



# The challenges, dynamics and activities in the building sector and its energy demand in Germany

D2.1 of WP2 from Entranze Project

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## ENTRANZE Project

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### Project consortium:

	<b>EEG</b>	Energy Economics Group, Institute of Energy Systems and Electrical Drives at Vienna University of Technology
	<b>NCRC</b>	National Consumer Research Centre
	<b>Fraunhofer ISI</b>	Fraunhofer Society for the advancement of applied research
	<b>CENER</b>	National Renewable Energy Centre
	<b>eERG</b>	end use Efficiency Research Group, Politecnico di Milano
	<b>Oeko</b>	Öko-Institut Institut für angewandte Ökologie Institute for Applied Ecology
	<b>SOFENA</b>	Sofia Energy Agency
	<b>BPIE</b>	Buildings Performance Institute Europe
	<b>Enerdata</b>	Enerdata
	<b>SEVEN</b>	SEVEN, The Energy Efficiency Center

## **The ENTRANZE project**

The objective of the ENTRANZE project is to actively support policy making by providing the required data, analysis and guidelines to achieve a fast and strong penetration of nZEB and RES-H/C within the existing national building stocks. The project intends to connect building experts from European research and academia to national decision makers and key stakeholders with a view to build ambitious, but reality proof, policies and roadmaps.

The core part of the project is the dialogue with policy makers and experts and will focus on nine countries, covering >60% of the EU-27 building stock. Data, scenarios and recommendations will also be provided for EU-27 (+ Croatia and Serbia).

This report provides an overview of the building stock of Germany and its related energy demand. It includes main buildings characteristics, space heating and cooling systems and energy consumption and is based on data collection that was carried out during WP2.

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## Content

<b>The ENTRANZE project .....</b>	<b>3</b>
<b>Content .....</b>	<b>4</b>
<b>List of figures .....</b>	<b>5</b>
<b>1. Building characteristics .....</b>	<b>7</b>
1.1 Building sector .....	7
1.2 Residential sector .....	9
1.3 Service sector .....	11
<b>2. Space heating and cooling systems .....</b>	<b>11</b>
<b>3. Energy consumption .....</b>	<b>13</b>
<b>4. Conclusions.....</b>	<b>15</b>
<b>5. References.....</b>	<b>16</b>
<b>6. Appendix.....</b>	<b>18</b>

## List of figures

<i>Figure 1: Decomposition of buildings by type (2008)</i> .....	7
<i>Figure 2: Breakdown of floor area by ownership structure (2008)</i> .....	8
<i>Figure 3: Dynamics of building construction</i> .....	9
<i>Figure 4: Residential dwellings according to construction date (2008)</i> .....	9
<i>Figure 5: Breakdown of ownership &amp; tenure (2008)</i> .....	10
<i>Figure 6: U-values by construction period (multifamily and single family, 2008)</i> .....	10
<i>Figure 7: Decomposition of service building areas by type (2008)</i> .....	11
<i>Figure 8: Dwelling stock according to space heating systems by energy (2008)</i> .....	12
<i>Figure 9: Dwellings according to centralisation of heat supply (2008)</i> .....	12
<i>Figure 10: Sales of energy efficient and renewable systems in recent years</i> .....	13
<i>Figure 11: Total energy consumption of the building sector (2008)</i> .....	14
<i>Figure 12: Total energy consumption by end-use (2008, real climate)</i> .....	14
<i>Figure 13: Specific consumption by age and by type of dwellings</i> .....	15

## List of tables

<i>Table 1: Decomposition of buildings by type (stock and floor area, 2008)</i> .....	7
<i>Table 2: Total energy consumption by sector (2008)</i> .....	18

## Some definitions/scope of country report

The common **database year** of these country reports is 2008. This year has been chosen because it is one of the most recent years with enough available data. And year 2009 has been avoided because of structural effects caused by the global crisis.

**The building sector**, as it is subject of this report, refers to two main categories of buildings: residential buildings and non-residential buildings. Whereas residential buildings are relatively homogenous and can further be divided into single/two-family houses and apartments blocks, non residential buildings are more heterogeneous. They refer to buildings in the service or tertiary sector and include several building categories (esp. office buildings, hospitals, schools and universities, hotels and restaurants, buildings in wholesale and retail trade). Within the residential stock, we consider only permanently occupied dwellings.

