Typology Approach
for Building Stock
Energy Assessment

Use of Building Typologies for Energy Performance Assessment of National Building Stocks. Existent Experiences in European Countries and Common Approach

– First TABULA Synthesis Report –

TABULA Project Team

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Abstract

The present study examines the experiences with building typologies in the European countries. The objective is to learn how to structure the variety of energy-related features of existing buildings. As a result of the enquiry it can be stated that there are a lot of different activities which are based on typological criteria. Some of them are concentrating on providing information material and conducting energy advice. On the other hand, building types are used for a better understanding of the energy performance of building portfolios on different levels: from the strategic planning of housing companies up to the evaluation of national policies and measures in the building sector.

On the basis of these experiences a common approach for building typologies has been developed. The core elements of this harmonised approach are a classification systematic, a structure for building and supply system data and a coherent energy balance method. Furthermore a uniform classification of statistical data enables a concerted approach for designing national building stock models.

Finally, a concise itinerary is described which allows experts to develop step by step a national or regional building typology which are compatible with the common TABULA approach.

1 Introduction

The construction of buildings has been subjected to a perpetual development in the course of time. Changes occurred due to the introduction of new materials and new construction techniques, to shifts of costs of natural resources and labour. Furthermore there were architectonical improvements or innovations, alterations of flavour, changes of wealth, reaction on structural damages, health care and energy saving. The driving forces have often been economical aspects (minimising of costs, competitiveness) but also administrative or juristic reasons (requirements by building code etc.).

In the present study the focus lies on the evolution of energy-related properties of buildings, as regards the energy performance of the particular building elements as well as the possibilities of improvement. One of the determining factors is the geometry – since the related envelope area is responsible for heat transmission losses. The fraction of the thermal envelope elements, i.e. roof, top ceiling, wall, windows and floor of a given building, depends considerably on its age and its size. In addition, the thermal transmittance of these construction elements differ from each other and are also related to the construction time. There are also certain time periods which impose characteristic restrictions to the improvement of the thermal envelope, e.g. historical appearances which are worth saving or neighbour-type situations impeding the outside insulation of walls.

The energy performance also depends on the type of heat generator and distribution system. These technical installations are subjected to shorter renovation cycles or complete exchanges. Therefore only a poor correlation of the supply system type with the construction period of the building can be expected. During the last decades the supply system technologies have been improved significantly. In consequence, strong correlations of losses can be found with the year of installation.

In conclusion the energy performance of buildings correlates with a number of parameters, among these are the construction year, building size and neighbour situation, the type and age of the supply system and the question of already implemented energy saving measures. If these features are known for a given building it will be possible to quickly give an estimation of its energy performance. This principle can also reduce the effort for the energy assessment of a total building portfolio (municipalities, housing companies) or a national building stock, as far as typological criteria are known.

The term “building typology” refers to a systematic describing of the criteria for the definition of typical buildings as well as to the set of building types itself.

Different experiences with building typologies have been made in European countries. The IEE project TABULA aims at examining them and coming to a concerted approach for the area of residential buildings. A focus is placed on the energy consumption for space heating and hot water. The overall objective is to enable an understanding of the structure and of the modernisation processes of the building sector in different countries and to learn from each other about successful energy saving strategies.

2 Existing Experiences in the Participating Countries

2.1 Germany

(by TABULA partner 1: IWU / Germany)

A first version of the national residential building typology was already developed in 1990 on the basis of energy saving audit reports and was applied during scenario analyses to determine the energy saving potentials of the German building stock [IWU 1990]. The German building typology was regularly updated according to new developments (e.g. new energy saving ordinances) and applied as a model for the building stock in several studies (e.g. [FZJülich 1994] [FIZ 1999] [IWU 2003]).

The current version consists of 44 residential building types classified by construction year and building size (see Figure 1). It describes the original state of the buildings (exception: double glazing). The building datasets are documented in [IWU 2003] and include the following information: basic data (floor area, number of apartments …), areas of building elements (wall, roof, ground floor, windows), U-values of building elements.

Also a number of regional building typologies have been developed during the past two decades for German cities or provinces (e.g. [ebök/ifeu 1996] [ebök/ifeu 1997] [Eicke-Hennig / Siepe 1997] [GERTEC / UTEC 1999] [ebök 2001] [IWU 2002] [ebök 2003] [IWU 2006]). The energy performance and saving potentials are usually documented in form of a two-page overview (see example Figure 2).

Apart from scenario analyses and energy advice brochures the regional and national building typologies were also used by a number of software applications as a set of example buildings (see example in Figure 3)

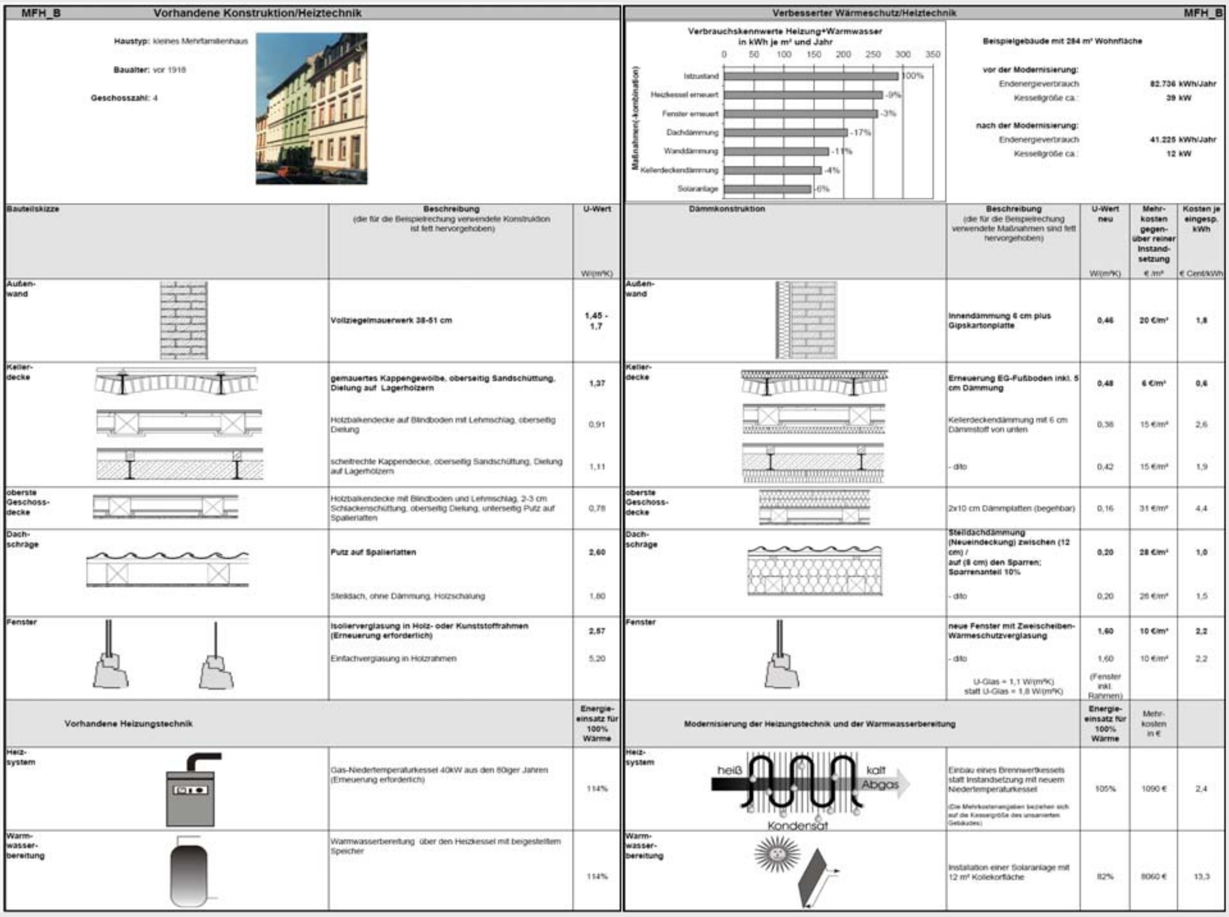
Figure 1: Classification scheme of the German Building Typology [IWU 2003]

Explanations

in columns: different building size classes: EFH = single family houses, RH = terraced houses, MFH = multi-family houses, GMH = apartment blocks, HH = tower buildings

in rows: different construction year classes and special cases (prefabricated single family houses from Western Germany / panel buildings ("Plattenbau") from Eastern Germany)

Figure 2: **Example for a two page building overview (Building Typology of the province of Hesse) [IWU 2002]**



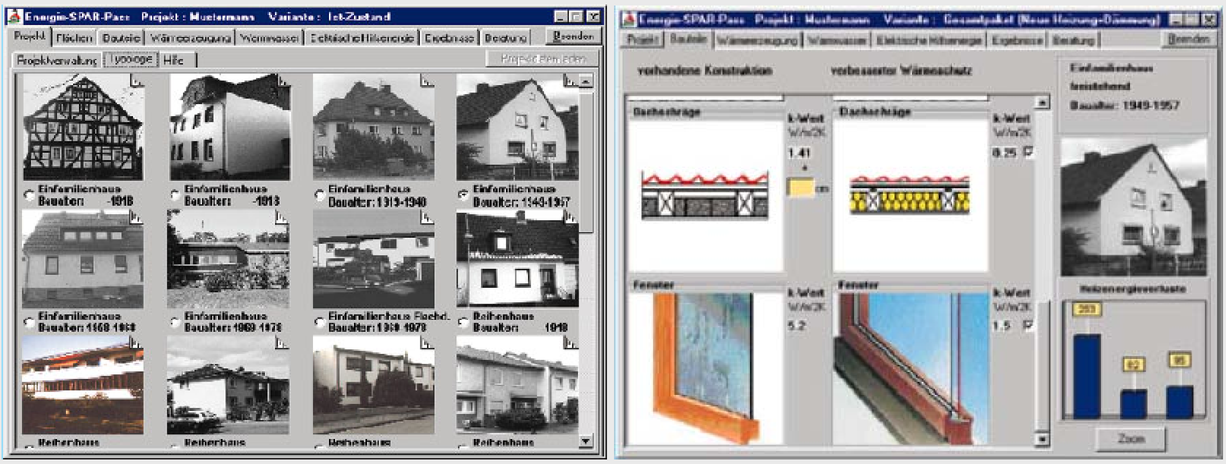
Explanations

left page: usual state of this type of buildings before modernisation

right page: refurbishment measures and state afterwards

in rows: typical structural elements (wall, cellar ceiling, roof, windows) with U-values and typical supply system

Figure 3: **Building Typology in an energy advice software, example from Germany**



Source: EPC Software Bially

A number of publications on typical construction elements exist in Germany in which U-values are listed classified by construction year, type, materials etc.: e.g. [Zapke / Ebert 1983] [Eicke-Hennig et al. 1997] [IWU 2004] [IWU 2005a] [ZUB 2009]).

Figure 4: Example for a sub-typology of walls [IWU 2005]

Außenwände			**Ur-zustand**	**zusätzliche Dämmung** 2 cm	5 cm	8 cm	12 cm	16 cm	20 cm	30 cm	40 cm
Bauart	**typischer Erstellungs-zeitraum**	**typische Konstruktion**	**Pauschalwerte für den Wärmedurchgangskoeffizienten in W/(m²K)**								
Mauerwerk	**bis 1918**	Ziegel- oder Bruchstein-mauer ca. 40 cm	2,2	1,05	0,59	0,41	0,29	0,22	0,18	0,13	0,10
Fachwerk	**bis 1918**	Holzfachwerk mit Lehm-ausfachung	2,0	1,00	0,57	0,40	0,29	0,22	0,18	0,13	0,10
Vollziegel-Mauerwerk	**bis 1948**	Ziegelmauer-werk, 25 - 38 cm	1,7	0,92	0,54	0,39	0,28	0,22	0,18	0,12	0,09
Vollziegel-Mauerwerk verbessert	**bis 1948**	einschalig 38 - 51 cm oder zweischalig	1,4	0,82	0,51	0,37	0,27	0,21	0,18	0,12	0,09
leichtes Mauerwerk	**1949 bis 1968**	Hohlblock- steine, Gitterziegel, Gasbeton	1,4	0,82	0,51	0,37	0,27	0,21	0,18	0,12	0,09
Bims-vollsteine	**1949 bis 1968**	Mauerwerk aus Bimsvollsteinen	0,9	0,62	0,42	0,32	0,24	0,20	0,16	0,12	0,09
leichtes Mauerwerk	**1969 bis 1978**	Leicht-Hochloch-ziegel mit Normalmörtel	1,0	0,67	0,44	0,33	0,25	0,20	0,17	0,12	0,09
Betonfertigteile	**1969 bis 1978**	Dreischicht- oder Leichtbeton-platte	1,1	0,71	0,46	0,34	0,26	0,20	0,17	0,12	0,09
Fertighaus oder Holzbau	**1969 bis 1978**	Holzständer-wand mit 6 cm Dämmung (Draufsicht)	0,6	0,46	0,34	0,27	0,21	0,18	0,15	0,11	0,09
leichtes Mauerwerk	**1979 bis 1983**	Leicht-Hoch-lochziegel mit Leichtmörtel	0,8	0,57	0,40	0,31	0,24	0,19	0,16	0,11	0,09
Porenbeton	**1979 bis 1983**	Mauerwerk aus Porenbeton-steinen ("Gasbeton")	0,6	0,46	0,34	0,27	0,21	0,18	0,15	0,11	0,09
Betonfertigteile	**1979 bis 1994**	Dreischicht-oder Leichtbeton-platte	0,9	0,62	0,42	0,32	0,24	0,20	0,16	0,12	0,09
Fertighaus oder Holzbau	**1979 bis 1983**	Holzständer-wand mit 8 cm Dämmung (Draufsicht)	0,5	0,40	0,31	0,25	0,20	0,17	0,14	0,11	0,08
leichtes Mauerwerk	**ab 1984**	Leicht-Hoch-lochziegel mit Leichtmörtel	0,6	0,46	0,34	0,27	0,21	0,18	0,15	0,11	0,09
Porenbeton	**ab 1984**	Mauerwerk aus Porenbeton-steinen ("Gasbeton")	0,5	0,40	0,31	0,25	0,20	0,17	0,14	0,11	0,08

Explanations

U-values for different wall systems and construction cycles

yellow: without insulation

green: with insulation (variation of insulation layer thickness)

Table 1: Example for a sub-typology of heating systems, here: heat generators for space heating [IWU 2005a]

Hg	Heizwärme Erzeugung		Erzeuger-Aufwandszahl $e_{H,g}$ [-]		Hilfsenergiebedarf $q_{H,g,HE}$ [kWh/(m²a)]	
			Wohnungsanzahl		Wohnungsanzahl	
Kürzel	Name	Baualtersklasse	1 bis 2	3 und mehr	1 bis 2	3 und mehr
		Basiswert für f_0	2,0	2,0		
		Basiswert für Q'_n	24	500		
KTK86	Konstanttemperatur-Kessel	bis 1986	1,33	1,21	2,4	0,4
KTK94	Konstanttemperatur-Kessel	1987 bis 1994	1,29	1,18	2,4	0,4
KTK95	Konstanttemperatur-Kessel	ab 1995	1,26	1,14	2,4	0,4
NTK86	Niedertemperatur-Kessel	bis 1986	1,23	1,18	2,4	0,4
NTK94	Niedertemperatur-Kessel	1987 bis 1994	1,18	1,12	2,4	0,4
NTK95	Niedertemperatur-Kessel	ab 1995	1,12	1,08	2,4	0,4
BWK86	Brennwert-Kessel	bis 1986	1,11	1,07	2,4	0,4
BWK94	Brennwert-Kessel	1987 bis 1994	1,08	1,04	2,4	0,4
BWK95	Brennwert-Kessel	ab 1995	1,06	1,03	2,4	0,4
GT94	Gas-Therme (Umlaufwasserheizer)	bis 1994	1,16	1,16	2,4	0,4
GT95	Gas-Therme (Umlaufwasserheizer)	ab 1995	1,08	1,08	2,4	0,4
GBT94	Gas-Brennwert-Therme	bis 1994	1,07	1,07	2,4	0,4
GBT95	Gas-Brennwert-Therme	ab 1995	0,99	0,99	2,4	0,4
WPE94	Elektro-Wärmepumpe Erdreich oder Grundw.	bis 1994	0,32	0,32	1,4	1,0
WPE94mHS	Elektro-WP Erdreich oder Grundw. mit Heizstab	bis 1994	0,36	0,36	1,4	1,0
WPE95	Elektro-Wärmepumpe Erdreich oder Grundw.	ab 1995	0,29	0,29	1,4	1,0
WPE95mHS	Elektro-WP Erdreich oder Grundw. mit Heizstab	ab 1995	0,32	0,32	1,4	1,0
WPL94	Elektro-Wärmepumpe Außenluft	bis 1994	0,42	0,42	1,4	1,0
WPL94mHS	Elektro-Wärmepumpe Außenluft mit Heizstab	bis 1994	0,45	0,45	1,4	1,0
WPL95	Elektro-Wärmepumpe Außenluft	ab 1995	0,35	0,35	1,4	1,0
WPL95mHS	Elektro-Wärmepumpe Außenluft mit Heizstab	ab 1995	0,38	0,38	1,4	1,0
FWU	Fernwärme-Übergabestation	-	1,02	1,02	0,0	0,0
Oelofen	Ölbefeuerter Einzelöfen mit Verdampfungsbr.	-	1,40	1,40	0,0	0,0
Ofen	Kohle- oder Holzöfen	-	1,60	1,60	0,0	0,0
GRH	Gasraumheizer	-	1,40	1,40	0,0	0,0
ESz	zentraler Elektro-Speicher	-	1,00	1,00	0,0	0,0
ENSp	Elektro-Nachtspeicherheizung	-	1,00	1,00	0,0	0,0
EDHG	Elektro-Direktheizgeräte	-	1,00	1,00	0,0	0,0
TSA	Thermische Solaranlage	-	0,00	0,00	0,0	0,0

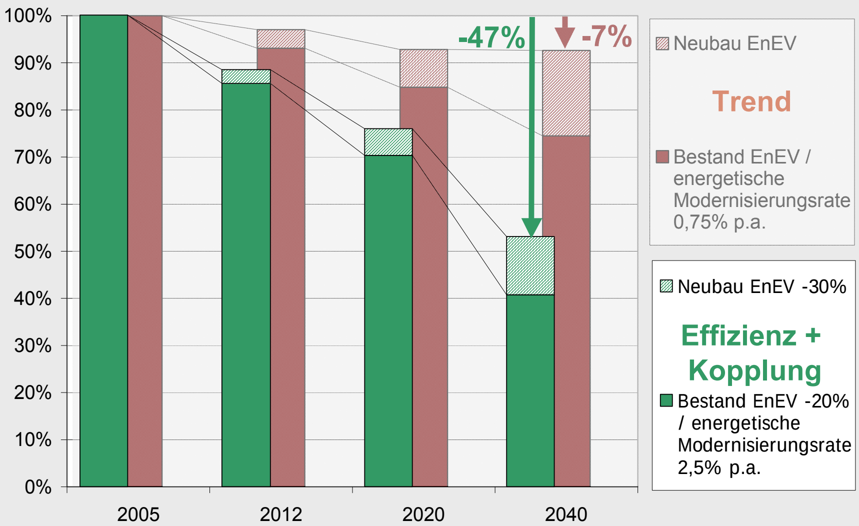
Explanations:

rows: different types of heat generators (boilers and heat pumps also arranged according to installation period)

columns yellow: expenditure factor (1/efficiency) of the generators when installed in single (left value) or multi-family houses (right value)

columns red: auxiliary electric energy demand per m² living space

Figure 5: Calculation of the carbon dioxide emission reduction potential for a region by use of a building typology, example from Germany - "Hessische Gebäudetypologie" = building typology of the province Hesse, source: [IWU 2005b]



Berechnung: N. Diefenbach (IWU) im Rahmen des Projektes InKlim

A classification of supply systems by generator type, installation year and other parameters can be found in different sources, for example in [IWU 2004] (tabled values for overall expenditure factors of systems) and in [DIN V 4701-10], [BekEnEV 2009], [IWU 2005a] (tabled values for expenditure factors, losses from the supply, generation, storage and distribution system components). An example is shown in Table 1.

Figure 6 shows a scenario analysis of CO_2 emission reduction in the province Hesse which was carried out with the help of the Hessian building typology. Statistical data on which such kind of analysis is based, like the number of building types in a province or in the whole country can be found in the “Bautätigkeitsstatistik” (German statistics on building construction) and the “Mikrozensus” (a sample of 1 % of the German households, every 4 years also delivering data about the buildings and heating systems, see Table 2).

Some detailed information are not provided by the available statistics until now, e.g. the number of German buildings which have been thermally refurbished. But more information about the modernisation state of the building stock will be available in autumn 2010 when a new empirical statistical survey will have been finished. During the study “Datenerhebung zur energetischen Qualität und zu den Modernisierungstrends im Gebäudebestand” carried out by IWU and Bremer Energieinstitut 10,000 owners of residential buildings are asked to fill in a questionnaire. The research project will deliver an updated statistical basis for the frequency of building types including detailed information on the state of construction elements and heat supply systems.

Further statistical data will also be available from the energy certificate database of the German energy agency DENA. The datasets are collected in the framework of the DENA database quality assurance for energy certificates “Gütesiegel Energieausweis”.

Table 2: German building stock (number of apartments and living space) 1994 – 2006
source: Statististisches Bundesamt, www.destatis.de [Mikrozensus]

1 Zusammenfassende Übersicht

1.1 Wohnungsbestand Deutschlands in den Jahren 1994 bis 2006 *)

Stichtag Land	Wohnungen		Wohnfläche			
	insgesamt	je 1 000 Einwohner	insgesamt	je Wohnung	je Einwohner	insgesamt
	Anzahl		1 000 m^2	m^2		
31. 12. 1994 Deutschland	35 370 790	434	2 952 927	83,5	36,2	154 030 827
Früheres Bundesgebiet	28 412 816	430	2 469 368	86,9	37,4	126 232 187
Neue Länder und Berlin-Ost	6 957 974	448	483 558	69,5	31,1	27 798 640
31. 12. 1995 Deutschland	35 954 317	439	3 005 457	83,6	36,7	156 520 740
Früheres Bundesgebiet	28 898 409	436	2 513 346	87,0	37,9	128 301 124
Neue Länder und Berlin-Ost	7 055 908	456	492 111	69,7	31,8	28 219 616
31. 12. 1996 Deutschland	36 492 323	445	3 054 302	83,7	37,2	158 818 421
Früheres Bundesgebiet	29 299 740	440	2 550 791	87,1	38,3	130 044 523
Neue Länder und Berlin-Ost	7 192 583	466	503 511	70,0	32,6	28 773 898
31. 12. 1997 Deutschland	37 050 369	452	3 106 250	83,8	37,9	161 256 212
Früheres Bundesgebiet	29 686 946	445	2 588 723	87,2	38,8	131 797 030
Neue Länder und Berlin-Ost	7 363 423	479	517 528	70,3	33,7	29 459 182
31. 12. 1998 Deutschland	37 529 144	457	3 153 846	84,0	38,4	163 466 990
Früheres Bundesgebiet	30 046 509	450	2 625 661	87,4	39,3	133 501 419
Neue Länder und Berlin-Ost	7 482 635	489	528 185	70,6	34,5	29 965 571
31. 12. 1999 Deutschland	37 984 298	462	3 201 599	84,3	39,0	165 648 026
Früheres Bundesgebiet	30 407 885	454	2 664 359	87,6	39,8	135 264 772
Neue Länder und Berlin-Ost	7 576 413	498	537 240	70,9	35,3	30 383 254
31. 12. 2000 Deutschland	38 383 645	467	3 245 487	84,6	39,5	167 636 286
Früheres Bundesgebiet	30 730 777	458	2 700 482	87,9	40,2	136 898 015
Neue Länder und Berlin-Ost	7 652 868	506	545 005	71,2	36,0	30 738 271
31. 12. 2001 Deutschland	38 681 801	469	3 280 295	84,8	39,8	169 181 697
Früheres Bundesgebiet	30 986 077	459	2 730 181	88,1	40,5	138 223 732
Neue Länder und Berlin-Ost	7 695 724	513	550 114	71,5	36,7	30 957 965
31. 12. 2002 Deutschland	38 924 836	472	3 310 205	85,0	40,1	170 507 512
Früheres Bundesgebiet	31 212 975	461	2 756 681	88,3	40,8	139 426 328
Neue Länder und Berlin-Ost	7 711 861	518	553 523	71,8	37,2	31 081 184
31. 12. 2003 Deutschland	39 141 543	474	3 339 229	85,3	40,5	171 725 052
Früheres Bundesgebiet	31 428 090	464	2 783 432	88,6	41,1	140 578 484
Neue Länder und Berlin-Ost	7 713 453	521	555 796	72,1	37,6	31 146 568
31. 12. 2004 Deutschland	39 362 266	477	3 368 920	85,6	40,8	172 989 964
Früheres Bundesgebiet	31 651 967	467	2 811 012	88,8	41,5	141 789 398
Neue Länder und Berlin-Ost	7 710 942	524	557 955	72,4	37,9	31 203 047
31. 12. 2005 Deutschland	39 551 203	480	3 394 782	85,8	41,2	174 075 880
Früheres Bundesgebiet	30 686 029	467	2 751 327	89,7	41,9	138 675 063
Neue Länder und Berlin	8 865 174	530	643 455	72,6	38,4	35 400 817
31. 12. 2006 Deutschland	39 753 733	483	3 421 384	86,1	41,6	175 195 906
Früheres Bundesgebiet	30 887 335	470	2 775 826	89,9	42,3	139 734 682
Neue Länder und Berlin	8 866 398	533	645 558	72,8	38,8	35 461 224

Table 3: Literature / sources Germany (non-exhaustive)

