooms and churches take up 2.5 % and 2.2 % respectively.

Table 14: Electricity use distribution per area. The values are weighted to a national level. The remaining posts are proportionally distributed to the different posts.

kWh/m^{2}A$_{temp}$	**All**	**Hotel**	**Restaurant**	**Conference**
Electric heating incl. heat pumps	34.5	44.5	62.2	27.1
Comfort cooling	2.7	2.8	8.7	2.1
Fans	21.3	27.0	59.6	15.3
Other building electricity	6.5	8.1	10.5	5.4

Lighting	**28.3**	**29.3**	**52.4**	**25.8**
Kitchens incl. wash. + refrigerat.	24.6	35.8	212.1	3.5
Other tenant electricity	9.0	12.9	15.5	6.5
Sum	126.9	160.4	420.9	85.7

On average hotels, restaurants, and halls use about 28.3 kWh/m^{2}yr for lighting ('belysning'). Operating hours per year are calculated to 1596 hours per year for the category, divided as follows:

- Hotels 2500 h
- Restaurants 3200 h
- Halls 1300 h

Sport facilities
A recent report(Statens energimyndighet, 2011) (Statens energimyndighet, 2009) presents detailed statistics describing how electricity is used in sports facilities in Sweden. Through a selection process, the project has chosen 107 sites (a total of 134 buildings) and studied in detail how they use their energy, with emphasis on electricity. The types of sports facilities included in the detailed inventory are:

- Sport halls
- Rinks
- Combination halls
- Bathhouses

Specific numbers per unit area has its limits when all categories are compared because stadiums generally have high ceilings. Another factor that distinguishes sports from other categories is that the indoor temperature varies. For ice rinks and other sports, temperatures are lower and for bathhouses, it is higher. The total area in relation to the pool or the ice surface is also significant. Therefore, it can be difficult to make comparisons between different types of premises.

Buildings with the highest use of electricity for lighting consist mainly of ice rinks and sports halls with a high proportion of conventional fluorescent fixtures. They also require a lot of light and long operating times. Electricity consumption for lighting in the various sub-groups per year and unit area is as follows:

- Sport halls: 31 kWh/m^2, year
- Rinks: 22 kWh/m^2, year
- Combination halls: 30 kWh/m^2, year
- Bathhouse: 34 kWh/m^2, year

Lighting operating times for the various sub-groups are as follows:

- Sport halls: 2400 hours per year
- Rinks: 2214 hours per year
- Combination halls: 2710 hours per year
- Bathhouse: 3546 hours per year

The average operating time for the lighting of sports facilities is 2538 hours per year.
The installed LPD in sports buildings according to light source is as presented in Figure 53 (Stengård, 2009) shows that 60% of lamp types are of the older type (T12 with conventional ballasts), 10% are T8 lamps with HF ballasts, 13% are T5 (with HF ballasts), 7% are incandescent lamps, 4% halogen lamps, 1% CFLs and 5% of other lamp types.

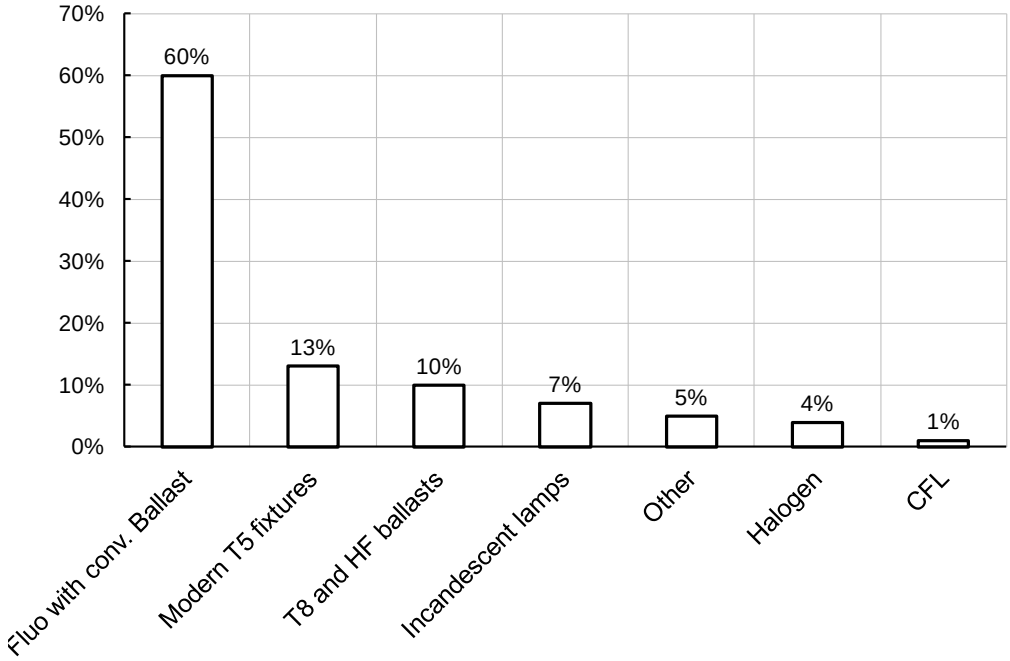


Figure 53: Distribution of lamp types in sports buildings in Sweden.

Table 15: Energy saving estimates per measure.

	Estimated national saving potential (TWh/year)
Office:	
Lighting operating times adjusted	0.05
Replacement of incandescent bulbs to CFLs	0.05
Replacement of conventional fluo to T5	0.20
Schools:	
Replacement of incandescent bulbs to CFLs	0.06
Replacement of conventional fluo to T5	0.36
Lighting operating times adjusted	-
Health Care:	
Replacement of incandescent bulbs to CFLs	0.05
Replacement of conventional fluo to T5	0.19
Lighting operating times adjusted	0.002
Sports:	
Replacement of incandescent bulbs to CFLs	0.005
Replacement of conventional fluo to T5	0.04

Churches

Churches represents only 2.2 % of the total floor space of 135 million square meters so this category is not so important.

Energy Efficiency measures

Table 15 shows the energy saving potential estimates according to proposed measure for the whole country (Statens energimyndigheten, 2010). Other possible measures are also suggested and these consists of:

- Better designed lighting fixtures
- Better / custom planning
- Lighter finishes with contrasts
- Different control systems, time and level
- More use of natural light/daylight

Results from (Statens energimyndigheten, 2010) show so far that offices, schools, healthcare facilities and sports facilities could save about 1 TWh per year through improved lighting technologies.

2.2.17. Switzerland

The BPIE data hub presents data about building stock distribution in Switzerland, see Figure 54 (BPIE, 2013). This figure shows that “offices” are dominant in Switzerland, followed by “educational buildings”, “hospitals” and “wholesale and retail trade”. “Hotels and restaurants” come in the fifth position. No data is available about energy use for lighting in the BPIE data hub.

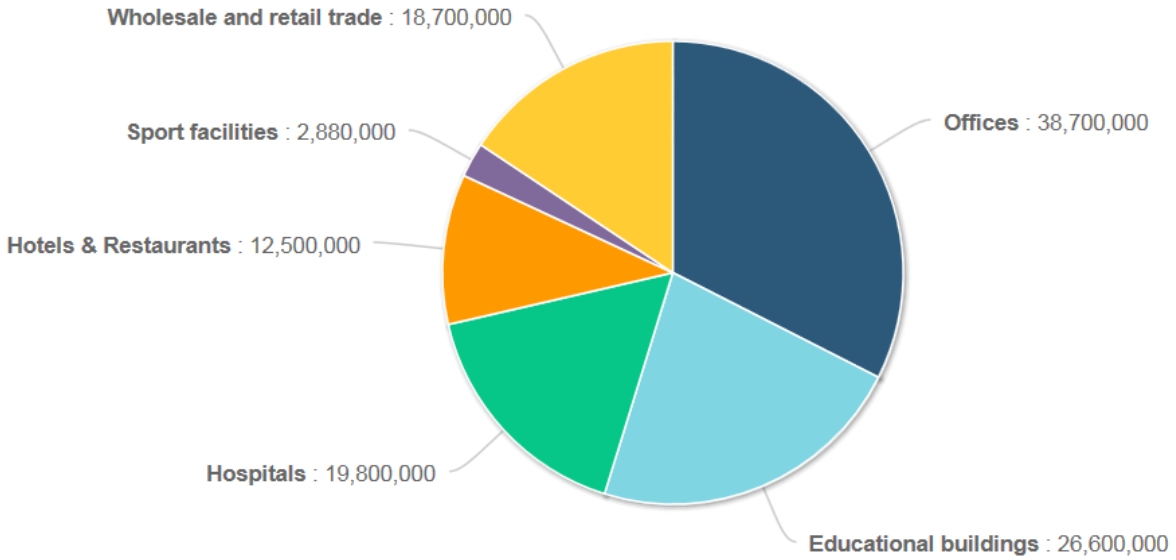


Figure 54: Breakdown of the building stock (in total m^2) by building types, Switzerland.

Other data is available from the Swiss Federal Office for Statistics (OFES). The information regarding the building stock is focused on residential buildings. No detailed information about commercial, office or industrial buildings is available. Other sources have been explored, but finally, data on all the buildings are quite “disparate”. Sometimes we have the number of buildings, sometimes the surfaces, sometimes the information is representative of a canton, etc. The following pages display some partial data found on the Internet.

Office buildings
Table 16 presents data about the Swiss office building stock from 2012 (Wuest & Partners, 2012). The estimated surface for offices is larger than in the BPIE data hub.

Table 16: Statistics 2012 for Swiss office buildings.

