Typology Approach for Building Stock Energy Assessment

Typology Approaches for Non-Residential Buildings in Five European Countries

- Existing Information, Concepts and Outlook -

– TABULA Thematic Report N° 3 –

TABULA Project Team

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Authors:

Britta Stein (ed.)	IWU (P 01)	Institut Wohnen und Umwelt / Institute for Housing and Environment	Darmstadt / Germany
Elena Dascalaki	NOA (P 02)	Group Energy Conservation National Observatory of Athens Institute of Environmental Research and Sustainable Development	Athens / Greece
Małgorzata Popiołek Jerzy Kwiatkowski	NAPE (P 08)	Narodowa Agencja Poszanowania Energii SA / National Energy Conservation Agency	Warszawa / Poland
Maria Amtmann	AEA (P 09)	Austrian Energy Agency	Wien / Austria
Zdravko Georgiev	SOFENA (P 10)	Sofia Energy Agency	Sofia / Bulgaria

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1 Summary

Whereas in some European countries typologies for residential buildings have been used for several decades now, approaches to record non-residential buildings in a comparable structure have not been successfully implemented yet. Apart from introducing or further developing typologies for residential buildings, five European partners of the TABULA project (AEA / Austria, SOFENA / Bulgaria, IWU / Germany, NOA / Greece, NAPE / Poland) have also dealt with national approaches for non-residential building typologies.

Because of the broad variety of uses and associated characteristics, setting up a typology for the non-residential sector is rather complex. It is therefore important to consider both, practicability of and data availability for such a structure.

In the reporting countries, available data sources and the knowledge about the non-residential building stock differ. In general, data from official statistics are fairly poor. For this reason, further knowledge is generated through national and European projects, energy audits and studies, e.g. in the framework of consulting activities. In the more recent past, databases to collect benchmarks or data from energy certificates have been set up in Austria and Poland. In Sofia/Bulgaria and Greece studies to assess the non-residential building stock have been conducted. In Germany analyses concerning possible structures of a non-residential building typology, benchmarks, and end energy uses in the tertiary sector have been carried out.

The proposed draft classification schemes of all five project partners refer to the different uses of non-residential buildings and their construction year classes as main parameters to differentiate building categories. For the distinction of further subtypes various suggestions are made concerning climate conditions, building size, building cubature, surface-to-volume ratio, supply systems, and the state of refurbishment. Some partners suggest to work with a limited number of building categories to begin with.

In general, the analysis shows that the current state of the European non-residential building stock and on-going retrofit processes are not very well known. It is therefore important to gather more information about energetically relevant characteristics of the buildings, their quantities and the state of retrofit through further studies and surveys. Setting up compulsory databases to analyze and evaluate energy certificates for example seems to be a promising approach.

Bearing in mind that the data available and even certification schemes in European countries are very different, a harmonized structure which might for instance be based on the DATAMINE project (http://env.meteo.noa.gr/datamine/) will be necessary to be able to compare and monitor the activities in the building sector on a regional, national and European level.

Also for comparability and practicability reasons, it will be necessary to work with a simplified and harmonized calculation method. A first step in this direction has been taken with the ASIEPI project (http://www.asiepi.eu) during which a method to compare the energy performance requirement levels of European countries was developed. The comparison method is accompanied by an Excel Tool which aims at the harmonization of primary energy calculations and is based on results of the EPA-NR project (http://www.epa-nr.org/).

In summary, it can be stated 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 Austria

(by TABULA partner AEA / Austria)

2.1 Existing typology concepts

Climate:active benchmark database

The project “ecofacility” database is a benchmark database of the national climate:active program and was founded in February 2004. It is used by the climate:active (http://www.klimaaktiv.at) commercial building consultants for construction and renovation, to perform a first rough check within an energy consultation. After entering the data, the consultant is able to compare and evaluate the electricity, water and energy consumption. The online database assists the energy consultant by offering an automatic estimation of the energy efficiency of the building. On the bases of a short report in a second step the energy consultant gives general energy saving advises and then, in a third step, proposes necessary energy saving measures.

There exist benchmarks for the following operating modes:

- Office building (4000–20,000 m², 500–4000 m², office buildings without air conditioning, data centre)
- Tourism (restaurants, hotel 1–2 star, hotel 3–4 star, hotel 5 star)
- Schools (not specific schools, kindergarten)
- Event Centres (general clubhouse, sport facilities, indoor swimming pools with pool surface up to 500 m², indoor swimming pools with over 500m² pool surface, heated outdoor pools, baths)
- Home Building (student housing, youth recreation children's home, youth hostel, nursing home, nursing home)
- Trade (outlets without air conditioning, food trade 1000–2000 m² of retail space, grocery store from 2,000 m² of retail space, grocery store 600–999 m² of retail space, grocery store less than 600 m² of retail space, sales location 1000–2000 m² of retail space, retail facility from 2,000 m² of retail space)
- Parking garages

The following data is collected individually for each building:
Annual electricity, water and heat consumption, gross floor area, number of nights, beds, equipment (Mechanical ventilation, air conditioning, canteen, laundry, kitchen, gym, heavy evening use etc.), class number, etc.

Currently, a total of over one thousand buildings are recorded in the database.

ZEUS and ImmoZEUS database

Statistics Austria provides only little information about non-residential buildings, and the requested data are not available. The ZEUS EPC-database (Energy Performance Certificate) operated by Salzburg, Carinthia and Styria and the EPC-database Immo-ZEUS contain currently 1690 data sets of non-residential buildings.

Immo-ZEUS (http://www.immozeus.at/) is an online database for the national management of energy certificates in the private sector. The Austrian Energy Agency and gizmocraft operate the online database. Immo-ZEUS is available to all construction companies, real estate companies and

Energy Performance Certificate advisers. It is Internet software, which makes possible that the EPC data from the respective calculation programs is automatically transferred into an Internet address. If necessary, the data of each building can be updated when there are changes in ownership.

The ZEUS database having become the widest-spread EPC database in Austria over the past 6 years, covering three provinces and being open to the private sector as well, only this Austrian database was analyzed in more detail and its data stock used for the TABULA project. The datasets of the non residential buildings from the years 2003 to 2010 were used for the TABULA analysis and to work out a draft classification scheme.

In the ZEUS and ImmoZEUS databases available building types:

- 205 “operational buildings” like factories or service buildings
- 227 remaining conditioned non-residential buildings
- 51 schools
- 50 trade buildings
- Less than 50: event centres, offices, hotels and hospitals

To get still more representative information out of the databases, more buildings will have to be recorded. Therefore, to begin with, the following classification types and age classes were decided to be established, taking into consideration also the before described ecofacility benchmark database.

2.2 Draft classification scheme for non-residential buildings

Within the TABULA project, the data of ZEUS and ImmoZEUS databases were evaluated in order to check their usability for establishing a non-residential building typology.

The data evaluation method consisted of the following steps:

- **Retrieve existing data stock**
  All EPC data, stored via XML within ZEUS, of Salzburg, Styria and ImmoZEUS is exported and made anonymous. The EPC data is provided by Excel sheets to identify the relevant EPCs and to apply statistical functions and calculations, classified as raw data.

- **Prepare existing data stock**
  The EPC raw data is analysed based on the predefined representative model buildings. Sample categorizations respective the heating energy demand (HWB), gross floor area (BGF), status (in progress, done) and building age class are made to qualify all possible EPCs.

- **Refine data stock**
  EPCs with creation dates ranging from 2007 to 2010 are qualified for comparison due to the usage of comparable data standards in this time period (comparable XML versions).
  EPCs at this stage count: 900.

- **Consolidate data stock**
  At the data consolidation stage buildings were identified where EPCs exist before and after redevelopment. Sample IDs were evaluated and XML data was further investigated for quality purposes.
  EPCs sample count: 10

- **Identify relevant IDs of EPCs for further investigations**
  Identification of relevant buildings was based on the representative model buildings.
  Final EPCs count: 22

- **Extract all Data of identified EPC IDs using the XML data structure and PDF**
  All data of the final identified EPCs were extracted. As mentioned, the XML data structure and in succession ZEUS keeps the bigger part of all EPC data. Some data is stored in the PDF only. So PDFs were made anonymous and data of building elements was extracted.

For a first draft version following non residential building typology is proposed:

Building types:

- operational buildings
- school
- trade buildings

Construction year classes:

I	- 1918
II	1919 – 1979
III	1980 – 1999
IV	2000 – 2010

Possible Supply system categories

Oil

Natural gas

District heating

2.3 Proposed proceeding / link with current national activities

Following sources for the proceeding for the classification scheme are available:

- “Handbuch Baustelle Schule- Leitfaden zur ökologisch nachhaltigen Sanierung von Schulen”, E. Haselsteiner, M. Lorbek, G. Stosch, R. Temel, BMVIT, 47b/2010
- „Handbuch für kommunale und regionale Energieplanung – Handbuch KREP 2000“, Joanneum Research Forschungsgesellschaft mbH, 2001
- „Handbuch für Energieberater“, Joanneum Research Forschungsgesellschaft mbH, 1993

Following sources for data of concrete example buildings are available:

- Best practise eco-facility projects (office building, tourism building, schools, event centre, trade building)
- ZEUS and ImmoZEUS database: The extracted EPC data will be analysed and used to show mean values for the respective categories.

Following statistics/ frequencies for the further proceeding are available:

Table 1: Quantities of non residential buildings from the statistical data of Statistik Austria: „Gebäude und Wohnungszählung 2001“

Austria	Non residential buildings
total	282,257
before 1919	62,841
1919 to 1944	22,327
1945 to 1960	30,493
1961 to 1980	71,740
1981 to 1990	32,815
1991 or later	7,545
Not reconstructable	54,496

Table 2: „GEMIS- Österreich Energetische Kennzahlen im Prozeßkettenbereich Nutzenergiedienstleistung“, Jungmeier et al.