**Floor area:** The floor area as it is reported in the following sections is the net floor area; it does not include the common areas in multifamily buildings (e.g. corridors, etc.).

**Specific consumption for space heating is calculated at normal climate:** it corresponds to the energy consumption required to heat one dwelling on average, it is calculated in final energy.

**Climate correction (normal climate):** Making climatic corrections enable to monitor energy indicator trends that are independent on the year-to-year variations in the winter climate. The climatic corrections are made only for the part of the final consumption corresponding to space heating.

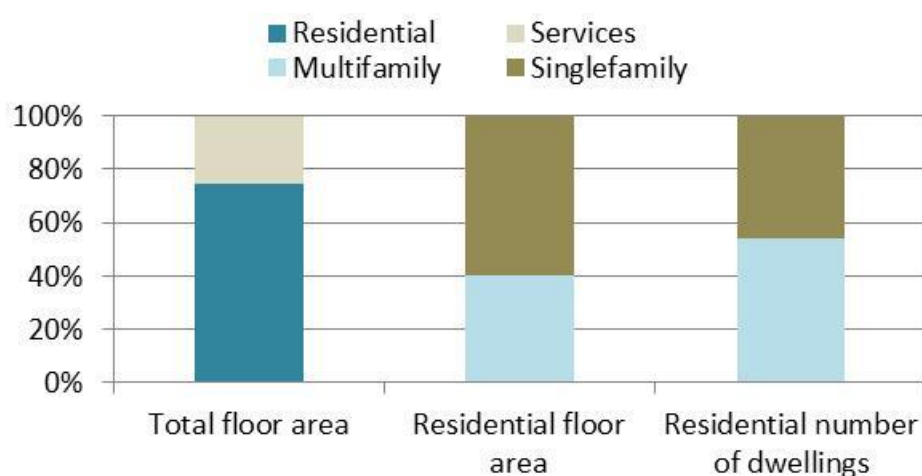
**Central heating systems:** it includes district heating, block heating, individual boiler heating and electric heating; a central heating system implies that all rooms are well heated, as opposed to room heating, where generally a stove provides heat to the main room only.

## 1. Building characteristics

### 1.1 Building sector

The total German building area is around 4°350 million m<sup>2</sup>: it is composed of ¾ by residential dwellings and the rest by services buildings (Figure 1 and Table 1). Slightly less than half of residential buildings are single-family dwellings 46% of all dwellings. Multi-family dwellings are on average 50% smaller than single-family dwelling, with an average size of 58 m<sup>2</sup>, compared to 110 m<sup>2</sup> for single-family dwellings. As a consequence, the share of single-family dwellings is even more dominant in the total floor area, with 60%.

**Figure 1: Decomposition of buildings by type (2008<sup>1</sup>)**



Source: Odyssee

**Table 1: Decomposition of buildings by type (stock and floor area, 2008)**

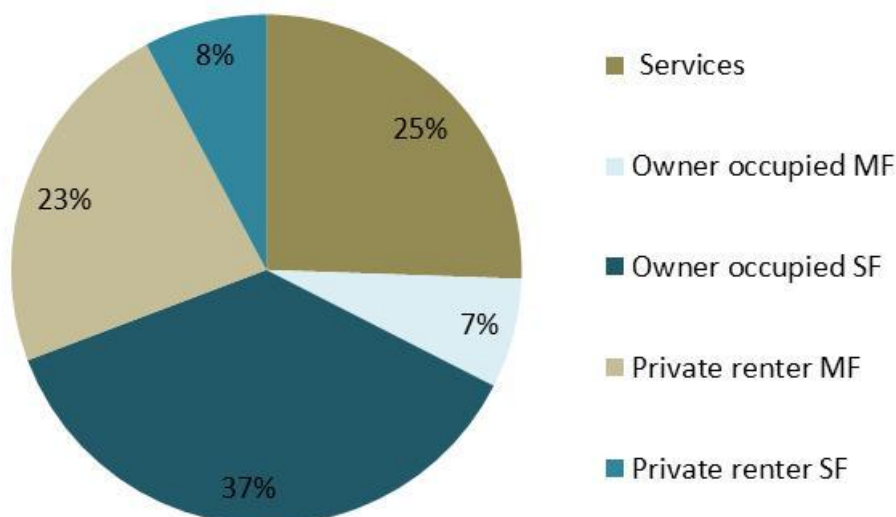
	Stock (k)	Floor area (Mm2)
<b>Total Residential</b>	39 050	<b>3 230</b>
<b>Multi-family</b>	21 054	1 306
<b>Single-family</b>	17 996	1 924
<b>Service</b>		<b>1°104</b>