Typical buildings / national level		
[IWU 1990]	First definition of the German Building Typology / application for scenario calculations	Ebel, W. et al.: Energiesparpotential im Gebäudebestand; IWU, Darmstadt 1990
[FZJülich 1994]	Description of the energy related properties of typical non-residential buildings	M. Gierga, H. Erhorn: Bestand und Typologie beheizter Nichtwohngebäude in Westdeutschland, Forschungszentrum Jülich, Jülich, 1994
[FIZ 1999]	Database for scenario calculations, including the German Building Typology [IWU 1990]	IKARUS-Datenbank; Fachinformationszentrum Karlsruhe, 1999
[IWU 2003]	German Building Typology: Systematic and datasets, revised	Deutsche Gebäudetypologie: Systematik und Datensätze, Institut Wohnen und Umwelt,

	version of typology used in [IWU 1990]	Darmstadt, 2003, and:
[IWU 2005a]	Simplified Energy Profile Procedure; developed methods: (1) envelope area estimation procedure / (2) typical U-values / (3) efficiencies of typical supply systems	Loga, Tobias; Diefenbach, Nikolaus; Knissel, Jens; Born, Rolf: Kurzverfahren Energieprofil. Ein vereinfachtes, statistisch abgesichertes Verfahren zur Erhebung von Gebäudedaten für die energetische Bewertung von Gebäuden; IWU, Darmstadt 2005; Bauforschung für die Praxis / Band 72; Fraunhofer IRB-Verlag, Stuttgart 2005
[IWU 2005b]	Integrated climate protection programme for the state of Hesse / model analysis for the Hessian building stock	Enseling, A.; Diefenbach, N.; Hinz, E.: Integriertes Klimaschutzprogramm Hessen 2012 – Themenbereich: Wärmeversorgung von Gebäuden, im Auftrag des Hessischen Ministeriums für Umwelt, ländlichen Raum und Verbraucherschutz; Institut Wohnen und Umwelt, Darmstadt 2005
[IWU 2007]	Basis data for extrapolation calculations, referring to the German Building Typology [IWU 2003]	N. Diefenbach, R.Born, Basisdaten für die Hochrechnung mit der Deutschen Gebäudetypologie des IWU, IWU, Darmstadt, 2007
[Mikrozensus]	Enquiry of ca. 380.000 households, every four year, official statistics by Federal Office of Statistics: - centralisation of supply system - main energy carriers - energy costs	Mikrozensus, Zusatzerhebung zur Wohnsituation, Statistisches Bundesamt
Typical buildings / regional level		
[ebök/ifeu 1996]	Building Typology for the city of Heidelberg	Stadt Heidelberg (Hrsg.): Heidelberger Wärmepass / Heidelberger Gebäudetypologie; ifeu, Heidelberg 1996
[ebök/ifeu 1997]	Building Typology for the city of Mannheim	Gebäudetypologie für die Stadt Mannheim; ebök/ifeu, Tübingen/Heidelberg 1997; im Auftrag der Stadt Mannheim
[Eicke-Hennig / Siepe 1997]	Building Typology for the province of Hessen	Eicke-Hennig, Werner; Siepe, Bennedikt: Die Heizenergie-Einsparmöglichkeiten durch Verbesserung des Wärmeschutzes typischer hessischer Wohngebäude; IWU, Darmstadt 1997
[GERTEC / UTEC 1999]	Building Typology for the province of Schleswig-Holstein	Investitionsbank Schleswig-Holstein / Energieagentur (Hrg.): Gebäudetypologie für das Land Schleswig-Holstein, Kiel 1999 (Bearbeitung: GERTEC / UTEC)
[ebök 2001]	Building Typology for the province of Sachsen	Gebäudetypologie für den Freistaat Sachsen; ebök, Tübingen 2001
[IWU 2002]	revised version of the Building Typology for the province of Hessen, including heating systems	Born, R.; Diefenbach, N; Loga, T.: Energieeinsparung durch Verbesserung des Wärmeschutzes und Modernisierung der Heizungsanlage für 31 Musterhäuser der Gebäudetypologie; Studie im Auftrag des Impulsprogramms Hessen; IWU, Darmstadt 2002
[ebök 2003]	Building Typology for the city of Münster	Hildebrandt, Olaf; Hellmann, Rosemarie; Zantner, Marc; Evaluation des Förderprogramms zur Altbausanierung in der Stadt Münster. Anhang zum Endbericht - Gebäudetypenblätter zur Gebäudetypologie; ebök (Tübingen) im Auftrag der Stadt Münster, Amt für Grünflächen

		und Umweltschutz – KLENKO (Koordinierungsstelle Klima & Energie); Münster 2003
[IWU 2006]	Building Typology for the province of Bayern	Hinz, E.: Gebäudetypologie Bayern: Entwicklung von 11 Hausdatenblättern zu typischen Gebäuden aus dem Wohngebäudebestand Bayerns; Studie im Auftrag des Bund Naturschutz Bayern e.V.; IWU, Darmstadt 2006
[Oeko-Institut 2003]	Scenarios for the province of Schleswig-Holstein on the basis of the regional Building Typology	Buchert, M.; Eberle, U.; Jenseit, W.; Stahl, H.: Nachhaltiges Bauen und Wohnen in Schleswig-Holstein; Öko-Institut, Darmstadt 2003
Typical construction elements and supply systems		
[Zapke / Ebert 1983]	U-values of old construction elements (first edition)	Zapke, W.; Ebert, H.: (Institut für Bauforschung e.V., Hannover): k-Werte alter Bauteile; Rationalisierungs-Kuratorium der Deutschen Wirtschaft (RKW); 1983
[Eicke-Hennig et al. 1997]	detailed description of typical construction elements according to construction period and possible energy saving measures	Eicke-Hennig, W.; Siepe, B.; Zink, J.: Konstruktionshandbuch - Verbesserung des Wärmeschutzes im Gebäudebestand; IWU, Darmstadt 1997
[DIN V 4701-10]	German Standard, including tabled flat values for typical supply system components (distribution, storage, generation), only for new buildings	DIN V 4701-10 / Energetische Bewertung heiz- und raumlufttechnischer Anlagen. Teil 10: Heizung, Trinkwassererwärmung, Lüftung; Deutsches Institut für Normung; Berlin, 2003
[IWU 2004]	method for the EP certificate field test in Germany, developed and documented on behalf of the German Energy Agency dena: including U-values of typical construction elements and efficiency values of typical supply system types	Loga, T.; Diefenbach, N.; Born, R.: Energetische Bewertung von Bestandsgebäuden. Arbeitshilfe für die Ausstellung von Energiepässen; Broschüre erstellt im Auftrag der Deutschen Energieagentur GmbH (dena); Darmstadt/Berlin, März 2004
[IWU 2005]	1. typical U-values according to construction year 2. tabled flat values for typical supply system components depending on installation year (distribution, storage, generation)	Kurzverfahren Energieprofil (see source mentioned above)
[BekEnEV 2009]	official paper of the German Ministry of Transport, Building and Urban Development, supplementing the German Energy Saving Ordinance ("Energieeinsparverordnung / EnEV 2009")	Bundesministerium für Verkehr, Bau und Stadtentwicklung (Hrsg.): Bekanntmachung der Regeln zur Datenaufnahme und Datenverwendung im Wohngebäudebestand; Berlin, 30. Juli 2009
[ZUB 2009]	systematic and comprehensive overview of construction elements, collected from different sources, escpecially from building typologies of different German regions and cities	Klauß, Swen; Kirchhof, Wiebke; Gissel, Dipl.-Ing. Johanna: Erfassung regionaltypischer Materialien im Gebäudebestand mit Bezug auf die Baualtersklasse und Ableitung typischer Bauteilaufbauten; ZUB Zentrum für Umweltbewusstes Bauen e.V. / Verein an der Universität Kassel; Kassel 2009

2.2 Greece

(by TABULA partner 2: NOA / Greece)

In Greece there is no elaborate monitoring of the building stock. EPBD implementation is approaching its final phase, following ratification of Law 3661/19.5.08 on the national adaptation of EPBD, the new Regulation for Energy Performance of Buildings – KENAK (KYA 5825/9.4.2010) and the publication of national technical guidelines (TOTEE) and tools expected by mid-2010. The provisions for the energy auditors/experts are near finalization. As a result, national building energy performance Certificates (EPCs) have not been issued yet; they are expected by the third quarter of 2010. At the same time, very limited efforts have been carried out to successfully collect and analyze detailed data on the building sector so far.

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

- involvement in European projects related to this subject over the past 15 years (EPIQR, INVESTIMO, EPA-ED and DATAMINE)
- involvement in national projects to assess the building stock and 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.

The most relevant source of information and experience related to TABULA 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". In the framework of this project, data on the Hellenic residential building stock were collected from various sources (National Hellenic Statistical Service -census of constructions 1990-2000 and published literature). The effort resulted in mapping the number and size of buildings for:

a. Building use (i.e. residential and non-residential buildings (offices/commercial, hospitals, hotels, schools))

b. Date of construction (i.e. three typologies – discretization based on the year of construction: pre-1980 (the national thermal insulation regulation came into force in 1980), the period 1980-2001 (when implementation to the code was gradually adapted), and projections until 2010)

c. Four climatic zones (A,B,C,D - discretization based on the number of heating degree days in accordance to the draft national Regulation for EPBD implementation).

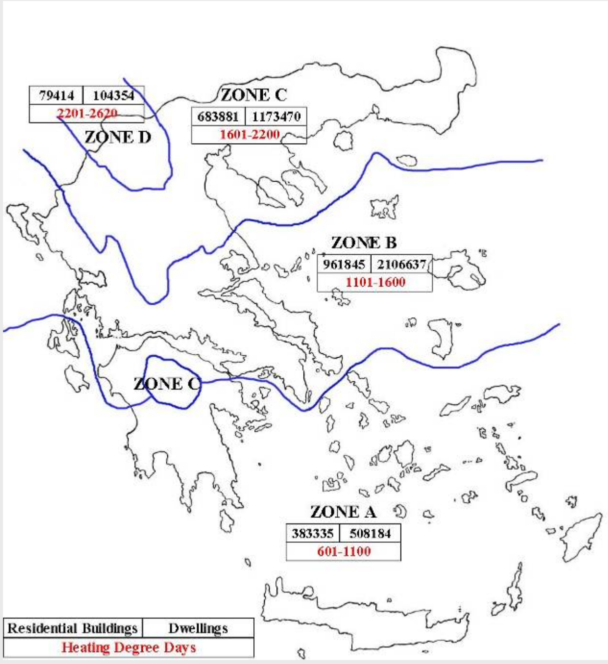
Similarly, a mapping of the annual operational specific electrical and thermal energy consumption was achieved for the different categories. Figure 6 illustrates the available data for the residential building stock, divided in two categories according to the building size: single dwellings and apartment buildings.

Additionally, a classification of the two categories of residential buildings mentioned above according to their thermal characteristics and installed heating systems was possible for three different construction periods, specifically: pre 1980, 1980 – 2001 and 2002-2010. The year 1980 is the critical period for the first introduction of the Hellenic Building Thermal Insulation Regulation (HBTIR) (OHJ 362/4-7-79) that sets the minimum requirements for thermal conductivity of the building envelope for different climatic zones; the regulation was never upgraded or modified ever since. As a result, the great majority of the Hellenic building stock is not thermally insulated, despite the fact that the HDDs range reach over 2600 HDD in the northern parts of the country. At the time of the study, the data regarding the last period (2002-2010) were mainly forecasts, based on well justified assumptions. Table 4 shows the derived classification.

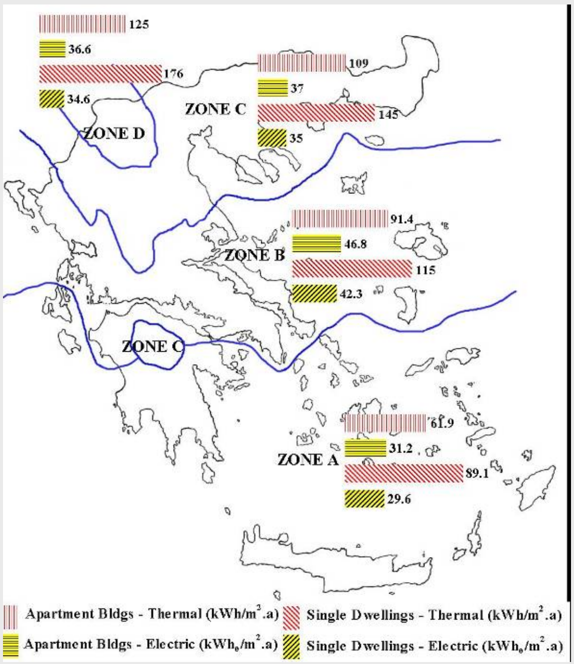
Figure 6: Distribution of Hellenic residential building stock estimated for the four climatic zones of Greece.

(a) Total number of residential buildings and dwellings for 2001, and the corresponding heating degree-days for each climatic zone.

(b) Average annual specific electrical and thermal (for central heating) energy consumption (kWh/m2) for single dwellings and apartment buildings for each climatic zone, estimated for 2001.



(a)



(b)

Table 4: Number of residential buildings for different subcategories with common characteristics

Subcategories	Single dwellings (pre-1980)	Apartment buildings (pre-1980)	Single dwellings (1980-2001)	Apartment buildings (1980 – 2001)	Single dwellings (2002-2010)	Apartment buildings (2002-2010)
Total building stock	**1,371,642**	**194,667**	**450,724**	**91,443**	**278,351**	**81,297**
Buildings without or inadequate external wall insulation	1,371,642	194,667	74,491	12,314	--	--
Buildings without or inadequate roof insulation	1,056,164	149,894	18,623	3,079	--	--
Buildings with central heating systems	741,979	79,647	436,598	89,981	278,351	81,297
Buildings with old central heating systems	519,385	55,753	17,210	2,932	--	--
Buildings without temperature balance control for central space heating	519,385	55,753	130,979	26,994	--	--
Buildings without space thermostats	667,781	71,682	34,421	5,865	--	--
Buildings with local air-conditioning	643,100	98,954	214,916	45,172	131,312	40,060
Building without solar collectors	1,097,314	155,734	289,057	57,944	139,176	40,649
Buildings without shading	321,550	49,477	107,458	22,586	65,656	20,030

The last part of the study involved a techno-economic assessment of the energy saving potential for selected energy conservation measures (ECMs) per climatic zone. Accordingly, ECMs were ranked based on their impact on the reduction of CO_2 emissions, but also on their financial viability. Table 5 summarizes the results for buildings of both residential and tertiary sectors. ECMs indicated by "✓" identify financially attractive measures that would not require the support of any financial instruments, while "*" identify measures with good potential but their implementation may require some kind of support instruments. Crosses identify ECMs that are not recommended for specific building uses.

Table 5: Priorities for the implementation of energy savings measures in Hellenic residential buildings

Energy conservation measures (ECMs)	Total annual energy savings in dwellings		Recommended ECMs for the climatic zones[c]				Comments
	Thermal[a]	Electrical[b]	A	B	C	D	
Space heating—building envelope							
#1. Thermal insulation of external walls	49% of space heating		*	*	✓	✓	
#3. Weather proofing (sealing) of openings	20% of space heating		*	*	✓	✓	Overall, this measure maybe considered applicable to all buildings in all climatic zones, given the low first cost.
#4. Double glazing	19% of space heating				*	*	
#2. Thermal insulation of roof	10% of space heating		*	*	*	*	
Space heating—heat production							
#5. Maintenance of central heating installations	11% of space heating		✓	✓	✓	✓	Given the low annual cost for this measure, and the environmental benefits, it is recommended for the entire building stock.
#6. Replacement of inefficient boilers with energy efficient oil-burners	17% of space heating		*	✓	✓	✓	
#8. Temperature balance controls for central space heating	4% of space heating		*	*	✓	✓	
#9. Space thermostats	4% of space heating		*	*	✓	✓	Not applicable for pre-1980 apartment buildings, due to the characteristics of the central heating systems.
#7. Replacement of inefficient boilers with energy efficient natural gas burners	21% of space heating			✓	✓		Applicable only in areas where natural gas is available (climatic zones B and D).
Cooling							
#12. Replacement of old and inefficient local air conditioning units		72% of cooling	✓	✓	✓	✓	Not applicable for apartment buildings in zone D.
#11. Ceiling fans		60% of cooling	✓	✓	✓	✓	
#10. External shading		15% of cooling	*	*	✓	✓	Require low financial subsidies for zone C and higher subsidies for zone D.
Sanitary hot water							
#13. Solar collectors for sanitary hot water production		68% of sanitary for hot water	*	*	*	*	Require low financial subsidies for zone A and higher subsidies for zone D.
Lighting							
#14. Energy efficient lamps		60% of lighting	✓	✓	✓	✓	

[a]Values are given as a percentage of the total thermal energy consumption for the specific final use and for the number of building that the ECM is applied to

[b]Values are given as a percentage of the total electric energy consumption for the specific final use and for the number of buildings that the ECM is applied to

[c]Symbols used to identify the recommended ECMs for different climatic zones: (✓) identifies financially attractive measures that would not require the support of any financial instruments; (*) identifies measures with good potential but their implementation may require some kind of support instruments.

Based on the experience gained so far and the current knowledge on the Hellenic building stock a preliminary typology of residential buildings in Greece could include **24 building types**, defined according to the :

- building age (3 construction periods),
- location (4 climatic zones) and
- size (family dwellings / apartment buildings).

However, the statistical research carried out in the framework of TABULA will permit to finalize the typology based on the availability of the required data. The main data sources for the project will be:

- National statistical data from recent released of the Hellenic Statistical Service
- National standards and regulations providing information on building construction types and heat supply systems
- Existing and on-going studies
- Empirical data on the Hellenic building stock
- Selected NAG members (e.g. architects, mechanical engineers).

Table 6: Literature / sources Greece

European Projects		
EPIQR (1996-1998)	A Cost Predictive European Retrofitting Evaluation Method for Improving the Energy Performance and the Indoor Environment of Existing Apartment Buildings	• C.A. Balaras, K. Droutsa, A.A. Argiriou, D.N. Asimakopoulos, Potential for Energy Conservation in Apartment Buildings, **Energy & Buildings**, 31, 143-154, (2000).
INVESTIMMO (2001-2004)	A Decision-making Tool for Long-term Efficient Investment Strategies in Housing Maintenance and Refurbishment	• C.A. Balaras, K. Droutsa, E. Dascalaki, S. Kontoyiannidis, Heating Energy Consumption and Resulting Environmental Impact of European Apartment Buildings, **Energy & Buildings**, 37, 429-442, (2005).
EPA-ED (2002-2004) EPA-NR (2005-2007)	Development of and preparations for the implementation of an Energy Performance Assessment Method for Existing Dwellings to stimulate RUE and the use of RES in the existing dwelling stock in Member States Energy Performance Assessment for Existing Non Residential Buildings	• C.A. Balaras, E. Dascalaki, S. Geissler, K.B. Wittchen, G. van Cruchten - Benchmarking for Existing European Dwellings. Final Technical report 155p. for EPA-ED, European Commission, DG TREN,, April (2003)
DATAMINE (2006-2008)	Collecting Data from energy certification to Monitor performance Indicators for New and Existing buildings	• E. Dascalaki, C.A. Balaras, P. Droutsa, S. Kontoyannidis and A. Gaglia, Data collection from energy audits for Hellenic buildings in the residential and tertiary sector, Hellenic Technical Report 83 p., Final Technical Report for DATAMINE, European Commission, Intelligent Energy Europe, December (2007).
National Projects		
Ministry of Environment (2001-2002)	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	• D. Lalas, C.A. Balaras, A. Gaglia, E. Georgakopoulou, S. Mirasgentis, I. Serafidis, S. Psomas, Evaluation 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, 650 p. *in Hellenic*, IERSD, National Observatory of Athens, Ministry for the Environment, Physical Planning and Public Works, Directorate Urban Planning & Housing, November (2002).

		• C.A. Balaras, A.G. Gaglia, E. Georgopoulou, S. Mirasgedis, Y. Sarafidis, D.P. Lalas, European Residential Buildings and Empirical Assessment of the Hellenic Building Stock, Energy Consumption, Emissions & Potential Energy Savings, **Building and Environment**, Vol. 42, No 3, p. 1298-1314, (2007). • 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). • E. Georgopoulou, Y. Sarafidis, S. Mirasgedis, C.A. Balaras, A. Gaglia, D. P. Lalas, Evaluating the need for economic support policies in promoting greenhouse gas emission reduction measure in the building sector: the case of Greece, **Energy Policy**, 34, 2012-2031, (2006). • S. Mirasgedis, E. Georgopoulou, Y. Sarafidis, C.A. Balaras, A. Gaglia and D.P. Lalas, CO_2 Emission Reduction Policies in the Greek Residential Sector: A Methodological Framework for Their Economic Evaluation, **Energy Conversion and Management**, 45, 537-557, (2004).
Other sources		
Hellenic Statistical Service		Census 2001 or more recent (to be defined)
Minisrty of Environment, Energy and Climatic Change	National standards and regulations providing information on building construction types and heat supply systems	To be issued in view of the national Regulation for EPBD implementation
Existing on-going studies	Empirical data on the Hellenic building stock	
NAG	Empirical data on the Hellenic building stock	

2.3 Slovenia

(by TABULA partner 3: ZRMK / Slovenia)

Existing building typologies

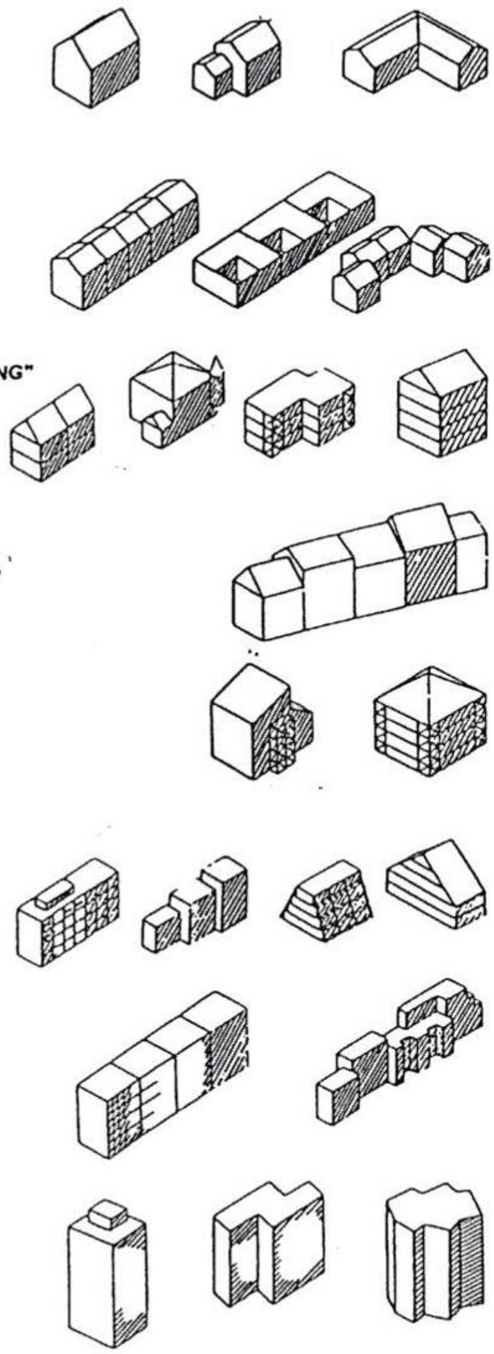
Some attempts to assemble building typologies have been made in the past. First there was a study in mid 90's. Study was concentrated on energy restoration of buildings. Then we have building typologies that is used for statistical purposes and one more that is used for CO_2 scenarios. The later is composed by only 2 types of construction (single family houses and apartment building) and multiple years of construction classes which correspond to energy efficiency levels. Not one of these tree typologies involves building systems.

Analysis of existing residential building stock (part of Energy Restoration of Existing Residential Buildings)

Building stock was divided according to different architectural design. In next step frequencies of each building type were made. Bases for the frequencies were census from 1991. Then only buildings erected until 1980 were taken into further analyzes. Year 1980 corresponds to the nation standard with stricter conditions regarding thermal properties of building components and building energy efficiency. These 18 building typologies were considered uninsulated and for each of them a refurbishment plan was proposed. Refurbishment plan took into account only building envelope. Differences between energy use of these two scenarios correspond to energy savings which were then calculated on a national bases.

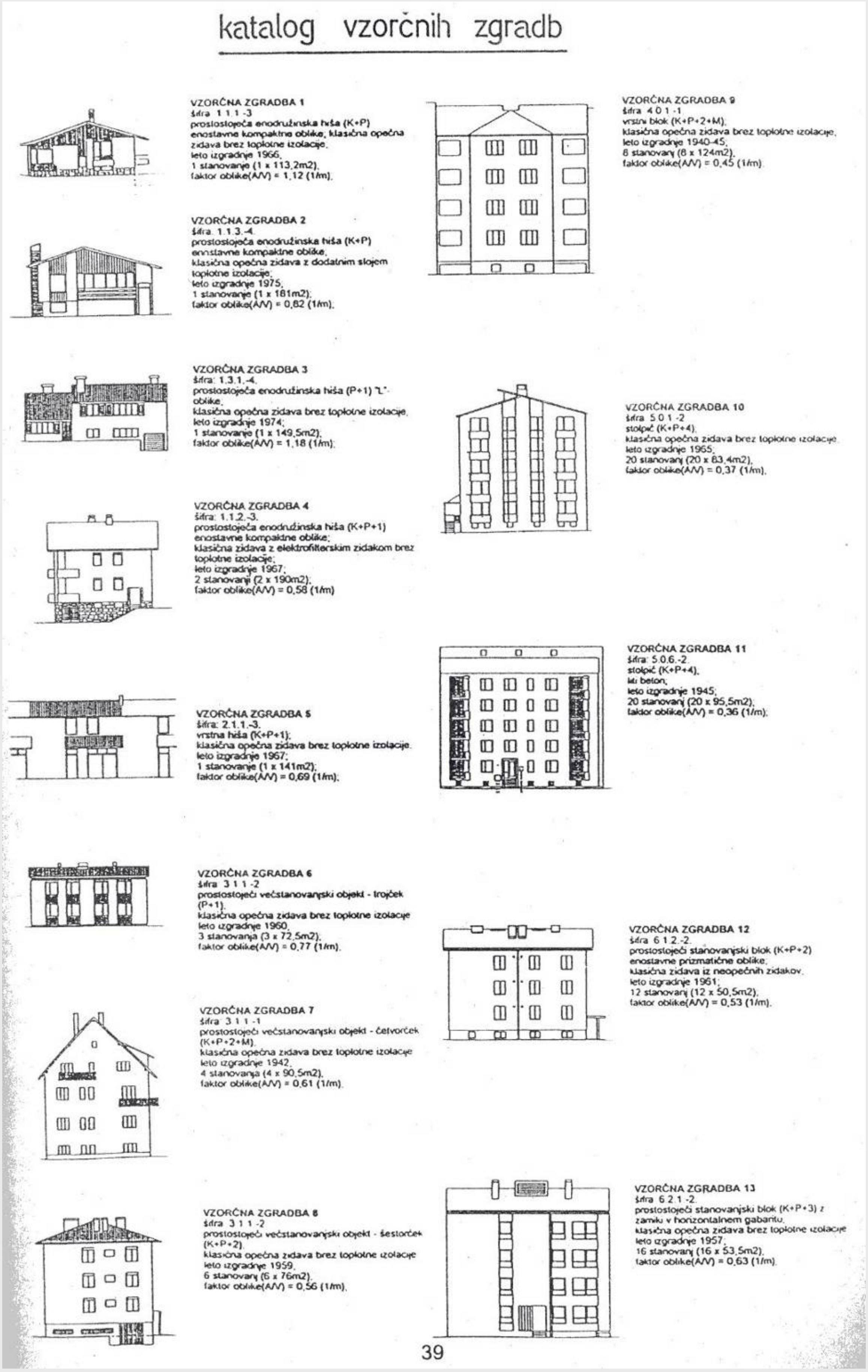
Figure 7: Residential buildings typology according to architectural criteria

1.0. ONE FAMILY HOUSES - "SELF-STANDING"
1.1. simple compact forms
1.2. deviation in horizontal and vertikal direction
1.3. special forms ("L-form")
2.0. ONE FAMILY HOUSES - "ON A STRING"
2.1. serial houses
2.2. atrium houses
2.3. other forms ("bunchy"-form, "teraced"-form,...)
3.0. MORE APARTMENTS HOUSES - "SELF-STANDING"
3.1. 4 or 6 apartments houses
3.2. villas
3.3. villa-blocks
4.0. MORE APARTMENTS HOUSES - "ON A STRING"
(down street houses up to: groundfloor + 3 floors)
5.0. MULTI-STOREY BUILDINGS
(up to: groundfloor + 5 floors)
6.0. APARTMENT BLOCKS - "SELF-STANDING"
6.1. simple prismatic form
6.2. deviation in horizontal and vertical direction
6.3. special forms ("teraced"-form,...)
7.0. APARTMENT BLOCKS - "ON A STRING"
7.1. simple prismatic forms
7.2. deviation in horizontal and vertical direction
8.0. MULTI-STOREY BUILDINGS
8.1. simple compact forms
8.2. deviation in horizontal direction
8.3. special forms



source: (3)