	Before 1919	1919 - 1945	1945 - 1960	1961 - 1970	1971 - 1980	1981 - 1990	Since 1991
NRB	103	106	120	103	104	78	60

Table 3: ÖSTAT/ ÖIR- HWZ 1991, Walter Hüttler

Number of buildings	Trade/ office	Factory/ operational	Tourism	Public
- 1880	8,404	4,967	3,500	5,025
1880-1918	7,927	6,291	2,141	3,440
1919-1944	4,454	5,751	1,468	1,764
1945-1960	7,005	9,396	2,373	3,096
1961-1970	8,366	11,443	3,992	3,945
1971-1980	9,920	13,138	4,941	4,531
1981 -	10,455	12,404	3,559	4,260
total	56,531	63,390	21,974	26,061
Gross floor area (m²)	**Trade/ office**	**Factory/ operational**	**Tourism**	**Public**
- 1880	13,930,724	7,144,596	4,259,481	5,678,504
1880-1918	18,942,421	11,110,819	2,158,258	7,096,492
1919-1944	6,047,604	7,939,765	1,277,937	2,371,890
1945-1960	8,310,161	11,257,905	2,112,512	4,322,751
1961-1970	14,385,015	17,358,723	3,845,046	7,212,950
1971-1980	21,134,553	23,718,989	5,477,169	10,499,270
1981 -	22,146,521	22,681,378	5,368,772	8,926,927
total	104,896,999	101,212,175	24,499,175	46,108,784
% of the total building stock	13.5%	13.0%	3.2%	5.9%

Following sources for the proceeding for identifying the energy saving measures are available:

- Major renovation of non-residential buildings, OIB- Richtlinie 6, "Energieeinsparung und Wärmeschutz", April 2007

  Calculated heating energy consumption must not exceed the following values (maximum values); calculated heating energy consumption refers to m^3 heated volume, to the reference climate, and is calculated based on a defined user-profile (HWB V,NWG,max,Ref); maximum values depend on the geometry of the building (lc=characteristic length). The absolute upper Limit is 30 kWh/(m^3a).

ab 1.1.2010	$HWB^*_{V,NWGsan,max,Ref} = 8,5 * (1+2,5/l_c)$ [kWh/m³a]	Höchstens jedoch 30,0 [kWh/m³a]

  The building is equipped with ventilation system with heat recovery: The maximum value is reduced by 2 kWh/(m³a) or 1 kWh/(m³a), if not more than half of the useful area is supplied by a mechanical ventilation system with heat recovery.

  Cooling: the maximum permitted cooling demand KB*V,NWG,max = 2.0 kWh/(m³a); takes into account the cooling demand caused by the climate of the location and refers to a defined user-profile and gross volume; infiltration nx = 0.15.

2.4 Conclusions

The following steps to implement a national non-residential buildings typology have been identified:

- Check and analyse different data sources of non residential buildings
- Comparison of the data to identify to build up the TABULA non residential building typology
- Display relation to the national residential building typology
- Final proposal for classification scheme
- Show example buildings

Table 4: Sources / References Austria

Reference shortcut	Short description	Reference
[1]	Project website	http://www.klimaaktiv.at
[2]	Project website	http://www.energieausweise.net
[3]	Project website	http://www.immozeus.at
[4]	Scientific paper	"Handbuch Baustelle Schule- Leitfaden zur ökologisch nachhaltigen Sanierung von Schulen", E.Haselsteiner, M. Lorbek, G.Stosch, R. Temel, BMVIT, 47b/2010
[5]	Scientific paper	„Handbuch für kommunale und regionale Energieplanung – Handbuch KREP 2000", Joanneum Research Forschungsgesellschaft mbH, 2001
[6]	Scientific paper	„Handbuch für Energieberater", Joanneum Research Forschungsgesellschaft mbH, 1993
[7]	Statistic data	„Gebäude und Wohnungszählung 2001", Statistik Austria, 2001
[8]	Scientific paper	„GEMIS- Österreich Energetische Kennzahlen im Prozeßkettenbereich Nutzenergiedienstleistung", Jungmeier et al.
[9]	Statistic data	„ÖSTAT/ ÖIR- Häuser und Wohnungszählung", Walter Hüttler et al. 1991

3 Bulgaria

(by TABULA partner SOFENA / Bulgaria)

3.1 Existing typology concepts

Non-residential buildings are those buildings which are not intended for living. There are no statistical data by building types systematically collected by the National Statistical Institute. Information for building typologies can be achieved from the building owners: private companies (industrial and commercial buildings), data from ministries and municipalities (education and science, health, culture, tourism) and other sources.

For the purposes of typology for non-residential buildings, the following types need to be studied separately due to the specific use, type of construction and installations:

- **Industrial buildings** – Here we have different types of building requirements according to the number of floors and their functionality (production buildings, energy buildings, ware-houses, etc.). In the Bulgarian Energy Efficiency Law and sub-laws all buildings in an industrial site are considered as a part of the industrial systems (administrative, canteen, production building, ware-houses, electrical substation, sport facilities etc.). Energy audits of industrial systems have to consider also the energy performance characteristics of all buildings on the industrial site. However, the information for the industrial buildings is not analysed by the Agency of Sustainable Energy Development in Bulgaria. The complexity comes also from lacking information for the year of construction, plans and documentation for renovation and other changes in the construction and installation. Usually the energy audits result in defining measures for insulation of the administrative building, renovation of the heating systems and lighting.
- **Office buildings** – The experience of SOFENA lies with municipal administrative buildings and some private office buildings. In Bulgaria it is obligatory for public buildings to have a certificate if the gross floor area exceeds 1000 m^2. There is also an obligation for issuing technical passports for new and existing buildings. This process can be used for the classification of these buildings into different types.
- **Commercial buildings** – There is a big variety of shopping centres and malls, including retail centres of big chains. There are some data from market researches for the newly constructed shopping areas by cities. There are no available data for the construction typologies and the variety is too big.
- **Educational buildings** – The educational buildings include schools, kindergartens and universities. In Bulgaria, there are about 2700 schools (2000 are municipal property, 700 state owned), 3200 kindergartens and 40 universities [1]. Some of the old schools have passports with some technical data for the premises and construction. This information and the existing information in the Ministry of Education, Youth and Science can serve as a basis for the development of a typology for these buildings.
- **Hotels** – There is a statistic for the hotels according to their capacity and category [1, 4]. However, there are no existing data on the year of construction and types, although more of the hotels are recently constructed and renovated. In Bulgaria about 30% of the hotels are seasonal, i.e. used only in the summer or winter season. There are some surveys for mountain huts and hotels in some regions which can be used for the classification purposes [5]. Some of the hotels have energy performance certificates for tax reductions.
- **Health buildings** – These buildings include hospitals, clinics and sanatoriums. In 2010 there are 312 health facilities in total – state and private [1]. Most of the buildings fall into the requirements for obligatory energy audits and some of them already have certificates and technical passports.
- **Other buildings** – There is a big variety of other types of buildings, including agricultural, religious, sport, transport, catering. There are no current typology concepts for those buildings, except from architectural point of view (for the monuments of culture, e.g.).

3.2 Draft classification scheme for non-residential buildings

Two typologies can be proposed for non-residential buildings:

- Typology for industrial buildings – For the industrial systems it will be useful to propose a typology for the lighting and heating systems and advanced measures for control and system replacement: SCADA and energy management (including heating and lighting), new technology solutions for heating, ventilation and air conditioning (HVAC systems) and systems for the building construction: insulation and glazing. It can be based on studies of the existing conditions in the main types of industrial buildings – production buildings, warehouses, and office buildings. The last, office buildings, can be classified also in the next category.
- Typology for public non-residential buildings – It includes office buildings, cultural buildings (excluding theatres, cinemas) and health buildings.

According to a current study of SOFENA for the public buildings in Sofia (under cRRescendo project [2]), including educational, office and health buildings the following groups could be identified:

- G I – (Group I) - buildings built since the beginning of last century to the middle of the century (until the fifties) - solid construction with vertical load-bearing walls of brick masonry. Floor slabs in most places are concrete, as there are single cases of construction type "Prussian vault" and wooden structures.
- G II – (Group II) - buildings built in the middle of last century to the late seventies - solid construction with reinforced concrete columns, beams and slabs.
- G III – (Group III) - buildings built after the seventies of last century - solid construction with reinforced concrete columns, beams and slabs with brick masonry or panel construction.
- G IV – (Group IV) buildings built after 2004.

The following tables represent the characteristics of the construction elements for public buildings:

Table 5: Walls – Reference coefficient - $U_{R\,W}$ = 0.35 W/(m^2K)

Short description of the current states in the audited buildings	Heat transmission coefficient U W / (m^2K)	Coefficient of thermal resistance R (m^2K) / W	Period of construction
External plaster 0,03 m Brick masonry with solid bricks 0,65 m Internal plaster 0,03 m	0.93	1.07	To the fifties of the last century
External plaster 0,03 m Brick masonry with solid bricks 0,52 m Internal plaster 0,03 m	1.10	0.91	To the fifties of the last century
External plaster 0,03 m Brick masonry with solid bricks 0,38 m Internal plaster 0,03 m	1.37	0.73	To the seventies of the last century
External plaster 0,03 m Brick masonry with ceramic hollow bricks 0,25 m Internal plaster 0,03 m	1.37	0.73	After the seventies of the last century
External plaster 0,03 m Polystyrene 0,05 m Brick masonry with ceramic hollow bricks 0,25 m Internal plaster 0,03 m	0.50	2.00	Ordinance No 1 from 5.01.99 for design of insulations

Table 6: Windows – reference coefficient - $U_{R\,WI}$ = 1.7 W/m^2K

Short description of the current states in the audited buildings	Heat transmission coefficient U W / (m^2K)	Coefficient of thermal resistance R (m^2K) / W	Period of construction
Wood frames, two glasses with ordinary glasses	3.45	0.29	To the nineties of the last century
With PVC frames and double glazing with ordinary glasses	2.00	0.50	Ordinance No 1 from 5.01.99 for design of insulations

Roofs

- Pitched “cold” roofs covered with tiles. Most of the attics in these buildings are not used (in some cases are used for storage). The slab on the floor of the attic (the ceiling of the heated floor) was insulated during the construction of the building.
- Flat “cold” roofs. The floor slab of the attic (ceiling of the top roofs) was insulated when the building was put into operation.
- Flat “warm” roofs. In this type roofs the heating insulation is part of the roof construction.

Table 7: For the attic slab of a cold pitched or flat roof – reference coefficient $U_{R\,S}$ = 0.30 W/m²K

Short description of the current states in the audited buildings	Heat transmission coefficient U W / (m²K)	Coefficient of thermal resistance R (m²K) / W	Period of construction
Heat insulation cinder 0,20 m Cement layer 0,04 m Reinforced concrete slab 0,20 m Internal plaster 0,03 m	0.81	1.24	To the fifties of the last century
Heat insulation Keramzit (Ceramic material) 0,15 m Reinforced concrete slab 0,10 m Internal plaster 0,03 m	1.11	0.90	To the nineties of the last century
Armed cement layer 0,03 m Thermal insulation mineral wool 0,12 m Reinforced concrete slab 0,15 m Internal plaster 0,03 m	0.30	3.28	Ordinance No 1 from 5.01.99 for design of insulations

Table 8: For flat “warm” floor – reference coefficient $U_{R\,S}$ = 0.30 W/m²K

Short description of the current states in the audited buildings	Heat transmission coefficient U W / (m²K)	Coefficient of thermal resistance R (m²K) / W	Period of construction
Armed cement layer 0,03 m Thermal insulation polystyrene 0,04 m Reinforced concrete slab 0,15 m Internal plaster 0,03 m	0.60	1.64	To the nineties of the last century
Armed cement layer 0,03 m Thermal insulation expanded polystyrene 0,09 m Reinforced concrete slab 0,15 m Internal plaster 0,03 m	0.30	3.31	Ordinance No 1 from 5.01.99 for design of insulations

Heat supply:

- From the district heating network - with indirect scheme of block substations with plate heat exchangers. They heat water for the heating and DHW (domestic hot water). The substations are fitted with systems for automatic control systems and metering of the heat consumption. There are still indirect schemes of substations with shell water to water heat exchangers.
- By local boiler on oil or gas for water heating for the heat installation and through electricity boilers for DHW.
- Heat supply by local boiler on renewable energy source – pellets.