Source: Odyssee

<sup>1</sup> The reference year chosen for this report is 2008, in order to get as much as possible available data among European countries.

Figure 2 represents the distribution of the total building floor area according to the status of occupation. Before services (25%), the main building stakeholders in Germany are owner occupant of single-family dwellings, with 37% of the total floor area. Private rental apartments make up 23% of total floor space. Rented single-family dwellings and owner occupied multi-family dwellings make up 8% and 7% respectively.

**Figure 2: Breakdown of floor area by ownership structure (2008)<sup>2</sup>**



Source: Eurostat and Odyssee

Between 2000 and 2010, 2.8 M residential dwellings were constructed, i.e. 251 000 per year on average. In 2008, dwellings built after 2000 represents 6% of total stock (Figure 3). Construction decreased on average by 9%/year between 2000 and 2010 and has slightly been affected by the global crisis in 2000, 2007 and 2009 (decrease of 22%, 15% and 17% respectively), followed by a slight rebound in 2010.

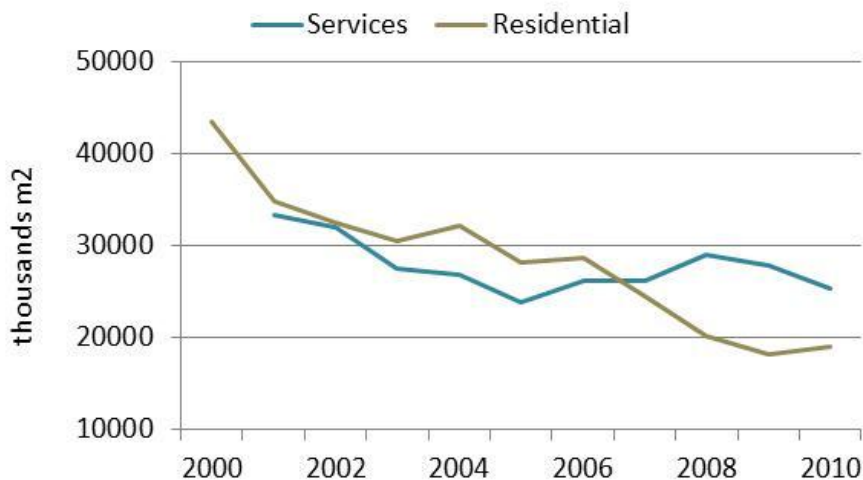
During this last decade, the share of single-family dwellings in annual construction became rose about 10%: from 50% of total construction in 2000, it increased to 56% in 2005 and then recovered to 49% until 2010.

Over the period 2000-2010, one half of the new floor area constructed has been in the service sector. Service buildings constructed between 2000 and 2008 represent only 5% of total floor area of service sector buildings in 2008 stock. Construction has only slightly been affected by the crisis.

<sup>2</sup> MF: Multi-family dwellings ; SF: single family dwellings.