Figure 8: Representatives of each building typology



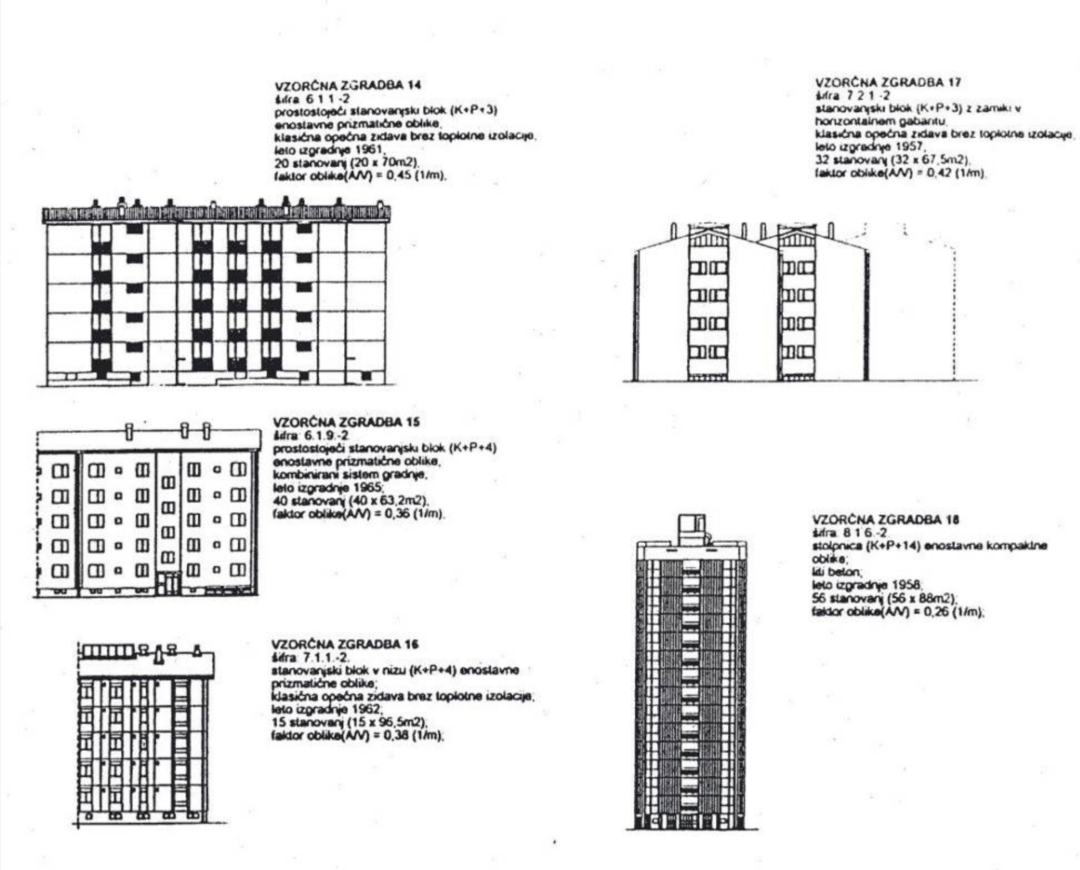


Table 7: Building frequencies according to typologies

ARCHITECTURAL GROUP	NUMBER OF RESIDENTIAL BUILDINGS	% OF ALL RESIDENTIAL BUILDINGS	NUMBER OF APARTMENTS	% OF ALL APARTMENTS
1.1.	186750	60,67	199815	29,18
1.2.	33750	10,96	35437	5,17
1.3.	4500	1,46	4500	0,66
2.1.	53300	17,32	54614	7,97
2.2.	10326	3,36	10326	1,51
2.3.	967	0,32	985	0,14
3.1.	851	0,28	3512	0,51
3.2.	976	0,32	2535	0,37
3.3.	2473	0,80	9681	1,41
4.0.	6950	2,26	33268	4,86
5.0.	1100	0,36	22817	3,33
6.1.	938	0,30	12359	1,80
6.2.	388	0,13	11664	1,70
6.3.	174	0,06	9324	1,36
7.1.	1601	0,52	61887	9,04
7.2.	1799	0,58	112767	16,47
8.1.	311	0,10	20171	2,95
8.2.	346	0,11	43461	6,35
8.3.	293	0,09	35718	5,22
TOTAL	307800	100,00	684841	100,00

Building typology based on Statistical building categories

Slovenian statistical Office is surveying construction works per year in residential and non-residential sectors. Typologies are limited to Classification of Types of Constructions (R – residential buildings, A – administrative buildings, C – cultural/educational buildings, M – medical buildings, PC – buildings related to physical culture, O – other public buildings, I – industrial buildings, E – other buildings in economy sector). For each category there are data on number of buildings, square area and volume. Residential buildings are not divided to further sub categories. (Table 8)

Building typology - developed for Energy and CO_2 Scenarios

Typology is used for Kyoto CO_2 studies and national EEAP. Residential buildings are divided into two building typologies, single family and apartment buildings. Each of these architectural typologies is further divided according to year of construction, before 1970, from 1971 until 1980, from 1981 until 2002 and after 2002 respectively. Time periods correspond to national energy standards and laws. Further separation was made with regards to the level of refurbishment or the level of initial thermal insulation. Frequencies of each building type ware derived from statistical sources. Division to the subtypes (refurbishment, insulation) was made on a data from small statistical studies and through the interviews from various experts on a subject. (Table 9)

Typologies on envelope elements and building systems

There were two studies that focused on envelope elements (typical construction principles) used in Slovenian building practice.

First (part of the Energy Restoration of Existing Residential Buildings) also provided with frequencies of those principles. Based on the architectural and technological criteria the typological groups of buildings have been formed. Using the available data the number of buildings and apartments in each group have been assessed. According to the changes in thermal insulation regulative correspondent thickness of thermal insulation layer was added to the building envelope. (Table 10)

Table 8: Building frequencies according to statistical categories

YEAR	UNIT	R	A	C	M	PC	O	I	E
1962	nr	2.693	19	41	23	6	87	61	44
	m^2	919.000	22.000	101.000	24.000	2.000	32.000	-	-
	m^3	2.767.000	76.000	384.000	80.000	7.000	91.000	-	-
1963	nr	2.657	28	43	26	4	82	75	93
	m^2	-	-	-	-	-	-	-	-
	m^3	-	-	-	-	-	-	-	-
1964	nr	2.611	13	39	15	6	95	89	41
	m^2	-	-	-	-	-	-	-	-
	m^3	-	-	-	-	-	-	-	-
1965	nr	3.255	18	37	16	5	125	91	47
	m^2	-	-	-	-	-	-	-	-
	m^3	-	-	-	-	-	-	-	-
1966	nr	3.840	14	40	19	8	248	51	93
	m^2	1.038.000	4.000	91.000	24.000	4.000	20.000	71.000	53.000
	m^3	3.086.000	22.000	400.000	87.000	21.000	73.000	452.000	224.000
1967	nr	3.866	7	27	9	5	312	87	178
	m^2	1.011.000	5.000	44.000	55.000	1.000	54.000	150.000	82.000
	m^3	2.959.000	15.000	168.000	199.000	7.000	131.000	940.000	335.000
1968	nr	3.849	11	26	8	7	352	78	142
	m^2	958.000	7.000	44.000	14.000	3.000	26.000	83.000	141.000
	m^3	2.727.000	18.000	179.000	54.000	19.000	72.000	462.000	678.000
1969	nr	4.485	12	40	13	22	171	141	165
	m^2	1.076.000	3.000	53.000	8.000	5.000	15.000	230.000	111.000
	m^3	3.154.000	9.000	103.000	25.000	15.000	41.000	1.440.000	413.000
1970	nr	4.926	7	35	5	18	91	182	186
	m^2	1.167.000	15.000	51.000	3.000	4.000	30.000	269.000	172.000
	m^3	3.260.000	53.000	196.000	32.000	6.000	96.000	1.649.000	594.000
1971	nr	4.825	8	36	7	32	93	220	174
	m^2	1.332.000	19.000	110.000	11.000	11.000	17.000	416.000	245.000
	m^3	3.950.000	346.000	370.000	72.000	39.000	42.000	2.634.000	935.000
1972	nr	4.537	16	36	7	23	238	292	128
	m^2	1.281.000	16.000	86.000	7.000	6.000	44.000	333.000	147.000
	m^3	4.423.000	60.000	372.000	66.000	22.000	134.000	2.122.000	659.000
1973	nr	4.885	16	34	7	16	121	181	116
	m^2	1.364.000	22.000	70.000	23.000	13.000	30.000	350.000	124.000
	m^3	4.017.000	82.000	300.000	108.000	84.000	92.000	2.148.000	589.000
1974	nr	5.029	26	43	21	12	50	268	189
	m^2	1.586.000	35.000	63.000	23.000	7.000	13.000	556.000	69.000
	m^3	4.017.000	67.000	254.000	57.000	50.000	48.000	3.250.000	296.000
1975	nr	5036	26	43	15	28	46	238	83
	m^2	1.786.000	39.000	52.000	59.000	26.000	36.000	550.000	74.000
	m^3	5.578.000	186.000	215.000	241.000	126.000	208.000	3.377.000	445.000
1976	nr	4.904	16	31	17	13	19	235	105
	m^2	2.049.000	17.000	48.000	51.000	30.000	14.000	528.000	953.000
	m^3	5.820.000	61.000	207.000	211.000	166.000	33.000	4.907.000	9.310.000
1977	nr	5.625	25	39	15	12	52	199	90
	m^2	1.787.000	29.000	130.000	11.000	16.000	33.000	366.000	152.000
	m^3	5.609.000	82.000	542.000	40.000	101.000	125.000	2.712.000	567.000
1978	nr	4.962	24	36	12	15	63	165	86
	m^2	1.570.000	39.000	78.000	65.000	22.000	112.000	354.000	56.000
	m^3	5.046.000	141.000	391.000	166.000	172.000	416.000	2.368.000	646.000
1979	nr	5680	33	38	25	9	75	182	88
	m^2	1.790.000	40.000	90.000	79.000	5.000	127.000	462.000	122.000

Table 9: Building floor area according to typology categories

Building groups according to the year of construction and thermal insulation level, respectively	Total energy consumption (kWh/m² a)	Total floor area 1997 (m²)	Increment in residential floor area in 1998, 1999 (m²)	Switch between categories due to energy restoration in years 1998, 1999	Residential sector categories (m²) Source: (Statistical yearbook 2001, 31.12.99 and ZRMK analyses)
Single family house					
SF before 1970 Standard JUS	185	13.141.121		- 131.411	**13.009.710**
SF before 1970, Refurbished	111	1.529.040		+ 131.411	**1.660.451**
SF 1971 – 1980 Standards	151	6.404.846		- 32.024	**6.272.822**
SF 1971 – 1980 Refurbished	111	44.752		+ 32.024	**76.776**
SF since 1981, Unfinished and in use	210	1.401.359			**1.401.359**
SF since 1981 Standard insul.	111	4.930.595	+ 328.944		**5.259.539**
SF since 1981 Recommended insul. Level	90	408.493	+ 657.888		**1.066.381**
SF after 2002 New regulation 2002	90				
SF after 2002 Better than 2002 regulations	77		+ 109.648		**109.648**
Apartment building					
AP before 1970 Standard JUS	125	11.669.647		- 116.696	**11.552.951**
AP before 1970 Refurbished	98	1.351.513		+ 116.696	**1.468.209**
AP 1971 – 1980 Standard	90	4.565.820			**4.565.820**
AP since 1981 Unfinished and in use	84	3.353.148	+ 44.856		**3.398.004**
AP since 1981 Standard insul.	75	293.666	+ 67.188		**360.854**
AP after 2002 New regulation 2002	75				
AP after 2002 better than 2002 regulation	64		+ 7.476		**7.476**
Total		49.094.000	1.246.000		**50.340.000**

Table 10: Typology sub categories of construction principles

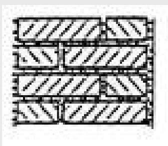
TECHNOLOGICAL GROUP	CONSTRUCTION PRINCIPLES (TECHNOLOGY)
1	classical brick construction without thermal insulation
2	classical construction with other (non-brick) materials
3	classical brick construction with thermal insulation
4	cast concrete construction in lost panelling
5	reinforced concrete frame with infill walls
6	cast concrete construction
7	light prefabricated construction
8	heavy prefabricated construction
9	combined system
10	out of any system

Table 11: Number of residential buildings according to construction principles

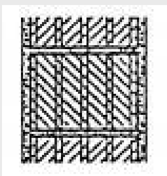
ARCH. GROUP		TECHNOLOGICAL GROUP										
		1	2	3	4	5	6	7	8	9	10	TOTAL
1.1.	build.	84339	42169	48193	1000	-	-	470	-	7205	3374	186750
	apart.	92528	44577	50601	1024	-	-	482	-	7229	3374	199815
1.2.	build.	21685	3614	6626	30	-	-	48	-	1325	422	33750
	apart.	23010	3855	6745	30	-	-	48	-	1325	422	35437
1.3.	build.	2289	1054	844	-	-	-	24	-	48	241	4500
	apart.	2289	1054	844	-	-	-	24	-	48	241	4500
2.1.	build.	34054	7103	6324	103	-	-	-	-	5716	-	53300
	apart.	35275	7103	6417	103	-	-	-	-	5716	-	54614

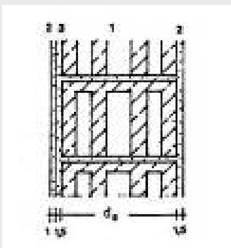
In a separate study a common building construction types ware analyzed. No frequencies ware proposed. A study was a part of the Manual for Energy Advisors.

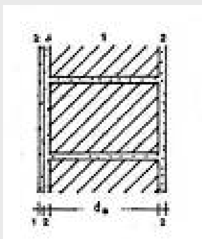
Figure 9: Common building construction types in old buildings (Manual for Energy Advisors)

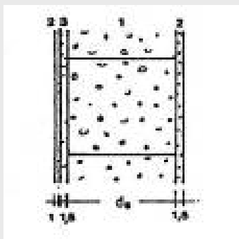


Full clay brick – 29 – 68 cm
U = 1.9 – 0.9 W/m²K









Hollow clay brick 29 – 55 cm, plaster
U = 1.5 – 0.9 W/m²K

Concrete hollow brick, plaster, 19 – 29 cm
U = 2.1 – 1.6 W/m²K

Slag -concrete hollow brick, plaster 25 – 29 cm
U = 1.54 – 1.39 W/m²K

Fly-ash concrete hollow brick, plaster, 29 cm
U = 1.43 W/m²K

Foam concrete brick, plaster, 17.5 – 30 cm
U = 1.39 – 0.93 W/m²K

Sources for new building typology

Sources for building typology are available mostly from:

- Registry of buildings
- National statistics:
  - Annual reports on progress in construction works
  - Census (2002) in contained some basic data on buildings and renovation
- Poll on the energy consumption in households (the last one according to EU methodology was done in 1996, a new poll is now in preparation)
- Other polls:
  - REUS (2009) – detailed poll on households, sample 1000, personal contact with clients, planned to be done yearly, on commercial basis, questions can be added
  - *"For efficient use of energy"* (1996) – poll about energy efficiency status and planned energy efficiency measures in households – sample 5000 households in Slovenia, direct mailing (GI ZRMK, financed by the ministry of environment, used as a background for later national subsidies programmes)
  - Annual poll among clients of Energy advisory network ENSVET (since 2000) – direct mailing, average sample of 500-1000 households per year, scope: to collect building status and energy use data, to investigate which of recommended measures were implemented and what the impact and client satisfaction were.
- National subsidies and energy audits
  - State subsidies for energy refurbishment investments and audits (since 1997 the subsidies for households were available for particular measures, since 2004 subsidies are available for holistic energy refurbishment of apartment buildings) – access to data may be difficult
- Energy performance certificate data base:
  - The data base is available for the pilot phase of the EPC implementation
  - The official data base is in preparation (transfer as proposed in DATAMINE)

Table 12: Literature / sources Slovenia

[STAT 2002]	Census 2002	Census 2002, Statistical office of the Republic of Slovenia 2002
[ZRMK 1993]	Energy Restoration of Existing Residential Buildings - part I and II	Šijanec Zavrl, M et al.: Energetska sanacija obstoječih stanovanjskih zgradb - I. in II. del; 1993
[ZRMK 1994]	National Programme of Energy Restoration of Buildings - part I	Šijanec Zavrl, M et al.: Nacionalni program energetske sanacije zgradb - I. del; 1994
[ZRMK 1995]	Concept of national programme for energy restoration of residential buildings	Šijanec Zavrl, M et al. 1995
[ZRMK 1996]	Manual for Energy Advisors	Malovrh, M. et al.: Priročnik za energetske svetovalce ; 1996

2.4 Italy

(by TABULA partner 4: POLITO / Italy)

In Italy, no building typology has been officially introduced so far on national basis.

As regards the building typology in Italy, some considerations on the building stock shall be highlighted:

- a large presence of historical buildings;
- a low renovation rate;
- a diffuse lack of inspections about the compliance with building energy performance regulations;
- significant climatic differences among regions;
- different construction traditions (heavy construction in the South, wooden construction in the alpine zones …);
- different U-values and different heating systems spread in the territory, without an exact correlation between building age and insulation level.

With reference to relevant national actions and data sources for building typology development, some studies have been performed which can provide useful data for TABULA project:

a) studies performed by POLITO DENER, within a number of research project, aimed at characterizing typical existing Italian building and assessing energy performance

b) research studies and developed national standards delivering information on building construction and heat supply systems in the Italian building stock, as well as energy saving measures. (e.g. studies mainly developed by the Italian National Energy Agency in the 80s and aimed at characterising the building stock typology);

c) national statistical data of the building stock, inter alia the detailed information of ISTAT (Statistics National Institute) and the CRESME (Centre Economical, Social and Market Surveys in the Building Sector) report;

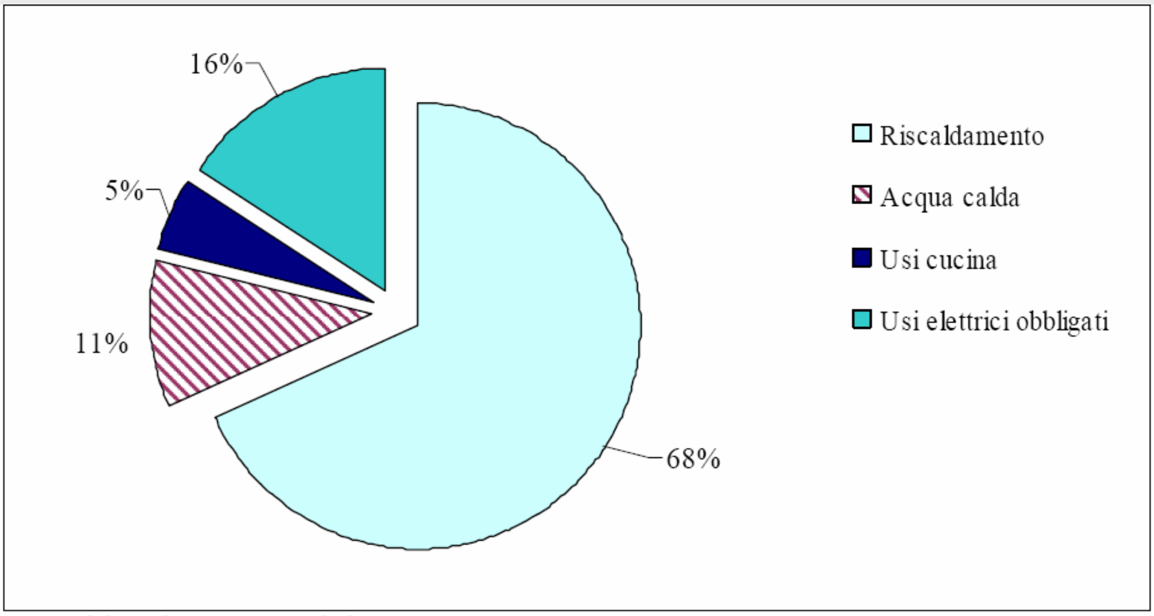
d) information on construction and system typologies obtained by regional construction associations;

e) energy certificate data sets collected by local energy agencies and by consultancy companies.

In order to give dedicated examples about the available data sources, some diagrams are shown.

In the following graph, an example of statistical data is presented from “Report on Energy and Environment 2006” (June 2007) of ENEA (National Energy Agency)

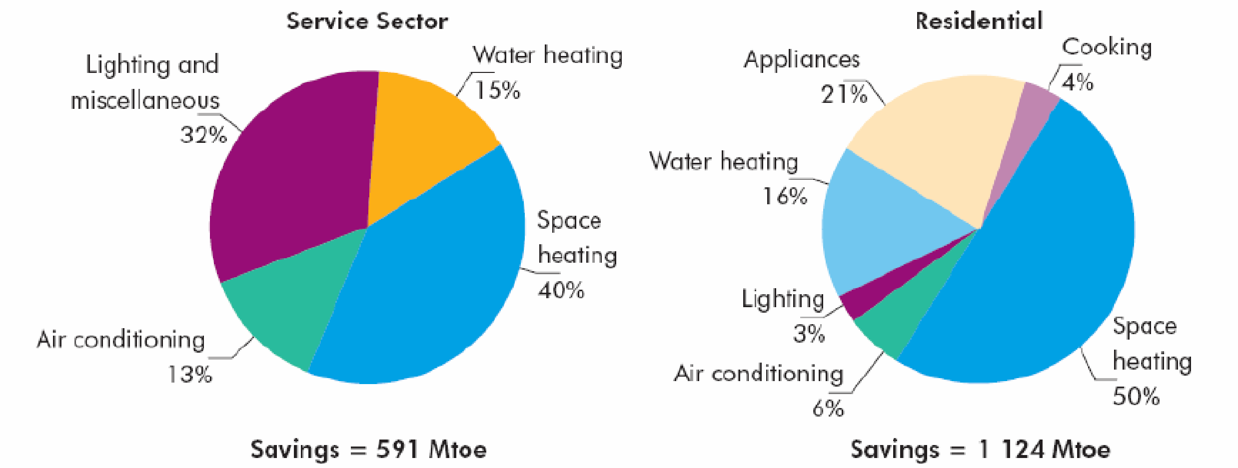
Figure 10: Energy consumption of the residential sector split by end uses (Year 2003)



Fonte: elaborazione ENEA su dati MAP

In the following figure, an other example is given taken from "Report on Energy and Environment 2006" (June 2007) of ENEA (National Energy Agency)

Figure 11: Primary energy savings in residential and commercial sectors split by end uses (Mtoe)

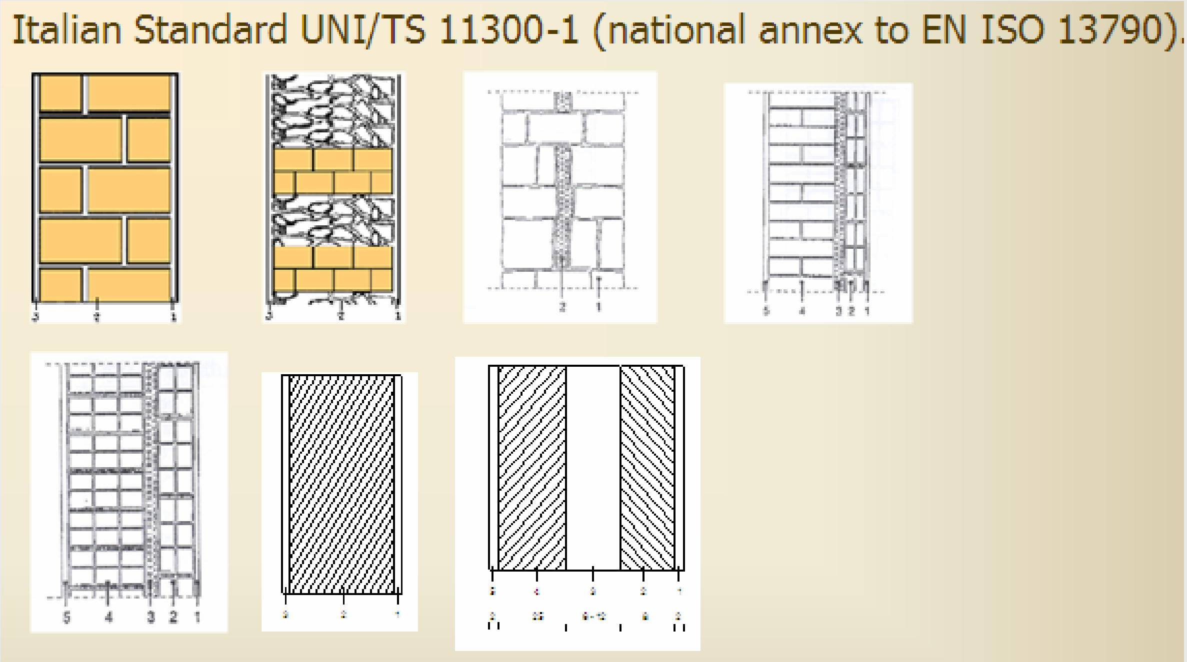


Fonte: Energy Technology Perspectives – Scenarios & strategies to 2050, International Energy Agency 2006

In Italian Standard UNI/TS 11300-part 1 (the national annex to EN ISO 13790), typical external walls are summarized. In particular, 19 typical constructions are presented. For each of them, the following parameters are shown:

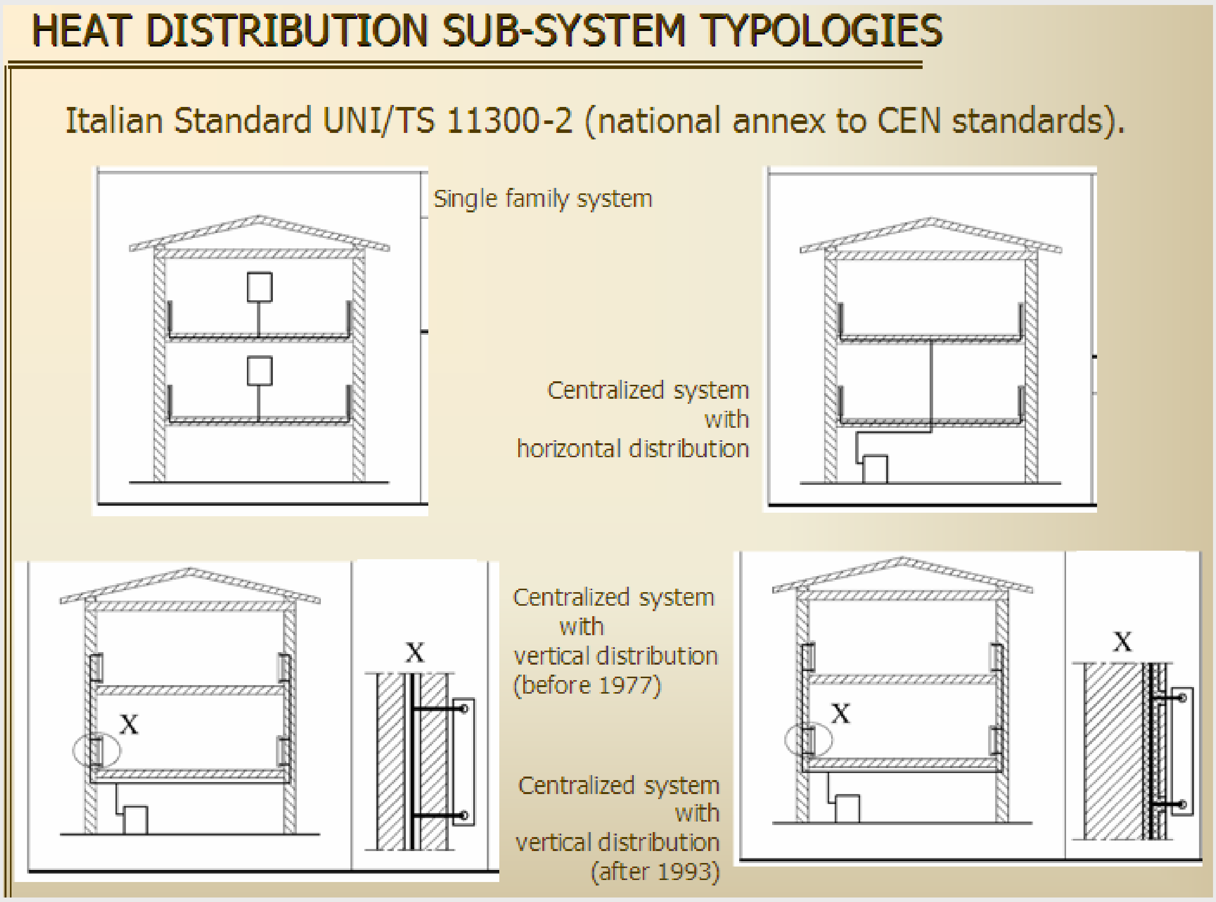
- the layers (material, thickness, density, thermal conductivity)
- the region where the construction is common
- the age when the construction was common

Figure 12



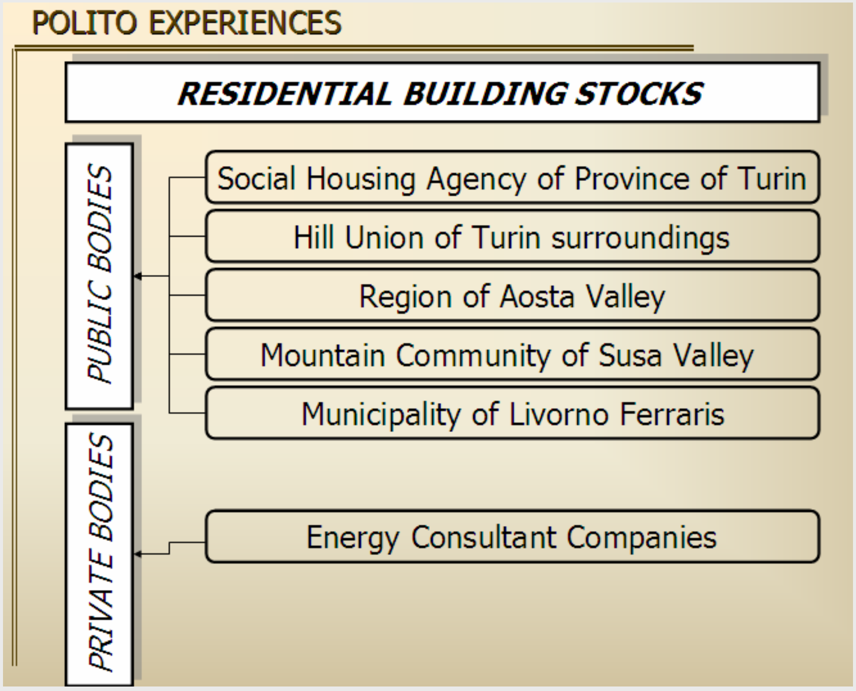
In part 2 of the same standard (UNI/TS 11300 – part 2), data about heat distribution sub-system types are shown.