Therefore the first draft typology for non-residential building typology will contain:

1. Building types:
   - Schools
   - Kindergartens
   - Public office buildings
   - Hospitals
   - Other buildings that fall into the typology
2. Construction year classes
   - before 1945
   - 1945 -1970
   - 1970--2004
   - after 2004
3. Heating systems
   - central DH systems
   - local gas, oil and biomass boilers

3.3 Proposed proceeding / link with current national activities

At present the only source of information on the energy performance of buildings are energy performance certificates. There are more than 700 certificates issued for public buildings [6]. Unfortunately the only analysis made is for the investments necessary for the proposed measures to define indicators for the specific investment – BGN/m^2. The other indicator published in the reports from the Agency for Sustainable Energy Development is the amount of savings to be achieved in MWh. The database of building certificates is not available to the public and the assessment of the data on the building envelope and systems is possible only on the basis of energy audits and certificate provided by the building owners.

3.4 Conclusions

Not all non-residential buildings could be classified in a building typology for energy performance analysis due to the following reasons:

- Some of the buildings are monuments of culture and energy auditing is not obliged for them (museums, theatres, cultural centres, others);
- Religious sites are excluded from energy auditing and certification scheme, as well as military sites;
- Commercial and sport centres for which the variety of typologies is too big.

The following steps are proposed in the future to create non-residential buildings typology for Bulgaria, mainly for public buildings:

1. Official classification and database from the national statistics on non-residential buildings;
2. Analysis of the existing data for office, educational, healthcare and social buildings;
3. Development of a building typology for non-residential buildings – building matrix for the different building categories;

Analyses of the building envelope by year of construction, type of buildings and systems is very necessary for policy and planning purposes, now focusing mainly to the residential building sector.

Table 9: Sources / References Bulgaria

Reference shortcut	Short description	Reference
[1]	Statistical data	National statistical Institute and Information from Ministries
[2]	Energy efficiency and RES in public buildings	Survey on the Possibilities for the Use of Renewable Energy Sources and Energy Saving Technologies in Municipal Buildings, Pilot in a Central ("Vazrajdane") and a Peripheral ("Vrabnitsa") District of Sofia Municipality – „cRRescendo" Project in the frame of initiative CONCERTO of the 6th FP of the EC
[3]	Information from energy performance certificates	Energy reports provided from municipalities, data collected during the implementation of DATAMINE project
[4]	Statistical data for the accommodation sector in Bulgaria	Georgiev, Z., Assenova, M., Application of Resource Efficiency and Cleaner Production Approach in Bulgaria to Support Sustainable Tourism Development, 2nd International Conference SUSTAINABLE CONSUMPTION AND PRODUCTION: how to make it possible 29-30 September, 2011 Kaunas, Lithuania
[5]	Study on the current state and possibilities for energy renovation and use of RES in tourism sector	Study on the Use of Renewable Energy Sources and Energy Saving Technologies in Objects of the Tourism Infrastructure on the Territory of Sapareva Banya Municipality, IEE Europe Project INTENSE
[6]	Analysis of building audits	Presentation on Energy Auditing in Bulgaria, Agency for Sustainable Energy Development

4 Germany

(by TABULA partner: IWU / Germany)

The non-residential building sector is characterized by a large number of different building types, each with specific functional, morphological and structural characteristics and parameters. In addition, the buildings differ on account of their age, the construction materials used in the corresponding periods and their technical equipment. Therefore, understanding energy use in the non-residential sector is complex as end-uses such as heating, ventilation, cooling, lighting, IT equipment and appliances vary greatly from one building category to another. Thus, multifaceted knowledge is needed to set up a proper typology. In the recent past some approaches have been made to reflect the current situation in terms of available information, but also in terms of finding appropriate ways to structure a non-residential building typology. Due to the poor availability of data so far, there is a great need for further research.

4.1 Existing typology concepts

In Germany there is no elaborate monitoring of the non-residential building stock. Reliable data are sparse and therefore insufficient. Nevertheless, two current studies deal with typological approaches concerning non-residential buildings. Regulations concerning the acquisition and use of data as well as the use of benchmarks have been set up. Apart from that, for the more recent past some statistical data are available.

Statistical data on building activities [Destatis]

Non-residential buildings are included in the building activity statistics compiled by the Federal Statistical Office (Destatis) for the whole of Germany since 1993. The building activity statistics cover the permits issued for building construction, the completion of construction projects, the volume of unfinished building projects at the end of year, and the retirements of structures. The buildings are classified as either residential or non-residential and further categorized by type of building. Non-residential buildings comprise the categories shown in Table 10.

Table 10: Categories for non-residential buildings according to the German building activity statistics [Destatis]

No.	German description of the Building Category	English description of the Building Category	Share of total non-residential usable floor area[1]
1	**Anstaltsgebäude**	**Institutional Buildings**	Approx. 4 %
2	**Büro- und Verwaltungsgebäude**	**Office and Administration Buildings**	Share decreasing: 1993 to 1995 17-18%; 2007 to 2010 8-9%
3	**Landwirtschaftliche Betriebsgebäude**	**Agricultural and Farm Buildings**	Share increasing: 1993 to 1994 8-9%; 2009 17%; 2010 22%
4	**Nichtlandwirtschafltiche Betriebsgebäude,** darunter	**Operational Buildings,** further subdivided into	Approx. 60%
4a	Fabrik- und Werkstattsgebäude	Factory and Workshop Buildings	Approx. 19%
4b	Handels- und Lagergebäude	Retail Buildings and Warehouses	Approx. 32”
4c	Hotels und Gaststätten	Hotels and Restaurants	Approx. 2%
5	**Sonstige Nichtwohngebäude**	**Other Non-Residential Buildings**	Approx. 8%

[1] Unless otherwise stated average values 1993 to 2010

Annual information is provided about the number of new buildings and accordingly building measures concerning existing buildings, floor spaces (useful area and living space), building volume, construction costs, and the number respectively the floor spaces of demolished buildings. New buildings are also categorized by heating system and energy carrier, although the associated heated floor areas are not available.

Apart from the statistics for the whole of Germany, data on permits and completions of non-residential buildings are available for the territory of the former Federal Republic (without West-Berlin) since 1961.

Statistics on building activities deliver a rough basis to determine current dynamics (new buildings vs. demolitions), but at the end, fairly little information is provided as for example heated floor spaces and net floor areas cannot be deduced, data for the period from 1961 to 1992 are very incomplete, and data for the period before 1961 are not available. Therefore, no statistical data about the total number of non-residential buildings in Germany is available today.

Related to the application of the German Energy Saving Ordinance (Energieeinsparverordnung), BMVBS published two documents with regulations concerning the acquisition and the use of data as well as energy consumption values and comparable figures/benchmarks for non-residential buildings:

Bulletin on the regulations concerning acquisition and use of data with reference to the non-residential building stock [BMVBS 2009a]

In this publication assistance for issuing energy performance certificates for existing non-residential buildings on the basis of calculations (energy balances) is given in the form of simplifications on how to acquire data of the building envelope and the zoning.

Apart from that, a table showing typical U-values of roofs, ceilings, walls, façade elements, construction elements in the soil or bordering unheated rooms, windows, shutters, and doors of different construction year classes is available. Eight construction year classes are distinguished:

- until 1918
- 1919-1948
- 1949-1957
- 1958-1968
- 1969-1978
- 1979-1983
- 1984-1994
- from 1995

In addition, U-values are given for subsequently insulated building elements.

Another table shows typical parameters of the technical equipment, depending on a building category and partly on construction year periods. The building categories distinguished are: Office and Administration Buildings, Schools, Operational Buildings, Retail Buildings, Hotels, and Other Non-Residential Buildings. Central heating-boilers are distinguished by their year of construction (until 1977, 1978-1986, from 1987).

Bulletin on the regulations concerning energy consumption values and comparable figures for non-residential buildings [BMVBS 2009b]

This publication aims at the comparability of energy consumption values in the existing non-residential building stock. In this context, instructions on how to adjust consumption values for climatic conditions are given.

Furthermore, conversion factors for several building types are complied to translate the net floor area of a building into main usable area, usable area and gross floor area.

Average values and comparable values/benchmarks for heating energy consumption and the consumption of electricity are given for several building types. As these values derive from real energy uses single appliances (heating, hot water, ventilation, cooling, lighting) are not distinguished.

These two publications do not show a building typology in itself, but as rules for simplifications and comparability are given, they are useful for setting up a typological system. The benchmarks given in [BMVBS 2009b] derive from a more detailed study which is described hereafter.

Benchmarks for the energy efficiency of non-residential buildings [BBSR 2009]

For this study the real energy consumption (data by energy supply companies) of approx. 5 000 non-residential buildings was evaluated. Benchmarks are given for the appliances “heat” and “electricity”.

The classification of benchmarks is based on the German “Bauwerkszuordnungskatalog (BWZK)”, a structure for building categories, which was developed to analyze building costs for public buildings. For the study, the BWZK was adapted to the needs of private buildings, and a consolidated structure for the non-residential building sector with 11 main categories and several subtypes, as shown in Table 11, was suggested.