**Figure 3: Dynamics of building construction**

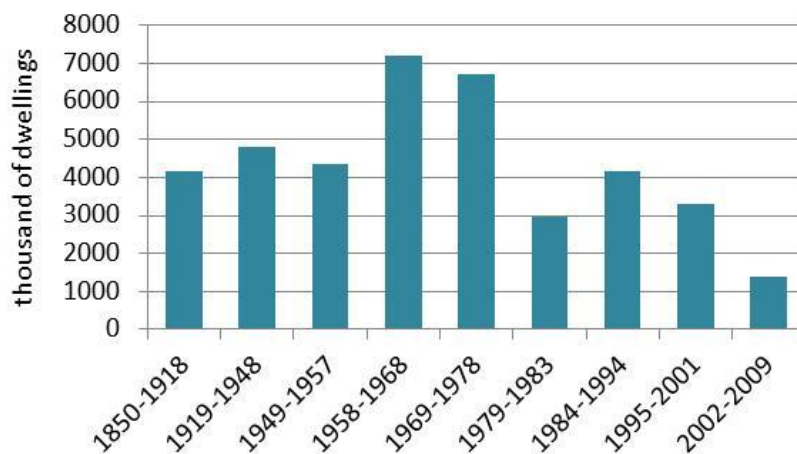


Source: destatis

## 1.2 Residential sector

The average age of buildings and the share of new buildings in the total stock represent a good indicator of the quality and standards of construction. The higher the share of recent dwelling, i.e. built with more efficient standards, the higher the energy performance of the stock: in Germany only about 26% of the dwelling stock existing in 2008 was built after 1977, date of the first thermal regulation (Figure 4).

**Figure 4: Residential dwellings according to construction date (2008)<sup>3</sup>**

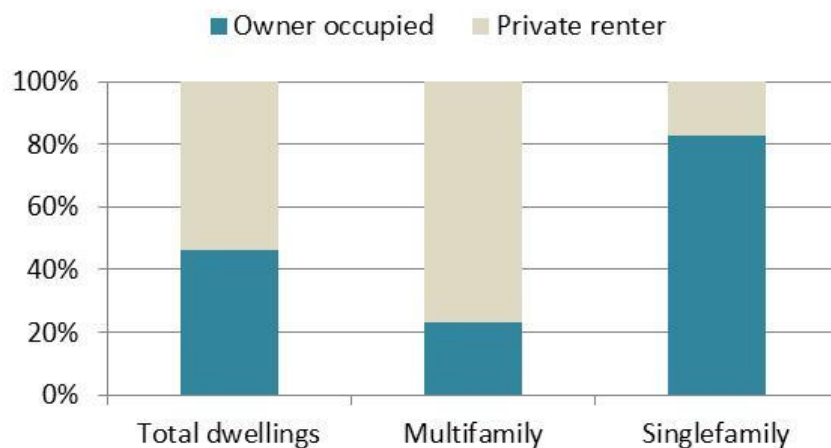


Source: IWU

<sup>3</sup> The age categories correspond the revision of building standards (i.e. 1975, 1982, 1989, 2001 and 2005).

Private renters are dominant in residential buildings, 54% of total stock and more than 76% in multi-family dwellings. Ownership structure is distributed opposite in single-family dwellings: 83% of owner occupant and only 18% of private (Figure 5).

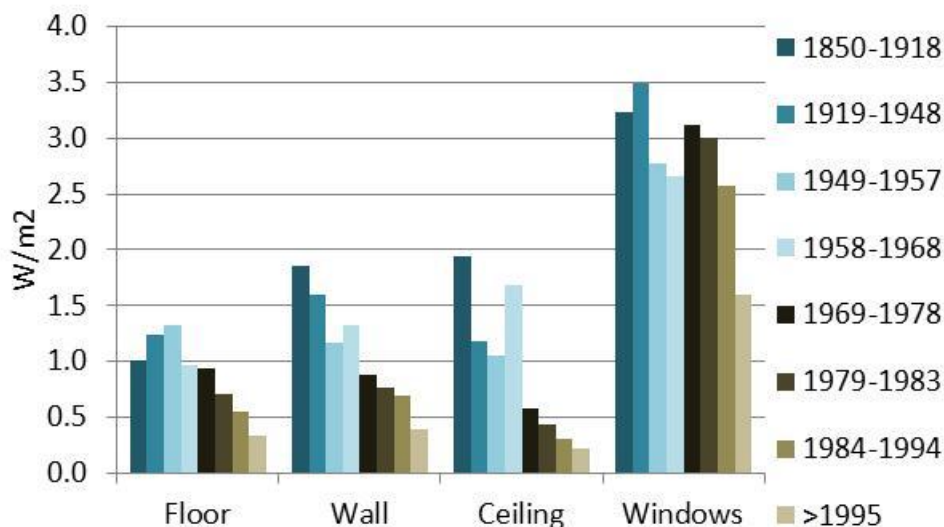
**Figure 5: Breakdown of ownership & tenure (2008)**



Source: Eurostat

Figure 6 shows the U-values that measure heat loss in building elements, such as wall, floor or roof, i.e. how well the buildings components are insulated. In Germany, U-values have decreased, and thus insulation improved, by minimum 50% in 30 years, biggest improvements occur for ceiling and window insulation.