	Parc (m² SBP, 2011)	Permis constr. (mio CHF, 1er t. 2013)	Taux vacant (2012)	Taux de l'offre (1er t. 2013)	Loyer de l'offre (médiane, 1er t. 2013)	Loyer prime (1er t. 2013)	Rend. prime (1er t. 2013)
Zurich	9'205'800 ↗	285.9 ↗	1.8% ↘	6.2% →	320 ↗	940 →	2.9% ↘
Berne	2'070'300 ↗	305.0 ↗	1.2% ↘	3.6% ↘	230 ↗	420 →	3.5% ↘
Bâle	4'322'300 ↗	101.2 ↗	2.8% ↗	2.1% →	250 ↗	400 ↘	3.7% ↘
Lausanne	2'100'200 →	15.3 ↘	1.7% ↘	4.3% ↘	290 →	530 ↗	3.5% ↘
Genève	3'389'600 ↗	21.4 ↘	2.1% ↗	11.0% ↗	520 ↗	1'100 ↗	3.0% ↘
Suisse	52'137'600 ↗	2'265.4 ↘	— —	6.2% →	210 ↗	— —	— —

Flèches: variations par rapport à l'année précédente à la même période.

Commercial buildings

Table 17 provides data about the Swiss commercial buildings stock in 2012 (total 33 047 700 m^2) (Wuest & Partners, 2012). Here the estimated surface occupied by commercial buildings is much large than the one reported by the BPIE data hub.

Table 17: Swiss commercial buildings stock in 2012.

	Parc (m^2 SBP, 2011)	Permis constr. (mio CHF, 1er t. 2013)	Taux vacant (2012)	Taux de l'offre (1er t. 2013)	Loyer de l'offre (médiane, 1er t. 2013)	Loyer prime (1er t. 2013)	Rend. prime (1er t. 2013)
Zurich	1'855'100 →	0.0 ↘	0.3% ↗	1.5% →	440 ↗	9'000 ↗	3.0% ↘
Berne	966'200 ↗	0.0 →	0.1% ↘	0.4% ↘	430 ↗	4'500 ↗	3.5% ↘
Bâle	927'800 →	20.0 ↘	2.1% ↘	1.6% ↘	270 ↗	3'700 ↗	3.8% ↘
Lausanne	466'000 →	0.0 ↘	1.0% ↘	2.3% →	460 ↗	3'700 ↗	3.7% ↘
Genève	639'600 →	2.5 ↘	2.3% ↗	4.2% ↗	450 ↗	7'600 ↗	3.2% ↘
Suisse	33'047'700 ↗	674.5 ↗	— —	1.1% →	230 ↘	— —	— —

Flèches: variations par rapport à l'année précédente à la même période.

Figure 55 shows the area of non-residential buildings, according to type, by statistical sector and by commune, for 2012, only in the Geneva Canton. This figure shows that office buildings (administratifs) are clearly dominant in the non-residential building sector of the Geneva Canton.

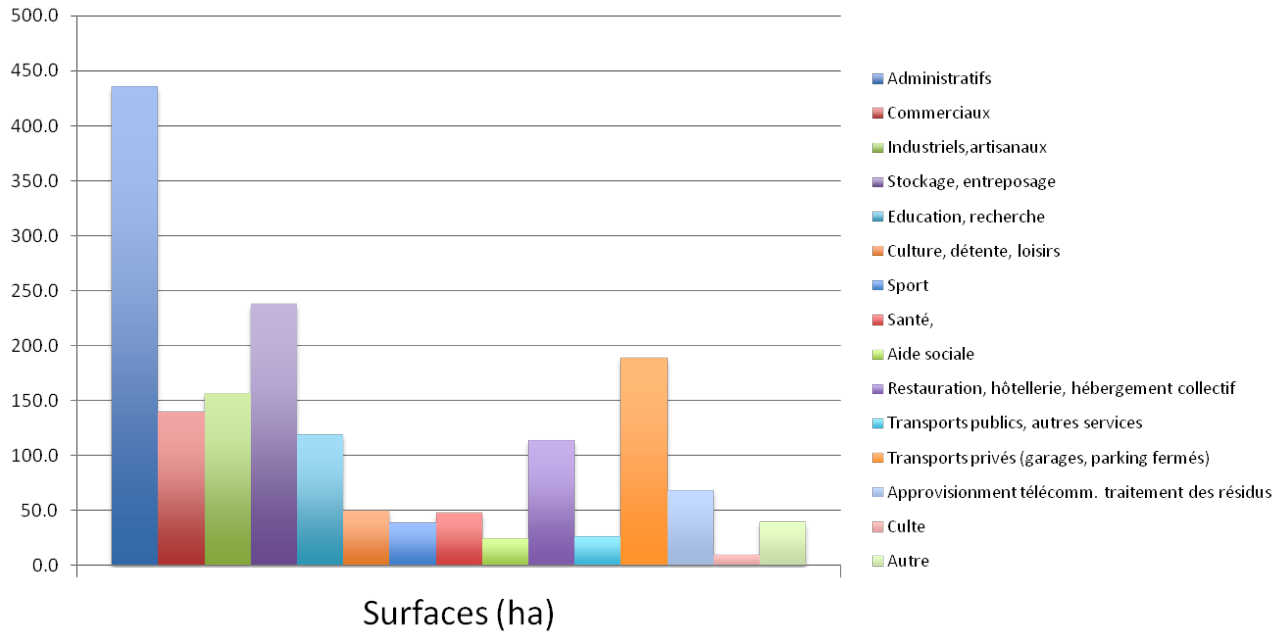


Figure 55: Area of non-residential buildings, according to type, by statistical sector and by commune, 2012, Geneva Canton.

Figure 56 shows the Energy used for lighting in Switzerland for stores, hospital, offices and schools and housing. The figure shows that offices and schools generally have a lower energy intensity than hospitals and stores, which is in line with data obtained from other countries.

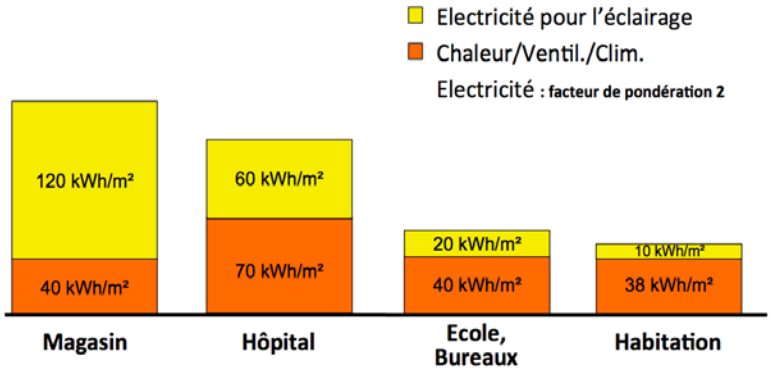


Figure 56: Energy use for lighting in Switzerland for stores, hospital, offices and schools and housing

In addition, Figure 57 shows the installed LPD in supermarkets in Switzerland, monitored in 62 buildings in 2005. This figure shows that the average LPD is 27 W/m^2, ranging from 21-36 W/m^2.

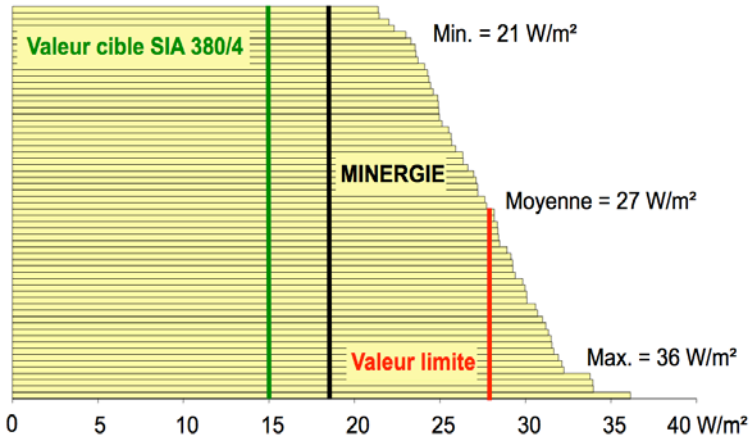


Figure 57: Installed LPD (W/m^2) in supermarkets measured in 62 buildings in 2005, Switzerland.

2.2.17. The Netherlands

According to one source (Thomsen, Wittchen, Jensen, & Aggerholm, 2007), there is far less information available for the Dutch non-residential sector. The sources are not always in accordance with each other and there are gaps in the information. There is a range of studies that cover parts of the non-residential building stock but not one study covering everything.

Nonetheless, data (for which building stock/energy/renovation data is available) is presented according to the following categories (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties (BZK), 2013):

- Offices
- Hospitals
- Healthcare
- Stores
- Education

Note that the industry sector is missing from the data. The BPIE data hub also presents data for The Netherlands, see Figure 58 (BPIE, 2013). This figure shows that "offices" are clearly dominant in The Netherlands, followed by "wholesale and retail trade", "educational buildings" and "hospitals".