Table 11: Suggestion for a consolidated structure of building categories for public and private non-residential buildings [BBSR 2009]

No.	German description of the Building Category	English description of the Building Category
1	**Öffentliche Einrichtungen** Parlamentsgebäude, Gerichtsgebäude, Justizvollzugsanstalten, Bereitschafts- und Notfalleinrichtungen	**Public Facilities** Parliament Buildings, Courthouses, Prisons, Facilities for emergencies
2	**Lehre und Forschung** Hörsaalgebäude, Institutsgebäude, Laborgebäude	**Education and Research** Lecture Halls, Institute Buildings, Laboratories
3	**Schulen** Allgemeinbildende Schulen, Berufsbildende Schulen, Sonderschulen, Kindertagesstätten, Weiterbildungseinrichtungen	**Schools** Grammar Schools, Vocational Schools, Special Schools, Nursery Schools, Schools for further education
4	**Hotel, Beherbergung** Hotels mit 1 und 2 Sternen, Hotels mit 3 Sternen , Hotels mit 4 und 5 Sternen, Jugendherberge,/Gästehäuser/ Ferien-/ Schulland-/Vereinsheime/Gemeinschafts-unterkünfte	**Hotel, Accommodation** 1- and 2-star Hotels, 3-star Hotels, 4- and 5-star Hotels, Youth Hostels/Guest Houses/Holiday Accommodations/Hostels/Club Houses/Communal Accommodations
5	**Gaststätten** Ausschankwirtschaft, Speisegaststätten/Restaurant, Kantinen/Mensen	**Public Houses/Restaurants** Bars, Restaurants, Canteens/Refectories
6	**Gebäude für Veranstaltungen und kulturelle Zwecke** Kino, Opernhäuser/Theater, Saalbauten/Stadthallen, Ausstellungsgebäude, Freizeitzentren/Jugendhäuser/Gemeindehäuser	**Buildings used for events and cultural purposes** Cinemas, Opera Houses/Theatres, Roofed Halls/Civic Centres, Exhibition Buildings, Recreation Centres, Youth Clubs, Community Halls
7	**Sportanlagen** Sporthallen, Mehrzweckhallen, Schwimmhallen/Hallenbäder, Freizeitbäder, Sportheim (Vereinsheim) Fitnessstudios	**Sports Facilities** Sports Halls, Multipurpose Halls, Indoor swimming Pools, Leisure Pools, Club houses, Gyms
8	**Handel/Dienstleistung** Handel Non-Food/sonstige persönlichen Dienstleistungen bis 300 m², Handel Non-Food über 300 m², Handel Food bis 300 qm, Handel Food über 300 m², Kaufhäuser, Warenhäuser, Einkaufszentren (Food und Non-Food), Geschlossene Lagerhäuser,/Speditionen, Freiberufliches Gesundheitswesen/Praxen, Kosmetik/Frisör	**Retail and Services** Retail Non-Food/other Services up to 300 m², Retail Non-Food more than 300 m², Retail Food up to 300 m², Retail Food more than 300 m², Stores, Malls, Shopping Centre (Food and Non-Food), closed Warehouses/Shipping Company, self-employed Health Care/Surgeries, Beauticians/Hair dressers
9	**Gesundheitswesen** Krankenhäuser bis 250 Betten, Krankenhäuser 251 bis 1000 Betten, Krankenhäuser mit über 1000 Betten	**Health Care** Hospitals with less than 250 beds, Hospitals with 251 to 1000 beds, Hospitals with more than 1000 beds
10	**Verkehrsinfrastruktur** Flughafen/Terminal, Flughafen/Frachthallen, Flughafen/Wartung/Hangar, Flughafen Werkstätten, Tiefgarage privater Nutzung, Tiefgarere öffentlicher Nutzung, Bahnhof < 5000m², Bahnhof > 5000 m²	**Transport Infrastructure** Airport/Terminal, Airport Cargo Buildings, Airport maintenance/Hangar, Airport Workshops, Private Underground Parking, Public Underground Parking, Train Station < 5000 m², Train Station > 5000 m²
11	**Bürogebäude** nur beheizt, temperiert/belüftet, Vollklimaanlage/Konditionierung völlig unabhängig von Außentemperatur	**Office Buildings** with Space heating only, Temperate/Ventilated, Completely air conditioned/Conditioning independent from outside temperature

Within the report, the practicability of these building categories is discussed. Is was found that the building categories work very well as long as there is a large number of buildings which can be assigned to each of the categories. A major difficulty, however, is that the consideration of complex buildings leads to an increased number of building categories, whereas at the same time, the amount of buildings assigned to one category is decreasing dramatically. Therefore, it does not seem useful to start an endless process of further differentiation of building categories. Therefore, four alternative approaches are suggested:

- The complexity of buildings often results from mixes uses. One possibility is to regard the main uses of the building and create a benchmark by assessing energy uses of corresponding building categories according to their share of floor area. In the frame of the European project EPLABEL this approach lead to good results.
- Some appliances or uses cannot be covered through building categories or mixed uses, e.g. laboratories consume different amounts of electricity according to their equipment. In these cases it is suggested to subtract the consumptions of special appliances from the overall consumption. This approach also was also successfully used during the project EPLABEL.
- Instead of relating benchmarks to building categories or types, it might be advantageous to relate benchmarks to building zones which are characterized by uniform boundary conditions of use. This way different uses can be depicted fairly exact. However, benchmarks for building zones cannot be evaluated statistically; they have to be set up empirically.
- Another approach is to work with “tailored benchmarks” derived from the area-weighted sum of benchmarks for all separate zones within a building. By setting up the tailored benchmark, certain parameters (e.g. times, frequencies) may be adjusted according to the real conditions, so that the tailored benchmark can be compared to the real consumption of a building without any further conversions.

Typology and stock of heated non-residential buildings [BMVBS 2011]

Within this project a typology approach for the non-residential sector was developed which encompasses 11 major categories each including a certain number of specific subtypes (see Table 12). The building types were chosen with special consideration to the specifications of the German Energy Saving Ordinance (Energieeinsparverordnung) and/or due to their quantitative relevance.

For each type and subtype further differentiations can be conducted on the basis of structural design, energy quality etc. An analysis of the defined subcategories showed, however, that the distinction of more refined subtypes has much less influence on the buildings’ energy performance than expected. On the whole, three most determining factors were identified: the year of construction, the compactness (surface-to-volume ratio), and the technical building equipment.

Based on typical U-values of the main building elements floors, walls, windows, and roofs, four construction year classes are distinguished:

- until 1976
- 1977 - 1983
- 1984 – 1994
- post 1994.

For three of the building categories, the study delivers spectra of energy performances differentiated according to the year of construction and compactness respectively in one case according to the year of construction and the form of heat transfer. For this purpose a number of synthetic buildings (between 10 and 36) were defined and calculated for each of the considered building categories. The results show spectra concerning the total final energy demand of the buildings, but individual demands for heating, hot water, ventilation, cooling, and lighting are not specified. It should also be noted that calculated results do not necessarily reflect and represent real consumptions, especially as the coherence between the German calculation method for non-residential buildings and the corresponding true consumptions is not yet known.

Table 12: Typological categories for non-residential buildings by [BMVBS 2011]

No.	German description of the Building Category	English description of the Building Category
1	**Bildungsgebäude** Schulgebäude, Kindertagesstätten, Hochschulen	**Education Buildings** Schools, Kindergartens, Universities
2	**Büro- & Verwaltungsgebäude** Banken, Versicherungen, Regierungsgebäude, Ämter	**Office and Administration Buildings** Banks, Insurance-buildings, Government buildings, Official buildings
3	**Fabrikgebäude** Großunternehmen, Fabrikationshallen	**Factory Buildings** Large-scale enterprises, Manufacturing buildings
4	**Werkstattgebäude** Handwerk, Gewerbe	**Workshop Buildings** Craft, Trade
5	**Heilbehandlungsgebäude** Krankenhäuser, Polikliniken	**Health Buildings** Hospitals, Polyclinics
6	**Handelsgebäude** Shopping-Center, Lebensmittel, Non-Food	**Retail and Trade Buildings** Shopping Centre, Food, Non-Food
7	**Lagerhallen** Zentrallager, Versandlager	**Warehouses** Central Warehouses, Shipping Depots
8	**Sporthallen** private, Schul- und Hochschulsport, Tennishallen	**Sports Halls** private, School and College Sports, Indoor Tennis Centres
9	**Schwimmhallen** Spaßbäder, kleine Schwimmsporthallen	**Indoor Swimming Pools** Leisure Pools, Small Indoor Swimming Pools
10	**Kulturgebäude** Oper, Theater, Konzert, Kino, Ausstellungsgebäude	**Cultural Buildings** Operas, Theatres, Concert Halls, Cinemas, Exhibition Buildings
11	**Beherbergungsgebäude** Hotels, Gaststättengebäude freistehend	**Accommodation Buildings** Hotels, detached Restaurants

Apart from the categorization of building types, different methods to estimate the quantitative structure of the existing non-residential building stock are discussed, e.g. the utilization of geographic information systems, the calculation on the basis of urbanistic reference values or the direct or indirect utilization of data gathered in official statistics.

Data and maps of geographic information systems seem to be a promising method where in theory all required information concerning numbers, floor spaces and storeys are available. Nevertheless, in practice there are limitations concerning the quality and accessibility of the data. Additionally, the efforts to gather all the numbers for the whole of Germany would be immense.

In addition to the statistics on building activities, indirect data concerning the net invested capital in Germany were evaluated. It was found that this method is helpful to determine a rough, but incomplete overview of the quantity of buildings.

Energy consumption in the sector trade, commerce, and services in Germany 2007 to 2010 [ISI et al. 2011]

In the course of another recent study a typology concept was developed based on extrapolated data on the energy consumption in the sector trade, commerce, and services (also referred to as the tertiary sector).

The basis for the determination of energy consumption in the tertiary sector is a broad survey which is conducted every two years. The size of the sample is approx. 2,000 workplaces. For the survey, the tertiary sector is divided into 14 groups (distinguished by industries), which are further subdivided into more detailed splits. The averages of the specific electricity and fuel consumption derived from the surveys were extrapolated for Germany using the total number of employees in the individual considered groups and splits. The energy consumption of agriculture, forestry and airports was determined using data from secondary statistics. Based on the collected information about energy consumption by end use within the individual groups, the electricity and fuel consumption determined were divided into the end-uses: space heating, process heat, air-conditioning, process cold, power, lighting, and communication. The results show, that 70% of the

energy demand for fuel in the tertiary sector in Germany is accounted for space heating, and lighting is the dominant use with regard to electricity (40% of the consumed electricity is used for lighting), while the share of air conditioning for cooling in electricity consumption is still low today.

The survey for the year 2008 was also used to gather information about the part of the building stock which is used by the sector trade, commerce, and services. To generate reliable data for extrapolations it was important to identify clearly defined building categories. Within this context, the buildings were classified as shown in Table 13.