**Figure 6: U-values by construction period (multifamily and single family, 2008)**

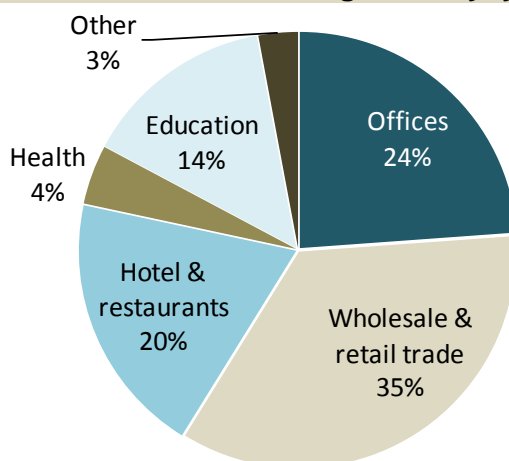


Source: IWU

### 1.3 Service sector

Wholesale and retail trade represent the highest share of total service sector floor area in 2008 (35%). It is followed by offices (24%), hotels and restaurants (20%), education buildings (14%) and health (4%).

**Figure 7: Decomposition of service building areas by type (2008<sup>4</sup>)**



Source: Odyssee

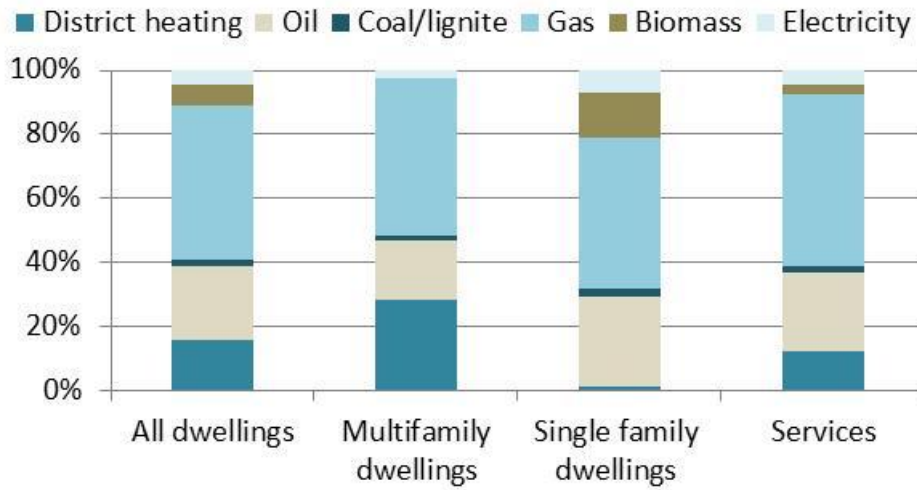
## 2. Space heating and cooling systems

Natural gas is the main source of energy for household space heating: 48% of residential dwelling are heated with gas, 23% with oil, 16% with district heating; other energy sources are marginal such as biomass and electricity (7% and 4% respectively). While Gas heating systems are dominant in all dwellings, district heating is significantly reduced to 1% in single-family dwellings. Consequently oil heating and biomass are more important in single-family dwellings (28% and 7% respectively).

The dominant energy source in the service sector is gas with a share of 54%, followed by oil (24%) and district heating (13%). Remarkable is the low contribution of biomass, only 4%.

<sup>4</sup> Official data provide only total offices, i.e. without distinction between private and public sector. Public offices stock has been estimated by CEREN and French government data. Private sector has been calculated by difference.