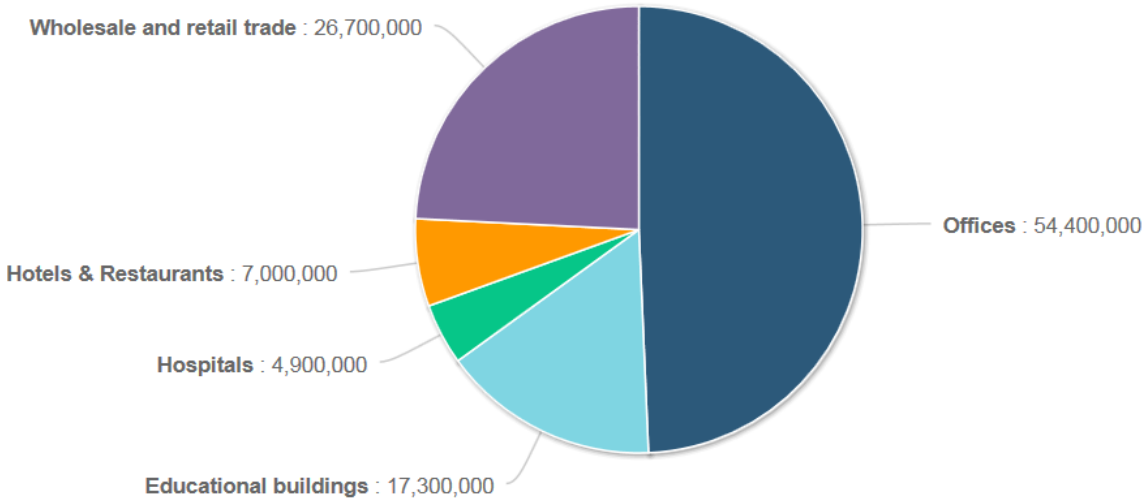


Figure 58: Breakdown of the building stock (in total m^2) by building types, The Netherlands.

Some information about the area covered by the different building types in the non-residential building sector can also be found in the report of the ENPER-EXIST project (Thomsen, Wittchen, Jensen, & Aggerholm, 2007), see Table 18. The numbers are slightly different from the ones presented by BPIE but they still show that the "office" sector is clearly dominant in the Netherlands.

Table 18: Building stock characteristics, energy consumption and potential savings for the non-residential building stock, The Netherlands.

		Building stock characteristics				Energy consumption					Potential energy savings	
		number of 1000*buildings	area * 1000 m²	% of total area	Information source	Heating [kWh/m²]	Cooling [kWh/m²]	Domestic hot water [kWh/m²]	Electricity [kWh/m²]	Information source	Savings [PJ]	Information source
nl	**Non residential**											
	Offices		53125	32	2	See specification below					1546.8	2
	Education		29065	18	2	See specification below					475.4	2
	Hospitals/health care					See specification below					307.4	2
	Hotels/restaurents		7000	4	2						77.9	2
	Farm houses											
	Factories/workshops											
	Other											
	Health care		14676	9	2							
	Retail sector		17000	10	2						255.5	2
	Sports/recreation/culture		45371	27	2						344.5	2
	shops					175			80	3 (2003)		
	supermarkets					155			467	3 (2003)		
	offices 200-500 m2					205			109	3 (2003)		
	offices 500-10.000 m2					125			85	3 (2003)		
	offices > 10.000 m2					590			79	3 (2003)		
	primary schools					130			18	3 (2003)		
	secondary schools					135			33	3 (2003)		
	higher education					205			57	3 (2003)		
	universities					120			85	3 (2003)		
	nursing homes					225			65	3 (2003)		
	hospitals					490			95	3 (2003)		
Total non-residential		**285745**	**166237**	**100**							**3007.6**	**2**

1 Benchmarking for existing European dwellings. EPA-ED (project for the European Commission in the Altener programme, contract no. 4.1030/Z/01-142/2001), WP1, April 16 2003.
2 Energiebesparing in de bestaande bouw - Eerste verkenning van potenties. Second draft. EBM-consult, in opdracht van Ministerie van Economische Zaken, 27 januari 2006. (p.34) NOT YET FORMALLY APPROVED BY MINISTRY OF ECONOMICAL AFFAIRS.
3 Cijfers en tabellen 2006. SenterNovem in opdracht van Ministry of Housing. January 2006. Averaged figures. For dwellings the following average floor area has been assumed: single family: 150 m², attached: 120 m², row: 100 m², multi family: 80 m².

Commercial Buildings
Some information about the number and age of non-residential buildings is presented in Table 19 (Mobius Consult, 2009).

Table 19: Number and age of commercial buildings in The Netherlands.

	1000-1900	1901-1950	1951-1974	1975-1990	1991-1999	after 2000	Total
offices	9 100	11 300	12 300	16 500	14 300	15 200	78 700
education	700	2 200	5 600	3 700	1 000	1 300	14 600
hospitals	100	100	200	100	100	100	700
nursing and care	200	400	1 500	1 300	800	1 000	5 200
stores	22 800	33 000	30 900	23 400	16 900	13 800	140 800
catering (excl hotels)	7 400	9 100	6 900	6 000	2 800	1 700	33 900
hotels	900	1 000	500	400	200	400	3 400
industrial buildings	8 600	18 300	45 800	32 400	26 400	28 100	159 700
sports facilities	300	500	2 600	3 200	900	900	8 300
pools and saunas	0	0	200	100	0	0	400
meeting	6 400	5 200	6 400	5 800	2 600	2 300	28 600
lodging	300	300	300	300	200	300	1 600
total	56 700	81 500	113 100	93 200	66 200	65 100	475 800

In addition, some information about the floor area of non-residential buildings can be retrieved from (Geon, 2012), see Table 20.

Table 20: Floor area of commercial buildings.

[%]
Nederland

	> 250 m2	250 - 500 m2	500- 1000 m2	1000- 2000 m2	2000- 2400 m2	2400 - 5000 m2	5000- 50000 m2	Totaal
automobile	23.8	22.7	24.1	18.3	2.8	6.3	2	100
Business Incubator Buildings	17.7	14.5	16.9	20.8	5	17.1	8	100
Outdoor	33.8	31.2	20.9	8.5	0.6	2.4	2.6	100
wholesale	9.4	13.5	20.5	21.2	7.1	17.1	11.3	100
Catering	49.2	31.5	14.5	3.8	0.3	0.5	0.2	100
MBO, HBO and university	4.3	3.8	11.5	15.3	7.2	20.6	37.3	100
primary education	5.6	8.4	24.2	40.7	5.7	11	4.4	100
regular Offices	35.4	25	18.1	11.2	2.1	5.2	3	100
Sports halls	8.6	29.1	19.4	21.1	4.9	11.4	5.5	100
Nursing and care	1.3	0.7	4.6	6	5.3	31.1	51	100
secondary education	2.8	1.6	5.6	11.4	4.4	23.7	50.6	100
Shops without cooling	48.6	26.4	13.6	6.7	1	2.5	1.1	100
hospitals	7.4	5.9	5.9	10.3	5.9	19.1	45.6	100
pools	17.9	16.4	9	22.4	7.5	11.9	14.9	100

Non-residential buildings energy consumption
Energy consumption of non-residential buildings is presented in Figure 59 and Table 21 (Meijer Energie & Millieumanagement B. V., 2008). This figure and table generally show results which are in line with other results found in the rest of the report i.e. sports halls (swimming pools) and hospital generally have a higher energy intensity for lighting than offices and educational buildings. Educational buildings have the lowest energy intensity among non-residential building types.

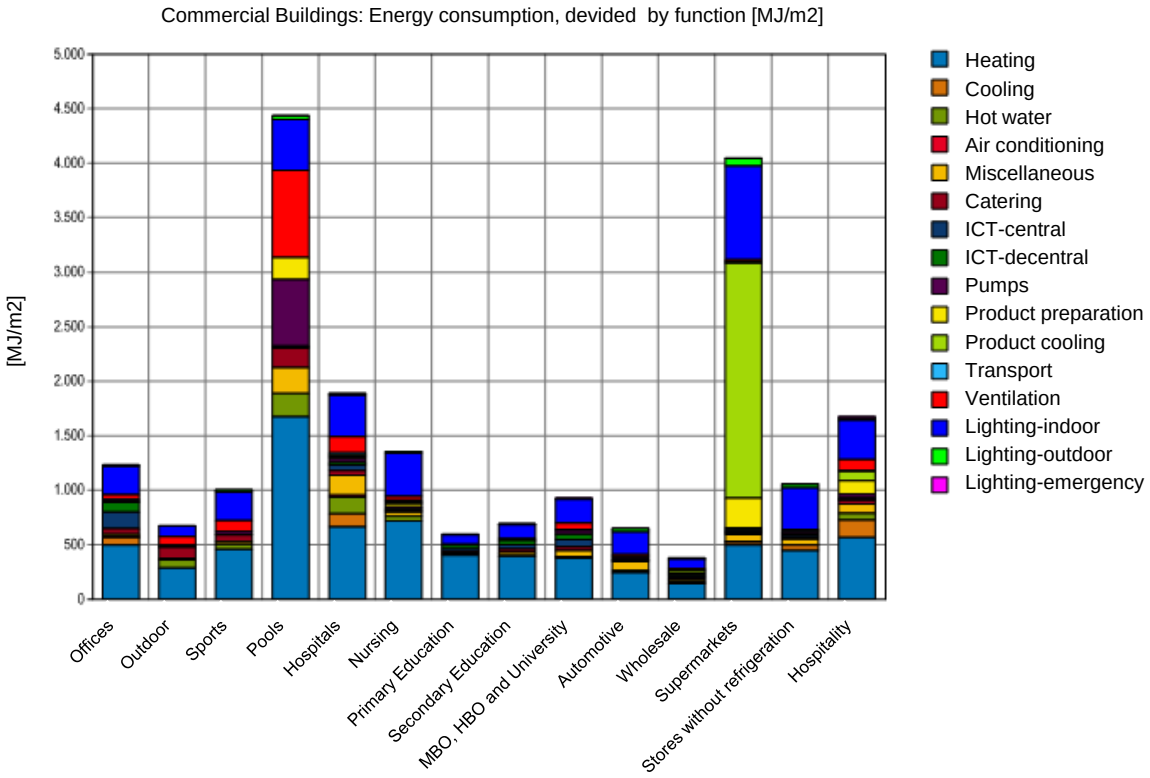


Figure 59: Energy consumption in non-residential buildings in the Netherlands.