Table 13: Categories for non-residential buildings according to [ISI et al. 2011]

No.	German description of the Building Category	English description of the Building Category	Share of total net floor area
1	**Wohngebäude mit Mischnutzung**	**Residential buildings with mixed uses** (buildings used predominantly for residential and subordinated for non-residential purposes)	17%
2	**Bürogebäude**	**Office Buildings**	12%
3	**Laden- / Verkaufsgebäude**	**Shops and Commercial Buildings**	11%
4	**Werkstattgebäude**	**Workshop Buildings**	13%
5	**Lager- / Garagengebäude**	**Warehouses and Garages**	29%
6	**Sonstige Gebäude ohne Wohnnutzung**	**Other Non-Residential Buildings**	18%

Apart from that, three construction year classes were distinguished:

- pre 1977
- 1977 – 2002
- post 2002.

The result of the survey provides data about the number of buildings, floor spaces such as total sums of the floor space, commercially used floor space, average floor space per building, average floor space per storey, and average number of storeys. The results were extrapolated for Germany and deliver the total numbers of buildings and floor spaces for each category as well as the energy consumption concerning fuels and district heating (not distinguished by appliance). As to the energy consumption, the indentified standard variance proves a large dispersion of values. Therefore, significant conclusions cannot be drawn on this basis.

Resume

The existing approaches concerning a German non-residential building typology differ in terms of the defined building categories, construction year classes and other relevant parameters, depending on the intended application and data availability. Neither specific data nor specific studies seem to be available for the industrial sector. Reliable statements about the entirety of non-residential buildings cannot be made.

Apart from the introduced publications, quite a few other studies refer to the energy performance of non-residential buildings and might be helpful for setting up a typology, especially as some of them deal with particular aspects like the cooling of buildings [UBA 2011] or urbanistic coherences [Everding 2007].

4.2 Draft classification scheme for non-residential buildings

To set up a typology for non-residential buildings, four main parameters seem to be determining:

- The utilization of the building (operational patterns, requirements); in the typology accounted for by building categories and, if necessary, sub categories. The additional consideration of building zones will be helpful to incorporate buildings with mixed uses.
- The year of construction; in the typology accounted for by construction year classes.
- The compactness or size of the building; in the typology accounted for by different indicators, e.g. the number of work places in an office building or the number of beds in a hospital or a hotel. Another possibility is the indication of the overall floor space or the surface-to-volume ratio, although this value is usually not known to the owners and users and might therefore be difficult to apply.
- The technical building equipment; in the typology accounted for by enlisting relevant technical components (systems for heating, ventilation, hot water, cooling, and lighting; if applicable: energy sources used).

The main ***building categories defined by [BBSR 2009] and [BMVBS 2011]*** (see Table 11 and Table 12) seem to be a good starting point to further develop the existing approaches. In the course of setting up an overall national typology it will have to be validated how to consolidate both structures and to what extent alterations and additions will have to be made. As a vast number of building types should be avoided, it has to be examined to what extend sub-categories have to be set up and which ***additional parameters (size, technical equipment)*** are the most determining for each of the sub-categories.

Apart from that, no more than three or four ***construction year classes*** should be defined. Account should be taken of the fact that short construction year spans might be tricky to survey as it is difficult to generalize on the basis of a small number of buildings. It is therefore suggested to use the construction year classes defined by [ISI et al. 2011]. However, because of specific architectural characteristics and building materials used before 1919, the addition of a class for this period of time appears to be useful:

- until 1918
- 1919 - 1977
- 1978 – 2002
- post 2002.

As to the structure of the typology, three levels of detailing are desirable:

On a first level (inventory) an overview of all building categories and related quantities (number of buildings and floor areas) should be given (see Table 14).

The second level (benchmarks) is to go into more detail and might show one matrix for each of the building categories with the relating building types, distinguished according to the year of construction and other determining factors like supply system or building size. Further characteristics might be accounted for through the introduction of individual subtypes. Following [BBSR 2009] typical benchmarks should be shown for the consumption of fuels and electricity (see Table 15).

The third level (showcase examples) consists of data sheets for example buildings and is to show typical construction elements and energy performance indicators for the non-refurbished building and two levels of refurbishment, standard and advanced. At this level energy uses (useful energy, final energy, primary energy) for the different appliances (heating, hot water, ventilation, cooling, and lighting) depending on a commonly used energy carrier should be given. As gathering the required data for this purpose will take some time it might be a possibility to start by calculating synthetic buildings (e.g. in terms of parameter studies) until results for example buildings are available.

Table 14: Draft classification scheme for non-residential buildings, first level; overview of building categories and related quantities

	Building category 1	Building category 2	…	Building category n	Amount	Percentage Share
Until 1918						
Floor area [m²]						
Number of buildings						
1919 – 1977						
Floor area [m²]						
Number of buildings						
1977 – 2002						
Floor area [m²]						
Number of buildings						
Post 2002						
Floor area [m²]						
Number of buildings						
Floor area [m²]						
Percentage share [%]						
Number of Buildings						
Percentage share [%]						

Table 15: Draft classification scheme for non-residential buildings, second level; exemplarily differentiated by building category, construction year class, and form of heat transfer; table based on [BMVBS 2011]

No.	Building Category / construction year class	Form of heat transfer	Benchmark final energy [kWh/(m²a)]	
			Consumption of Fuels	Consumption of Electricity
8	**Sport Halls**			
8.1	until 1918	Gas, radiant heating		
8.2		Underfloor heating, ceiling heating elements		
8.3		Radiators, air heating		
8.4	1919 - 1977	Gas, radiant heating		
8.5		Underfloor heating, ceiling heating elements		
8.6		Radiators, air heating		
8.7	1978 – 2002	Gas, radiant heating		
8.8		Underfloor heating, ceiling heating elements, radiators, air heating		
8.9	Post 2002			

4.3 Proposed proceeding / link with current national activities

IWU proposes three major steps to set up a non-residential building typology:

1) Definition/Review of building categories

As mentioned before, the building categories defined by [BBSR 2009] and [BMVBS 2011] seem to be a good basis to proceed, but they have to be consolidated and modified. Further research is necessary to identify the most important energy influencing factor for each of the buildings categories; e.g. whereas for warehouses the surface-to-volume ratio might have the most influence, this does not necessarily apply for the category “Sports Halls” for which the technical equipment might have a higher impact (see [BMVBS 2011]).

It is also important to bear in mind that a significant share of the non-residential floor area in Germany seems to be located in buildings with mixed uses (either in terms of residential and non-residential uses or in terms of different non-residential uses) (see e.g. [ISI 2011]). Therefore an approach concerning the implementation of those floor areas into the typology, e.g. by using building zones, will be necessary.

2) Determination of quantities

In Germany there is a need to gather substantial data concerning the quantities of buildings (in total and according to building categories and construction year classes), quantities of floor spaces, cubatures, building equipment, the state of the current building stock, the share of already refurbished buildings, building elements respectively renewed technical equipment, and current trends (How many buildings and heating systems are being refurbished every year?).

With respect to the statistical aspects a better, centralized and compatible structure for the data is required. Needed data might be derived from large surveys like the German census or e.g. the Datenbasis Gebäudebestand. A further development of the geographic information systems accomplished by a simultaneous improvement of the accessibility at least for scientific purposes would support in reducing the existing deficits.

In any case, the introduction of a regular inquiry will be necessary to monitor the development and effects of the applied measures. The availability and regular update of the relevant statistical data will be an important basis for the development and evaluation of a national non-residential building typology.

3) Assessment of energy performance indicators (example buildings)

For each of the buildings categories, example buildings are to be identified. For the assessment of comparable energy performance indicators, the calculation of energy balances will be necessary. The German method to calculate energy balances for non-residential buildings is complex, and very detailed knowledge – especially about the technical equipment of the building – is needed. For the typological approach a simplified calculation method is needed. Within the research project “Teilenergiekennwerte (TEK)” (Partial Energy Indicators), funded by the Federal Ministry of Economics, IWU is currently developing such a tool. In the course of the project, 75 existing non-residential buildings are going to be assessed, and might serve as example buildings for quite a few categories of the non-residential typology.

Another approach for a simplified calculation method might derive from the project “Verbrauchsstrukturanalyse für Nichtwohngebäude” (Structural analysis of energy consumption in non-residential buildings). In the course of the project a calculation tool is developed to compare the real energy consumption of a building with a calculated tailored benchmark which allows a rough estimation of energy saving potentials.

A third project IWU is currently working on is called „Typologiegestützte Analyseinstrumente für die energetische Bewertung bestehender Nichtwohngebäude“ (Typology of public buildings owned by the federal state of Hessen) and funded by the Hessian Ministry of Environment. Ten public buildings of different construction year classes are being assessed with the help of the TEK tool. For

each of the buildings refurbishment measurements are proposed on two levels, standard and advanced. Based on the residential typology, data sheets are developed for the selected buildings to sum up the setup of the construction elements, the supply systems, and the energy demands of the three refurbishment levels.

4.4 Conclusions

In Germany, quite a few efforts have been made to set up a non-residential building typology. Different approaches have been developed depending on diverse goals, objectives, and methodologies. As only very few reliable data on the quantities of non-residential buildings are available, no qualified results can be drawn yet for the entirety of non-residential buildings.

Another difficulty is the complex calculation method used for non-residential buildings. For setting up a building typology that is supposed to be comparable to other countries a simplified and harmonized calculation method is needed.

It is therefore important not only to gather more information about the existing non-residential building stock through studies and surveys, but also to explore how the obtained data may contribute to an applicable building typology.