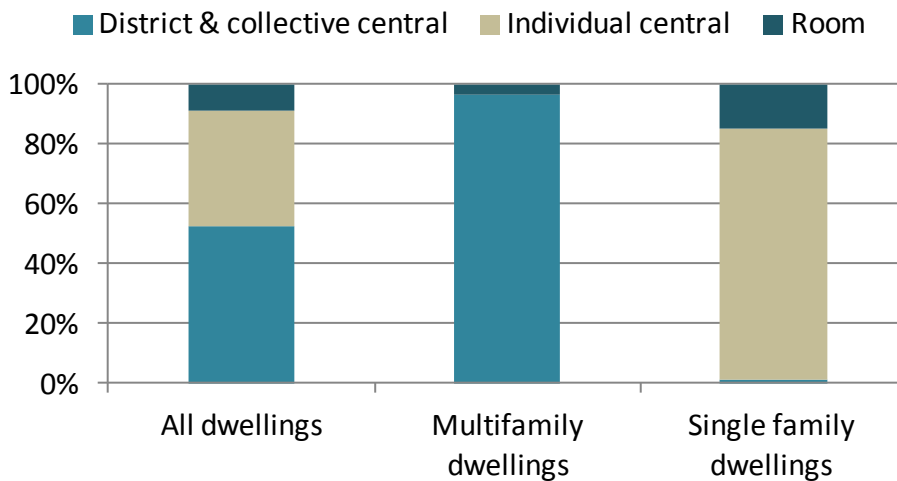
**Figure 8: Dwelling stock according to space heating systems by energy (2008)**



Source: Odyssee

Figure 9 shows the penetration of heating systems. In Germany almost the entire housing stock is heated by central heating systems: room heating has almost disappeared, except in rural areas in single family dwellings. Collective heating systems<sup>5</sup> represent around 97% of multi-family dwellings. Single-family buildings mostly have an individual central heating system (84%). 17% of dwellings are heated by district heating. Altogether, about 53% of dwellings are supplied by collective heating systems while 39% have an individual central heating system.

**Figure 9: Dwellings according to centralisation of heat supply (2008)**

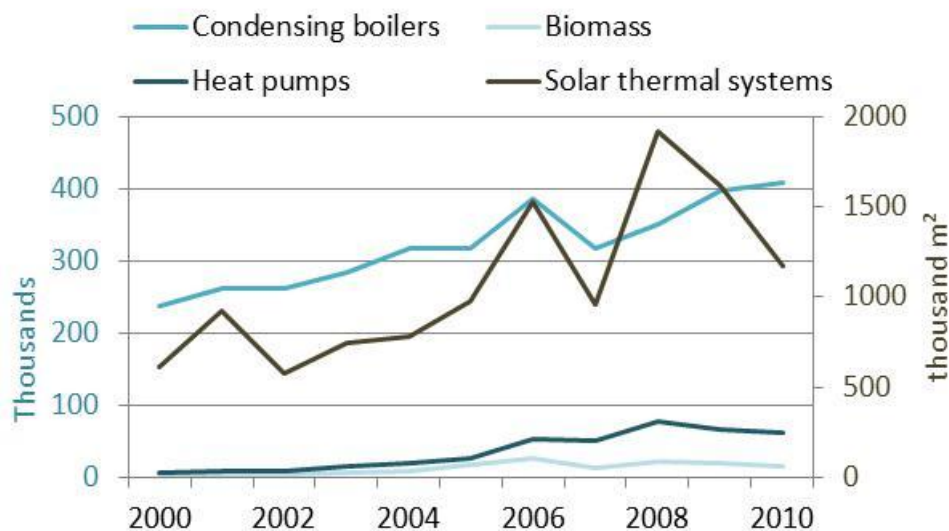


Source: Odyssee

<sup>5</sup> Including district heating.

The diffusion of efficient and renewable heating systems, such as condensing boilers and heat pumps, promoted by several subsidies, significantly improve the average heating energy efficiency. The sales of condensing boilers and heat pumps are increasing over time. Sales of thermal solarsystems fluctuated significantly but are rising over time.