Table 21: Non-residential buildings' energy consumption.

energy consumption in commercial buildings, divided by function [MJ/m2]

	offices	outdoor	sports	pools	hospitals	nursing	primary education	secondary education	universites	automobile	wholesale	super-markets	stores wo refrigeration	catering	Total
Space heating	500	290	460	1,680	670	720	410	400	380	250	150	500	450	570	7,430
Cooling	70	0	0	0	120	4	0	0	10	10	5	30	50	160	459
Hot water	6	75	50	210	150	40	10	6	6	6	6	6	6	65	642
Air conditioning, moistening	2	0	0	0	20	0	0	0	0	0	0	0	0	0	22
Miscellaneous	25	15	25	240	185	40	10	25	55	80	20	65	50	85	920
Catering	50	100	60	180	40	10	10	35	35	10	10	10	12	30	592
ICT central	150	0	2	9	50	4	25	40	65	8	15	15	15	10	408
ICT decentralized	90	3	0	8	20	8	35	35	55	8	15	15	15	10	317
Pumps	15	15	30	610	40	25	8	15	30	20	20	20	20	40	908
Product Preparation	0	0	0	200	20	30	0	0	0	0	0	270	0	120	640
Product Cooling	0	0	0	0	10	15	0	0	0	0	20	2,160	0	85	2,290
Transport	15	0	0	0	20	15	0	0	10	0	9	9	9	10	97
Ventilation	40	80	100	800	150	40	0	4	55	20	10	20	20	100	1,439
Lighting inside	260	95	260	470	380	390	85	130	220	210	90	860	380	360	4,190
Lights outside	10	3	20	25	10	15	2	5	6	30	10	65	30	20	251
Emergency lighting	5	3	5	10	10	6	8	5	10	2	4	7	7	20	102
total	1,238	679	1,012	4,442	1,895	1,362	603	700	937	654	384	4,052	1,064	1,685	20,707

Detailed data about the type of lighting technology as well as advanced lighting technology used in different building types is also available in The Netherlands, see Table 22 to Table 31 (Panteia, 2008, 2010).

The 'technology options' referred to with TL, HF and HF+ stand for

- TL: (Tubular) Fluorescent lamp(s) with electro-magnetic (EM) gear/driver
- HF: Fluorescent lamp(s) with electronic high-frequency (HF) gear/driver
- HF+: Fluorescent lamp(s) with dimmable high-frequency (HF) gear/driver

Table 22: Hospitals, lighting technology used (%), The Netherlands.

Incandescent	4
CFL	13
Halogen	3
TL	42
HF	27
HF+	10
LED	1

Table 23: Hospitals, advanced lighting technology used (%), The Netherlands.

	2004	**2006**	**2008**	**2010**
Daylight control	34	48	49	60
Mirror optics fittings	79	85	85	83
Presence control	55	67	74	80
Sweep control	55	48	54	55

Table 24: Offices, lighting technology used (%), The Netherlands.

Incandescent	4
CFL	13
Halogen	8
TL	60
HF	10
HF+	3
LED	3

Table 25: Offices, advanced lighting technology used (%), The Netherlands.

	2004	**2006**	**2008**	**2010**
Daylight control	10	6	10	17
Mirror optics fittings	43	58	57	55
Presence control	3	8	13	17
Sweep control	10	12	8	15

Table 26: Educational buildings, lighting technology used (%), The Netherlands.

Incandescent	2
CFL	10
Halogen	2
TL	61
HF	15
HF+	10
LED	0

Table 27: Educational buildings, advanced lighting technology used (%), The Netherlands.

	2004	2006	2008	2010
Daylight control	20	21	27	25
Mirror optics fittings	44	58	63	70
Presence control	14	21	31	37
Sweep control	12	15	14	13

Table 28: Shops, lighting technology used (%), The Netherlands.

Shops - Type of Lighting Technology [%]	
Incandescent	5
CFL	18
Halogen	18
TL	42
HF	12
HF+	2
LED	3

Table 29: Shops, advanced lighting technology used (%), The Netherlands.

	2004	2006	2008	2010
Daylight control	15	11	12	12
Mirror optics fittings	35	41	45	50
Presence control	8	9	12	12
Sweep control	20	28	24	34

Table 30: Nursing and care, lighting technology used (%), The Netherlands.

Incandescent	15
CFL	33
Halogen	4
TL	36
HF	8
HF+	3
LED	0

Table 31: Nursing and care, advanced lighting technology used (%), The Netherlands.

	2004	2006	2008	2010
Daylight control	28	27	23	26
Mirror optics fittings	43	51	51	54
Presence control	22	29	35	38

Sweep control	33	38	37	34

2.2.18. United States

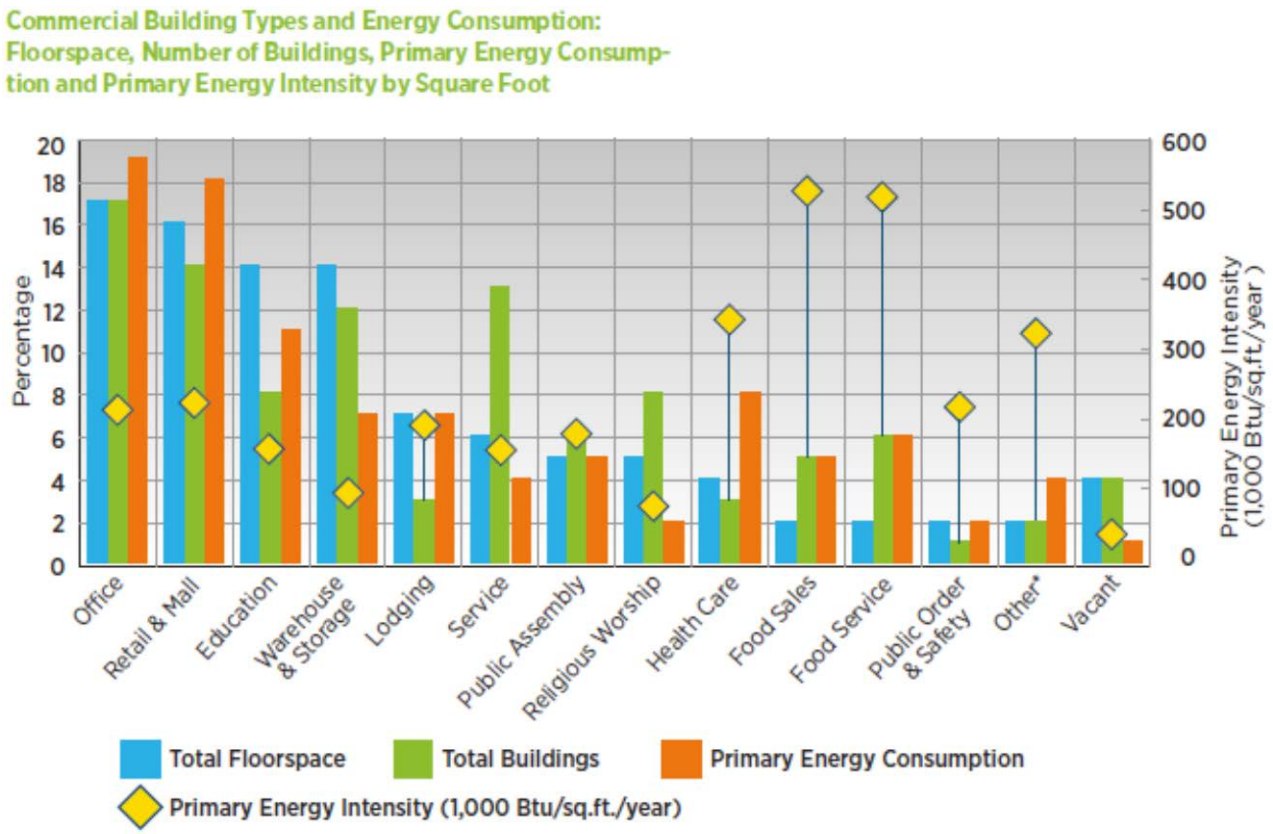
The United States has developed energy-use surveys based on sampling of their commercial building stock (Isaacs & Hills, 2013), which is undertaken by the US Energy Information Administration (EIA) since 1979, with the ninth survey in 2013 (for the 2012 year).

Lighting Market Characterization in the US typically follows the following categories, see Table 32 (Navigant Consulting Inc., 2002) (McKinsey & Company , 2012):

- Residential
- Commercial
  - Largest share: Office, retail, education, warehouse and storage (each approx, 14-17%) (McGraw-Hill Construction, 2010), see Figure 60, confirmation in Table 33 (Navigant Consulting Inc., 2002).
  - Largest energy use: Office (19%), retail (18%) and education (17%) (McGraw-Hill Construction, 2010), see Figure 60 (US Department of Energy, 2009), confirmation in Table 34.
- Industrial
- Outdoor

Information about total floor area per building type is found in Figure 60, Table 32 and Table 33. In addition, Table 34 presents figures concerning energy intensity for electric lighting. Table 32 shows that the non-residential sector represents about a third in floor area of the residential sector in the USA and that the industrial sector corresponds to roughly one tenth of the non-residential building sector[1]. Figure 60 and Table 33 show that the dominant sectors in the USA are: offices, retail and mall (same as wholesale and retail trade), education and warehouse and storage. Table 34 (Navigant Consulting Inc., 2002) shows data that are generally in line with previous data collected for other countries i.e. the healthcare sector is characterised by high energy intensity for lighting along with wholesale and retail trade, followed by offices while the education sector has a generally low lighting intensity.