Table 16: Sources / References Germany

Reference shortcut	Short description (in English)	Concrete reference (in respective language)
[BBSR 2009]	Study on benchmarks for non-residential buildings	BMVBS / BBSR (ed.): Benchmarks für die Energieeffizienz von Nichtwohngebäuden, BBSR-Online-Publikation 09/2009
[BMVBS 2011]	Several typological approaches for heated non-residential buildings in Germany are listed and compared	BMVBS (ed.): Typologie und Bestand beheizter Nichtwohngebäude in Deutschland. BMVBS-Online-Publikation 16/2011
[BMVBS 2009a]	Disclosure of regulations concerning data acquisition and use of data with reference to the non-residential building stock	Bundesministerium für Verkehr, Bau und Stadtentwicklung (ed.): Bekanntmachung der Regeln zur Datenaufnahme und Datenverwendung im Nichtwohngebäudebestand Vom 30. Juli 2009
[BMVBS 2009b]	Disclosure of regulations concerning energy consumption values and comparable figures for non-residential buildings	Bundesministerium für Verkehr, Bau und Stadtentwicklung (ed.): Bekanntmachung der Regeln für Energieverbrauchskennwerte und der Vergleichswerte im Nichtwohngebäudebestand Vom 30. Juli 2009
[Destatis]	Publications on buildings activities by the German Federal Statistical Office	Statistisches Bundesamt (e.d.): Publikationen im Bereich Bautätigkeit, Wohnungsbau. Online: http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/DE/Content/Publikationen/Fachveroeffentlichungen/BauenWohnen/BautaetigkeitWohnungsbau/BaugenehmigungenBaufertigstellungen,templateId=renderPrint.psml [2012-02-16]
[Everding 2007]	Publication on solar urban planning	Everding, D. (ed.): Solarer Städtebau. Kohlhammer GmbH, Stuttgart 2007
[ISI et al. 2011]	A regular survey on energy consumption in the tertiary sector has been carried out for 10 years. The objective of these surveys is to further improve the statistical basis on energy consumption for this sector. In this study, the survey results for the years 2006 until 2010 are shown.	Fraunhofer-Institut für System- und Innovationsforschung (Fraunhofer ISI); Lehrstuhl für Energiewirtschaft und Anwendungstechnik (IfE), Technische Universität München; GfK Retail and Technology GmbH; IREES GmbH Institut für Ressourceneffizienz und Energiestrategien; BASE-ING. GmbH: Energieverbrauch des Sektors Gewerbe, Handel, Dienstleistungen (GHD) in Deutschland für die Jahre 2007 bis 2010. Bericht an das Bundesministerium für Wirtschaft und Technologie (BMWi). Karlsruhe/ München/ Nürnberg, August 2011
[IWU 2010]	Final report of the project „Datenbasis Gebäudebestand“	Diefenbach, N.; Cischinsky, H.: Rodenfels, M.; Clausnitzer, K.-D.: Datenbasis Gebäudebestand – Datenerhebung zur energetischen Qualität und zu den Modernisierungstrends im deutschen Wohngebäudebestand, Institut Wohnen und Umwelt, Darmstadt, Dezember 2010
[UBA 2011]	Study on Climate Protection by Reducing Cooling Demands in Buildings	Bettgenhäuser, K.; Boermans, T.; Offermann, M.; Krechting, A.; Becker, D.: Klimaschutz durch Reduzierung des Energiebedarfs für Gebäudekühlung. Edited by the Umweltbundesamt, Dessau-Roßlau 10/2011

5 Greece

(by TABULA partner NOA / Greece)

5.1 Existing typology concepts

In Greece there is no elaborate monitoring of the building stock. The "Regulation on the Energy Assessment of Buildings – KENAK" (Ministerial Decision D6/B/5825) was published in April 2010. The process of the Energy Performance Certification of buildings was launched in January 2011 starting with the residential sector. The certification of non residential buildings is expected to start in June 2011. At the same time, very limited efforts have been carried out to successfully collect and analyze detailed data on the building sector so far. Therefore, comprehensive information and official data for the non-residential (NR) building stock is rather limited, although it is the fastest growing energy demand sector.

Knowledge on the energy-related aspects of the non-residential building sector can be derived from treating scattered data coming from various sources, mainly the building construction activities, statistical reports periodically issued by the National Hellenic Statistical Service (NHSS) and various publications usually focussing on the energy retrofitting of representative examples in the tertiary sector.

NOA's knowledge on the non - residential building sector comes from:

- involvement in European projects related to this subject over the past 15 years (TOBUS [1], XENIOS [2], EPA-NR [3] and DATAMINE [4])
- involvement in national projects to assess the building stock, the potential for energy conservation and the abatement of environmental pollution
- involvement in short energy audits and energy studies in the framework of consulting activities.

In the framework of TOBUS and XENIOS projects dealing with the retrofitting of office and hotel buildings respectively, a total of four offices and 3 hotels were thoroughly investigated in order to assess the potential of retrofit measures for upgrading the indoor environmental quality and energy performance of the buildings. In the framework of EPA-NR project dealing with the energy performance assessment of non-residential buildings, a total of six buildings (an office, a hospital and four schools) were also audited regarding the energy-related characteristics of their envelope and the installed systems. Data from a total of 84 non-residential buildings have been included in DATAMINE structure in a preliminary test of its applicability in extracting results regarding the Hellenic building stock based on data coming from the national EPCs. In the absence of EPCs at the time of the project, the data supplied to DATAMINE came from previous energy audits in buildings and energy studies in the framework of NOA's consulting activities.

The most relevant source of information and experience for extending the concept of TABULA to the non-residential building sector is a national project assigned to NOA by the Ministry of Environment (2001-2002) on the: "Investigation of supporting policies for the advancement of the Ministry's policies in relation to the abatement of CO_2 emissions in the residential and tertiary sectors" [5]. In the framework of this project, data on the non-residential building stock were collected from various sources (NHSS - census of construction activities 1990-2000 and published literature). The effort resulted in mapping the number and size (floor area) of non-residential buildings classified according to the building use, date of construction and climate. Similarly, a mapping of the annual operational specific electrical and thermal energy consumption was achieved for the different categories.

Non-residential buildings represent about the 25% of the total number of Hellenic buildings for 1990 [6]. A first classification is presented in [6]. Accordingly, the main categories of the Hellenic non-residential building stock according to their end use are: *offices/commercial* (2.74% of the total number of Hellenic buildings), *schools* (0.41%), *hotels* (0.26%) and *hospitals* (0.05%). Other uses of NR buildings include churches, factories, athletic facilities, storage areas, closed parking spaces etc, which account for 21.9% of the total stock, the majority of which have periodic use and a limited overall contribution to the total energy consumption. Therefore, from the energy consumption point of view the non-residential building sector would be reasonably represented by the four main categories mentioned above. Table 17 summarizes the number and total floor area of buildings per construction year band for each of the four categories.

Table 17: 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

Figure 1 illustrates the distribution of non-residential buildings in the four climatic zones defined in the Regulation for the Energy Performance Assessment of Buildings (KENAK). Information on the energy-related characteristics of the buildings in the NR sector can be drawn from Table 3 giving a distribution of the buildings in different subcategories with common characteristics.

Figure 1: Distribution of Hellenic non-residential building stock estimated for the four climatic zones of Greece and the corresponding heating degree-days for each climatic zone. [5, 6]

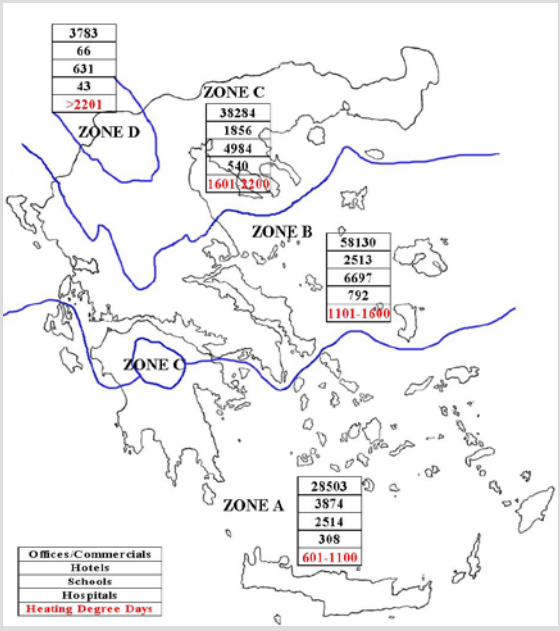
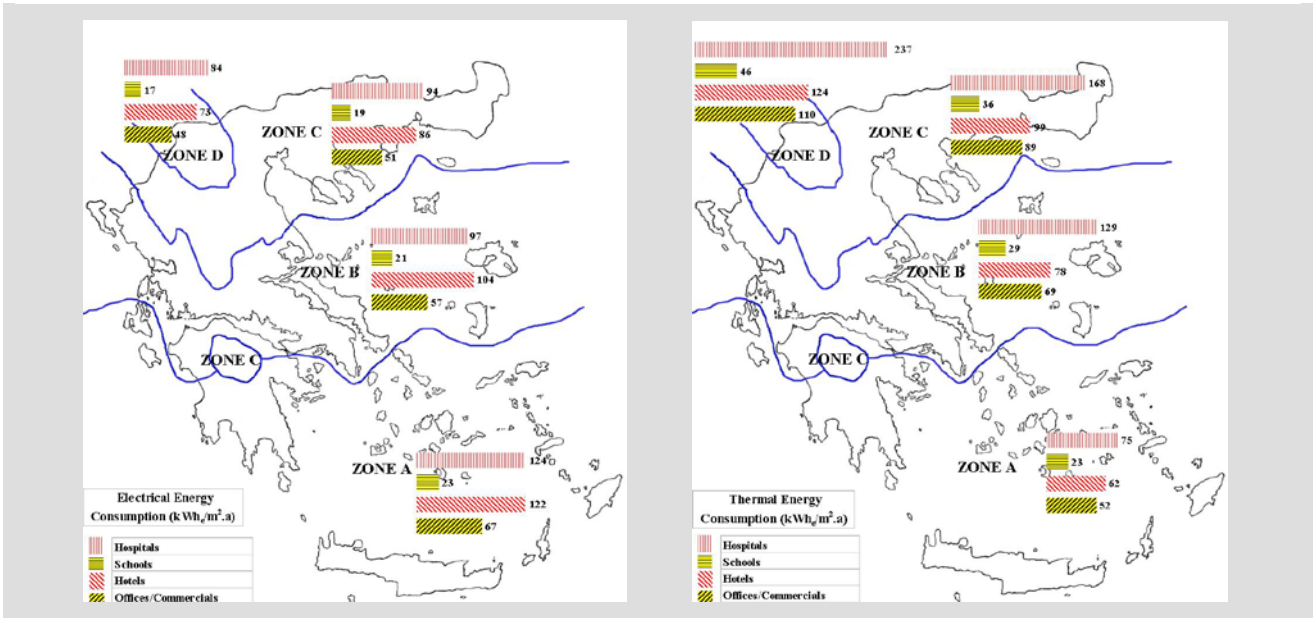


Figure 2 presents the estimated average annual specific electric (left) and thermal (right) energy consumption (kWh/m^2) for 2001. The thermal energy consumption refers to buildings with central heating systems using fossil fuels (i.e., oil, gas).

Figure 2: **Distribution of estimated average annual specific electrical (left) and thermal (right) energy consumption in 2001 for the non-residential building stock in the four Hellenic climatic zones. [5, 6]**



In the framework of the national project [5] the impact of various energy conservation measures (ECMs) on the energy performance of non residential buildings was assessed. The ECMs per climatic zone are ranked according to the amount of energy savings for the different final uses (heating, cooling, sanitary hot water, and lighting). Results are summarized in Table 4. The total annual energy savings are expressed as a percentage of the total thermal & electrical consumption for the different building categories that each ECM was applied to. Some ECMs are financially attractive and would not require the support of any financial instruments, while their total contribution in the reduction of CO_2 emissions is about 77%. These recommended ECMs are identified for the corresponding building category by the (✓) symbol in Table 18. The recommended ECMs that need some kind of support are identified for the corresponding building category by the (*) symbol.