**Figure 10: Sales of energy efficient and renewable systems in recent years**



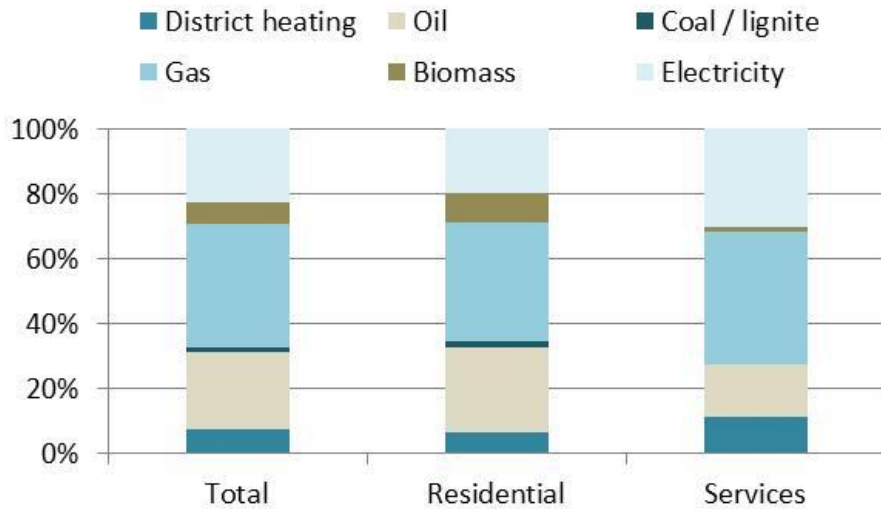
Source: Odyssee, Erneuerbare Energien in Zahlen, IWU, AGEE-Stat

### 3. Energy consumption

Natural gas is the dominant source of energy in German buildings with 38% of the total and residential market (Figure 11). Oil is slowly being phased out but still represents 24% in 2008 both in total and residential stock.

In the service sector, natural gas and electricity are the dominant sources of energy with 41% and 30% respectively. The share of electricity has increased a lot due to the greater use of electricity especially for information/communication technologies and air conditioning. Oil represents 16% of total service sector energy consumption.

**Figure 11: Total energy consumption of the building sector (2008)**

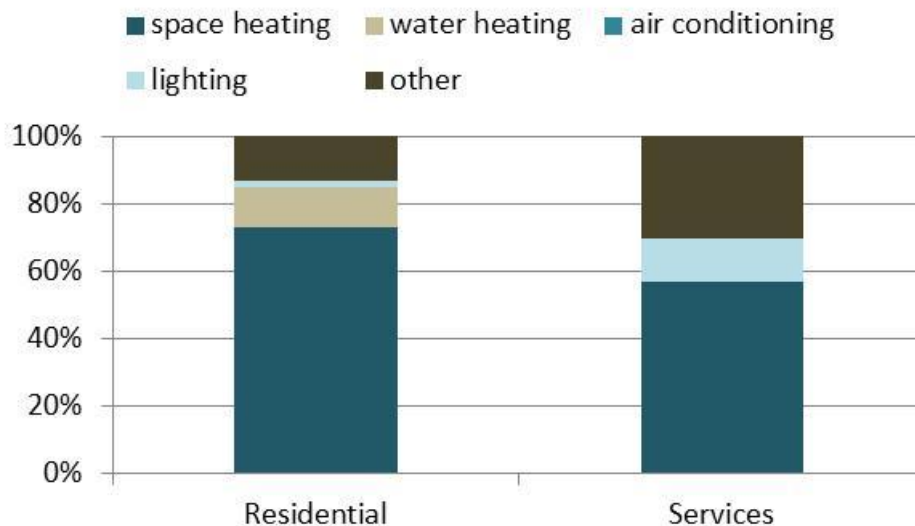


Source: Odyssee

Space heating represents the largest share of household energy use: it corresponds on average to almost 84% of total energy consumption. Water heating consumption equals 14% of the consumption. Lighting makes up 2% of household consumption. Air conditioning still represents a marginal share of residential consumption.

In the service sector, space heating and water heating represent 82% and 18% respectively of total consumption. Air conditioning is still insignificant.