Figure 13



In the following figure, the main experiences made by POLITO DENER are presented, including consultancies both to public and to private bodies.

Figure 14



Further statistical data may also be available from the energy certificate database of the National Energy Agency (ENEA) and from the Italian Society of Air Conditioning, Heating, Refrigeration (AICARR).

Table 13: Literature / sources Italy

Typical Buildings / National Level		
[ENEA and FINCO 2004]	White book on energy, environment and buildings	ENEA, National Energy Agency, March 2004
[CRESME 2005]	CRESME 13th Trend Report on the Construction Market	CRESME, Centre Economical, Social and Market Surveys in the Building Sector, 2005
[ISTAT 2004]	ISTAT Report 2004	Statistics National Institute, 2004
[ENEA 2006]	Report on Energy and Environment 2005	ENEA, National Energy Agency, February 2006
[ENEA 2007]	Report on Energy and Environment 2006	ENEA, National Energy Agency, June 2007
Typical Buildings / Regional Level		
[Province of Turin, 2005]	4th Report on Energy - Energy Program of Turin Province	AA.VV, March 2005

[Province of Turin, 2007]	5th Report on Energy - Energy Program of Turin Province	AA.VV, June 2007
Typical construction elements and supply systems		
[UNI 2008]	TS-11300-1. Energy performance of buildings. Part 1. Evaluation of energy need for space heating and cooling.	Italian Standards Organizations, 2008
[UNI 2008]	TS-11300-1. Energy performance of buildings. Part 2: Evaluation of primary energy need and of system efficiencies for space heating and domestic hot water production.	Italian Standards Organizations, 2008

BENDS (Building Energy and eNvironmental Data Structure), a multi-language web application for gathering, importing, exporting and collecting data developed within DATAMINE project, will be used in order to describe example buildings, constructions and supply systems.

2.5 France

(by TABULA partner 5: ADEME / France)

To date, no formal detailed typology of the residential building stock is available. All energy potential studies are based on the synthetic typology which is the basis of our energy statistics system

Type of building/ construction period	Individual housing	Collective dwellings
Before 1975		
After 1975		

For each of these clusters, detailed information is available as indicated on the following table (for the entire stock)

Table 14

Ensemble des Résidences Principales (Maisons + Appartements)

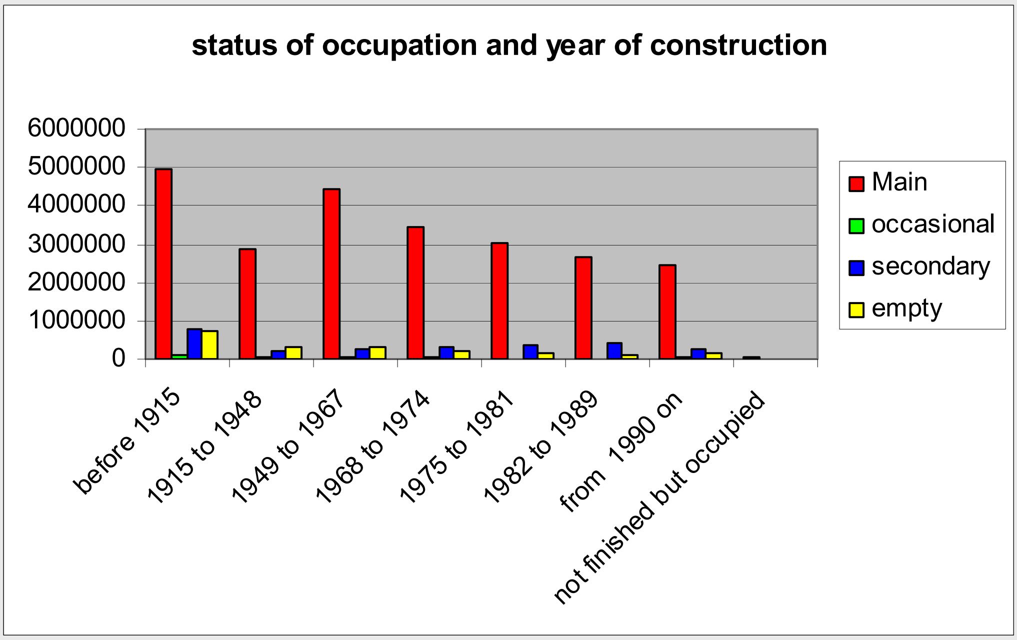
Anciens + Neufs (Consommation à climat normal : 2250°j base 18)

Années	Parc		Surface	Consommation unitaires en kWh/m²						Consommation unitaires en kWh/logt.						Conso. totale du parc en GWh	Prix éner. Ettc 92 constant par kWh
	milliers	% rés. prin.	m²	Chauffage 1ère base	Chauffage autre(1)	E.C.S.	Cuisson	Electricité spécifique	Total	Chauffage 1ère base	Chauffage autre(1)	E.C.S.	Cuisson	Electricité spécifique	Total		
1973	16 998,7	100	74,0	297,4	14,4	24,9	14,3	13,8	364,8	22 003	1 063	1 842	1 056	1 022	26 987	458 736	0,027
1974	17 393,0	100	74,5	251,5	13,5	25,5	14,2	14,5	319,3	18 735	1 006	1 897	1 061	1 082	23 781	413 632	0,036
1975	17 820,5	100	75,1	232,8	13,3	26,0	14,2	15,2	301,5	17 496	997	1 951	1 067	1 141	22 653	403 682	0,034
1976	18 102,7	100	75,9	229,2	13,1	26,7	14,5	16,2	299,7	17 402	993	2 026	1 104	1 229	22 755	411 923	0,037
1977	18 356,2	100	76,8	237,2	13,2	27,1	14,7	16,9	309,1	18 221	1 013	2 079	1 130	1 299	23 741	435 795	0,038
1978	18 623,0	100	77,8	232,2	13,1	27,0	14,7	17,6	304,6	18 060	1 020	2 104	1 141	1 368	23 694	441 246	0,041
1979	18 878,1	100	78,8	216,5	13,0	26,7	14,4	18,3	288,8	17 048	1 023	2 102	1 131	1 438	22 742	429 335	0,045
1980	19 075,7	100	79,7	202,9	13,1	26,4	14,6	19,0	275,9	16 159	1 043	2 104	1 159	1 514	21 979	419 272	0,051
1981	19 324,8	100	80,5	194,9	13,1	25,7	14,1	19,2	267,0	15 693	1 058	2 068	1 132	1 546	21 497	415 428	0,059
1982	19 585,0	100	81,3	188,8	12,8	25,1	13,3	19,6	259,5	15 350	1 037	2 042	1 084	1 590	21 102	413 287	0,061
1983	19 860,6	100	82,1	181,1	13,4	24,4	13,1	20,1	252,0	14 869	1 099	2 003	1 076	1 648	20 696	411 032	0,062
1984	20 107,8	100	82,9	175,8	12,9	24,2	12,8	20,2	245,9	14 562	1 071	2 004	1 058	1 675	20 371	409 610	0,063
1985	20 379,3	100	83,4	172,3	13,0	23,9	12,9	20,3	242,4	14 382	1 085	1 993	1 074	1 697	20 230	412 271	0,066
1986	20 626,4	100	84,1	172,6	13,2	23,9	12,9	20,7	243,2	14 509	1 110	2 010	1 081	1 736	20 447	421 740	0,057
1987	20 883,6	100	84,7	168,4	13,3	23,9	12,8	21,0	239,4	14 261	1 131	2 027	1 084	1 776	20 279	423 493	0,054
1988	20 982,6	99	85,6	172,0	13,4	24,2	12,7	21,2	243,5	14 712	1 148	2 072	1 089	1 810	20 830	437 073	0,055
1989	21 037,7	98	86,2	172,1	13,9	24,3	12,5	21,4	244,1	14 829	1 196	2 095	1 076	1 842	21 038	442 589	0,053
1990	21 386,4	99	86,3	171,6	14,0	24,5	12,6	21,7	244,4	14 806	1 208	2 117	1 085	1 872	21 089	451 009	0,053
1991	21 712,5	100	86,2	172,5	14,1	24,7	13,1	22,2	246,7	14 870	1 217	2 133	1 132	1 916	21 268	461 781	0,055
1992	21 903,7	100	86,3	171,7	14,5	24,8	13,5	22,7	247,1	14 820	1 254	2 138	1 162	1 955	21 328	467 168	0,054
1993	22 149,6	100	86,7	167,6	14,2	24,7	13,8	23,0	243,2	14 524	1 234	2 141	1 194	1 992	21 085	467 030	0,055
1994	22 376,5	100	87,1	164,1	14,0	24,5	13,8	23,2	239,6	14 294	1 216	2 137	1 198	2 022	20 866	466 914	0,054
1995	22 626,9	100	87,5	161,1	14,3	24,5	13,8	23,5	237,2	14 102	1 251	2 145	1 206	2 058	20 761	469 766	0,053
1996	22 919,1	100	88,0	157,9	14,7	24,4	13,7	23,9	234,5	13 891	1 290	2 143	1 210	2 103	20 637	472 980	0,054
1997	23 232,8	100	88,3	151,5	16,2	24,1	13,5	24,3	229,6	13 382	1 429	2 132	1 195	2 144	20 282	471 216	0,053
1998	23 579,9	100	88,6	153,6	16,5	23,9	13,5	24,9	232,5	13 609	1 464	2 121	1 198	2 209	20 601	485 760	0,051
1999	23 979,0	100	88,9	152,5	16,7	23,8	13,5	25,4	231,9	13 552	1 482	2 114	1 199	2 261	20 608	494 166	0,049
2000	24 322,1	100	88,8	152,7	15,2	23,4	13,2	26,0	230,7	13 570	1 354	2 083	1 174	2 314	20 494	498 453	0,052
2001	24 624,9	100	89,0	154,5	16,4	23,0	12,9	26,9	233,5	13 753	1 459	2 045	1 144	2 391	20 792	512 007	0,051
2002	24 891,6	100	89,1	150,2	16,2	22,6	12,7	27,5	229,2	13 391	1 444	2 019	1 131	2 451	20 436	508 681	0,050
2003	25 185,4	100	89,2	143,2	16,6	22,3	12,7	28,2	223,0	12 775	1 480	1 993	1 133	2 516	19 896	501 092	0,050
2004	25 498,6	100	89,3	139,8	17,1	22,3	12,7	28,5	220,5	12 492	1 528	1 996	1 138	2 543	19 697	502 242	0,050
2005	25 811,6	100	89,4	134,2	17,8	22,3	12,5	28,9	215,6	11 998	1 590	1 991	1 122	2 581	19 282	497 709	0,053

This is not directly usable for the purpose of our project but must be kept in mind as the building typology has to keep consistency with the available data.

The major difficulty comes from the fact that the largest share of the existing building stock has been built before 1975 with almost 1/3 previous to 1948 as shown on the following figure.

Table 15



Two main sources will be used for the project in its starting phase :

- EPC calculation method which is largely based on a simplified typology approach for lodgings
- A starting serie of type cases

EPC calculation method

Information in the EPC (called DPE in France) calculation method – titled 3CL DPE – that can be directly used is the work on efficiencies of heating and domestic water systems. As an illustration, the table of values is indicated underneath before the translation and correspondence work has been started.

Table 16

Heating system type	Distribution efficiency	Emission efficiency	Control efficiency	Heat generation efficiency	Energy carrier
Installation de chauffage	Rd	Re	Rg	Rr	Energie
Convecteurs électriques NF électricité performance catégorie C	1	0,95	1	0,99	électrique
Panneaux rayonnants électriques ou radiateurs électriques NF..C	1	0,97	1	0,99	électrique
Plafond rayonnant électrique	1	0,98	1	Rr2	électrique
Plancher rayonnant électrique	1	1,00	1	Rr2	électrique
Radiateur électrique à accumulation	1	0,95	1	0,95	électrique
Plancher électrique à accumulation	1	1,00	1	0,95	électrique
Electrique direct autre	1	0,95	1	0,96	électrique
Pompe à chaleur (divisé) - type split	1	0,95	2,6	0,95	électrique
Radiateurs gaz à ventouse	1	0,95	0,73	0,96	gaz naturel ou GPL
Radiateurs gaz sur conduits fumées	1	0,95	0,6	0,96	gaz naturel ou GPL
Poêle charbon	1	0,95	0,35	0,8	charbon
Poêle bois	1	0,95	0,35	0,8	bois
Poêle fioul	1	0,95	0,55	0,8	fioul
Poêle GPL	1	0,95	0,55	0,8	GPL
Chaudière individuelle gaz installée jusqu'à 1988 (*)	0,92	0,95	0,6	Rr1	gaz naturel ou GPL
Chaudière individuelle fioul installée jusqu'à 1988 (*)	0,92	0,95	0,6	Rr1	fioul
Chaudière gaz sur sol installée jusqu'à 1988 et changement de brûleur (*)	0,92	0,95	0,65	Rr1	gaz naturel ou GPL
Chaudière fioul sur sol installée jusqu'à 1988 et changement de brûleur (*)	0,92	0,95	0,65	Rr1	fioul
Chaudière gaz installée entre 1989 et 2000 (*)	0,92	0,95	0,73	Rr1	gaz naturel ou GPL
Chaudière fioul installée entre 1989 et 2000 (*)	0,92	0,95	0,73	Rr1	fioul
Chaudière gaz installée à partir de 2001 (*)	0,92	0,95	0,78	Rr1	gaz naturel ou GPL
Chaudière fioul installée à partir de 2001 (*)	0,92	0,95	0,78	Rr1	fioul
Chaudière gaz installée basse température	0,92	0,95	0,8	Rr1	gaz naturel ou GPL
Chaudière fioul installée basse température	0,92	0,95	0,8	Rr1	fioul
Chaudière gaz condensation	0,92	0,95	0,83	Rr1	gaz naturel ou GPL
Chaudière fioul condensation	0,92	0,95	0,83	Rr1	fioul
Chaudière bois classe inconnue	0,92	0,95	0,3	0,9	bois
Chaudière bois classe 1	0,92	0,95	0,34	0,9	bois
Chaudière bois classe 2	0,92	0,95	0,41	0,9	bois
Chaudière bois classe 3	0,92	0,95	0,47	0,9	bois
Chaudière charbon	0,92	0,95	0,5	0,9	charbon
Réseau de chaleur	0,92	0,95	0,9	0,9	réseau de chaleur
Chaudière électrique	0,92	0,95	0,77	0,9	électrique
Pompe à chaleur air/air	0,85	0,95	2,2	0,95	électrique
Pompe à chaleur air/eau	0,92	0,95	2,6	0,95	électrique
Pompe à chaleur eau/eau	0,92	0,95	3,2	0,95	électrique
Pompe à chaleur géothermique	0,92	0,95	4	0,95	électrique

Type cases

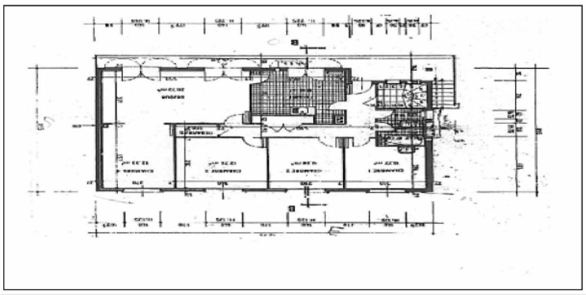
In order to be able to provide information on a wide variety of topics, including general public on incentives , tax credits and other financial supports for energy efficiency in buildings, Ademe together with the Ministry of Housing has started to elaborate Type cases of “representative” French housing. The outcome of the work is presented underneath

Figure 15

Type de bâtiment :	Maison individuelle
Typologie :	Briques creuses
SHAB (m²) :	114
SHON (m²) :	128
Nb niveaux :	1,5
hauteur sous plafond	2,5
Département	35
Année de construction	1970-1980

		DESCRIPTIF
DESCRIPTION DE L'ENVELOPPE		
Murs	Système constructif	Murs en briques creuses isolées
	Isolation	3 cm de laine minérale
Toiture	Type	Combles aménagés
	Isolation	8 cm de laine minérale
Plancher bas	Type	Plancher bas / sous –sol (garage)
	Isolation	NON
Fenêtres	Type	Double vitrage 4/6/ 4 en bois
	Uw / Ujn (W/m².K)	3/2.8
	Volets	OUI
portes	Type	Porte opaque pleine/porte vitrée 4/6/4 en bois
	Uw (W/m².K)	3,5 /3.3
DESCRIPTION DES SYSTEMES		
Chauffage	Génération	Chaudière ancienne gaz
	Emission	Radiateur à eau chaude
	Distribution	Production individuelle en volume habitable sans réseau bouclée ni tracée
	Régulation	Aucune
ECS	Génération	ECS instantanée sur chaudière
	Distribution	En volume habitable
Ventilation	Système	VMC auto réglable avant 1982

Enveloppe	Surface (m²)	Type paroi	Uparois
Paroi Nord	31.125	Briques creuses isolées	0,809
Baies Nord	0.75	Double vitrage 4/6/4 en bois	2.8
Paroi Sud	33.37	Briques creuses isolées	0,809
Baies Sud	0.75	Double vitrage 4/6/4 en bois	2.8
Parois Est	24,315	Briques creuses isolées	0,809
Baies Est	7,56	Double vitrage 4/6/4 en bois	2.8
Parois Ouest	20,625	Briques creuses isolées	0,809
Portes Ouest	9,45	Porte opaque pleine/Porte vitrée 4/6/4 en bois	3,5/3.3
Combles aménagés (surface des rampants)	111.43	combles aménagés	0,52
Plancher bas	114	Poutrelle hourdis /Sous sol (garage)	0.60
Ponts thermiques (m)			**PSI**
PB/ME	43,4		0,25
TRampants /ME	43,4		0.05
ME/ME	10.5		0.25
Appuis	5,6		0,07
Linteaux	5,6		0,07
Tableaux	9,08		0,07



The two initial pages present the situation as is, with the detailed information on data, dimensions, areas, thermal properties of building fabric, heating system..

Figure 16

TYPE DE TRAVAUX (y compris travaux induits)	NATURE DES MATERIAUX/EQUIPEMENTS
SCENARIO 1	
Isolation des combles aménagés	- Dépose de l'ancien isolant et parement intérieur. - Isolation double-couche (R=5) (10cm entre pannes et 10cm entre chevrons) + nouveau parement intérieur type BA13
Mise en place de radiateurs à eau	- 5 radiateurs à eau de puissance moyenne chacune 800W équipés de robinets thermostatiques - 5 radiateurs à eau de puissance moyenne chacune 1200 W équipés de robinets thermostatiques
Mise en place d'une chaudière à condensation	- Remplacement de la chaudière ancienne par une chaudière à condensation de puissance 25Kw (Logano Plus GB 202 de chez Buderus) + dispositif de programmation de chauffage - Tubage du conduit de cheminée
Option ECS solaire thermique	- Installation de panneaux solaire thermique pour la production d'ECS (chauffe eau solaire à éléments séparés) → Surface des capteurs vitrés : 2 m^2 →Coefficient de pertes : Kc : 8.04 ($W/m^2.K$) →Rendement optique : 0.75 →Inclinaison 45° →Orientation 45° →Ballon de stockage de capacité Vn = 200L →Appoint relié à la chaudière

The 3rd page introduces a list of potential retrofits which are the most likely adapted to the situation of the building. This will be complemented by calculation of the energy performance before and after the retrofits and the investment costs.

In a later phase, the various incentives (tax credits, no interest rate loans, …) are planned to be calculated in order to be able to propose a detailed information to the building owner who has a similar housing type.

The BATAN project

One difficulty is to be able to "merge" type cases with an adequate typology, sufficiently representative and discriminating the actual situation. The BATAN project concentrates on buildings constructed before 1948 and has targeted the following 3 main situations:

Figure 17

- Collective dwellings

- Coupled (or shared) houses

- Individual houses

Additional information to be used in the course of the project

The most important data source that is planned to be used is the EPC database that is under construction and should provide an image of the penetration rate of energy conservation options in the various sub sectors of the housing stock.

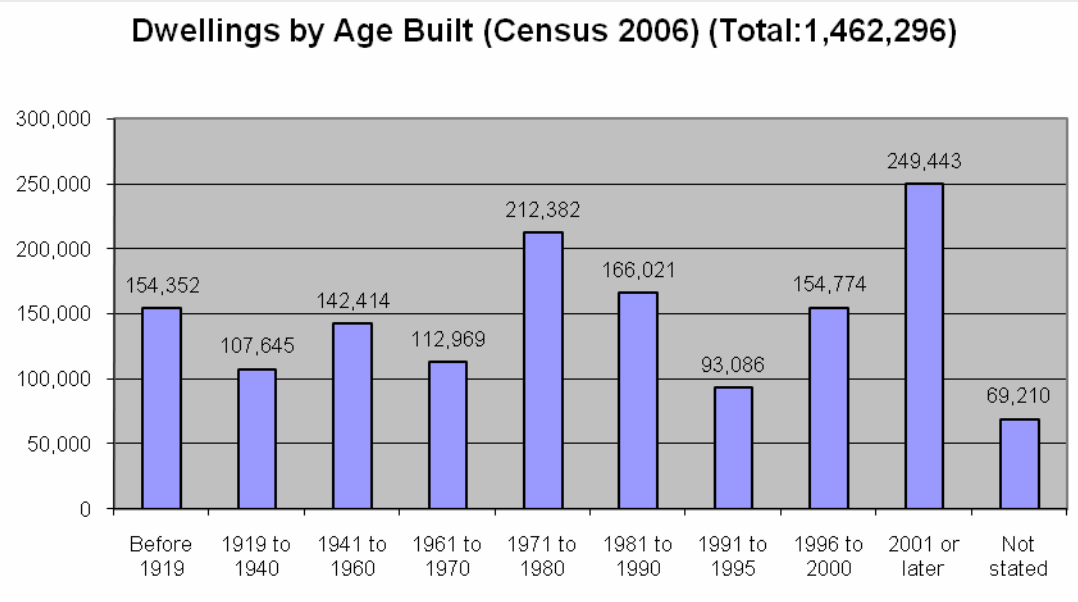
2.6 Ireland

(by TABULA partner 6: Energy Action / Ireland)

No formal building typology has been compiled in Ireland on either a national or regional level. However, there have been several reports published within the last 10 years that contain useful building typology data.

The Irish census (2006) gives a good summary of the number of Irish Dwellings based on year built. In addition to the 1.46 million Irish dwellings recorded in the 2006 census, approximately 150,000 further dwellings were built in the period 2007-2009.

Figure 18



The 2006 Irish census also gives a breakdown of the types of residential dwellings such as detached houses, semi-detached houses and apartments etc.. It is important to note, that the Irish approach is to record each individual apartment or flat as a single dwelling. Similarly, the Irish method for calculating the energy performance of buildings produces an individual rating for each apartment unlike the practice elsewhere in Europe, where the apartment building is given a rating rather than individual apartments or flats.

Table 17 shows the breakdown by dwelling type of Irish residential buildings for different age bands provided in the 2006 census.

Table 17: Dwelling Type by Age Band [Census 2006-table 32A]

Dwelling Type	Total	Detached house	Semi-detached house	Terraced house	Flat or apartment in a pur-pose-built block	Flat or apartment in a converted house or commercial building	Bed-sit	Not stated
Before 1919	154,352	82,951	15,748	37,111	3,037	11,235	2,678	1,592
1919 to 1940	107,645	48,394	22,056	29,146	2,552	3,339	978	1,180
1941 to 1960	142,414	49,140	40,935	43,461	4,634	2,300	661	1,283
1961 to 1970	112,969	41,777	40,435	22,727	5,248	1,369	486	927
1971 to 1980	212,382	98,182	67,698	37,306	5,763	1,348	417	1,668
1981 to 1990	166,021	85,700	45,064	24,337	7,977	1,134	396	1,413
1991 to 1995	93,086	43,071	30,232	8,341	9,604	927	243	668
1996 to 2000	154,774	71,973	51,327	11,455	17,093	1,450	355	1,121
2001 or later	249,443	94,408	71,378	32,957	44,991	2,230	783	2,696
Not stated	69,210	10,392	13,487	10,681	8,967	4,674	1,754	19,255
Total	1,462,296	625,988	398,360	257,522	109,866	30,006	8,751	31,803

A typology will be developed by combining data from both existing research sources and from new sources, many of which have evolved since the legal requirement for the production of BER certificates for existing dwellings when sold or rented from 1 January 2009.

The Irish building typology will focus on Identifying dwelling types primarily based on:

- single dwellings or apartments/ flats
- age on construction
- wall types
- single storey, two storey and dormer building types

Many older dwellings (especially those built before the 1980s) will have been refurbished by their owners. The most common measures would include replacement of windows, the installation of oil or gas boiler central heating systems and the installation of attic/roof insulation. The addition of wall insulation for the whole dwelling has been less common up until now due to the higher costs involved and the absence of any national promotion of this type of measure until very recently. Also, the addition of floor insulation would also be less common due the higher costs and difficulty of installation.