Table 18: Priorities for the implementation of ECMs in Hellenic NR buildings (O/C: offices/Commercial, H: Hotels, S: Schools, HC: Health Care) [6]

Energy Conservation Measures (ECMs)	Total annual energy savings in NR buildings								Recommended ECM			
	Thermal				Electrical							
	O/C	H	S	HC	O/C	H	S	HC	O/C	H	S	HC
Space heating – building envelope												
#1: Thermal insulation of external walls	31%	40%	31%	37%	4%	5%		4%	✳	✓	✳	✓
#2: Thermal insulation of roofs	5%	6%	5%	6%	2%	2%		2%		✳		✳
#3: Installation of double-glazing	11%	19%	18%	18%								✳
Space heating - heat production												
#4: Maintenance of central heating installations	11%								✳	✓	✳	✓
#5: Replacement of inefficient boilers with energy efficient oil-burners	17%								✓	✓	✓	✓
#6: Replacement of inefficient boilers with energy efficient natural gas - burners	21%								✓	✓		✓
#7: Temperature balance controls for central space heating	5%								✳	✓		✓
#8: Space thermostats	5%								✓	✓		✓
Cooling												
#9: External shading					14%	17%	15%	14%	✳	✳		✳
#10: Ceiling fans					60%				✓	✓	✳	✓
#11: Night ventilation					16%				✳			
Sanitary hot water												
#12: Solar collectors for SHW production					43%	76%	33%	64%		✳		✳
Lighting												
#13: Energy efficient lamps					60%				✓	✓	✓	✓
Total Energy Management												
#14: BMS - Building Management System	20%	20%		20%	30%	30%		30%	✓	✓		✓

5.2 Draft classification scheme for non-residential buildings

The non-residential sector presents a large variety of building uses that differ in terms of operation time and indoor environmental requirements, which has a significant effect on their energy demand and consumption. Therefore, a national typology of non-residential buildings should be based on three parameters, namely:

- *building utilization*, affecting the operational patterns and the indoor air requirements
- *construction year band*, characterizing the architectural features and envelope construction as well as the system installations to some extent
- *climate*, affecting the construction trends and determining the energy demand of the buildings.

Along these lines, a classification of the non-residential buildings is presented in [6]. According to the building use, four discrete typologies are presented, namely:

- Offices / commercial
- Hotels
- Hospitals
- Schools

Three construction year bands are defined:

- pre 1980 when the national Thermal Insulation Regulation (TIR) came into force
- 1981-2000 when implementation of the TIR was gradually adapted
- 2001-2010 full implementation of TIR

Table 19: Number of non-residential buildings for different subcategories with common characteristics [2]

	OFFICES/COMMERCIAL			HOTELS (number of complexes)			SCHOOLS (number of complexes)			HEALTH CARE		
Construction period	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Total	**89,352**	**39,348**	**23,850**	**3,015**	**2,580**	**1,214**	**14,126**	**700**	**750**	**1,566**	**117**	**59**
Without or inadequate wall insulation	89,352	--	--	1,543	--	--	14,126	--	--	282	282	282
Without or inadequate roof insulation	89,352	--	--	1,543	--	--	14,126	--	--	42	42	42
With central heating systems	15,539	32,465	23,850	3,015	2,580	1,214	14,126	700	750	--	--	--
With old central heating systems	10,877	9,740	--	2,279	750		9,888	210	--	783	783	783
No temperature balance control	15,539	22,726	--	1,453	586	--	14,126	490	--	59	59	59
No space thermostats	10,887	16,233	--	772	234	--	9,888	350	--	29	29	29
No solar collectors	17,870	7,870	4,770	2,279	1,875	877	2,825	140	150	1,566	1,566	1,566
No shading	5,361	9,444	--	547	1,125	--	848	63	--	--	--	--

Four climatic zones are used, as defined in KENAK, on the basis of the number of heating degree days, namely:

- A: 601-1100
- B: 1101-1600
- C: 1601-2200
- D: > 2201

Despite the fact that no significant differences should be expected between residential and non-residential buildings regarding the envelope characteristics, the system installations in the tertiary sector buildings present a higher level of complexity, since a wider variety of systems must be considered in order to include cooling, ventilation and air conditioning technologies that play a very significant role in the energy consumption of these buildings.

Among the above mentioned building uses, the simplest is schools, as it includes buildings operating only a few hours a day and nine months a year. The system installations mainly include boilers (oil/ gas) and they seldom incorporate cooling technologies, due to the fact that schools remain closed during the summer period. Therefore, the overall complexity of this typology is similar to the one of residential buildings. Table 20 summarizes the frequencies available for the twelve classes (three construction periods x four climatic zones) of the school building typology [6].

Table 20: Frequencies (number of complexes, floor area) for the classes of the school building typology [6]

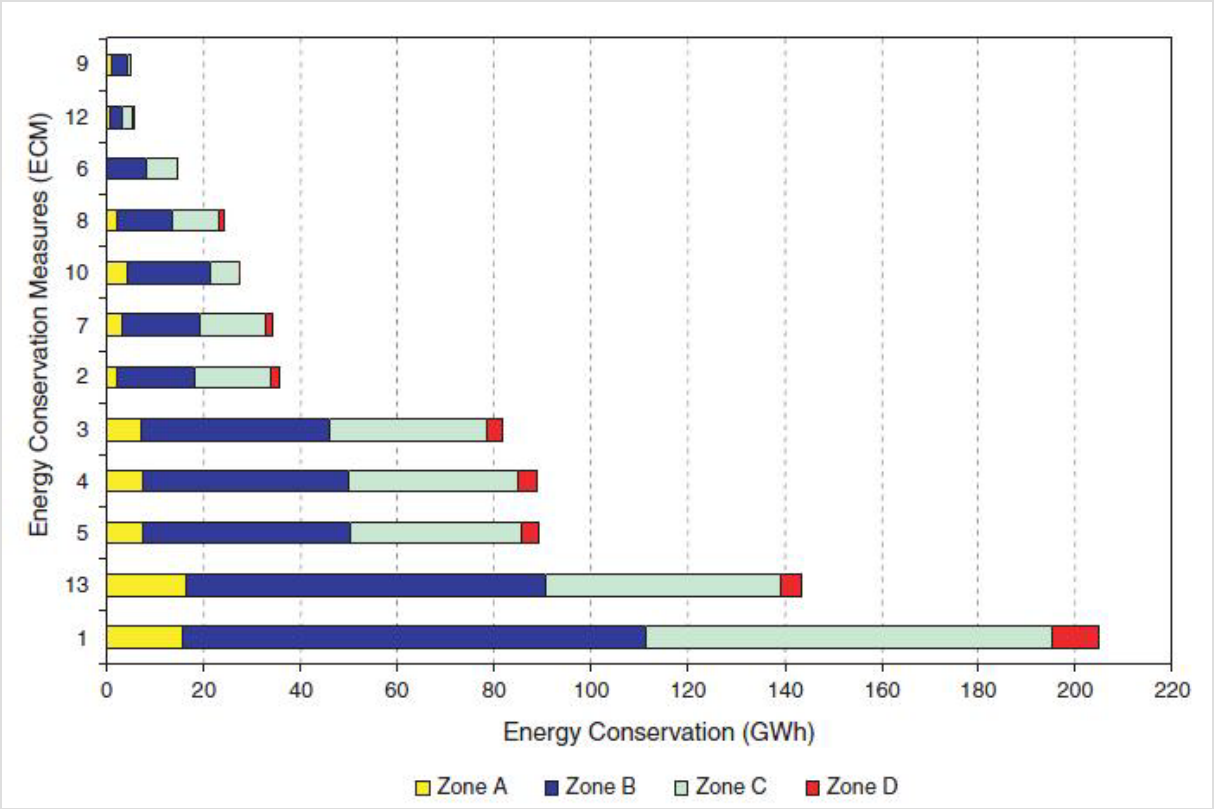
	Number of school complexes			Floor area (m^2)		
	Pre 1980	1981-2000	2002-2010	Pre 1980	1981-2000	2002-2010
Zone A	2,395	119	127	2,395,303	130,567	152,610
Zone B	6,381	316	339	10,847,369	600,770	677,560
Zone C	4,749	235	252	7,123,025	400,038	453,824
Zone D	601	30	32	601,208	32,771	38,304
Total	**14,126**	**700**	**750**	**20,966,906**	**1,164,145**	**1,322,299**

The estimated number of school complexes and floor areas for each of the 12 building categories and the number of school complexes for each of the subcategories for the three different construction periods were estimated using data from the Organization of School Buildings (OSB) (i.e. number of classrooms, area per classroom, classrooms per school etc), the construction activity during the 1990s and relevant existing studies.

Figure 3 illustrates the ECMs described in Table 19 ranked for the school building stock according to the amount of energy savings for the different final uses (heating, cooling, sanitary hot water, and lighting).

The most effective ECMs for schools are the ones dealing with the reduction of thermal energy for space heating. First is the addition of thermal insulation to reduce heat losses through exposed walls, followed by the replacement of old oil boilers and the frequent maintenance of central heating installations. The installation of energy efficient lamps, due to the high-energy consumption for artificial lighting in schools, is also an effective measure.

Figure 3: Ranking of energy conservation measures for the Hellenic school building stock in 2010 [6]



5.3 Proposed proceeding / link with current national activities

As discussed on section 1.1.2 a non-residential buildings typology should be based on the building use rather than on building size. Due to the lack of official data/information that would permit a refined representation of the different uses in a typology, a first

In the DATAMINE platform, a total of 85 non-residential buildings were included, among which, 29 airports, 3 hotels, 5 offices, 4 schools, 10 hospitals, 18 sports halls and 16 swimming pools. Data to feed the non-residential building typologies can be drawn from this pool. In the cases where this is not possible, information on the non-residential building sector can be retrieved from the following sources:

- Empirical data for the Hellenic building stock
- Existing and on-going studies
- National standards and regulations providing information on building construction types and heat supply systems
- National statistical data from recent releases of the Hellenic Statistical Service

Furthermore, the building energy certification process, which, for the tertiary sector, is expected to start in June 2011, presents an excellent opportunity to get an insight of the energy-related features that differentiate buildings according to use by analyzing the EPC data as they become available.

The energy assessment method for the non-residential building typologies should be based on the final European Standards and the national requirements incorporating the relevant national technical guidelines prepared by the Technical Chamber of Greece (TEE). The TEE-KENAK software was developed by NOA for the Technical Chamber of Greece (TEE), based on a preceding energy performance assessment tool developed within the framework of a European project (www.epa-nr.org). The calculations are performed according to EN 13790 (2008) for preparing an EPC and assessing energy conservation measures, taking into account the national technical guidelines (TOTEE). The TEE-KENAK software is used as a stand-alone tool for energy audits and benchmarking, and is also adapted by all commercial software companies that develop building design tools for engineers.