**Figure 12: Total energy consumption by end-use (2008, real climate)**

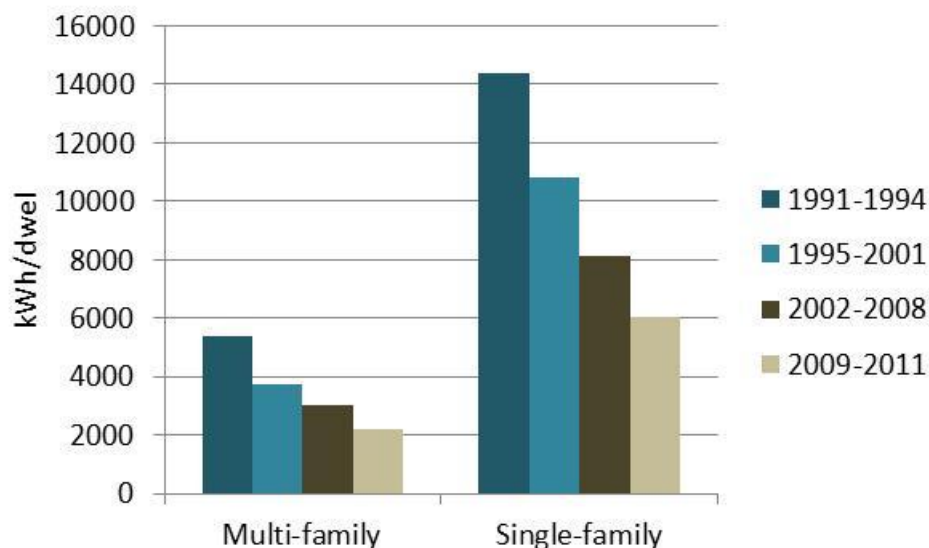


Source: Odyssee

Energy efficiency standards enforced on new dwellings have an impact on the space heating energy performance. However, the magnitude of this impact depends on the

frequency of thermal regulations updates and on their severity. These standards require theoretical maximum heating unit consumption for new buildings, as shown in Figure 13. In Germany, six thermal regulations were implemented since the 70's<sup>6</sup>. The last thermal regulation implemented in Germany in 2009 implies a specific consumption reduced by 30% compared to the thermal regulation implemented in 2007.

**Figure 13: Specific consumption by age and by type of dwellings**



Source: Odyssee

## 4. Conclusions

Residential buildings represent 75% of total floor area and the main stakeholders in Germany are private renters of multi-family dwellings, with 41% of the total floor area. This last decade, around 3 M of residential dwellings have been constructed, i.e. 6% of 2008 total stock. Germany has renewed its residential dwelling stock quite slowly compared to other European countries: 16% of the dwelling stock was built after 1983.

U-values decreased by a minimum of 50% in 30 years, thanks to six thermal regulations implemented since the late 70's: the largest improvements occur for ceiling and window insulation.

In Germany almost the entire housing stock is heated by central heating systems. 37% of residential dwellings are heated with gas systems, 26% by oil and 20% by electricity. Other energy systems are marginal such as biomass and district heating (9 and 6% respectively). Space heating represents the largest share of household energy use: it

<sup>6</sup> The graph only shows the impact of the 4 most recent regulations.

corresponds on average to almost 83% of total energy consumption. Water heating consumption equals 15% of total energy consumption. Air conditioning still represents a marginal share of residential dwelling consumption. Diffusion of air conditioning is steadily increasing in the residential sector. The sales of condensing boilers and heat pumps are increasing rapidly in recent years over time.

In the service sector, space heating and water heating represent 75 and 6% respectively of total consumption. Lighting has a share of 15% and air conditioning is more significant than in the residential sector, and reached 1% of total consumption with around 9% of service buildings equipped with air conditioning.

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TABULA, Typology Approach for Building Stock Energy Assessment,  
<http://www.building-typology.eu/country.html>

## 6. Appendix

**Table 2: Total energy consumption by sector (2008)**

Mtoe	District heating	Oil	Coal / lignite	Gas	Bio-mass	Elec-tricity	Total
<b>Residential</b>	3.92	16.18	1.07	22.46	5.48	12.00	61.10
of which: space heating	3.43	14.65	0.99	18.88	5.13	1.54	44.62
of which: water heating	0.49	1.49	0.08	3.13	0.21	2.03	7.43
of which: air conditioning	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
of which: lighting							0.91
<b>Services</b>	2.66	3.79	0.03	9.51	0.35	7.09	23.44
of which: space heating	2.17	3.09	0.03	7.75	0.00	0.37	13.40
of which: water heating	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
of which: air conditioning	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
of which: lighting							2.97

Source: Odyssee