The Republic of Ireland has one national building energy rating method for residential buildings known as the Dwelling Energy Assessment Procedure (DEAP). For existing dwellings, Appendix S of the DEAP method (similar to the UK SAP method) has assigned the range of construction age bands for Irish dwellings. These age bands are used for the purposes of assigning U-values and other data.

Table 18: Construction Age Bands for Irish Dwellings

Age band	Years of construction
A	before 1900
B	1900-1929
C	1930-1949
D	1950-1966
E	1967-1977
F	1978-1982
G	1983-1993
H	1994-1999
I	2000-2004
J	2005 onwards

From the mid 1970s, constructional changes have been primarily caused by amendments to draft or actual Building Regulations for the conservation of fuel and power which have called for increasing levels of thermal insulation. The dates in Table 18 are generally two or three years after a change in regulation (see Table 19) to account for likely transition periods.

Table 19: Building Regulation Summary

Year of Regulations	Applicable age band	U values (W/m2K)		
		Roof	Wall	Floor
1976 (Draft)	F	0.4	1.1	0.6
1981 (Draft)	G	0.4	0.6	0.6
1991	H	0.35	0.45	0.45/0.6
1997	I	0.35	0.45	0.45/0.6
2002	J	0.25[3]	0.27	0.37

U values of wall types are determined from the construction type and date of construction. Where Building Regulations are available, the associated U-value from Table 19 is used. Any other walls with insulation can have non-default U-values entered.

Table 20: Exposed Wall U-values (Appendix S)

Age Band	A	B	C	D	E	F[1]	G	H	I	J
Wall type	Before 1900	1900-1929	1930-1949	1950-1966	1967-1977	1978-1982	1983-1993	1994-1999	2000-2004	2005 onwards
stone	2.1	2.1	2.1	2.1	2.1	1.1	0.6	0.55	0.55	0.37
225mm solid brick	2.1	2.1	2.1	2.1	2.1	1.1	0.6	0.55	0.55	0.37
325mm solid brick	1.64	1.64	1.64	1.64	1.64	1.1	0.6	0.55	0.55	0.37
300mm cavity	2.1	1.78	1.78	1.78	1.78	1.1	0.6	0.55	0.55	0.37
300mm filled cavity	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.55	0.55	0.37
solid mass concrete	2.2	2.2	2.2	2.2	2.2	1.1	0.6	0.55	0.55	0.37
concrete hollow block	2.4	2.4	2.4	2.4	2.4	1.1	0.6	0.55	0.55	0.37
timber frame	2.5	1.9	1.9	1.1	1.1	1.1	0.6	0.55	0.55	0.37

Within most building construction age bands, the most notable distinction between dwellings can be made based on wall type. Thus, the development of the Irish building types will begin by identifying building types based on wall type and construction age.

The Homes for the 21st Century report in 1999 developed a computer model to estimate the energy performance of the existing Irish housing stock. The model used 1,824 representative dwelling types each representing a percentage of the national dwelling stock. The computer model considered 8 dwelling forms. The purpose of the report was to analyse the social, health and financial impact of bring the existing Irish housing stock to the 1997 building standards. However, this scope of this study did not include publication of the typologies in brochure format for energy advice purposes.

The Irish National Survey of Housing Quality (2001-2002) gathered detailed information on the Irish Housing Stock based on a representative sample of 40,000 householders. This report contains much useful energy-related information such as stating the percentages of dwellings by building age with roof insulation, wall insulation, double glazing, hot water cylinder insulation, low energy lighting etc…

Energy Action published the Ballyfermot Residential Energy & Fuel Poverty report in 2004. Ballyfermot is a district containing over 6,000 houses in Dublin City. This report identified over 40 residential building types. It modelled the energy performance of the 6,000 buildings and the impact of four separate energy saving packages.

Since the introduction of EPBD in Ireland, over 95,000 building energy rating certificates have been produced and are registered on the National Administration system. Many organisations (some of whom are members of the National Advisory Group) are beginning to gather and analyse EPC certificate data on their own housing stock develop their own housing stock. The Irish TABULA project will actively seek data from multiple such sources in creating the Irish Building Typology.

Table 21: Literature / Sources Ireland

ERG,UCD 1999	Homes for the 21st Century. Detailed report on the impact of upgrading the energy performance of Irish housing stock to the 1997 building standard. It includes an analysis of 8 dwellings, representating a range of different dwelling types.	Homes for the 21st Century V Brophy, F Convery, C King, J Clinch, J Healy. O Lewis
Energy Action (2004)	Ballyfermot Residential Energy & Fuel Poverty Report. Energy analysis of 40 typical dwelling types in a district in Dublin with 6,500 dwellings	Ballyfermot Residential Energy & Fuel Poverty Report B Sheldrick, M Hanratty
ESRI (2002)	Irish National Survey of Housing Quality. Research report on a national survey of 40,000 dwellings when energy efficiency data was gathered and assessed. Data included methods of heating, presence of insulation and other energy-saving measures	Irish National Survey of Housing Quality D. Watson, J Williams
Irish Census (2006)	Irish Census 2006. Contains data on dwellings by construction age band.	Central Statistics Office, Irish Government

2.7 Belgium

(by TABULA partner 7: Vito / Belgium)

In Belgium there is no general accepted or referable building typology for residential buildings nor other types of buildings which can be used for purposes like energy advice or scenario analyses. One of the reasons therefore is also a challenge for the Belgian building typology which will be developed during the Tabula project. Belgium is a federal state which consists of three regions; the Flemish, the Walloon and the capital region of Brussels. Since energy in buildings is a regional authority they also have more or less 3 different ways of policymaking (e.g. implementation of the EPBD). The consequence is that there is no consistency between databases from different regions. Another issue is that it is often not attractive for research or academic institutions to develop a project for Belgium on their own while the potential customer is mostly only one region.

Already several times reference buildings were derived in the framework of a project where it forms a subtask e.g. for preparation of the other work packages. Too often, the application or usability of those typical building doesn't go much further then its own project scope. Usually these typical buildings are based on common data sources and thus in fact the same work is repeated over and over again.

One set of typical buildings was derived during the SuFiQuaD project. The acronym stands for Sustainability, Financial and Quality evaluation of Dwelling Types. The basic idea of the project is to search for an integrated method to evaluate the sustainability of different dwelling types in Belgium. The proposed research wants to lead to 'identifiable' results instead of general statements. To reach this aim, the research will focus on different dwelling typologies, amongst others apartments, freestanding houses and terraced houses. The selection of the representative dwellings was based on 2 parameters, i.e. the type, age.

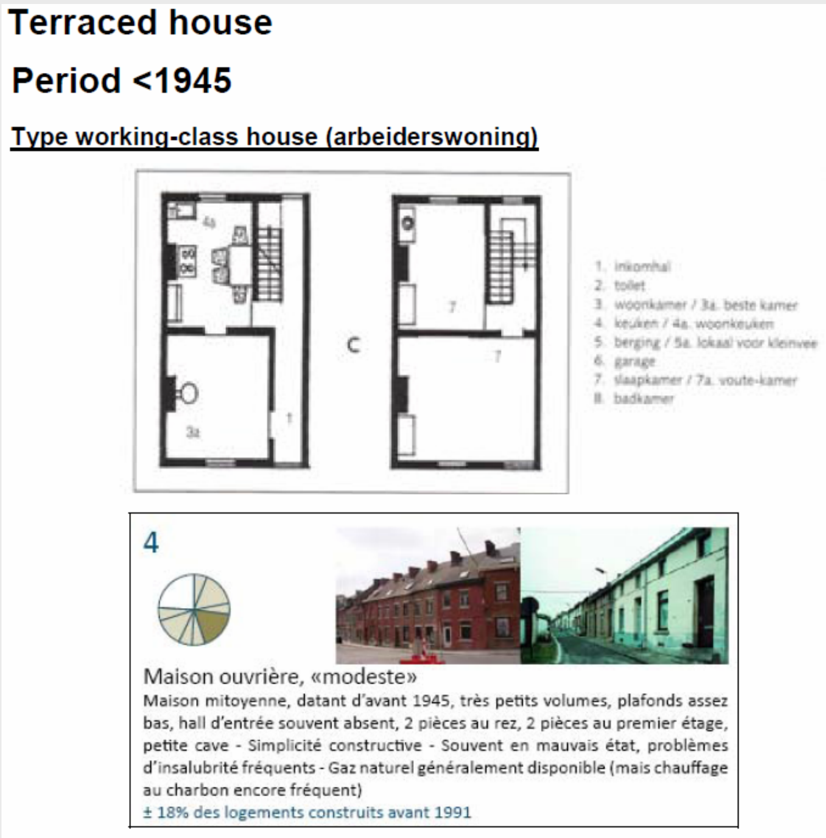
Table 22: SuFiQuaD Selection of representative dwellings

BELGIUM	freestanding			semi-detached			terraced			flats		
<1945	5,95%	20,29%	269.771	8,26%	41,56%	375.000	16,90%	66,12%	766.884	6,86%	27,15%	311.066
1946-1970	6,82%	23,26%	309.263	6,08%	30,57%	275.838	5,35%	20,95%	242.952	6,32%	25,03%	286.826
1971-1990	9,84%	33,58%	446.481	3,48%	17,52%	158.123	1,93%	7,56%	87.706	4,96%	19,65%	225.136
1991-2007	6,70%	22,87%	304.057	2,06%	10,35%	93.345	1,37%	5,37%	62.307	7,12%	28,18%	322.897
total	29,30%	100%	1.329.572	19,88%	100%	902.306	25,56%	100%	1.159.849	25,25%	100%	1.145.925
FLANDERS	**freestanding**			**semi-detached**			**terraced**			**flats**		
<1945	4,76%	14,75%	125.772	5,58%	27,33%	147.381	13,97%	57,50%	368.916	4,27%	18,55%	112.769
1945-1970	8,19%	25,38%	216.419	7,54%	36,94%	199.174	6,18%	25,46%	163.328	5,57%	24,21%	147.202
1971-1990	11,42%	35,38%	301.722	4,50%	22,03%	118.810	2,48%	10,20%	65.452	4,68%	20,33%	123.631
1990-2007	7,90%	24,49%	208.790	2,79%	13,69%	73.827	1,66%	6,84%	43.858	8,50%	36,92%	224.471
total	32,28%	100,00%	852.703	20,41%	100%	539.192	24,29%	100%	641.554	23,02%	100%	608.074
WALLOON REG.	**freestanding**			**semi-detached**			**terraced**			**flats**		
<1945	9,60%	35,23%	142.105	14,96%	60,81%	221.483	21,14%	68,03%	313.027	6,65%	38,94%	98.524
1945-1970	6,10%	22,38%	90.267	4,69%	19,09%	69.517	3,99%	12,84%	59.075	3,49%	20,40%	51.614
1971-1990	7,83%	28,75%	115.961	3,05%	12,38%	45.103	2,89%	9,31%	42.850	2,90%	17,00%	43.006
1990-2007	3,71%	13,63%	54.991	1,90%	7,72%	28.123	3,05%	9,81%	45.150	4,04%	23,67%	59.886
total	27,24%	100%	403.325	24,60%	100%	364.226	31,07%	100%	460.102	17,09%	100%	253.030
BCR	**freestanding**			**semi-detached**			**terraced**			**flats**		
<1945	0,45%	33,18%	1.894	1,46%	39,97%	6.136	20,27%	77,52%	84.941	27,12%	39,41%	113.636
1946-1970	0,62%	45,15%	2.577	1,71%	46,56%	7.147	4,90%	18,75%	20.549	24,27%	35,27%	101.699
1971-1990	0,18%	13,23%	755	0,27%	7,46%	1.146	0,48%	1,83%	2.000	9,41%	13,67%	39.409
1991-2007	0,11%	8,44%	482	0,22%	6,00%	921	0,50%	1,90%	2.077	8,03%	11,66%	33.627
total	1,36%	100%	5.708	3,66%	100%	15.350	26,15%	100%	109.567	68,82%	100%	288.370

For each of the dwelling types (e.g. freestanding house) always four representative dwellings, i.e. one for each of the construction periods (e.g. <1945, 1946-1970, 1971-1990 and 1991-2007), were selected. This results in a selection of 4x4=16 representative dwellings for the Belgian region. Some remarks about this are the following:

- At first instance, no differentiation is made between the different regions (i.e. Flanders, Walloon Region and Brussels Capital Region). This implies that in principle only one representative dwelling is selected on Belgian level. Only in cases, where it seems relevant or necessary for the correct selection of representative types, a differentiation between the regions were made.
- In the current selection of representative dwelling types, generally one example for each dwelling type and construction period is selected. However, in some cases, it is necessary to take into account two or more representative dwelling types (e.g. renovated dwelling and newly built dwelling or fermette and bungalow) for one construction period. In these cases, the selection thus consists of more than one dwelling per construction period;

Figure 19: SuFiQuaD example of a typical building



An overview of the general and physical parameters of the selected representative dwelling types is offered in the following figure. Legend: Opp Vloer Verwarmd: heated floor surface, VL: Flanders, Wall: Walloon Region, Brussel: Brussels Capital Region).

Table 23: SuFiQuaD overview typical buildings with corresponding geometrical properties and U-values

Algemene parameters						Bouwfysische parameters			
Bouwperiode	type bebouwing	Opp Vloer Verwarmd		Aantal bouwlagen		U Vloer boven kruipruimte	U Gevel	U Dak	U Raam
		VL- WALL	Brussel	VL- WALL	Brussel				
		m²	m2			W/m²K	W/m²K	W/m²K	W/m²K
<1945	open bebouwing	137	137	1	2 à 3	1,33	2	1,6	4,6
1946-1970	open bebouwing	134	134	1	2 à 3	1,33	1,5	1,6	4,6
1971-1980	open bebouwing	136	136	1	2 à 3	1,33	1,5	0,6	2,92
1981-1990	open bebouwing	138	138	1	2 à 3	1	0,75	0,6	2,92
1991-2007	open bebouwing	140	140	1	2 à 3	0,67	0,7	0,5	1,86
<1945	halfopen bebouwing	137	84,5	2 à 3	2 à 3	1,33	2	1,6	4,6
1946-1970	halfopen bebouwing	134	84,5	2 à 3	2 à 3	1,33	1,5	1,6	4,6
1971-1990	halfopen bebouwing	136	84,5	2 à 3	2 à 3	1,33	1,5	0,6	2,92
1981-1990	halfopen bebouwing	138	84,5	2 à 3	2 à 3	1	0,75	0,6	2,92
1991-2007	halfopen bebouwing	140	84,5	2 à 3	2 à 3	0,67	0,7	0,5	1,86
<1945	rijwoning	84,5	84,5	2 à 3	2 à 3	1,33	2	1,6	4,6
1946-1970	rijwoning	84,5	84,5	2 à 3	2 à 3	1,33	1,5	1,6	4,6
1971-1990	rijwoning	84,5	84,5	2 à 3	2 à 3	1,33	1,5	0,6	2,92
1981-1990	rijwoning	84,5	84,5	2 à 3	2 à 3	1	0,75	0,6	2,92
1991-2007	rijwoning	84,5	84,5	2 à 3	2 à 3	0,67	0,7	0,5	1,86
<1945	appartement	?	?	?	?	1,33	2	1,6	4,6
1946-1970	appartement	?	?	?	?	1,33	1,5	1,6	4,6
1971-1990	appartement	?	?	?	?	1,33	1,5	0,6	2,92
1981-1990	appartement	?	?	?	?	1	0,75	0,6	2,92
1991-2007	appartement	?	?	?	?	0,67	0,7	0,5	1,86

On the regional level, the Flemish model for energy consumption in households is an extensive calculation model used for energy prognosis for space heating and domestic hot water use [VITO 2009]. The model was initially developed by VITO for the Flemish government in 2003 and recently updated in 2009 with new data and specifications. The model contains a characterisation of the Flemish dwelling stock as the situation was in 2006 and is used for prognosis up to 2020.

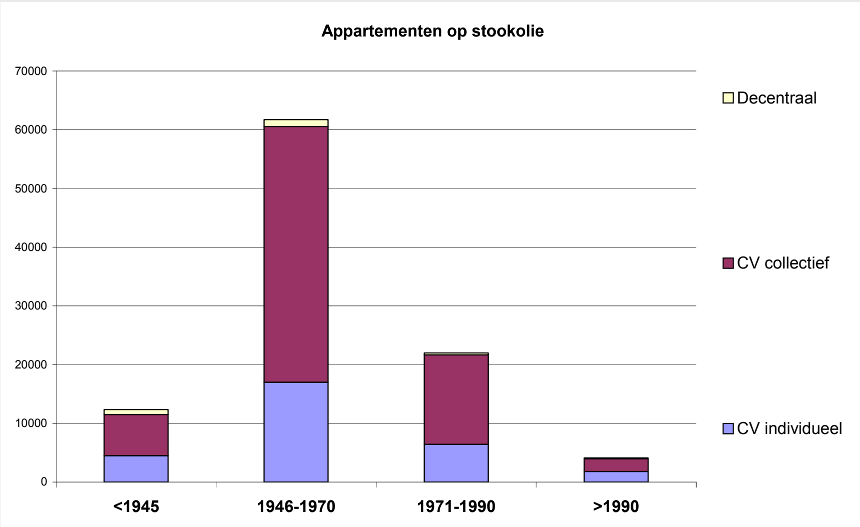
Since it is an abstract calculation model, the emphasis is more on a detailed characterisation of the building stock then on the presentation of the typical buildings in graphs and leaflets . The model consists of large data tables with average values. The model is not directly transferable into a typology due to the average values and structure of the model, although it offers a great point to start from. The Belgian Socio-economic survey from 2001 [NIS 2001] is the main data source which is further completed with data like from the Flemish Energy Balance [VITO 2006], the energy advice procedure [VEA&VITO 2009]

Table 24: Printscreen of the Flemish calculation model for energy consumption in housholds

	Type woning	Verwarming	Brandstof	Ouderdom	Isolatie		Aanname % reeds aanwezic 2001			Nieuwbouw	Sloop en be	Toewijzing k	Balans na n	Tellen van h	Selecteren	Check1	Brandstofs
2																	
7	**Appartement**	Centraal individue	Stookolie	<1945		Centraal individueelStookolie		4513	100%	0	0		4513		0		0
8		Centraal individue	Stookolie	<1945	Dubbel glas	Centraal individueelStookolieDubbel glas		2183	48%	0	0		2183		0		0
9		Centraal individue	Stookolie	<1945	Dak weinig isolatie	Centraal individueelStookolieDak weinig isolatie				0							
10		Centraal individue	Stookolie	<1945	Dak (wet)	Centraal individueelStookolieDak (wet)		2167	48%	0	0		2167		0		0
11		Centraal individue	Stookolie	<1946	Buitenmuren weinig isolatie	Centraal individueelStookolieBuitenmuren weinig isolatie				0							
12		Centraal individue	Stookolie	<1945	Buitenmuren (wet)	Centraal individueelStookolieBuitenmuren (wet)		1337	30%	0	0		1337		0		0
13		Centraal individue	Stookolie	<1945	Verwarmingsbuizen	Centraal individueelStookolieVerwarmingsbuizen		2445	54%	0	0		2445		0		0
14		Centraal individue	Stookolie	<1945	Zonneboiler	Centraal individueelStookolieZonneboiler		14	0%	0	0		14		0		0
15		Centraal individue	Stookolie	<1945	Doorstroombegrenzers	Centraal individueelStookolieDoorstroombegrenzers	75%	3385	75%	0	0		3385		0		0
16		Centraal individue	Stookolie	<1945	Spaardouchekop	Centraal individueelStookolieSpaardouchekop	25%	1128	25%	0	0		1128		0		0
17		Centraal individue	Stookolie	<1945	Afstelling en onderhoud	Centraal individueelStookolieAfstelling en onderhoud	25%	1128	25%	0	0		1128		0		0
18		Centraal individue	Stookolie	<1945	Nachtverlaging	Centraal individueelStookolieNachtverlaging	75%	3385	75%	0	0		3385		0		0
19		Centraal individue	Stookolie	<1945	Vloer (wet)	Centraal individueelStookolieVloer (wet)	10%	451	10%	0	0		451		0		0
20		Centraal individue	Stookolie	<1945	Vloer (min)	Centraal individueelStookolieVloer (min)	0%	0	0%	0	0		0		0		0
21		Centraal individue	Stookolie	<1945	Vloer (max)	Centraal individueelStookolieVloer (max)	0%	0	0%	0	0		0		0		0
22		Centraal individue	Stookolie	<1945	Dak (min)	Centraal individueelStookolieDak (min)	0%	0	0%	0	0		0		0		0
23		Centraal individue	Stookolie	<1945	Dak (max)	Centraal individueelStookolieDak (max)	0%	0	0%	0	0		0		0		0
24		Centraal individue	Stookolie	<1945	Buitenmuren (min)	Centraal individueelStookolieBuitenmuren (min)	0%	0	0%	0	0		0		0		0
25		Centraal individue	Stookolie	<1945	Buitenmuren (max)	Centraal individueelStookolieBuitenmuren (max)	0%	0	0%	0	0		0		0		0
26		Centraal individue	Stookolie	<1945	Verbeterd dubbel glas	Centraal individueelStookolieVerbeterd dubbel glas	0%	0	0%	0	0		0		0		0
27		Centraal individue	Stookolie	<1945	HR+ glas	Centraal individueelStookolieHR+ glas	0%	0	0%	0	0		0		0		0
28		Centraal individue	Stookolie	<1945	Keteltype jaren '70	Centraal individueelStookolieKeteltype jaren '70	39%	1765	39%	0	0		1765		1	1765	0
29		Centraal individue	Stookolie	<1945	Keteltype jaren '80	Centraal individueelStookolieKeteltype jaren '80	28%	1255	28%	0	0		1255		0		
30		Centraal individue	Stookolie	<1945	Keteltype jaren '90	Centraal individueelStookolieKeteltype jaren '90	33%	1494	33%	0	0		1494		0		
31		Centraal individue	Stookolie	<1945	Hoogrendementsketel	Centraal individueelStookolieHoogrendementsketel				0			0		0		
32		Centraal individue	Stookolie	<1945	Condenserende ketel	Centraal individueelStookolieCondenserende ketel				0			0		0		
33	**Appartement**	Centraal individue	Stookolie	1946-1970		Centraal individueelStookolie		**16994**	**100%**	0	0		16994		0		0
34		Centraal individue	Stookolie	1946-1970	Dubbel glas	Centraal individueelStookolieDubbel glas		9244	54%	0	0		9244		0		0
35		Centraal individue	Stookolie	1946-1970	Dak weinig isolatie	Centraal individueelStookolieDak weinig isolatie				0							
36		Centraal individue	Stookolie	1946-1970	Dak (wet)	Centraal individueelStookolieDak (wet)		9665	57%	0	0		9665		0		0
37		Centraal individue	Stookolie	1946-1970	Buitenmuren weinig isolatie	Centraal individueelStookolieBuitenmuren weinig isolatie				0							
38		Centraal individue	Stookolie	1946-1970	Buitenmuren (wet)	Centraal individueelStookolieBuitenmuren (wet)		7427	44%	0	0		7427		0		0
39		Centraal individue	Stookolie	1946-1970	Verwarmingsbuizen	Centraal individueelStookolieVerwarmingsbuizen		10414	61%	0	0		10414		0		0
40		Centraal individue	Stookolie	1946-1970	Zonneboiler	Centraal individueelStookolieZonneboiler		20	0%	0	0		20		0		0
41		Centraal individue	Stookolie	1946-1970	Doorstroombegrenzers	Centraal individueelStookolieDoorstroombegrenzers	75%	12746	75%	0	0		12746		0		0
42		Centraal individue	Stookolie	1946-1970	Spaardouchekop	Centraal individueelStookolieSpaardouchekop	25%	4249	25%	0	0		4249		0		0
43		Centraal individue	Stookolie	1946-1970	Afstelling en onderhoud	Centraal individueelStookolieAfstelling en onderhoud	25%	4249	25%	0	0		4249		0		0
44		Centraal individue	Stookolie	1946-1970	Nachtverlaging	Centraal individueelStookolieNachtverlaging	75%	12746	75%	0	0		12746		0		0
45		Centraal individue	Stookolie	1946-1970	Vloer (wet)	Centraal individueelStookolieVloer (wet)	10%	1699	10%	0	0		1699		0		0
46		Centraal individue	Stookolie	1946-1970	Vloer (min)	Centraal individueelStookolieVloer (min)	0%	0	0%	0	0		0		0		0
47		Centraal individue	Stookolie	1946-1970	Vloer (max)	Centraal individueelStookolieVloer (max)	0%	0	0%	0	0		0		0		0
48		Centraal individue	Stookolie	1946-1970	Dak (min)	Centraal individueelStookolieDak (min)	0%	0	0%	0	0		0		0		0
49		Centraal individue	Stookolie	1946-1970	Dak (max)	Centraal individueelStookolieDak (max)	0%	0	0%	0	0		0		0		0
50		Centraal individue	Stookolie	1946-1970	Buitenmuren (min)	Centraal individueelStookolieBuitenmuren (min)	0%	0	0%	0	0		0		0		0
51		Centraal individue	Stookolie	1946-1970	Buitenmuren (max)	Centraal individueelStookolieBuitenmuren (max)	0%	0	0%	0	0		0		0		0
52		Centraal individue	Stookolie	1946-1970	Verbeterd dubbel glas	Centraal individueelStookolieVerbeterd dubbel glas	0%	0	0%	0	0		0		0		0
53		Centraal individue	Stookolie	1946-1970	HR+ glas	Centraal individueelStookolieHR+ glas	0%	0	0%	0	0		0		0		0
54		Centraal individue	Stookolie	1946-1970	Keteltype jaren '70	Centraal individueelStookolieKeteltype jaren '70	39%	6645	39%	0	0		6645		1	6645	0
55		Centraal individue	Stookolie	1946-1970	Keteltype jaren '80	Centraal individueelStookolieKeteltype jaren '80	28%	4724	28%	0	0		4724		0		
56		Centraal individue	Stookolie	1946-1970	Keteltype jaren '90	Centraal individueelStookolieKeteltype jaren '90	33%	5625	33%	0	0		5625		0		
57		Centraal individue	Stookolie	1946-1970	Hoogrendementsketel	Centraal individueelStookolieHoogrendementsketel				0			0		0		
58		Centraal individue	Stookolie	1946-1970	Condenserende ketel	Centraal individueelStookolieCondenserende ketel				0			0		0		

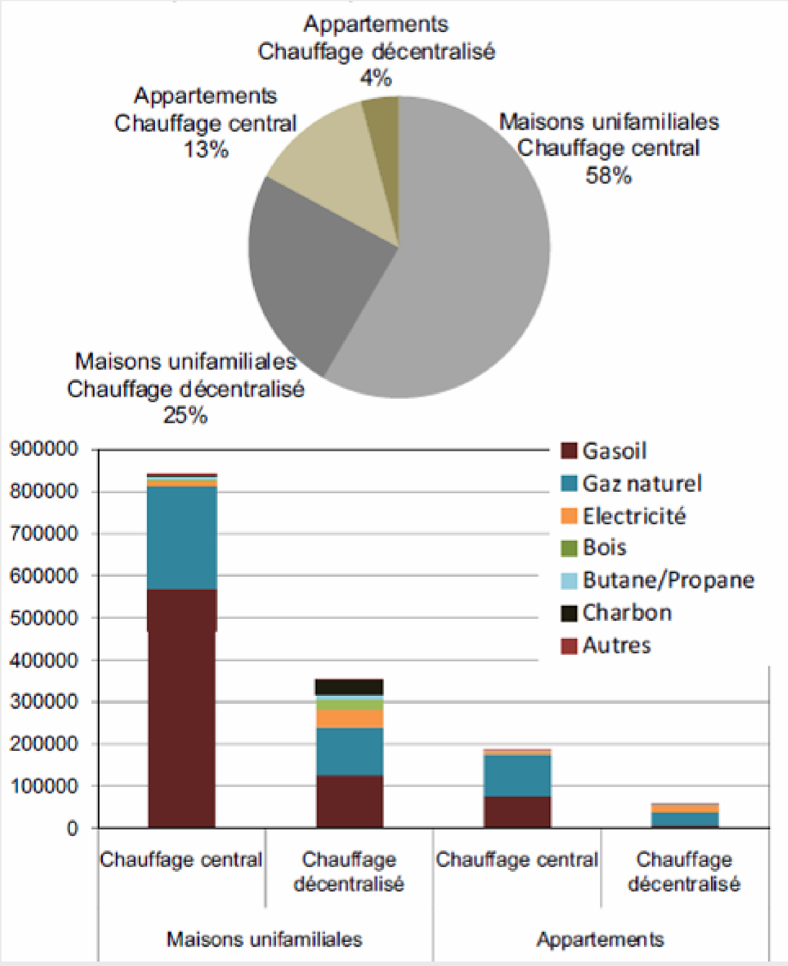
Woningen 2001 rekentabel (2) / REG2008 / REG2007 / REG2006 / REG2005 / REG2004 / REG2003 / appart olie / totaal olie / totaal gas / appart gas / appart elekt / totaal elekt / Chart7 / Chart8 / a

Figure 20: exemplary graph derived from the Flemish model regarding the type of heating system for appartments using heating oil as main energy carrier according to building period



Important data about the Walloon building stock was recently summarised in a subtask report of the LEHR project (Low Energy Housing Retrofit; WTCB, UCL, PHP; 2007-2009) in collaboration with the Walloon government. This report makes an analysis of the existing Walloon building stock and emphasis on the most urgent building types with respect to the energy saving potential. Important data sources were the Belgian Socio-economic survey from 2001 [NIS 2001], the Walloon energy balance [ICEDD 2007] and the survey about the housing conditions in Wallonia [RW 2007]

Figure 21: Exemplary graph from the heating systemes for the Walloon dwelling stock



Comparable studies and data sources are available for the capital region of Brussels like e.g. the energy balance of Brussels [BIM 2007]. In general for the different regions it is not too difficult to find information regarding the macroscopic level. More detailed information will have to be gathered from mainly smaller studies, books and data sets who are not consistent to each other.