[1] Note that North Americans use the term “commercial” for non-residential buildings but since this may induce confusion with the “wholesale and retail trade” sector, we prefer using the term “non-residential buildings”.



Source: 2009 Buildings Energy Data Book, U.S. Department of Energy, October 2009, Table 3.1.10 and Table 3.2.2 <http://buildingsdatabook.eren.doe.gov>.

* Other buildings refer to buildings that are industrial or agricultural with some retail space; buildings having several different commercial activities that, together, comprise 50 percent or more of the floorspace, but whose largest single activity is agricultural, industrial/ manufacturing, or residential; and all other miscellaneous buildings that do not fit into any other category.

Figure 60: Non-residential building types and energy consumption in the United States.

Table 32: Floor space according to building types, United States.

	# of buildings (x 1000 pcs)	**(million ft²)**
Residential	113 153	240 868
Commercial	5 497	81 203
Industrial	455	9 866
	119 105	331 937

Table 33: Estimated number and floor space of commercial buildings.

Type	Average area (ft²)	# of buildings	Total area (x 1000 ft²)
Education	25 580	454 000	11 604 995
Food Services	5 569	34 900	1 943 960
Food Store	5 553	266 000	1 475 012
Healthcare - Inpatient	238 125	9 000	2 238 962
Healthcare - Outpatient	10 397	142 000	1 478 538
Lodging	35 887	16 700	5 989 372
Offices (non-medical)	14 816	986 000	14 348 165
Public Assembly	14 220	326 000	4 629 540
Public Order and Safety	15 352	83 000	1 281 086
Religious Worship	10 146	435 000	4 412 108
Retail - Mall & Non-Mall	17 035	772 000	13 154 052
Services	6 511	731 000	4 759 999
Warehouses and Storage	16 881	702 000	11 844 758
Other	22 000	93 000	2 042 686

Table 34: Lighting electricity use by non-residential building type in 2010.

Type	Average # of lamps per 1000 ft²	LPD (W/ft²)	Electricity Use per Building (kWh/yr)	Intensity (kWh/yr/ft²)	kWh/yr (x 1000)
Education	17	0.6	65 100	2.5	29 012.49
Food Services	32	1.3	30 100	5.4	10 497.38
Food Store	40	1.8	40 800	7.3	10 767.59
Healthcare - Inpatient	26	0.8	768 100	3.2	7 164.68
Healthcare - Outpatient	37	1.3	55 900	5.4	7 984.11
Lodging	18	0.6	85 300	2.4	14 374.49
Offices (non-medical)	33	1.0	60 800	4.1	58 827.48
Public Assembly	24	1.0	58 900	4.1	18 981.11
Public Order and Safety	19	0.7	43 200	2.8	3 587.04
Religious Worship	27	1.1	45 100	4.4	19 413.28
Retail - Mall & Non-Mall	34	1.5	107 800	6.3	82 870.53
Services	28	1.4	37 400	5.7	27 131.99
Warehouses and Storage	17	1.1	71 900	4.3	50 932.46
Other	18	0.8	70 500	3.2	6 536.60

Table 35 to Table 38 (Navigant Consulting Inc., 2002) (McKinsey & Company , 2012) provide additional information about the lighting technology used in the USA. These tables show that non-residential buildings mainly use linear fluorescent lamps, while the residential

sector uses incandescent and compact fluorescent lamps. The industrial sector uses some linear fluorescent and some HID lamps while most HID lamps are used in outdoor lighting.

Table 35: Summary of lighting market characteristics in 2010.

	# of lamps (x 1000)	Average daily operating hours (h)	Average Wattage per lamp (W)	Annual electricity use (TWh)
Residential	5 811 769	1.8	46	175
Commercial	2 069 306	11.2	42	349
Industrial	144 251	13.0	75	58
Outdoor	178 374	11.7	151	118

Table 36: Lighting Market Characterization 2010.

	Total (%)	Residential (%)	Commercial (%)	Industrial (%)	Outdoor (%)
Incandescent	45	44	1		
Halogen	4	3	1		
Compact Fluorescent	19	16	3		
Linear Fluorescent	29	7	20	2	
HID	2				1
Other (LED, Miscellaneous)	1	1			
Total		71	25	2	2

Table 37: Lighting Market Characterization 2010 from Lighting the way.

	Residential (%)		Commercial (%)		Industrial (%)		Outdoor (%)	
Incandescent	62	26	4	3		1	10	
Halogen	4	27	2	5		1	2	
Compact Fluorescent	23	28	10	16		5	7	
Linear Fluorescent	10	11	80	53	89	66	16	8
HID			2	10	10	23	52	86
Other (LED, Miscellaneous)	1	7	2	13		9	12	6

Table 38: Lamp distribution by non-residential building type in 2010.

Type	Incandescent (%)	Halogen (%)	CFL (%)	Linear Fluore-scent (%)	HD (%)	Other (%)
Education	1	2	10	85	1	2
Food Services	20	1	8	67	1	3
Food Store	1	1	3	94	1	1
Healthcare - Inpatient	1	1	13	84		1
Healthcare - Outpatient	1	1	9	88		1
Lodging	18	2	25	53		2
Offices (non-medical)	1	1	14	82		1
Public Assembly	8	1	21	58	3	9
Public Order and Safety	1	1	6	89	1	2
Religious Worship	4	1	8	84	1	2
Retail - Mall & Non-Mall	5	6	6	79	3	1
Services	1	1	4	90	3	1
Warehouses and Storage		2	6	86	5	1
Other	2	4	9	79	2	3
Total	4	2	10	80	2	2

(average operating hours for incandescent 10,4 h, halogen 12,4 h, CFL 10,4 h, linear fluorescent 11,1 h, HID 11,1 h and other light sources approximately 23,5 h, except for public assembly with 13,5 h).

3. Cross country analysis and data aggregation

3.1. General overview of building types and names used in different countries

Table 39 presents an overview of the different building categories described in different documents by each country. The categories have been sorted with the most frequent ones on top. Also, some categories are given different names in different countries but they refer to the same type of building. In this case, the names have also been grouped under a single category. A usage criteria (first column) has also been added, where A represents a ‘continuous occupation’, B a ‘non continuous occupation’ and C a ‘sporadic occupation’. This table indicates that categories 1-11 are mentioned by at least seven countries and are mostly of the type ‘non-continuous to continuous” occupation (except for “warehouses/storage/storehouses”. These categories should thus be prioritized since they are relatively common and correspond to buildings where people stay for long periods of time. Categories 11-16 are not considered separately as often, as shown by the table, since they are mentioned by less than five countries. Categories 17-28 are only listed separately by less than two countries. The Netherlands has a special category called ‘nursing/care’, which is different from ‘hospitals’ but it is the only country listing this category as different from “hospitals”. Most other types are very specific types of buildings, which are probably included under ‘others’ in most countries or grouped with other categories. For the pursuit of this analysis, only building types 1-16 are considered.

Table 39: Overview of the categories defined by each country.

	Categories included by each country	Usage	AUSTRIA	BELGIUM	BULGARIA	CANADA	CHINA	CZECH REPUBLIC	DENMARK	FINLAND	FRANCE	GERMANY	GREECE	JAPAN	LATVIA	NORWAY	POLAND	SLOVAKIA	SWEDEN	SWITZERLAND	NETHERLANDS	UNITED STATES	BPIE	DATAMINE	EN 15193	ENPER-EXIST	
1	Hospitals/healthcare/medical facilities/health buildings/social assistance/health and related services	A	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	23
2	Offices/administrative buildings/administrations/government	A	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	23
3	Schools/education/educational facilities/educational services/research	A	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	23
4	Stores/retail/commercial/trade/shops/wholesale/non food stores/trade and services	B	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	22
5	Hotels/accomodation/lodging/tourism	A	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	22
6	Restaurants/pubs/cafes/bars/catering/gastronomy	B	1	1				1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	19
7	Others/other services/other production		1	1	1	1			1	1	1	1		1	1	1	1	1	1	1		1		1		1	17
8	Sports/spas/health buildings/event centres/sports facilities/swimming pools/saunas	B	1	1				1	1	1	1	1			1	1		1	1	1	1		1		1	1	15
9	Industry/factory/workshop/manufacture/industrial buildings/goods depots	A	1	1	1					1		1	1	1			1			1	1	1			1	1	12
10	Transportation/public transport/transport and garage/transport and information	B	1		1	1	1			1	1	1								1						1	8
11	Warehouses/storage/storehouses/warehousing/trade and storage	C				1					1		1		1					1	1	1					7
12	Churches/cult/religious workship	B			1				1											1	1	1					5
13	Meeting places/public assembly/public areas	B					1			1												1					4
14	Agriculture/farm houses	C			1							1	1													1	4
15	Theatres and amusement/leisure places/cinemas/culture	B												1					1	1							3
16	Food service/accommodation/catering	B			1	1																1					3
17	Heated garages/parking garages	C	1																1	1							2
18	Street lighting/outdoor	C		1																		1					2
19	Art galeries/arts/entertainment/recreation	B				1	1																				2
20	Exhibition/cultural industries/information/culture	B	1			1	1																				2
21	Library buildings	B					1		1																		2
22	Museums/science museums	B					1		1																		2
23	Groceries/food sales	B																				1					1
24	Nursing/care	A																			1						1
25	Public order and safety	B																				1					1
26	Service buildings	B																				1					1
27	Social aid	B																		1							1
28	telecommunication/waste treatment	C																		1							1

3.2. Distribution of total floor area by building types

In the next step, the area covered by the 16 most common non-residential building types identified in Table 39 are further analyzed, excluding the areas covered by the sectors "industry" and "agriculture" since this data is only available for a few countries. This step consists of analyzing the total floor space according to building type. This data is currently only available for 18 countries (Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Japan, Latvia, Norway, Poland, Sweden, Switzerland, The Netherlands, United States). The data is presented in Figure 61 in terms of percent of total floor area. This figure is a bit misleading since data is missing from many building types in some countries. The last column presents an average of all values, in order to indicate which categories are the most important (on top) and which ones are the least important (bottom).