5.4 Conclusions

The TABULA typology concept could be expanded to apply to non-residential buildings. As there is a large variety of building uses and operational characteristics in the tertiary sector, it is necessary to classify buildings according to their use rather than their size. Accordingly, a preliminary classification could include the following building categories:

- Schools
- Offices / Commercial
- Hotels
- Hospitals

Additionally, the three construction year bands used in the residential building typology: pre-1980, 1981-2000 and 2001-2010 to reflect the different trends in the envelope construction before and after the national Thermal Insulation Regulation that came into effect in 1980. The four climatic zones A, B, C and D defined in the recent Energy Performance Regulation of Buildings – KENAK could also be used. Therefore, each typology related to a building use will include a total of 12 building classes (3 age bands x 4 climatic zones).

As in TABULA residential typology, the above typologies will have to be complemented by two sub-typologies, namely, the “building element” and the “systems” sub-typologies. In the case of non-residential buildings the “building elements” sub-typology would be more or less the same as the one prepared for the residential buildings. However, as cooling, mechanical ventilation and air conditioning are very important factors of energy consumption in the tertiary sector, the “Systems” sub-typology would have to be expanded to include the large variety of relevant technologies that are commonly met in the tertiary sector.

Table 21: Sources / References Greece

Reference shortcut	Short description	Reference
[1]	Scientific paper	Balaras CA, Droutsa K, Argiriou AA, Wittchen K. Assessment of energy and natural resources conservation in office buildings using TOBUS. Energy and Buildings 2002;34(2):135–53.
[2]	Scientific paper	Dascalaki E., C.A. Balaras, XENIOS – A Methodology for Assessing Refurbishment Scenarios and the Potential of Application of RES and RUE in Hotels, Energy & Buildings, 36, 1091-1105, (2004).
[3]	EPA-NR project: Final technical report	Lahrech R. (Editor). Overall report on pilot projects, Final Report, Report Number: EPA-NR CSTB 8, Energy Performance Assessment for Existing Non Residential Buildings, European Commission, Intelligent Energy – Europe, EIE/ 04/125/S07.38651, June 2007. www.epa-nr.org.
[4]	Scientific paper	Dascalaki, E., P. Droutsa, A. Gaglia, S. Kontoyiannidis and C.A. Balaras. 2010. Data collection and analysis of the building stock and its energy performance – An example for Hellenic buildings. Energy & Buildings 42 (8): 1231-1237.
[5]	Final technical report	D. Lalas, C.A. Balaras, A. Gaglia, E. Georgopoulou, S. Mirasgedis, I. Sarafidis, S. Psomas, Evaluation of supporting policies for the advancement of the Ministry's policies in relation to the abatement of CO2 emissions in the residential and tertiary sectors, 650p.(in Greek). IERSD (NOA), MEPPPW, November 2002.
[6]	Scientific paper	A.G. Gaglia, C.A. Balaras, S. Mirasgedis, E. Georgopoulou, Y. Sarafidis, D. P. Lalas, Empirical Assessment of the Hellenic Non-Residential Building Stock, Energy Consumption, Emissions and Potential energy Savings, Energy Conversion and Management, Vol. 48, No.4 p.1160-1175, 2007.

6 Poland

(by TABULA partner NAPE / Poland)

6.1 Existing typology concepts

In Poland a building is regarded 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 comprise:

- industrial buildings;
- commercial buildings;
- educational buildings;
- health buildings;
- other buildings.

Unfortunately statistics related to these buildings is very poor.

The implementation of the EPBD in Poland was executed by the Ministry of Infrastructure, under the supervision of the Ministry of Economy.

The Ordinance on the methodology of energy performance calculations and template of certificates defines the energy performance requirements (different for new and existing buildings) and the methodology for the energy assessment of buildings/ apartments that quantifies the essential parameters needed for the preparation of the energy performance certificate, according to the results of a detailed assessment.

Additionally, the Ordinance determines the scope of and a template for the energy per1formance certificate. The Ordinance on the methodology of energy performance calculations for whole buildings, separate apartments or building parts constituting separate technical/functional areas, along with the scope of and a template for energy performance certificates, defines 4 types of certificates:

- certificate of energy performance for residential buildings.
- certificate of energy performance for other buildings (non-residential).
- certificate of energy performance for apartments.
- certificate of energy performance for building parts constituting separate technical/ functional areas (non- residential).

New buildings and major renovations are subjected to a certification process on two stages:

At the planning stage, where design assessment of buildings' conformity with

- technical regulations is required.
- At the start of operation of newly erected building, the energy certificate is required by local building authorities.

For existing buildings – residential and non-residential - the energy certificate is required in case of transaction (renting, selling). The responsibility of having a certificate lies always with the building owner but, in practice, due to the lack of control and penalties, certificates are issued only when demanded by at least one party. Therefore it is estimated that only 1% of existing buildings being

sold or rented have energy certificate, and information about non-residential building coming from the energy certificate (non-official) data base are very limited.

Official statistics presented by the Main Statistics Office is relatively poor- Annual Statistics Bulletin give information only about new construction. Any information about energy quality of these buildings are not officially available.

NAPE's knowledge on the non - residential building sector comes mainly from:

- energy audits done for the purpose of the Thermomodernisation Fund. That fund was created on the basis of provisions of the Thermomodernisation Act, dating from 1998 (full name: "Act on Support for Thermomodernisation Investment in Buildings"), covers the rules for providing investors (building owners or administrators) with financial support, in the form of a premium which can cover up to 25% of a credit loan granted for the realization of thermal modernization investments,
- involvement in European projects related to this subject over the past 15 years (DEMOHOUSE, DATAMINE)
- Build-Desk certificates database.

In the available dataset of building most of buildings are schools and hospitals. Very poor information refers offices and industrial buildings, since they are not subject of energy audits.

Table 22: Non-residential building statistics in 2000 and 2010

	number of units in		number of buildings in	
	2000	*2010*	*2000*	*2010*
Trade	**430 656**	**371 000**	**143 552**	**123 667**
in which over 400 m2	3 838	8 946	3 838	8 946
Restaurants	**55 242**	**71 679**	**55 242**	**71 679**
Schools in which:	**33 944**	**28 538**	**46 794**	**38 874**
primary schools	16 766	13 922	16 766	13 922
secondary	16 868	14 216	25 378	18 952
universities	310	400	4 650	6 000
Health care in which:	**6 854**	**18 171**	**18 748**	**33 405**
Health care institutions	5 685	16 608	6 822	19 930
Hospitals	767	818	9 463	9 979
chronic medical care	126	327	378	981
Nursing homes	49	126	49	126
Hospices	26	59	26	59
Health resort treatment	201	233	2 010	2 330
Culture objects in which:	**10 344**	**9 808**	**11 866**	**11 430**
Libraries	8 900	8 400	9 790	9 240
Museums	632	782	1 264	1 564
Theatres	125	183	125	183
Cinemas	687	443	687	443
Hotels and similar facilities	**5 413**	**7 206**	**8 120**	**10 809**
Offices		n/a		
total			**284 322**	**289 863**

Table 22 presents the number of buildings in 2000 and 2012. Since from 2002 the new energy efficiency requirements were introduced to the Polish Buildings regulation it can be assumed that all the buildings constructed after 2000 fulfil present obligation and energy standards. Buildings constructed before 2000 should be a subject of major or minor modernisation.

Percent of non-residential building constructed in the chosen time period is presented in the Table 23.

Table 23: Non-residential buildings by constructed year (in %)

	before 1945	1945-1970	1971-1978	1979-1988	1989-1995	1966-1988	1989-2000	after 2000
percent of buildings	28.1	28.9	17.8	14.9	4.9	1.5	2.0	1.9

According to the polish requirements refers to the energy standard of the buildings the energy consumption by buildings constructed in the particular period are presented in the Table 24.

Table 24: Energy standards of new buildings

Construction period	Legal Act	max. U value	Average energy consumption	
			End-use kWh	primary energy GJ
1945 - 1966	Building Code a) central Poland b) western Poland	 1.16 1.40	 240-280 300-350	 1.31-1.61 1.76-2.05
1967-1985	PN-64/B-03404 from 1.01.1966 PN-74/B-02020 from 1.01.1976	1.16	240-280	1.31-1.61
1986-1992	PN-82/B-02020 from 1.01.1983	0.75	160-200	0.88-1.17
1993-2002	PN-91/B-20020 from 1.01.1992	0.55	120-160	0.73-0.88
2002-2008	Technical requirements about buildings	0.30	90-120	0.25-0.66
after 2009	Technical requirements about buildings (U or Ep)	0.30	90-120	0.25-0.66
		EP	**A/V≤0.2** EP_{H+W} = 73 +ΔEP **0,2<A/V≤1.05** EP_{H+W} = 55+90*(A/V)+ΔEP **A/V>1.05** EP_{H+W} =149.5 +ΔEP	

6.2 Draft classification scheme for non-residential buildings

For the future proceedings it is suggested to include, as a first step, only some categories of buildings:

1. school buildings – 50 in the NAPE database
2. hospitals – 31 in the NAPE database

For the chosen type of buildings the following data are available:

1. construction year
2. cubature
3. heating area
4. U-value for all building envelopes
5. Heating system

Therefore the first draft typology for non-residential building typology will contain:

1. Building types:
   - schools
   - hospitals
2. Construction year classes
   - before 1945
   - 1946 -1985
   - 1986-2000
   - after 2000
3. Heating systems
   - central DHS
   - local gas boilers

6.3 Proposed proceeding / link with current national activities

It is expected that the introduction of the EPBD Recast into Polish legal system:

1. makes the certificates for public buildings obligatory
2. the official database of issued certificates with free access will be establish

This should allow to widen the database and create in nearest future the consistent non-residential buildings typology.

6.4 Conclusions

The following steps have to be implemented in the future to create non-residential buildings typology:

1. Create, based on different available sources, database for non-residential buildings;
2. Analyse of data to build up the typology, relevant to TABULA tool;
3. Create final building matrix for defined buildings category

Table 25: Sources / References Poland

Reference shortcut	Short description	Reference
1	Statistics data	Statistical Yearbooks 2000-2010
2	Statistics data	Construction – activity results 2000-2010 – Main Statistic Office
3	Scientific paper	„SOCOOL" project - tri-generation units in offices, hospitals and commerce buildings
4	National scientific TABULA report	TABULA report for Poland