Regarding a classification of typical elements only few work has been done in the past to summarize representative construction parts. One classification is made during the SuFiQuaD project [SuFiQuaD 2008-2] were a summary was made of the most important individual building elements (=materials) according to their application (floor, wall, etc.). Later on those individual elements were composed into representative construction elements. Unfortunately no categorisation is made according to building period.

Figure 22: SuFiQuaD Exemplary table of individual insulation elements for roof insulation

Type	Construction / techniques	References
rigid insulation boards	▪ *insulation materials*: ○ synthetic materials: - PUR (e.g. 120-170 mm) - PIR - EPS - XPS - phenolic foam ▪ mineral materials: - rock wool - cellular glass - expanded perlite ▪ natural materials: - cork ▪ composite materials: - two or more materials, optionally reinforced ▪ *attachment*: ○ warm bitumen ○ bituminous cold glue ○ synthetic glue ○ mechanical attachment with screws ○ loosely laid	▪ [23][24] (table 18) [4]
soft insulation	▪ mineral wool (rock wool or glass wool) ▪ cellulose flakes between joists (e.g. 36 mm)	[4]

A classification of supply systems by generator type, installation year and other parameters can be found in different sources. Like there are the calculation procedures for energy certification of existing residential buildings in Flanders [VEA 2008] or Wallonia [RW 2009]. Here, classifications are used for selection of default parameters to determine the efficiency of e.g. a certain type of central heating boiler. Although these tables do not represent an overall subtypology of supply systems, they offer a suitable starting point to derive this subtypology.

Table 25: classification of flue gas efficiencies of boilers from the EPC calculation procedures of existing residential buildings in Wallonia

Type de chaudière	Chaudière mazout	Chaudière gaz
Chaudière sans label, < 1975	0.83	0.85
Chaudière sans label, de 1975 à 1984 inclus	0.86	0.87
Chaudière sans label, ≥ 1985	0.90	0.90
Chaudière avec label, indépendamment de l'année de fabrication	0.90	0.90
Les seuls labels considérés sont les labels OPTIMAZ pour les chaudières à mazout et BGV-HR ou HR-+ pour les chaudières gaz		

Table 26: Classification of boiler standstill percentages from the EPC calculation procedures of existing residential buildings in Wallonia

Type de chaudière	Chaudière mazout	Chaudière gaz atmosphérique, sans ventilateur	Autre chaudière gaz
Chaudière sans label, < 1970	3.2	3.8	3.0
Chaudière sans label, de 1970 à 1979 inclus	2.2	2.8	2.0
Chaudière sans label, de 1980 à 1989 inclus	1.4	2.2	1.4
Chaudière sans label, ≥ 1990	1.0	1.5	0.7
Chaudière avec label, indépendamment de l'année de fabrication	1.0	1.5	0.7
Les seuls labels considérés sont les labels OPTIMAZ pour les chaudières à mazout et BGV-HR ou HR-+ pour les chaudières gaz			

During the SuFiQuaD project, also a selection of representative installations for heating, domestic hot water and ventilation was made related to a certain building type and period [SuFiQuaD 2008-3]. It offers a great starting point for further refinement and development of the sub-typology because most relevant parameters all already incorporated in this approach.

Table 27: SuFiQuaD Exemplary table of characterisation of typical heating systems for freestanding dwelling types according to building period

Freestanding dwelling types

Criteria*	CH-F-1 *<1970*	CH-F-2 *1971-1990*	CH-F-3 *1991-2000*	CH-F-4 *2001-2007*
A	TYPE OF HEATING			
	central heating	*central heating*	*central heating*	*central heating*
B	HEAT PRODUCTION			
1	*oil boiler*	*oil boiler*	*oil boiler*	*gas boiler*
2	*non condensing*	*non condensing*	*non condensing*	*condensing*
3	*<1970*	*1980*	*1996*	*2004*
4	*T=cte*	*T=cte*	*T=var*	*T=glid*
5	*cast iron*	*cast iron*	*steel plate*	*stainless steel*
6	*-*	*-*	*-*	*-*
7	*outside protected volume*	*outside protected volume*	*inside protected volume*	*inside protected volume*
8	*-*	*-*	*-*	*-*
9	*-*	*-*	*-*	*-*
C	DISTRIBUTION			
1	*water*	*water*	*water*	*water*
2	*one-pipe*	*two-pipe*	*two-pipe*	*pre-sleeved*
3	*no tubing outside PV*	*no tubing outside PV*	*no tubing outside PV*	*no tubing outside PV*
4	*steel*	*steel*	*steel*	*synthetic*
D	EMISSION			
	column radiators	*column radiators*	*panel radiators*	*panel radiators*
E	CONTROL			
	manual valves	*room thermostat*	*room thermostat + TRV*	*outside termp sensor*
F	CIRCULATION PUMP			
	pump - no regulation	*pump - no regulation*	*pump - no regulation*	*pump with regulation*

Table 7: Literature / sources Belgium (non-exhaustive)

Typical buildings / national level		
[SUFIQuaD 2008-1]	Selection of representative dwellings for Belgium	Janssen, Ann; Putzeys, Katrien et al.:Note on selection of representative dwelling types;SuFiQuaD, Leuven, 2008
Typical buildings / regional level		
[VITO 2009]	Calculation model for scenario analysis of the Flemish dwelling stock	Briffaerts, Katleen:Energieprognoses huishoudens 2006-2020; VITO, Mol, 2009
Typical construction elements and supply systems		
[VEA 2008]	EPC Calculation procedure for energy certification of existing residential buildings in Flanders	Builddesk: EP-certificatiemethode woningen Vlaanderen - Formulestructuur; VEA, Brussels, 2008
[RW 2009]	EPC Calculation procedure for energy certification of existing residential buildings in Wallonia	BBRI, ICEDD, UCL, VITO: Procedure de calcul pour la certification énergétique des bâtiments residentiels existants; RW DGTRE, Namur, 2009
[SUFIQuaD 2008-2]	SuFiQuaD Note on selection of representative element types	Janssen, Ann; Putzeys, Katrien et al.:Note on selection of representative dwelling types;SuFiQuaD, Leuven, 2008
[SUFIQuaD 2008-3]	SuFiQuaD Note on selection of representative technical installations	Cyx, Wouter; Desmedt, Johan; Vekemans, Guy:Note on selection of representative technical installations;SuFiQuaD, Leuven, 2008
Data bases and other studies		
[NIS 2001]	Social economic survey about the situation of Belgian households in 2001	Socio-economische enquête 2001;NIS, Brussels, 2001
[VEA & VITO 2009]	Derived results from Energy Advice Procedure (EAP) data base update 2009	VITO: Cyx, Wouter: Verwerking EAP-gegevens; gegevensupdate maart 2009; VEA, Mol, 2009]
[BIM 2007]	The Energy balance of the capital region of Brussels 2007	ICEDD: Energiebalans van het Brussel hoofdstedelijk gewest 2007; BIM, Brussels, 2008
[ICEDD 2007]	3. The Walloon Energy balance	ICEDD:Bilan énergétique de la region Wallonne 2005; RW DGTRE, Namur, 2007
[VITO 2006]	4. The Flemish Energy balance of 2006	VITO: Aernouts, Kristien; Jespers, Kaat: Energiebalans Vlaanderen 2006; VEA, Mol, 2007)

2.8 Poland

(by TABULA partner 8: NAPE / Poland)

From 1989 the official statistics about building stocks do not exists in Poland. Main Statistics Office presents each year data about new apartments (number, area) constructed but without information about their location (rural, urban), building type (single, multifamily). Construction of the walls, used windows or heating systems are not the subject of the statistics.

NAPE's knowledge of the buildings in the residential sector comes from three main sources:

- energy audits done by NAPE for the purpose of the Thermomodernization Act during last 10 years – more than 2000 building in our database
- European projects NAPE was involved in - DATAMINE, InoFIN, GreenBUILDING
- certificates done by NAPE
- certificates registered in the Certificates database managed by the BUILD-DESK company (at the moment more than 13 000 certificates for the residential buildings).

Important source of information are data coming from the Save II project "Technical and economic assessment of possible improvements of energy efficiency of the residential building/heating systems in Poland - 2002". For the purpose of the project data on the Polish residential building stock were collected from the set of sources. Within the project 19 categories of the buildings and their heating systems were defined covering 97% of total systems existing in 2002.

15 categories represent existing building stock, last 4 represents the categories not popular in 2002 but expected to grow in the nearest future (especially from the point of view of applied heating systems – eg. RES and heating pump).

Two tables below presents the general description approved categories, heating systems and wall construction. Table 28 gives general overview of the residential building in Poland (for 2002)- number of apartments, useful area of the buildings, power and heat demand.

Table 28: General overview of residential sector in 2002

Kategoria	number of flats	useful area	square per person	power demand	heat demand
	tys.	tys. m^2	m^2/ person	MW	TJ/a
Kategoria 1	1 260	120 914	20	16 544	89 338
Kategoria 2	1 630	101 175	17	14 352	56 835
Kategoria 3	2 346	119 721	16	12 340	102 173
Kategoria 4	694	61 960	22	7 897	42 645
Kategoria 5	1 181	62 277	19	7 785	36 068
Kategoria 6	534	52 336	26	6 685	55 351
Kategoria 7	1 200	50 341	17	5 741	47 533
Kategoria 8	357	20 662	18	2 757	10 916
Kategoria 9	205	13 611	21	1 839	15 226
Kategoria 10	64	13 205	26	1 246	10 316
Kategoria 11	227	11 927	19	1 130	9 355
Kategoria 12	218	10 175	18	1 160	4 590
Kategoria 13	146	7 177	16	780	6 176
Kategoria 14	56	6 476	31	665	5 390
Kategoria 15	21	1 958	20	152	1 205
Kategoria 16	0	0	0	0	0
Kategoria 17	2	240	16	16	158
Kategoria 18	1,6	100	17	8	60
Kategoria 19	0	0	0	0	0
TOTAL CATEGORIES	**10 146**	**654 256**	–	**81 096**	**493 335**
TOTAL in POLAND	**11 280**	**725 212**	–	**89 593**	**530 111**

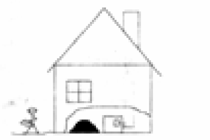
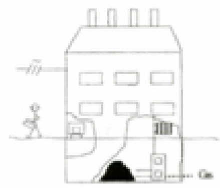
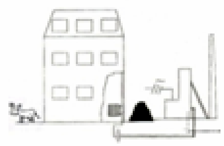
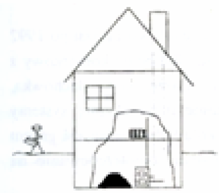
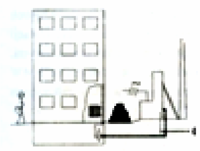
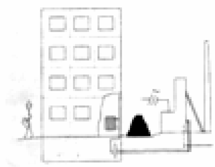
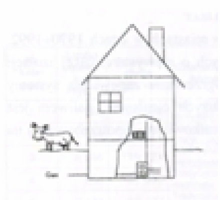
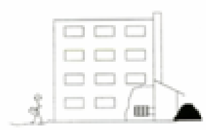
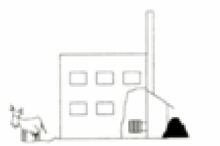
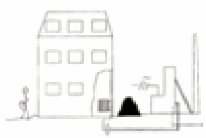
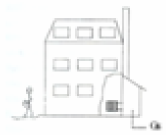
Table 29 presents more detailed description of the 15 existing buildings categories – with wall construction, U values, and average heat consumption per m2.

Table 29

Cat. No	Wall construction	U value for walls W/m2K		U value for roofs W/m2K		U value for windows W/m2K		Heating source efficiency	Heat demand
		from-to	average	from-to	average	from-to	average	%	kWh/m2a
1	brick / concrete blocks	0,8 - 1,4	1,1	0,7-0,9	0,8	2,4-2,8	2,6	55	205
2	bricks, ceramics tiles	1,0-1,6	1,4	0,8-1,1	0,9	2,2-2,6	2,4	45	356
3	concrete blocks	1,1-1,5	1,3	0,65-0,85	0,75	2,4-2,8	2,6	88/94	237
4	bricks /ceramics tiles	1,2-1,6	1,4	0,50-0,90	0,7	2,4-2,8	2,6	55	241
5	bricks, stones, wood	0,57-1,6	1,38	0,8-1,1	0,9	2,4-2,8	2,6	45	261
6	bricks, ceramics tiles	0,8-1,4	1,1	0,50-0,90	0,7	2,4-2,8	2,6	87	249
7	hollow brick, aerated concrete	0,57-1,6	1,2	0,65-0,85	0,75	2,4-2,8	2,6	88	262
8	wood, bricks,eternit	0,8-1,1	0,9	0,75-0,95	0,85	2,4-2,8	2,6	45	147
9	bricks, stone, ceramic tiles	0,6-1,4	1,1	0,7-1,0	0,8	2,4-2,8	2,6	63	311
10	brick, hollow brick, eternit	0,5-0,6	0,55	0,33-0,37	0,35	1,5-2,1	1,6	90	117
11	ferro-concrete,aerated concrete	0,4-0,6	0,5	0,28-0,35	0,3	1,4-1,8	1,6	90	118
12	silicat, eternit	0,8-1,15	1,2	0,65-0,85	0,75	2,2-2,8	2,4	45	125
13	concerete blocks, flat roofs, isulated	0,6-1,0	0,75	0,28-0,35	0,3	2,0-2,4	2,2	71	159
14	silicat, bricks,	0,4-0,7	0,55	0.35-0,65	0,5	1,4-1,8	1,6	70	121
15	red bricks, hollow bricks	0,4-0,6	0,5	0,3-0,40	0,35	1,4-1,8	1,6	91	111

On the Figure 23 the relation between categories and year of construction is presented in the matrix form.

Figure 23: Building categories vs year of construction and location

	rural		urban	
	single family	multifamily	single family	multifamily
up to 1945	 kat. 2 -8%		 kat 8 – 4%	 kat 5 -9%
1946-1966	 kat. 2 -8%	 kat. 12 – 1%	 kat. 4 – 6%	 kat. 7 -10%
1967-1985	 kat. 1 – 18 %		 kat. 6 -8%	 kat. 3 -14%
1986-1992	 kat. 9 -3%			 kat.13 – 3%
1993-2002	 Kat. 10 – 1%	 kat 14 – 1%	 kat 10 – 1%	 kat. 11 – 2%
after 2002				 kat. 15 -1%

The table below presents the general statistics about Polish residential buildings in 2009

Table 30: Residential buildings in Poland 2009

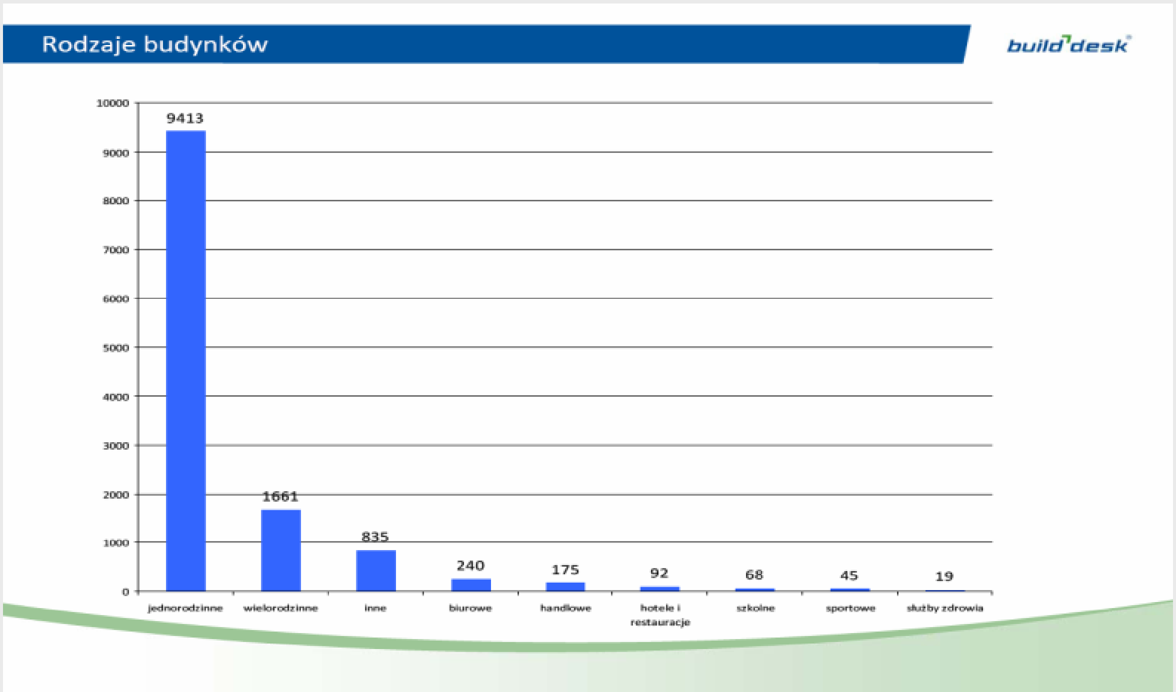
Number of buildings in urban area	-	2 550 600
Number of buildings in rural area	-	4 061 200
TOTAL number of buildings	-	6 611 800
Number of apartments in urban area	-	10 047 700
Number of apartments in rural area	-	4 654 000
TOTAL number of apartments	-	**11 813 100**

Based on the date from the Main Statistics Office and project mentioned above it is possible to distinguished buildings between year of constructed, see next table.

Table 31

Constructed	APARTMENTS	BUILDINGS
up to 1945	2 931 469	1 985 674
1946-1966	4 205 388	1 985 656
1967-1985	2 098 465	911 106
1986-1992	650 262	386 865
1993-2002	1 365 205	856 874
after 2002	562 311	485 625
TOTAL	11 813 100	6 611 800

Figure 24



Up to 2008 in Poland we had 5 climatic zones which in last year were replaced by the 61 meteorological stations. Since no special difference in building construction were observed between the zones Polish typology will cover all the country.

Any official statistics about building performance is not available at the market, and therefore for the purpose of the project the database from certified buildings, provided upon the agreement with BuildDesk company, will be use.

At the moment in this database contain about 14000 buildings, and each month additional 1000 are registered, in which 90% are residential buildings.

Summary

Based on the available data on building stock and the usefulness of the typology Polish preliminary typology will cover:

- 6 different construction period

before 1945	1946-1966	1967-1985	1986-1992	1993-2002	after 2002

- 5 buildings categories

with possible distinguishing between the construction material:

brick concrete blocks hollow brick single layer multilayer

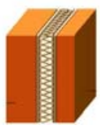
    

Table 32: Possible refurbishment of buildings construction

Building element	U value according to the Building Code W/m²K	U value economically profitable W/m²K
roof	0,30	0,20
multilayer external walls	0,30	0,25
single layer external walls	0,50	0,25
ceiling over the cellar	0,6	0,33
floor over the ground	0,6	0,33
window	2,6	1,3
external door	2,6	2,0

Table 33: Literature / sources Poland

European Projects		
XVII/4,1031/P/99-33 – 2000-2002	"Technical and economic assessment of possible improvements of energy efficiency of the residential building/heating systems in Poland - 2002".	H.Gaj and project team
DATAMINE (2006-2008)	Collecting Data from energy certification to monitor performance indicators for new and existing buildings	M.Popiolek – Data collection from energy audits done for the purpose of the Thermomodernization Act
Statistics		
GUS	Housing economy in Poland	2008
GUS	Residential sector – general overview	2009
Studies		
Energy and Buildings - 12(32)2009	Certification procedures for residential buildings	J. Zurawski
Energy and Buildings - 07-08(28)2009	Building construction assessment	A.Panek

2.9 Austria

(by TABULA partner 9: AEA / Austria)

In Austria there is no building typology existing, but different sources of information are available. There are books, like “Austrian architecture of the 19th and 20th century” [jaeger 2005] and “Architecture of the 20th and 21st century” [a_schau 2006] where the characteristic constructions and used materials are to be found. Also there is the “Guideline for energy consultants” [frey 1994], where typical constructions are shown and described, including the resulting U-values of the elements. For refurbishment measures, there are books like “New standards for old houses” [haselsteiner 2006] or similar (e.g [bluemel 2004], [mueller 2008]). For the advanced stage refurbishment there are books like “Refurbishment by using passive-house components” [guschlbauer 2004]. Additionally information from different national research projects like “wohn:modern” is available.

The technical information about supply systems are to be found in books like “Heizungsanlagen” [tiator 2006] or similar (e. g. [recknagel 2007], [schlagnitweit 2006], [buderus 2002], [uponoor 2009]) which is standard-literature used in Austria. Additionally the refurbishment measures for installation system are to be found in research projects like [krapmeier 2003].

Additionally the Austrian Energy Agency handles national and international projects, where parts of the needed information is to be found and there are the databases “ZEUS” and “ImmoZEUS” (data collection of Energy Performance Certificates) where information e. g. about typical building sizes can be found.

The frequencies of building types and supply systems are allocated by the Statistical Office Austria, which announces the micro census every ten years. The last one was done in 2001, and updated partially in 2005. Therefore the “Building Age Classes” will be adjusted with the building erection periods summarised by this micro census. Additionally there are existing national standard supply systems used in the seven national energy performance certificate-calculation programmes.

For the example building pictures the Austrian Energy Agency will use different sources: on the one hand own pictures, made during different projects, on the other hand the NAG members will have the possibility to provide example building pictures.