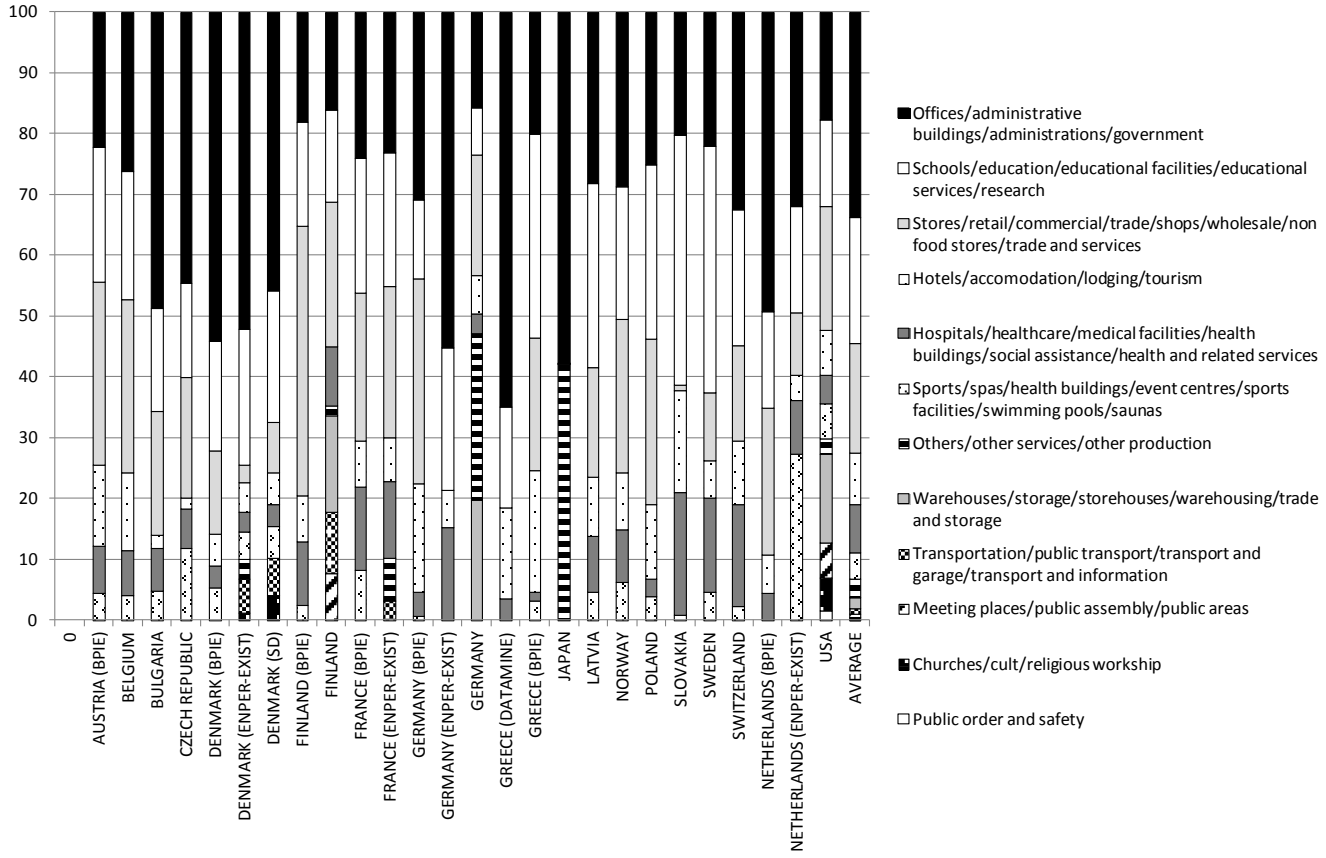


Figure 61: Percent of total floor are in the non-residential sector, calculated for some countries where this data is available

Figure 61 indicates that the nine most important non-residential building types which cover the largest floor areas are, in order:

1. OFFICES
   (Offices/administrative buildings/administrations) 33.7%
2. EDUCATIONAL BUILDINGS
   (Schools/education/educational facilities/educational services/research) 20.8%
3. WHOLESALE AND RETAIL TRADE
   (Stores/retail/commercial/trade/shops/wholesale) 18.0%
4. HOTELS AND RESTAURANTS
   (Hotels/accomodation/lodging/tourism or Restaurants/pubs/cafes/bars/catering) 8.4%

5. HOSPITALS AND HEALTHCARE
   (Hospitals/healthcare/medical facilities/health buildings/social assistance/health and related services) 8.0%
6. SPORTS
   (Sports/spas/health buildings/event centres/etc.) 4.3%
7. OTHER
   (Others/other services/other production) 3.0%

All other building types represent on average less than 2% of the total building stock and they could thus be considered under the category called “other”. Data for industrial and agriculture buildings are integrated in Figure 62. This figure is a bit misleading as data for one of the building type (agriculture or industry) is missing from some databases. The figure is presented simply to show that compared to all other categories of non-residential buildings, industrial and agricultural buildings represented a very large share of total floor space. Denmark in particular has a huge space devoted to agriculture. Industrial buildings are also very dominant in Japan and Germany, two highly industrialized countries.

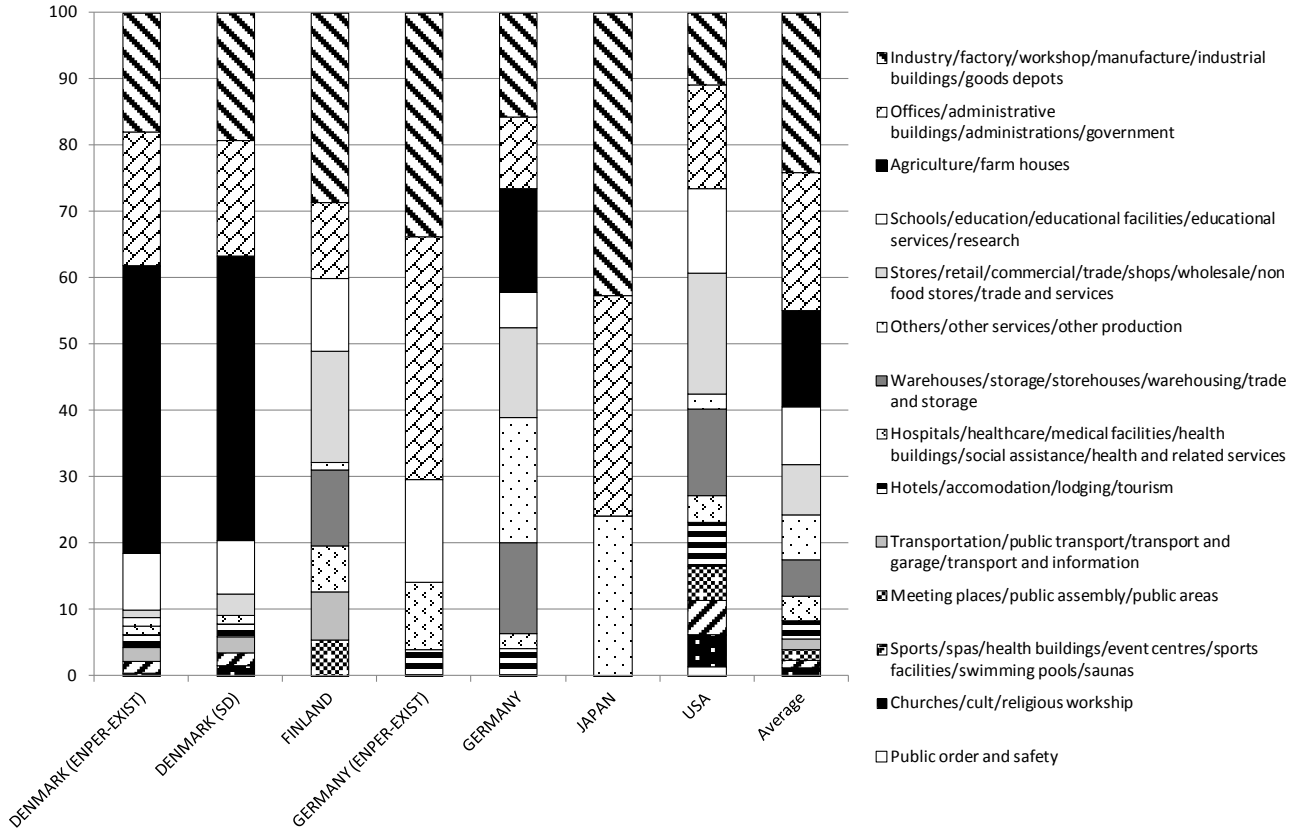


Figure 62 Percent of total floor area in the non-residential sector, including agriculture and/or industrial buildings, calculated for some countries where this data is available.