Figure 25: Construction periods, example from Austria

Source: Austrian architecture of the 20th and 21st century [a_schau 2006]

Figure 26 Construction periods and number of buildings, example from Austria

Tabelle G1b: Gebäude nach Bauperiode

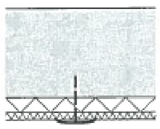
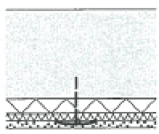
	Bundesland, Politischer Bezirk	Gebäude						
		Insgesamt	Bauperiode					
			vor 1919	1919 bis 1944	1945 bis 1960	1961 bis 1980	1981 bis 1990	1991 oder später bzw. nicht rekonstruierbar
	ÖSTERREICH	**2.046.712**	**353.379**	**175.946**	**252.984**	**619.134**	**296.528**	**348.741**
1	**Burgenland**	**114.403**	**12.846**	**10.142**	**15.759**	**41.508**	**17.297**	**16.851**
101	Eisenstadt (Stadt)	3.304	343	272	490	1.030	465	704
102	Rust (Stadt)	1.182	153	26	170	614	149	70
103	Eisenstadt-Umgebung	18.043	1.519	1.254	2.276	7.306	2.875	2.813
104	Güssing	10.994	1.572	1.147	1.623	3.523	1.552	1.577
105	Jennersdorf	6.963	1.735	531	699	1.886	1.114	998
106	Mattersburg	14.519	1.239	1.394	2.266	5.381	2.057	2.182
107	Neusiedl am See	20.946	997	1.641	2.821	8.204	3.791	3.492
108	Oberpullendorf	17.118	2.104	1.868	2.364	6.331	2.296	2.155
109	Oberwart	21.334	3.184	2.009	3.050	7.233	2.998	2.860
2	**Kärnten**	**162.075**	**23.244**	**12.889**	**25.933**	**50.918**	**23.646**	**25.445**
201	Klagenfurt (Stadt)	19.085	1.830	2.493	3.693	5.654	2.421	2.994
202	Villach (Stadt)	11.238	1.179	1.321	2.010	3.322	1.575	1.831
210	Feldkirchen	10.165	1.494	524	1.298	3.294	1.660	1.895
203	Hermagor	7.217	1.805	627	1.037	1.993	909	846
204	Klagenfurt Land	20.383	2.613	1.258	2.617	6.589	3.598	3.708
205	Sankt Veit an der Glan	16.412	3.272	1.274	2.428	4.479	2.274	2.685
206	Spittal an der Drau	24.535	3.912	1.918	3.856	8.183	3.251	3.415
207	Villach Land	22.160	2.994	1.624	3.642	7.371	3.232	3.297
208	Völkermarkt	15.173	2.211	984	2.573	4.843	2.307	2.255
209	Wolfsberg	15.707	1.934	866	2.779	5.190	2.419	2.519
3	**Niederösterreich**	**553.604**	**108.699**	**53.400**	**56.358**	**158.155**	**81.567**	**95.425**

Source: Micro census 2001 [micro census 2001]

Figure 27 Refurbishment measures of building elements, example from Austria

ALTBAUVERBESSERUNG – MASSNAHMENBESCHREIBUNG

4. DECKEN ZU NICHT BEHEIZBAREM KELLER

Schnitt-zeichnung	Beschreibung
4. Verb. 1: 	– Zweischichtverbundplatten Holzwolle mit Polystyrol; – ohne Verkleidung Arbeitskosten öS/m² inkl. MWSt.: 340,–
4. Verb. 2: 	– Zweischichtverbundplatten Holzwolle mit Polystyrol; – 2 cm Sandputz mit Gewebeeinlage Arbeitskosten öS/m² inkl. MWSt.: 660,–

Source: Guideline for energy consultants [frey 1994]

Figure 28 Supply system losses, example from Austria

ABSCHÄTZUNG DER VERLUSTGRÖSSEN NEUER WÄRMEERZEUGER — Datenblatt 55

Wärmeerzeuger	Brennstoff	Wärmeerzeugungsverluste [%]				η_{RW}
		Mittlerer Abgas-verlust	Spez. Auskühlverlust über die Oberfläche	Spez. Auskühlverlust über den Rauchfang	Spez. Regelungs-verlust	für grobe Abschätzung (f_{Dim} = 1,5)
Durchbrandkessel	Holz	30	1,8	0,2	1,5	0,51
	Braunkohle	25	1,8	0,2	1,5	0,56
	Koks, Steinkohle	20	1,8	0,2	1,0	0,63
Untenabbrandkessel	Holz	25	1,8	0,2	1,0	0,58
	Kohle	20	1,8	0,2	1,0	0,63
mit Gebläse	Holz	20	1,8	0,1	0,5	0,66
	Kohle	15	1,8	0,1	0,5	0,71
Retortenfeuerung	Hackgut	15	2,8	0,1	–	0,68
Vorofenfeuerung	Hackgut	15	2,8	0,1	–	0,68
Umstellbrandkessel	Heizöl EL	15	2,8	–	–	0,69
	Holz	25	2,8	0,2	1,0	0,53
Öl Spezialkessel atm	Heizöl EL	20	0,8	–	–	0,74
Gas Spezialkessel atm	Gas	10	0,8	–	–	0,83
Gas Heiztherme	Gas	10	–	–	–	0,87
Öl-Gas Gebläsekessel HT	Heizöl EL / Gas	10	0,8	–	–	0,83
Öl-Gas Gebläsekessel NT	Heizöl EL / Gas	10	0,6	–	–	0,84
Brennwertkessel	Gas	5	0,6	–	–	0,96 [1)]
Elektro-Zentralspeicher	Strom	–	2,0	–	–	0,92
Elektro-Durchflußkessel	Strom	–	0,5	–	–	0,95
Fernwärmeumformer	Heißwasser	–	0,5	–	–	0,95
Wärmepumpe	Strom	Siehe Datenblatt 46				

1) in Abhängigkeit von Vorlauf und Rücklauftemperatur: 0,89 bis 0,96

Source: Guideline for energy consultants [frey 1994]

Figure 29 Technical refurbishment of existing supply systems, example from Austria

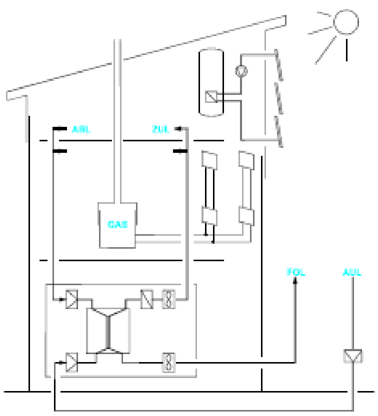


Abbildung 19: Konventionelles Heizsystem mit Lüftungsgerät und Solarer Warmwasserbereitung (Quelle: Ing. Christof Drexel)

Source: Refurbishment of existing buildings using passive-house components [guschlbauer 2004]

Table 34: Literature / sources Austria

[micro census 2001]	Austrian Statistical Office, micro census	Statistik Austria: Gebäude- und Wohnungszählung; Wien 2001
[jaeger 2005]	Austrian architecture of the 19th and 20th century	Jaeger, C.: Österreichische Architektur des 19. und 20. Jahrhunderts; nw Verlag, Wien/Graz 2005
[a_schau 2006]	Austrian architecture of the 20th and 21st century	Architekturzentrum Wien: Architektur in Österreich im 20. und 21. Jahrhundert; Birkhaeuser Verlag, Basel 2006
[mueller 2008]	Sustainable refurbishment solutions for the existing building stock	IFB eV: Atlas Bauen im Bestand – Katalog für nachhaltige Modernisierungslösungen im Wohnungsbaubestand; Mueller Verlag, Koeln 2008
[haselsteiner 2006]	Refurbishment of existing buildings, regarding todays legal framework	Haselsteiner et al: Neue Standards für alte Häuser; bmvit, Wien 2006
[bluemel 2004]	Systematic refurbishment of social housing	Blümel E.et al: Systematische Siedlungssanierung im sozialen Wohnbau; Berichte aus Energie- und Umweltforschung, bmvit, Wien 2004
[guschlbauer 2004]	Refurbishment of existing buildings, using passive-house components	Guschlbauer-Hronek, K. et al: Althaussanierung mit Passivhauspraxis; Berichte aus Energie- und Umweltforschung, 02/2004 bmvit, Wien 2004
[frey 1994]	Guideline for energy consultants; practical advices to display energy performance certificates	Frey, K. et al: Handbuch für Energieberater; Joanneum research, Wien 1994
[recknagel 2007]	Guideline for heating and air conditioning; practical advices for dimensioning, tabulations, engineering drawings	Recknagel et al: Taschenbuch für Heizung und Klimatechnik 07/08; Oldenbourg Verlag, München 2007
[tiator 2006]	Supply systems; basic equipment of supply systems	Tiator, I.: Heizungsanlagen; Vogel Buchverlag, 3. aktualisierte und erweiterte Auflage, Wuerzburg 2006
[schlagnitweit 2006]	HVAC installations; dimensioning of HVAC, schemes, diagrams etc.	Schlagnitweit, H. et al: Sanitaer- und Klimatechnik – Heizungs- und Lüftungsinstallationen; Jugend & Volk, Wien 2006
[buderus 2002]	Heating Engineering; practical advices for storage and distribution	Buderus: Handbuch für Heizungstechnik; Buderus, Wetzlar 2002
[uponor 2009]	Guideline for technical building equipment; esp. installation systems and panel heating and cooling	Uponor: Praxishandbuch der technischen Gebäudeausrüstung (TGA) für Installationssysteme, Flächenheiz- und –kühlsysteme, sowie Vertragsrecht für Architekten und Ingenieure; Beuth Verlag 2009
[krapmeier 2003]	Technical refurbishment of existing supply systems; practical advices	Krapmeier, H.: Von 150 auf 30 - junge Technik in alten Häusern; Tagungsband Althaussanierung mit Passivhauspraxis bmvit, Wien 2003
ZEUS / ImmoZEUS	platforms for datacollection of EPCs	www.immozeus.at for private sector www.energieausweise.net for the provinces

2.10 Bulgaria

(by TABULA partner 10: SOFENA / Bulgaria)

Existing building typologies and national statistics

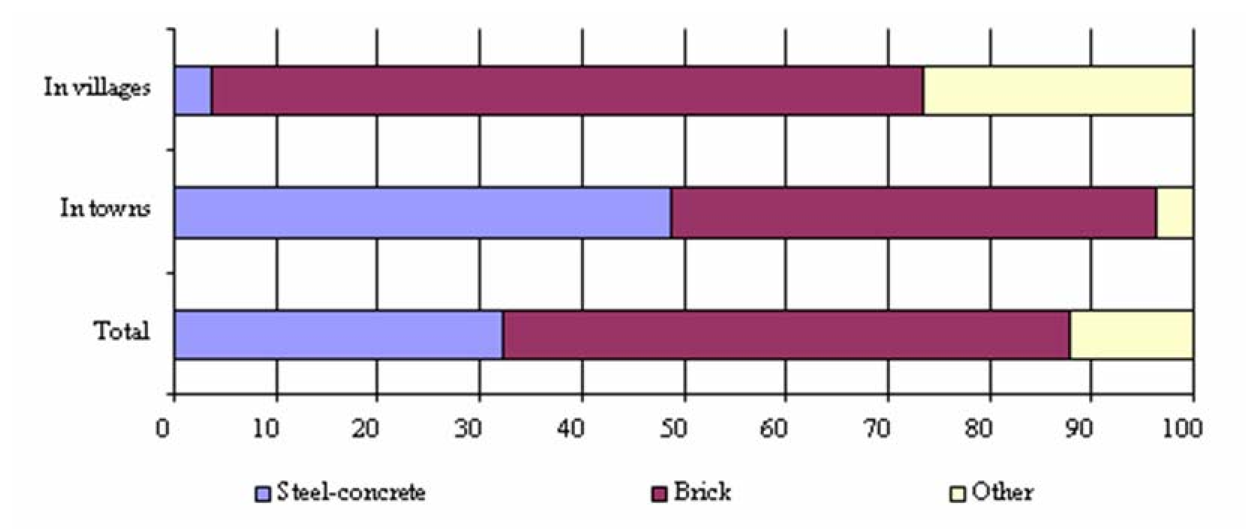
Information for the housing fund in Bulgaria is provided by the National Statistical Institute, Business Statistics Department, Construction, Investment, and Tourism Statistics Division. The data about balance of dwelling stock as of 31st of December every year is obtained on the base of the results of the census of the dwelling stock on the 1st of March 2001. So as the data about the newly dwellings is added and the data about the destroyed dwellings is deducted through the relevant calendar year. The units of the survey are the residential buildings, the dwellings and dwellings floor space. The statistical information about dwelling stock is used as a base on preparation of analysis and prognoses about the housing policy at municipal and national level.

According to the accepted definition: "Residential buildings are the buildings which by initial building or after reconstruction are suitable for living by one or several households… inhabited and uninhabited residential buildings, cook-houses (as separate buildings), hostels, boarding-houses, cloisters and the homes for elderly people in which live joint households".

Up to 2000 the national statistics identify 4 main construction types for the housing sector: panel system, steel-concrete construction, solid structures and frame-built structure. From 2001 there are 3 main classifications for buildings:

- Steel-concrete - the carrier and the floor constructions are built of steel-concrete and the walls are made of panels, brick masonry or other materials.
- Solid structures - the carrier walls are of brick and stone masonry and the belts, the beams and the floor construction are made of steel-concrete but have no steel-concrete columns. The buildings of which the floor elements are precast reinforced concrete units also refers to the solid structures.
- Other buildings - structures that are built of stones, sun-dried brick, wood and other materials.

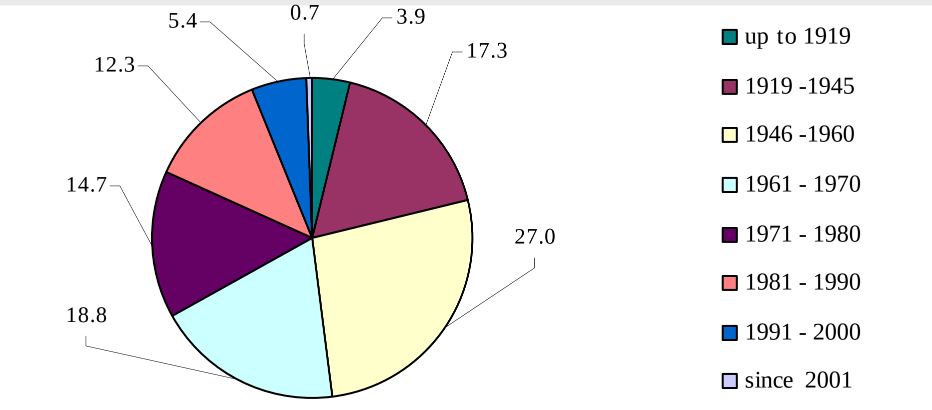
Figure 30: Dwellings by structure of building in 2008 , %
Source: Housing Fund 2008, National Statistical Institute



There is also information for the year of construction.

Typical for the Bulgarian housing fund is that in 2008 96.8% of the buildings were private and only 3.2% owned by the state and municipality.

Figure 31: Residential building by period of construction in 2008 - %
Source: Housing Fund 2008, National Statistical Institute



National strategic documents and legislation

There are two basic national strategic documents for the Bulgarian housing stock:

- National Housing Strategy, adopted by the Council of Ministers on 14 May 2004.

- Program for the Renovation of Residential Buildings (NPRRB) officially announced in January 2005. In this program the residential buildings in Bulgaria are classified according to the constructive systems and type of constructive materials, construction systems and number of floors, year of construction. In the same document the construction systems for the period 1959 – 1992 are classified. The period is characterized with mass construction of panel buildings but also brick buildings (Table 35).

The implementation of the Building Directive 2002/91/EO in Bulgaria is the responsibility of the Minister of Energy, Economy and Tourism, the Executive Director of the Energy Efficiency Agency and the Minister of Regional Development and Public Works. The legal requirements of the EPBD are transposed in the national legislation with the Energy Efficiency Act adopted by the National Assembly of Bulgaria on 19 February 2004. The Law on amendment and supplementation to the EE law was adopted in July 2007 and published in a State Gazette on 6th July 2007 and it implemented the energy passport (label) as a part of the technical passport of the building. It amended the terms and certificate validation requirements depending on the application of EE measures from renewable energy sources. From, November 2008 a new Energy Efficiency Act is in force. By the Act are regulated the public relationships and connected with the conduction of the state policy for improvement of energy efficiency and the realization of energy efficiency services. Amended sub-laws are ready and approved by the ministers.

Figure 32: Typical panel block of flats in Bulgaria

Table 35: Thermal characteristics of the surrounding walls per construction systems

№	Const-ruction system	d m	d m	d m	Ro	Ko	Re st Ro	λ	Ad-diti-onal insu lati-on, m	Pe-riphe ral ther mal bridg e	Addi-tional insu-lation, m	Coef fi-cient "low qua-lity"	Addi-tional insu-lation, m
							Brick masonry						
1	Brick masonry Solid bricks - 38см	Internal plaster 0.02	Brick masonry 0.38	External plaster 0.02	0.70	1.42	1. 30	0.03	0.03 9		0.039	1.15	0.045
2	Brick masonry Solid bricks - 25см	Internal plaster 0.02	Brick masonry 0.25	External plaster 0.02	0.54	1.86	1. 46	0.03	0.04 4		0.044	1.15	0.050
3	Brick masonry Hollow bricks - 25см	Internal plaster 0.02	Brick masonry 0.25	External plaster 0.02	0.70	1.42	1. 30	0.03	0.03 9		0.039	1.15	0.045
4	Brick masonry Hollow bricks with 4 hallows - 25см	Internal plaster 0.02	Brick masonry 0.25	External plaster 0.02	0.80	1.25	1. 20	0.03	0.03 6		0.036	1.15	0.041
							Pannels						
1	Rk =2.00; kmax =0.50 Sf-Al.Tolstoy (60)	Cinder concrete 1200 kg/m3 0.22	Wallbo-ard 0.04		0.84	1.19	1. 16	0.03	0.03 5		0.035	1.1	0.038
2	Rk =2.00; kmax =0.50 Sf-Traen mir (60)	3-layers thermal insul. 0.25			0.79	XPS 1.26 0.03		1.21	0.03 6		0.036	1.1	0.040
3	Rs-Bn-VIII-Rs(62)	Armored concrete 0.09	Cellular concrete 800 kg/m3 0.10	Armored concrete 0.06	0.65	XPS 1.55 0.03		1.35	0.04 1		0.041	1.1	0.045
4	B-V-Gl	Armored concrete 0.05	Perlite concrete 800 kg/m3 0.10	Armored concrete 0.05	0.62	XPS 1.62 0.03		1.38	0.04 2		0.042	1.1	0.046
5	2-63 obedine-na(63)	Armored concrete 0.05	Cellular concrete 800 kg/m3 0.10	Armored concrete 0.05	0.62	1.62	1. 38	0.03	0.04 2	0.354	0.044	1.05	0.046

Table 35 (continuation)

6	Bs VIII Sf	Armored concrete 0.05	Cellular concrete 800 kg/m3 0.10	Armored concrete 0.05	0.62	1.62	1.38	0.03	0.042	0.354	0.044	1.05	0.046
7	Claydite concrete 1300 kg/m3 2-64-Zemlyane (64) 0.26		Protective layer 0.02		0.75	1.34	1.25	0.03	0.038		0.038	1.1	0.041
8	Aggloporite concrete 1300 kg/m3 Bs-V-VIII-1-68Plovdiv 0.26		Protective layer 0.02		0.70	1.42	1.30	0.03	0.039		0.039	1.1	0.043
9	Claydite concrete and Claydite-perlite concrete for the facades 1100 kg/m3 Bs-69-Sf 0.26				0.85	1.17	1.15	0.03	0.034		0.034	1.1	0.038
10	75 and 77year Bn-IV-VIII-Gl-69	Armored concrete 0.10	EPS 0.06	Armored concrete 0.04	1.88	0.53	0.12	0.03	0.004	0.354	0.017	1.25	0.022
11	Bp 79-Gl 60mm	Armored concrete 0.10	EPS 0.06	Armored concrete 0.04	1.88	0.53	0.12	0.03	0.004	0.354	0.017	1.25	0.022
12	Rk =2.00 ; kmax =0.50 Bp 79-Gl 80mm	Armored concrete 0.08	EPS 0.08	Armored concrete 0.04	2.41	0.42	-0.41	0.03	-0.012	0.354	0.006	1.25	0.008
	The same for blank wall	0.08	0.08	0.04	2.41	0.42	-0.41	0.03	-0.012	0.354	-0.004	1.3	-0.005
13	Gl/Bl Bn-IV-VIII-72-Gl	Керамзитобетон 1300 кг/м3 0.20			0.60	1.68	1.40	0.03	0.042	0.354	0.042	1.1	0.046

Source: National Program for the Renovation of Residential Buildings

Energy performance of the housing buildings in Bulgaria

The first normative requirements for thermal insulation in Bulgaria were applied from 1961 as the main requirement is the achievement of minimal value of the total thermal resistance of heat transfer in order not to cause condensation of water vapors on the internal surface of the building shell during the coldest winter day, which is a hygienic requirement.

Due to the low prices of energy and state subsidies the heating installations were designed in non-efficient way and are generally oversized. After the oil crises in the end of 1970s the building characteristics of panel buildings were improved. In 1987 new normative requirements were applied and the thermal requirements are increased with about 35-40%. The building characteristic overall heat transfer coefficient is in use since 1987.

Table 36: Overall heat conductivity coefficient

No	Type of the surrounding construction	Normative values of Kmax (Ro)						
		Up to 1987		After 1987			After 1999	
		Normative values of Kmax (Ro)		Normative values of Kmax (Ro)			Kmax	Ro
		From	To	From	To	Sofia		
1.	External walls – one layer (bricks, light concrete)	1,25(0,8)	1,4(0,71)	0,89(1,12)	1,1(0,91)	1,0(1,0)	0,5	2,0
2.	Internal walls – three layers (panels)	1,25(0,8)	1,4(0,71)	0,45(2,22)	0,59(1,7)	0,5(2,0)		
3.	Roofs	0,9(1,11)	1,15(0,87)	0,48(2,08)	0,65(1,54)	0,53(1,86)	0,3	3,33
4.	Ground floors	0,95(1,05)	1,15(0,87)	0,7(1,43)	0,95(1,05)	0,8(1,24)	0,5	2,0

Source: National Program for the Renovation of Residential Buildings

The main problems and defect of the thermal insulation are related to the deficiency of the insulation in comparison to the norms from 1999, problems with the quality of panel composition and construction, increase of the designed thermal bridges and formation of new ones, low quality of the insulation material, etc.

National Program for the Renovation of Residential Buildings gives also packets of measures with cost per dwelling with total area 75 m2.

According to the studies of the Ministry of Economy, Energy and tourism the building shells have real coefficients of heat conductivity 3-5 times higher than the norms from 1999. In 80% of the housing stock basements and roofs are without insulation. Heat losses through windows can reach 50% of the total heating losses.

On 1 March 2005, the Minister of Regional Development and Public Works adopted the minimum requirements for all new buildings. The requirements come into force for building permits requested after 1 March 2005. The type and level of requirements are governed by the function of and the type of building - residential buildings and non residential building \education, hospitals, offices, hotels, schools\ and may cover:

- Maximum U-value;
  - (1) The heat conduction coefficient (U) is determined in accordance to Bulgarian БДС EN ISO 6946.
  - (2) The U values for heated buildings may not be higher than the values shown in Table 36. Requirement on average insulation level;
- Maximum primary energy consumption per m² of floor area. (Table 38)

Table 37: Maximum U values for heated buildings

	Type of building wall constructions and elements	U, W/(m2K)	
		For buildings with standard internal temperature 19 °C	For low temperatures buildings
1.	External walls and those surrounded by non heated areas	0,50	0,83
2.	Bar walls in heated areas	1,60	10,00
3.	External walls, bordering on land	0,70	1,20
4.	Bar walls in heated attic areas	1,35	2,00
5.	Floors, bordering on land	0,45	0,83
6.	Garret plate on cold roof	0,35	
7.	Floor plate on non heated undersurface floor	0,50	
8.	Wall, attic or floor, bordering on external air or with land, at built-in area heating.	0,50	0,57
9.	Warm roof	0,35	0,83

Source: Implementation of the EPBD in Bulgaria: Status March 2008

Table 38: The maximum values of the annual heat consumed for heating of 1 sq.m. useful residential area depending on form factor and the degree-days (DD), at internal air temperature , higher than 19 °C

f_o, m^{-1}	$_{uh}AQ/_{max}$, kWh/m^2			
	DD, K.d			
	2100	2500	2900	3300
1	2	3	4	5
≤ 0,2	50,0	51,8	54,0	56,5
0,3	55,4	57,3	59,4	61,9
0,4	60,8	62,7	64,8	67,3
0,5	66,2	68,1	70,2	72,7
0,6	71,6	73,5	75,6	78,1
0,7	77,1	78,9	81,1	83,6
0,8	82,5	84,3	86,5	89,0
0,9	87,9	89,7	91,9	94,4
1,0	93,3	95,1	97,3	99,8
≥ 1,05	96,0	97,84	100	102,5

Source: Implementation of the EPBD in Bulgaria: Status March 2008

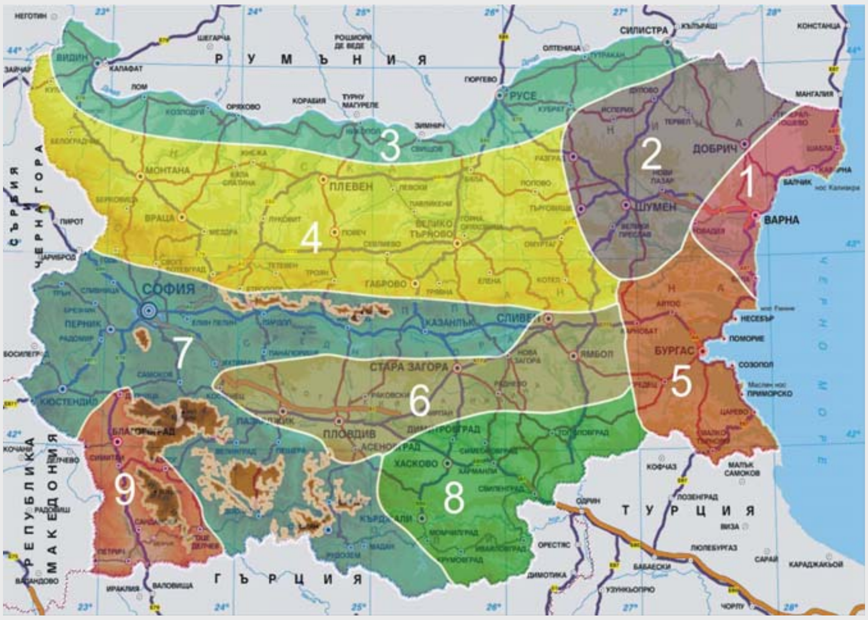
Also on 1 March 2005, the Minister of Regional Development and Public Works adopted the minimum requirements for existing buildings – building renovation, extensions and repairs.

Main criteria for energy and heat saving expenses for residential and non-residential buildings with standard internal temperature of 19°C and for non-residential low temperature buildings is the heat conductivity coefficient through the building enclosure constructions and elements.

The heat conductivity coefficient values should not exceed the given values, when:

- the area being reconstructed/renovated/repaired or reorganized exceeds 25% of the original building enclosure, construction and elements;
- the heating volume is increased with more than 30 m3.

Figure 33: Map of the climatic zones in Bulgaria



Bulgaria is divided into 9 climatic zones (Figure 33) with the following calculated degree days factor:

Table 39: Calculated degree days

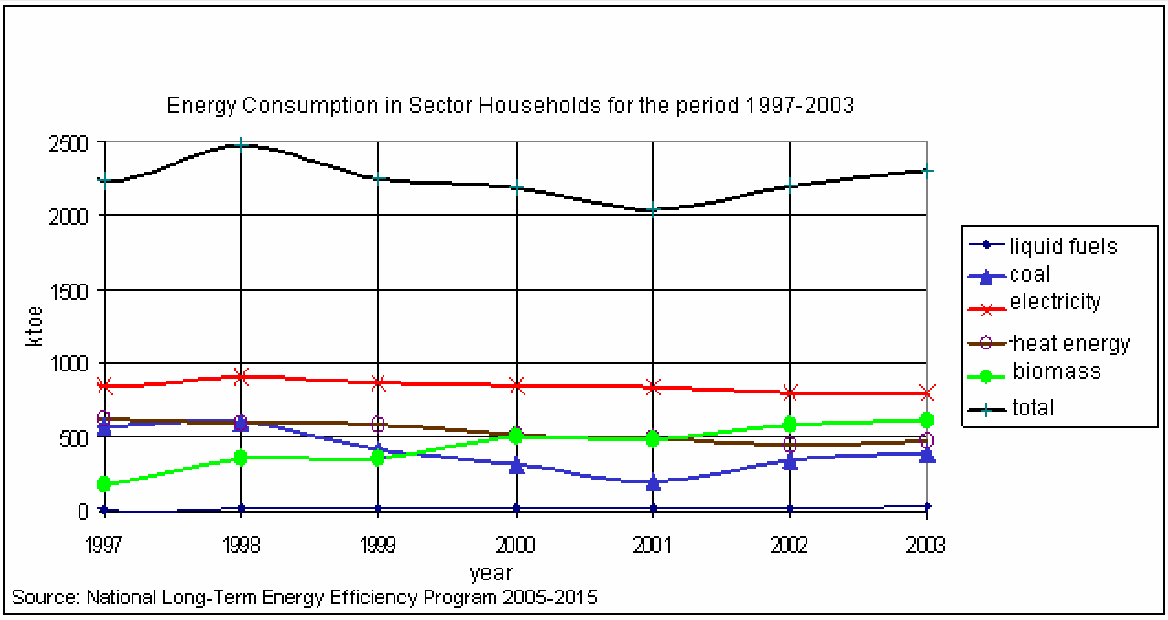
Climatic Zone	Degree days [cd/a]
Zone 1	2400
Zone 2	2800
Zone 3	2600
Zone 4	2700
Zone 5	2300
Zone 6	2400
Zone 7	2900
Zone 8	2300
Zone 9	2100

Installations

The main source of information for the final energy consumption in residential sector is the National Long-Term Energy Efficiency Program 2005-2015, developed by the state Energy Efficiency Agency in 2005.

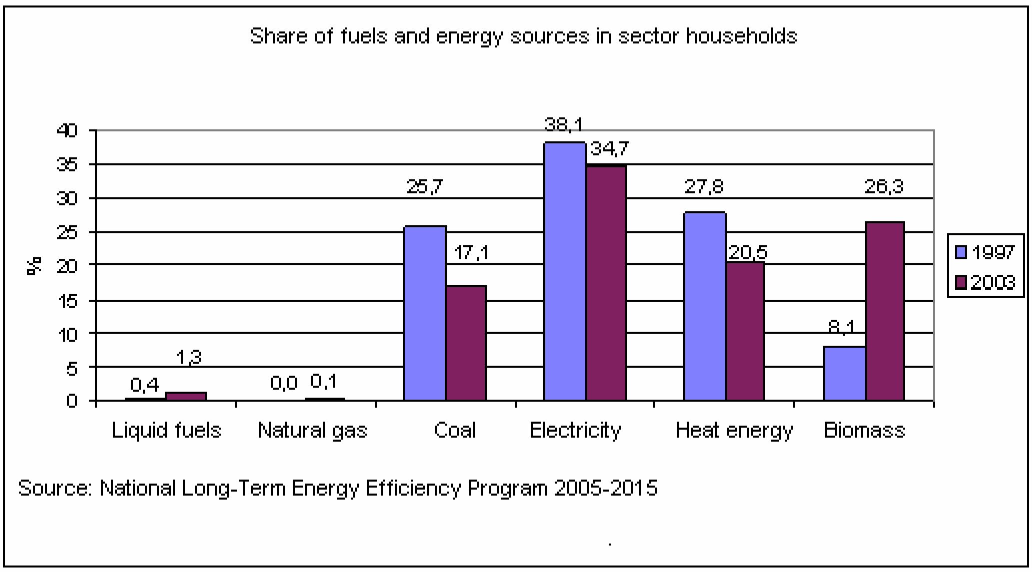
The share of final energy consumption for the residential sector in 2003 is about 24,7% (2304 ktoe). Figure 5 presents the final energy consumption by sources and years. After 1991 there is a notable increase of use of biomass (mainly wood logs in inefficient stoves) and coal.