Agriculture buildings mostly house animals and not people and therefore reflections should be pursued as to whether this building type should be included or not in IEA Task 50. On the other hand, industrial buildings should definitely be included in IEA Task 50.
Note that the results presented in the section are generally in line with the overall results obtained for European countries by BPIE (see Figure 2) although the types are presented in a slightly different order.

3.3. Energy intensity for electric lighting according to building type

In the next step, the energy intensity used for electric lighting was analyzed according to building type, except for industrial and agricultural buildings, for which very few data was available. This data, available for twelve countries (Austria, Bulgaria, Czech Republic, Denmark, Finland, Greece, Latvia, Norway, Slovakia, Sweden, Switzerland, The Netherlands, United States), is presented in Figure 63. This figure shows that all building types have average energy intensity for lighting above 22 kWh/m^{2}yr. The highest intensities are for “wholesale and retail trade”, followed by “warehouses and storage”, “hospital and healthcare”, “sports”, etc. For “warehouses and storage” and “sports”, the energy intensity is high but the total floor area is relatively small. Although they cover a very large total floor area, “offices” and “educational buildings” have lower energy intensity.

1. WHOLESALE AND RETAIL TRADE (51 kWh/m^{2}yr)
2. WAREHOUSES AND STORAGE (46 kWh/m^{2}yr)
3. HOSPITALS AND HEALTHCARE (45 kWh/m^{2}yr)
4. SPORTS (39 kWh/m^{2}yr)
5. HOTELS AND RESTAURANTS (36 kWh/m^{2}yr)
6. OFFICES (27 kWh/m^{2}yr)
7. EDUCATIONAL BUILDINGS (22 kWh/m^{2}yr)

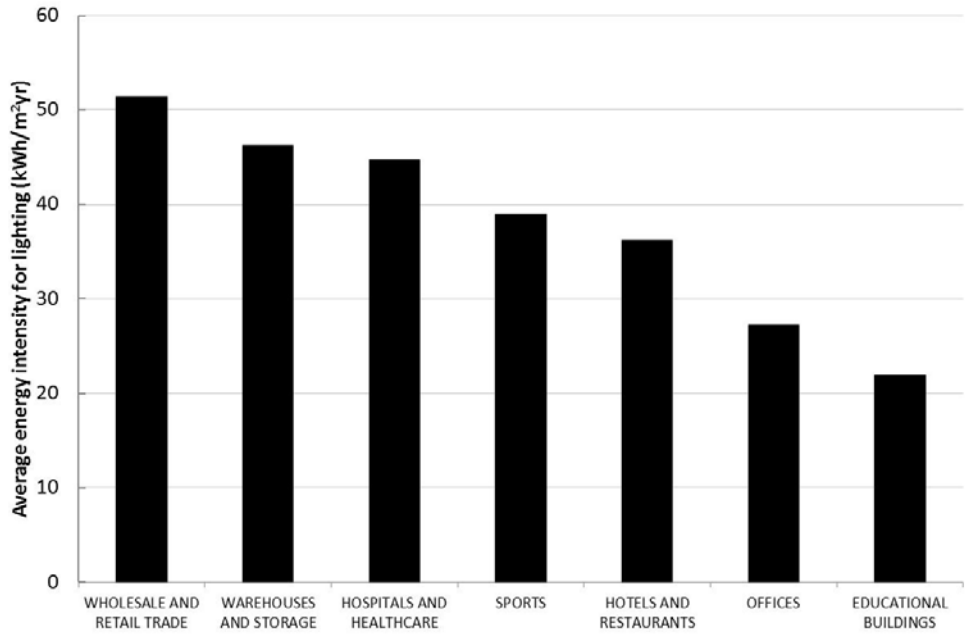


Figure 63: Average energy intensity (kWh/m2yr) for lighting for eight building types for which data is available.

3.4. Typical electric lighting installations in existing buildings by building type

Data about the typical electric lighting installations in existing buildings is still very scarce. So far, only Sweden, The Netherlands and the United States have provided some information about electric lighting installations according to building type. This information only concerns the type of lamp used. No information about the type of lighting fixture or lighting design scheme is available so far. Table 40 summarizes the information found about light source by building type. This table shows in general that fluorescent lighting, especially of the older type with conventional ballasts, is predominant in the non-residential sector, with still some

minor prevalence of incandescent lighting and some penetration of CFLs. LED lighting is still very seldom used and HID is not really reported. Some countries perhaps have placed HID lighting under the category “other”.

Table 40: Distribution of light source type according to building type.

		Fluorescent (%)	CFL (%)	Incand. (%)	Halogen (%)	LED (%)	HID (%)	Other (%)
OFFICES	Sweden	46 T12 10 T8 (HF b.) 17 T5 (HF b.)	7	12	7		8	1
	The Netherlands	60 10 HF 3 HF+	13	4	8	3		
	United States	82	14	1	1			1
EDUCATIONAL BUILDINGS	Sweden	59 T12 14 T8 (HF b.) 7 T5 (HF b.)	5	11	1			3
	The Netherlands	61 TL 15 HF 10 HF+	10	2	2	0		
	United States	85	10	1	2		1	2
HOSPITALS AND HEALTHCARE	Sweden	56 T12 2 T8 (HF b.) 7 T5 (HF b.)	5	26	1			3
	The Netherlands	42 (36*) TL 27 (8*) HF 10 (3*) HF+	13 33*	4 15*	3 4*	1 0*		
	United States	84-88	9-13	1	1			1
WHOLESALE AND RETAIL TRADE	The Netherlands	42 TL 12 HF 2 HF+	18	5	18	3		
	United States	79	6	5	6		3	1
SPORTS	Sweden	60 T12 10 T8 (HF b.) 13 T5 (HF b.)	1	7	4			5

*The Netherlands presents a separate figure for a sector called “nursing and care”.

4. Conclusions

As part of the work of Subtask D, this report aimed to analyze the current distribution of the building stock in the non-residential sector in order to define the most important building types to include in IEA Task 50. Another aim of this report was to harmonize the name of each building type while generally providing a structure for IEA Task 50. Finally, a secondary aim was to investigate the current average electricity use for lighting by building type and obtain some knowledge about the typical characteristics of the electric lighting installations according to building type.

The analysis presented in this report shows that the non-residential sector represents roughly 25% of the total building stock and generally comprises a more complex and heterogeneous building type distribution than the residential sector. By country data presented shows that much of the available data is incomplete or contradictory. One great difficulty lies also in the fact that some building belonging to the same category in one country are placed under two different categories in another country. Also, some building types are split into several specific categories in some countries while they are grouped under the same heading in another country.

The report shows that five building types should be given priority in this IEA Task 50:

1. OFFICES
2. EDUCATIONAL BUILDINGS
3. WHOLESALE AND RETAIL TRADE
4. INDUSTRIAL BUILDINGS
5. AGRICULTURAL BUILDINGS

The data shows that the first three building types each cover roughly 20-30% of the total floor area of the non-residential building sector. The wholesale and retail trade sector is particularly important since data also indicates high energy intensity for lighting in this sector. In addition, industrial and agriculture buildings may represent a very large floor space and should therefore be given consideration. Agriculture buildings mainly house an animal, which entails other types of lighting issues and solutions and for this reason, we recommend to exclude this building sector from IEA Task 50.
Apart from the category called “other”, three other non-residential building types, which cover roughly 2-10% of the total floor area, should be given a second priority within the IEA Task 50:

1. HOTELS AND RESTAURANTS
2. HOSPITALS AND HEALTHCARE
3. SPORTS

Among the different building types, hospitals and healthcare, hotels and restaurants and sports buildings have high energy intensity (higher than offices and education buildings) and should thus be considered as very important for this IEA Task 50. The type “other buildings” could also be excluded from the task since it is very difficult to know what the data really represents for this category (some countries have placed industrial buildings under the category “other”).

Finally, the report indicates that for most non-residential buildings, data about the typical lighting installations is really scarce. However, some data found for Sweden, The Netherlands and the United States indicate that fluorescent lighting is the dominant light source, that LED lighting is still very rare and that there is still some incandescent lighting. Data available about type of fluorescent lighting indicate that roughly half or existing fluorescent lighting is of the older type i.e. T8 or T12 with conventional ballasts and thus, large energy savings could be achieved by simply upgrading these lighting sources to modern T5 lamps with HF ballasts or LED solutions.

5. References

Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry. (2010). Retrieved 12 02, 2013, from http://www.enecho.meti.go.jp/topics/hakusho/2013energyhtml/index.html

(n.d.). *Bearbetning av SCBs energistatistik för lokaler samt summeringsrapporter.*

Belysningsbranschen. (2008). *Upplys Sverige! Rapport om landets övergang till energisnål belysning.* Stockholm: Swedish Lighting Association.

BMWFJ. (2012). *Bundesministerium für Wirtschaft, Familie und Jugend.* Retrieved 11 20, 2013, from Energiestatus Österreich: http://www.bmwfj.gv.at/EnergieUndBergbau/Energieversorgung/Documents/Energiestatus%202012.pdf

BPIE. (2011). *Europe's Buildings under the Microscope - A country-by-country review of the energy performance of buildings.* Retrieved from Buildings Performance Institute Europe: http://bpie.eu/uploads/lib/document/attachment/21/LR_EU_B_under_microscope_study.pdf

BPIE. (2013). *Building Performance Institute of Europe*. Retrieved 07 30, 2013, from Data hub for the energy performance of buildings: http://www.buildingsdata.eu/results

Danmarks statistik. (2011). Retrieved 09 10, 2013, from http://www.statistikbanken.dk/ene3n

Danmarks statistik. (2012). Retrieved 09 13, 2013, from http://www.statistikbanken.dk/statbank5a/default.asp?w=1680

DOE. (2013). *Buildings Energy Data Book: Energy efficiency and renewable energy.* retrieved 2013-08-05 via http://buildingsdatabook.eren.doe.gov/ChapterIntro1.aspx?1#1: US Department of Energy.

Energi styrelsen. (2011). *arkiv publikationer*. Retrieved 09 11, 2013, from http://www.google.dk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0CEcQFjAB&url=http%3A%2F%2Fwww.ens.dk%2Farkiv%2Fpublikationer%2Fvejledninger%2Fse-elforbrug%2Fat_download%2FFile&ei=9pExUt3BJoXasgaA-oHgAw&usg=AFQjCNEQYgAgOHfyRV3I-Ruh7-n3wMT2LA

Energiwiki. (2013). Retrieved 11 26, 2013, from http://energiwiki.dk/index.php/Belysning (last accessed 13 September 2013)

Enkvist, P. A., Naucler, T., & Rosander, J. (2007). A cost curve for greenhouse gas reduction: A global study of size and cost of measures to reduce greenhouse gas emissions yields important insights for businesses and policy makers. *McKinsey Quarterly: the online journal of McKinsey & Co*.

ET. (2010).

Federal Bureau of Statistics. (????). *Building permits - completions of non-residential buildings, Long series since 1980.* Federal Bureau of Statistics.

Federal Ministry of Transport. (2011). *Building and Urban Development: Typology and building stock of unheated non-residential buildings in Germany, BMVBS-online-publication, Nr. 16/2011.* Berlin: Federal Ministry of Transport.

Geon. (2012). Retrieved 03 18, 2013, from http://senternovem.databank.nl/

IEA. (2006). *Light's Labour Lost: Policies for Energy-efficient Lighting.* retrieved 2013-08-05 http://www.iea.org/publications/freepublications/publication/light2006.pdf: In Support of G8 Plan of Action, International Energy Agency, OECD, Energy efficiency policy profiles.

IEE. (2012). *DATAMINE: Collecting data from energy certification to monitor performance indicators for new and existing buildings.* Intelligent Energy Europe, Contract EIE/05/097.

Isaacs, N., & Hills, A. (2013). Understanding the New Zealand non-domestic buildings stock. *Building Research and Information*, DOI:10.1080/09613218.2013.831274.

Isaacs, N., & Hills, A. (2013). Understanding the New Zealand non-domestic uildings stock. *Building Research and Information,*, published online DOI:10.1080/09613218.2013.831274.

Kapusta, D., Jandrokovic, M., & Mandl, D. (2012). *Energieinstitut: der Wirtschaft GmbH.* Retrieved 11 20, 2013, from Energiekennzahlen in Dienstleistungsgebäuden: http://www.energieinstitut.net/portal/page/portal/DLG_HOME/DLG_DOWNLOADS/Endbericht_Audits.pdf

Kohler, N., Hassler, U., & Paschen, H. (1999). *Material flows and costs in the sector of construction and housing, Enquete-Commission of the 13. German Bundestag "Protection of people and the environment ".* Berlin/Heidelberg/New York: Springer Verlag.

LABORELEC. (2007). *Lighting in Belgium Some facts -19/04/07 – 7.*

McGraw-Hill Construction. (2010). *Energy Efficiency Trends in Residential and Commercial Buildings.* Office of Energy Efficiency and Renewable Energy. United States Department of Energy.

McKinsey & Company . (2012). *Lighting the Way: Perspectives on the global lighting market – Second edition.*

Meijer Energie & Millieumanagement B. V. (2008). Retrieved 03 20, 2013, from http://senternovem.databank.nl/.

Ministerie van Binnenlandse Zaken en Koninkrijksrelaties (BZK). (2013). *Ministerie van Binnenlandse Zaken en Koninkrijksrelaties (BZK).* Retrieved 03 20, 2013, from Binnen Agentschap NL: http://senternovem.databank.nl/

Ministry of Land, Infrastructure, Transport and Tourism. (2013). Retrieved 12 02, 2013, from http://www.mlit.go.jp/report/press/joho04_hh_000322.html

Ministry of the Environment. (2007). *National Building Code of Finland - D5 - Calculation of energy use and need of heating, guidelines.* Available: http://www.finlex.fi/data/normit/29520-D5-190607-http://www.finlex.fi/data/normit/29520-D5-190607-suomi.pdf.

Mobius Consult. (2009). Retrieved 03 20, 2013, from http://senternovem.databank.nl/

Munck, K., & Clausen, V. (2008). *Krav til elforbruget i belysningsandel i offentlige og private bygninger 2008-2020.* Stenløse: Dansk Center for Lys.

Natural Resources Canada. (2010). Retrieved 07 30, 2013, from Energy Use Data Handbook: http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=HB&sector=com&juris=00&rn=1&page=5&CFID=29374639&CFTOKEN=18d1457ee56e8b6-A6377CAD-DC86-AB27-A9C4832

Navigant Consulting Inc. (2002). *U.S. Lighting Market Characterization, Volume I: National Lighting Inventory and Energy Consumption.* Office of Energy Efficiency and Renewable Energy, Building Technologies Program. United States Department of Energy.

Official statistics Finland. (2012). *Official statistics Finland*. Retrieved 06 05, 2013, from Buildings and summer cottages, Helsinki: Tilastokeskus, ISSN=1798-677X: http://tilastokeskus.fi/til/rakke/tau.html

Panteia. (2008, 2010). Retrieved from http://senternovem.databank.nl/

Pout, C., Moss, S., & Davidson, P. J. (1998).

SCB. (????). *Statistics Sweden.*

Statens energimyndighet. (2008). *Energianvändning i vård lokaler - förbättrad statiktik för lokaler STIL 2.* Stockholm: Statens energimyndighet.

Statens energimyndighet. (2009). *Energiandvändning i idrottsanläggningar - Förbättrad statistik för lokaler STIL2.* Eskiltuna: Energimyndigheten.

Statens energimyndighet. (2010). *Energianvändning i handelslokaler - förbättrad statistik för lokaler STIL 2.* Stockholm: Statens energimyndighet.

Statens energimyndighet. (2011). *Energi i idrottsanläggningar.* Eskilstuna: Energimyndigheten.

Statens energimyndighet. (2011). *Energianvändning i hotell, restauranger och samlingslokaler - Förbättrad statistik för lokaler, STIL2.* Eskiltuna: Energimyndigheten.

Statens energimyndigheten. (2006). *Förbättrad energistatistik för lokaler – Inventeringar av kontor och förvaltningsbyggnader.* Eskiltuna: Energimyndigheten.

Statens energimyndigheten. (2010). *Energi i våra lokaler. Delrapport från Energimyndighetens projekt Förbättrad energistatistik i samhället.* Eskiltuna: Energimyndigheten.

Statens offentliga utredningar. (2008). *Ett energieffektivare Sverige.* Stockholm: Statens offentliga utredningar.

Statistic Austria. (2012). *Statistik Austria*. Retrieved 11 20, 2013, from Energiebalanzen: https://www.statistik.at/web_de/statistiken/energie_und_umwelt/energie/energiebilanzen/index.html

Statistics, T. F. (2012). *Buildings and apartments - Inventory of homes and residential buildings, demolition of flats and residential buildings, long series 1969 - 2011.* The Federal Bureau of Statistics.

Statistik Austria. (2011). *Statistik Austria: Die informationsmanager*. Retrieved 11 30, 2013, from Bestand an Gebäuden und Wohnungen: http://www.statistik.at/web_de/statistiken/wohnen_und_gebaeude/bestand_an_gebaeuden_und_wohnungen/index.html

Statistik Austria. (2012). Retrieved 11 20, 2013, from Energiestatistik: Strom- und Gastagebuch: https://www.statistik.at/web_de/static/durchschnittlicher_stromverbrauch_der_haushalte_2012_nach_verbrauchskatego_071028.pdf

Statistik Austria, BMWFJ, Lebensministerium, & E-control. (2011). *Statistik Austria.* Retrieved 11 20, 2013, from Direktion Raumwirtschaft, Energie: Projektbericht Energieeinsatz im Dienstleistungssektor

Stengård, L. (2009). *Global Energifakta. Statens energimyndigheten.* Retrieved 05 01, 2009, from http://195.67.76.248/Global/Energifakta/F%C3%B6rb%C3%A4ttrad%20energistatistik/Festis/STIL2-belysning-stengard.pdf

Swedish Standards Institute. (2007). *SS-EN 15193 Energy performance of buildings - Energy requirements for lighting.* SIS.

TABULA. (2012). *Typology approaches for non-residential buildings in five European countries - existing information, concepts and outlooks. Tabula thematic report no. 3, Deliverable 9.* Intelligent Energy Europe Contract No. IEE/08/495.

The Swedish Energy Agency. (n.d.). *STIL investigation.*

Thomsen, K. E., Wittchen, K. B., Jensen, O. M., & Aggerholm, S. (2007). *ENPER-EXIST Applying the EPBD to improve the Energy Performance Requirements to Existing Buildings, WP3: Building stock knowledge.* Intelligent Energy Europe.

US Department of Energy. (2009). *Buildings Energy Data Book*. Retrieved 07 01, 2013, from http://buildingsdatabookeren.doe.gov

Wuest & Partners. (2012). *Marché immobilier Suisse.* Retrieved 08 05, 2013, from www.wuestundpartner.com/index_f.phtml

Ziesing, H.-J. (2013). *Anwendungsbilanzen für die Endenergiesektoren in Deutschland in den Jahren 2010 und 2011.* Studie beauftragt vom Bundesministerium für Wirtschaft und Technologie, Berlin.