Figure 34:



The consumption of natural gas for households in 2003 is only 0,1%. (Figure 34)

Figure 35:



In Bulgaria the specific energy consumption is about 0,83 toe/housing and for EU countries 1,7 toe/housing (2000).

The main characteristics of the heating installations in housing sector are:

- not good technical conditions of district and local heating systems;
- less than 1% of the households are connected to the natural gas network;
- low energy efficient systems and fuels are in use;
- low efficient lighting system;
- low efficient electrical appliances.

In 2001 the share of dwellings connected to the district heating is 12,7% and covers 42 towns. 2,4% of the total number of dwellings are lacking any access to infrastructure.

The information for the number of buildings is important for further analysis of the possibilities for decentralized heating and co-generation (Table 40).

Table 40: Number of buildings per floors

	Floors	**Up to 3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**
Total buildings	91 551	49 444	16 428	9 257	4 913	2 673	5 655	1 006	2 175
%	100	54	18,0	10,1	5,4	2,9	6,2	1,1	2,4

Source: Housing Fund 2008, National Statistical Institute

There are no official reports and studies on the efficiency of heating installations in Bulgarian housing sector. Comparative tables on the heating cost for different type of fuel are published on the web pages of suppliers of natural gas, district heating and biomass (Table 47).

Table 41: Comparison of the heating systems and cost of fuel in Bulgaria

Fuel/Energy Type	Energy content kWh	Unit	Average Heating System Efficiency %	Fuel Price, euro/unit	Unit	Heat Production Cost euro/kWh	Monthly Heating Cost* euro	Rate %
Coal	4.1	kWh/kg	80	80	eur/ton	0.025	48	58.5
Wood	3.1	kWh/kg	85	32	eur/m3	0.026	51	62.2
Wooden chops	2.6	kWh/kg	85	60	eur/ton	0.028	55	67.1
Cherry/plum pits	3.4	kWh/kg	85	102	eur/ton	0.035	70	85.4
Wooden pellets	4.8	kWh/kg	85	166	eur/ton	0.041	81	98.8
Natural gas	**9**	kWh/m3	**90**	**336**	eur/kilo m3	**0.042**	**82**	**100.0**
Propane Gas (LPG)	12.8	kWh/kg	93	795	eur/ton	0.062	123	150.0
Electricity	1	kWh	98	0.075	eur/kWh	0.076	152	185.4
Light Fuel Oil	11.6	kWh/kg	90	953	eur/ton	0.091	181	220.7

Source: EnEffect

Summary of the existing statistical information and studies. Further needs for research

The existing statistical information and surveys on the housing fund in Bulgaria are summarized in the table below:

Table 42

Source of information	Content	Year
Housing Fund, National Statistical Institute	The units of the survey are the residential buildings, the dwellings and dwellings floor space	Annual edition
Survey of Arch. Stavrev, 1999, on the conditions of the panel apartment buildings in Sofia	Full inventory of the construction technologies in Sofia for the period 1958-1989	1999
National Program for the Renovation of Residential Buildings	Classification of construction systems, typical energy efficiency measures and needs of investments	2005
National Long-Term Energy Efficiency Program 2005-2015	Information on the energy consumption of households	2005

Additional studies are necessary for the actualization of the identified typical measures for energy efficiency in the Bulgarian housing fund resulting from the new legislative requirements for renovation. There are no studies available for the buildings constructed before 1919, most of them cultural monuments that requires special technical solutions and case-specific measures. There is no independent study on the efficiency of the typical heating systems in residential buildings and typical solutions for fuel and system change. Use of RES for heating and cooling in residential sector is not studied in details, as there are mainly case studies and information for best practices.

2.11 Czech Republic

(by TABULA partner 12: STU-K / Czech Republic)

The national residential building typology has not been developed in the Czech Republic so far.

However the evolution of the energy related requirements defined by the Czech standards especially by the the CSN 730540 is well documented. Still many old buildings in the Czech Republic have remained technically unchanged till these days. The originally used materials and products are documented, the dimensions are known and the corresponding U-values are also available.

The classification scheme of the Czech building typologies is currently under development (see Figure 36) with the aim to find the most representative patterns for each category.

The best documented part of the Czech housing stock is from the period 1950-1990. In this period the former Czechoslovak industry went through a huge expansion of precast concrete technologies. Many standardised solutions were applied in those times as a result of which one third of the existing housing stock consists of large panel buildings.

Figure 36: Classification scheme of the Czech building typologies

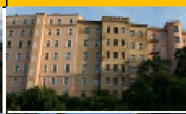
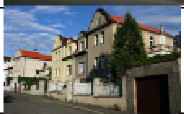
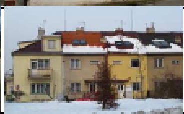
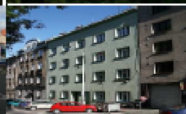
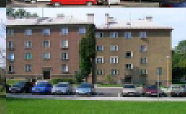
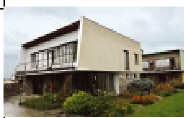
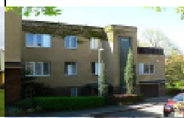
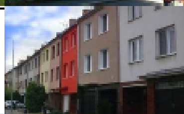
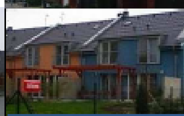
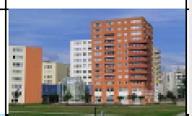
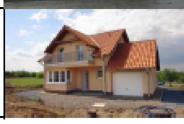
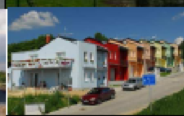
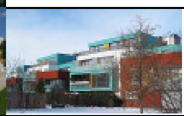
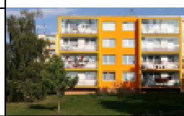
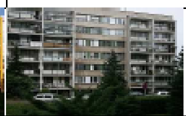
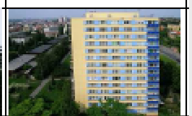
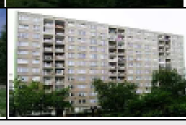
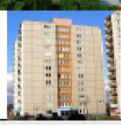
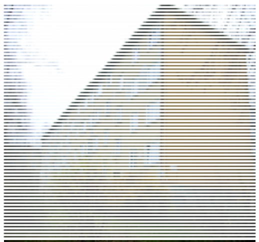
Age class			Material, technology	Single family house	Terraced houses	Multifamily houses	Appartment blocks	High rise
A		before 1920	stone, bricks, clay bricks unburnt					X
B		1921-1945	stone, bricks, cast in situ					X
C		1946-1960	bricks, breeze blocks, cast in situ	X	X			X
D		1961-1980	bricks, lightweight concrete blocks, cast in situ, timber					
E		1981-1994	bricks, lightweight concrete blocks, cast in situ, timber	X		X	X	X
F		1995-2001	bricks, lightweight concrete blocks, cast in situ, timber			X	X	
G		after 2001	bricks, lightweight concrete blocks, cast in situ, timber					X
Special cases - Large panel buildings 1957-1990								
	P1	1957-1980	Large panel building	X	X			
	P2	1981-1990	Large panel building	X	X			

Figure 37: Example of two page overview of typical building from the building typology scheme

Type of house: Multi-family building
Building age: 1961 – 1970
No. of floors: 5 (1 + 4)



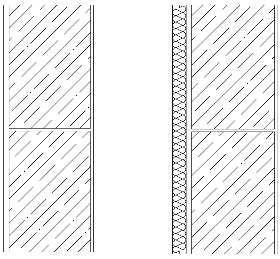
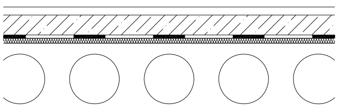
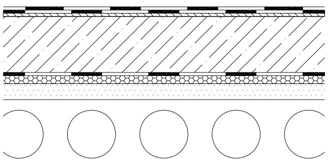
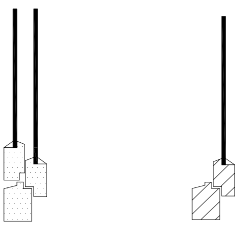
Sketch	**Description**	**U-value W/(m²K)**
External wall 	Cinder – pumice concrete panel blocks, plastered Cinder – pumice concrete panel blocks, plastered, added insulation (50mm polystyrene)	1,46 0,55
Cellar ceiling 	Hollow core concrete slabs 215mm, mineral wool 15mm, waterproofing paper, floor (wear layer: parquet or xylolite + PVC) 84mm	1,20
Flat roof 	Hollow core concrete slabs 215mm, cinder filling 50mm, Sven board 25mm, waterproof paper, cinder concrete 100 – 270mm (on average 185mm), cement screed 10mm, asphalt roofing	0,84
Window 	Double window, wooden frames, each frame single glazed Single glazing in metallic frame	2,80 6,50

Figure 37 (continuation)

			Requirement
Building: e_V [kWh/m^{3}a]	Energy consumption for heating	50,2	**Requirement**
			30,5
			Level of energy performance
			165%

Level of energy performance

A	SEN ≤	40%	extremely saving
B	SEN ≤	60%	highly saving
C	SEN ≤	80%	saving
D	SEN ≤	100%	convenient
E	SEN ≤	120%	inconvenient
F	SEN ≤	150%	markedly inconvenient
G	**SEN >**	**150%**	**extremely inconvenient**

			Requirement
Building: U_{em} [W/m^{2}K]	Average heat transmisson coefficient	1,37	**Requirement**
			0,70
			Level of energy performance
			197%

Level of energy performance

A	STN ≤	40%	extremely saving
B	STN ≤	60%	highly saving
C	STN ≤	80%	saving
D	STN ≤	100%	convenient
E	STN ≤	120%	inconvenient
F	STN ≤	150%	markedly inconvenient
G	**STN >**	**150%**	**extremely inconvenient**

Heating technology	Description	Energy use for 100%
Heating system	District heating: Delivery station in the basement, two branches, two-pipe system, equithermal control, cast-iron radiators with thermostatic valves	118
Hot-water system	District heating: Delivery station in the basement, water-to-water heat exchanger, water accumulator (for peak load hot water consumption)	118

Table 43: Material solutions and dimensions of exterior walls with their thermal properties

Konstrukce	Tepelný odpor R [m².K/W] Min. / Max.	Součinitel (k) prostupu tepla U [W/(m².K)] Max. / Min.	Zkondenzované množství vodní páry GK [kg/m².rok]	Celoroční bilance GV-GK [kg/m².rok]
Zdivo CP 300 - bez železobet. prvků- se železobet. prvky	0,39 / **0,41** 0,37 / **0,39**	1,80 / 1,74 1,86 / 1,80	PK / 0,16 PK / PK	PK / 2,72 PK / PK
Zdivo CP 450 - bez železobet. prvků- se železobet. prvky	0,56 / **0,60** 0,54 / **0,56**	1,36 / 1,31 1,42 / 1,36	0,05 / 0,06 0,05 / 0,05	2,00 / 2,10 1,99 / 2,00
Zdivo CP 600 - bez železobet. prvků- se železobet. prvky	0,74 / **0,78** 0,71 / **0,74**	1,10 / 1,05 1,14 / 1,10	0,03 / 0,04 0,03 / 0,03	1,95 / 2,12 1,92 / 1,95
Zdivo smíšené 600	0,47 / **0,53**	1,57 / 1,43	0,04 / 0,03	1,57 / 1,43
Zdivo škvárobeton. 375	0,62 / **0,80**	1,27 / 1,03	0,26 / 0,31	4,01 / 3,82
Zdivo porobet. leh. 300	0,82 / **0,99**	1,01 / 0,86	0,23 / 0,37	3,91 / 3,68
Zdivo křemelina 250	0,61 / **0,79**	1,29 / 1,05	0,18 / 0,20	4,17 / 3,98
Zdivo CDm 375	0,57 / **0,66**	1,35 / 1,21	0,13 / 0,14	3,46 / 3,94
Zdivo CDK 375	0,53 / **0,62**	1,43 / 1,28	0,13 / 0,26	3,30 / 4,02
Zdivo CDK 450	0,63 / **0,73**	1,25 / 1,11	0,09 / 0,20	2,87 / 4,01
Zdivo CD TÝN 300	0,55 / **0,63**	1,39 / 1,25	0,21 / 0,47	4,18 / 3,82
Zdivo CD INA 375	0,87 / **1,01**	0,96 / 0,85	0,16 / 0,37	3,99 / 3,68
Zdivo CD IVA 450	0,94 / **1,10**	0,91 / 0,79	0,11 / 0,23	3,84 / 3,77
Zdivo -THERM 375	1,65 / **2,00**	0,55 / 0,46	0,45 / 0,48	3,44 / 3,38
Panel struskobet. 240- Speciální složení- Nespecifikované slož.	0,34 / **0,39** 0,28 / **0,36**	1,96 / 1,78 2,24 / 1,89	PK / 0,05 PK / PK	PK / 2,43 PK / PK
Panel struskobet. 300- Speciální složení- Nespecifikované slož.	0,43 / **0,51** 0,35 / **0,46**	1,67 / 1,47 1,94 / 1,60	0,04 / 0,03 PK / 0,04	1,98 / 2,07 PK / 2,01
Panel škvárobeton. 300	0,30 / **0,36**	2,16 / 1,91	PK / PK	PK / PK
Panel expanditbet. 270	0,42 / **0,52**	1,70 / 1,46	0,11 / 0,25	6,26 / 9,57
Panel expanditbet. 300	0,47 / **0,58**	1,56 / 1,34	0,09 / 0,21	5,78 / 9,50
Panel keramzitbet. 270	0,44 / **0,76**	1,64 / 1,08	0,06 / 0,06	3,44 / 4,80
Panel keramzitbet. 300	0,49 / **0,85**	1,51 / 0,99	0,05 / 0,05	3,17 / 4,37
Panel keramzitbet. 320	0,53 / **0,91**	1,44 / 0,93	0,04 / 0,05	3,01 / 4,12
Panel křemelina 200	0,41 / **0,54**	1,72 / 1,42	0,15 / 0,16	4,60 / 5,85
Panel keramický jedn.300	0,50 / **0,57**	1,49 / 1,35	0,06 / 0,06	3,96 / 4,18
Panel keramický dvou.300	0,52 / **0,59**	1,46 / 1,31	0,06 / 0,06	4,02 / 4,27
Panel pórobeton. 250	0,93 / **1,39**	0,91 / 0,64	0,10 / 0,11	7,27 / 9,13
Panel pórobeton. 300	1,11 / **1,66**	0,78 / 0,55	0,08 / 0,09	6,06 / 7,07
Panel žb. s PPS 40	0,54 / **0,76**	1,42 / 1,08	0,11 / 0,15	1,14 / 1,04
Panel žb. s PPS 60	0,76 / **1,09**	1,08 / 0,78	0,09 / 0,12	1,08 / 1,00
Panel žb. s PPS 80	0,98 / **1,42**	0,87 / 0,63	0,07 / 0,09	1,06 / 1,00
Panel žb. s PPS 100	1,20 / **1,75**	0,73 / 0,52	0,06 / 0,07	1,05 / 0,99

The most frequently used materials for the external walls and their thermal properties are listed inTable 43.

Table 44: Historical overview of the U_{value} requirements for the external walls

Period	External walls U_{value} W/(m^2.K)	Comments	Standard
before 1963	1,396		CSN 1450, CSN 730020
1963-1978	1,38 - 1,47	climate zones interior comfort based	CSN 730540 „new“
1979-1992	0,79 - 0,89	climate zones, interior comfort based	CSN 730540 revised
1992-1994	0,46 - 073	new/renovations energy demand based	CSN 730540, revised 4
since 1994	0,35 - 0,50	**heavy walls** recom./min.	CSN 730540-2
	0,31 - 0,44	**light walls** recom./min.	
		climate zones energy demand based	

It is not easy to describe the part of the stock that has been already partly renovated. Unfortunately the degree of renovation is not uniform. The most common energy efficiency measures that were taken are replacement of the windows, renovation of the roofing layers with additional thermal insulation, additional facade insulation (ETICS). More efficient heat control systems have been installed. Most of the multifamily dwellings and apartment blocks are heated with district heating. The district heating networks are regularly maintained and step by step modernized. The heating systems in family houses and terraced houses using solid fuels like coal and coke were mainly converted to gas boilers or reasonably priced off-peak hours electricity.

Table 45: Literature / sources Czech Republic

Typical buildings / national level		
[ČEA, STÚ-e]	Catalogue of model solutions for additional thermal insulation of residential buildings	Mrázek,K., Horáková A. - Katalog vzorových řešení zateplení obytných budov. Praha 1997
[OPET]	Reducing energy demand for the heating of residential buildings	Šála, Machatka - Snížení spotřeby tepla na vytápění obytných budov. Praha/Brno 2002
[OPET]	Thermal defects and disorders of large panel buildings and the repairs.	Šála, Machatka-Tepelně-technické vady a poruchy panelových budov a jejich sanace. Praha/Brno 2002

Typical buildings / regional level		
[STU-k]	Energy sustainable asset management. Tool for scenario calculation including the simplified energy profile.Havířov region.	Vimmr.T. - Energeticky udržitelné řízení bytového fondu. Havířov, 2008
[STU-k]	Restructuring SORELA urban area in Havířov region.	Vimmr T. – Restrukturalizace městské zóny SORELA. Havířov 2009
Typical construction elements and supply systems		
[STU-e]	Repairs of supply systems and technical devices and in the large panel buildings.	Mrázek a kol.- Opravy a obnova technických zařízení budov v panelových bytových domech. Praha 2005
[STU-e]	Economical evaluation of the optional solutions to support the housing renovations.	Mrázek a kol. Ekonomické hodnocení vybraných opatření na podporu oprav, modernizace nebo regenerace bytových domů. Praha 2005
[IC CKAIT]	Energy efficient renovations of buildings 2nd international conference proceedings, Brno 2000	Tepelná ochrana budov – opravy bytových domů. Sborník přednášek z 2.mezinárodní konference, Brno 2000
[VÚPS]	Overview of technologies of various large panel building types	VÚPS Praha, Gottwaldov 1978
[VUPS]	Thermal and hygrometry parameters of building materials and structures	Mrlík F. - Vlhkostní a tepelně technické konstanty stavebních materiálů a konstrukcí. Praha 1986

2.12 Denmark

(by TABULA partner 13: SBi / Denmark)

Former building constructions and energy regulations

Building tradition and building regulations have changed over time. It is thus crucial to gain knowledge about typical building constructions, building practices and regulations in different periods of time. In Denmark, buildings can be divided into eight different time-typical periods according to the energy regulations; according to the design, construction and materials, a shorter list of periods can be identified, for multi-storey residential buildings e.g. three main types can be pointed out.

The building construction can be considered more or less uniform in each of the periods (Wittchen, 2009 & Wittchen, 2004). The periods are identified partly from acknowledged shifts in building practice and partly by shifts in energy requirements in the Building Regulations (BR), which are:

1. 1850–1930
2. 1931–1950 (introduction of hollow core masonry walls)
3. 1951–1960 (insulation of cavity in exterior walls)
4. 1961–1972 (first nation wide energy requirements in BR61)
5. 1973–1978 (tightening of energy requirements in BR72)
6. 1979–1998 (tightening of energy requirements in BR78)
7. 1999–2005 (tightening of energy requirements in BR95 / BR-s98)
8. 2006–2010 (tightening of energy requirements in 2005 / BR08 and planned further tightening in 2010)

This kind of information can be gathered from reviews of earlier Building Regulations as well as personal knowledge and interviews with persons who have in depth knowledge about typical building practice in different periods of time.

Building stock register (BBR)

BBR was created in 1976. The register was originally designed to deliver basic information for assessment of real estate and for censuses. Originally all information in BBR was provided by the building and dwelling owners.

Over time BBR have been used in conjunction with other administrative tasks by the state, regions and municipalities.

Today, BBR holds information about 1.6 million properties, 3.8 million buildings and 2.7 million dwellings and commercial units.

The data model and the plans for a new BBR was created in the years around 1995, while the responsibility for the registry was at the National Survey and Cadastre agency. With the new plans, a deal about the framework and the targets for the future development of BBR and the basic structure was fixed. More then 10 years have passed, but now the changes are being implemented.

The new BBR is expected to be launched during the autumn of 2009.

In the current version of BBR, it is possible to extract information about each property in the register regarding (only information which can be used in the definition of a Danish typical building typology are listed):

Areas

- Total building area
- Total residential area
- Total commercial area
- Build up area
- Number of storeys
- Total area of attic
- Area of unexploited part of attic
- Total basement area
- Basement area with ceiling cote less than 1.25 meters above terrain
- Other areas
- Source for building areas
- Area of in-house garage
- Area of in-house carport
- Area of in-house shed
- Area of patio
- Area of legal residential share of partly exposed basement
- Area of covered terrace
- Area of waste-room at terrain level
- Not covered areas
- Area of finished part of building
- Temporary finished area.

Building constructions:

- Constructional issues
- External walls materials
- Roof covering material

Installations:

- Heating installation
- Heating source (oil, gas, district heating, etc.)
- Energy supply
- Elevators
- Date for energy certificate
- Additional heating

In addition to this, BBR contains information about the main usage of the building divided into:

- Farm houses
- Detached houses
- Terraced house
- Blocks of flats
- Students hostels
- Residential home
- Other whole year dwelling
- Trade/Farm
- Trade/Industry
- Supply plants
- Other production buildings
- Transport
- Office/Trade
- Hotel & service
- Other trade & service
- Culture bldg.
- Education

- Hospitals
- Day care
- Other institutions
- Summer cottages
- Vacation bldg.
- Sport facilities
- Allotments
- Other leisure bldg.

In addition to knowledge about how buildings have been constructed in different periods of time, knowledge about the size of the building stock is vital for establishing the national overview. It should thus be possible to summarise the number and size (build up area and total heated floor area) of buildings in each of the time periods and for each of the evaluated building categories.

Buildings energy performance certification database

All kinds of information collected while performing an inspection to be able to issue an energy certificate are being collected in one central register. Among these kinds of information are:
- Areas of all building constructions and their corresponding U-values
- Heated floor area
- Orientation, thermal and optical properties of all windows including information about shadings
- Type and efficiency of heating supply systems
- Efficiency and size of heating and domestic hot water distribution systems
- Efficiency and areas of renewable energy systems (PV and thermal solar)
- Efficiency and size of lighting armatures (only in case of non-residential buildings).

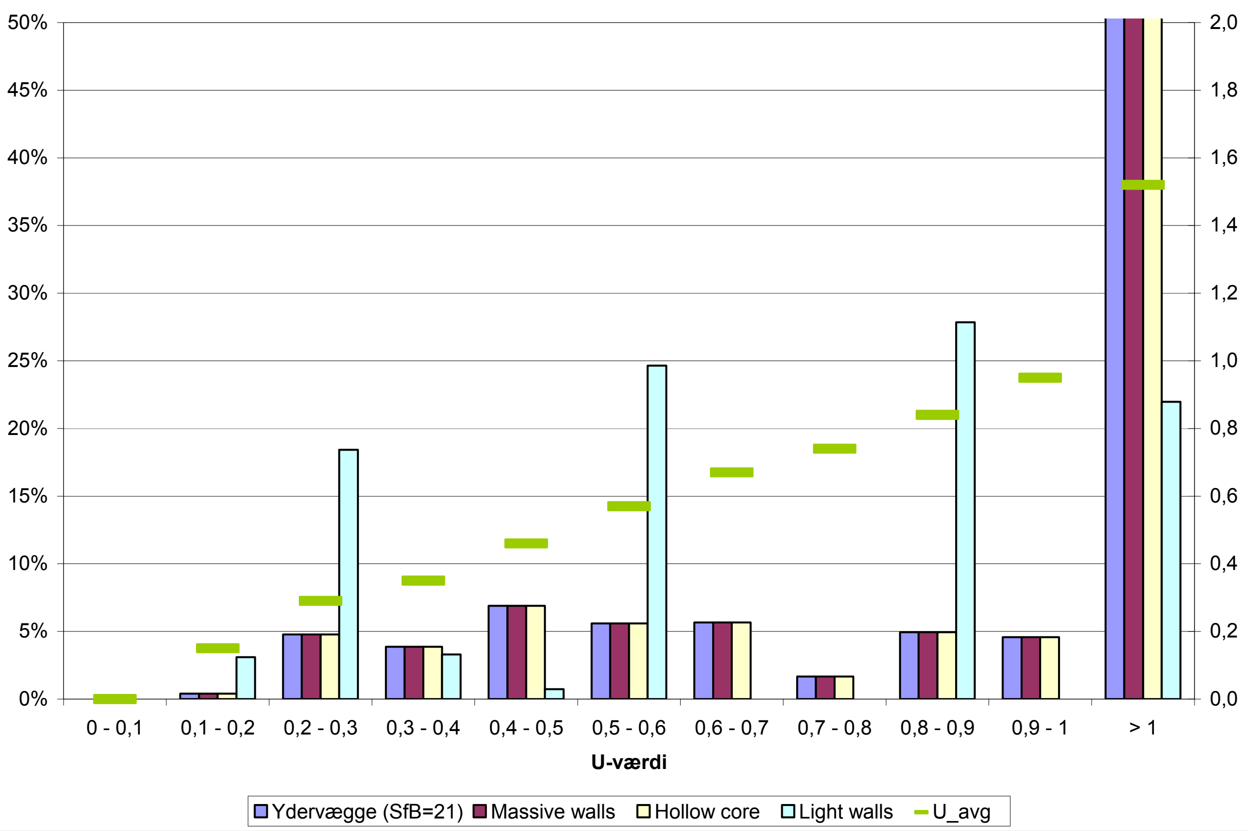
In addition to these pieces of factual information about the building and its envelope, the registered as well as the calculated energy consumption are being stored together with the expert's suggestions for energy saving measures and the matching investments as well as calculated energy savings. Finally there is information about the age of the building and the year for the most recent energy refurbishment.

Energy performance

To be able to evaluate the average energy performance of buildings in the selected categories and construction periods, it is important to know the energy related conditions of existing buildings. The requirements given in the different Building Regulations outlines the minimum requirements, and there are thus many explanations why this differs from the situation in the existing buildings. Among these explanations are:
- previous refurbishments/improvements of the building envelope,
- extensions of the original building, constructed under more rigid regulations than the older sections of the building,
- building regulations have not been followed 100 % (some constructions have better performance than required and some have worse),
- the building was constructed with a better energy performance than required in the Building Regulations at the time of construction.

The energy certification schemes, which according to the EPBD (Energy Performance of Buildings Directive) should bee implemented in all EU Member States (including Norway and Croatia) by now, could give an overview of the real conditions in terms of energy in the existing building stock. The energy certification scheme in Denmark is based on calculated energy performance of all building types. The entire building envelope and all systems in the certified buildings are recorded. This information is being collected in a central database and data can be extracted for other purposes than certification. It is e.g. possible to extract information about areas and energy performance (like U-values) and distribute data according to summarised areas with certain U-values.

Figure 38 Danish example (Wittchen, 2004) on distribution of external wall areas (percentage of the total area on y-axis) with different U-values for blocks of flats constructed in the period 1931-1950.

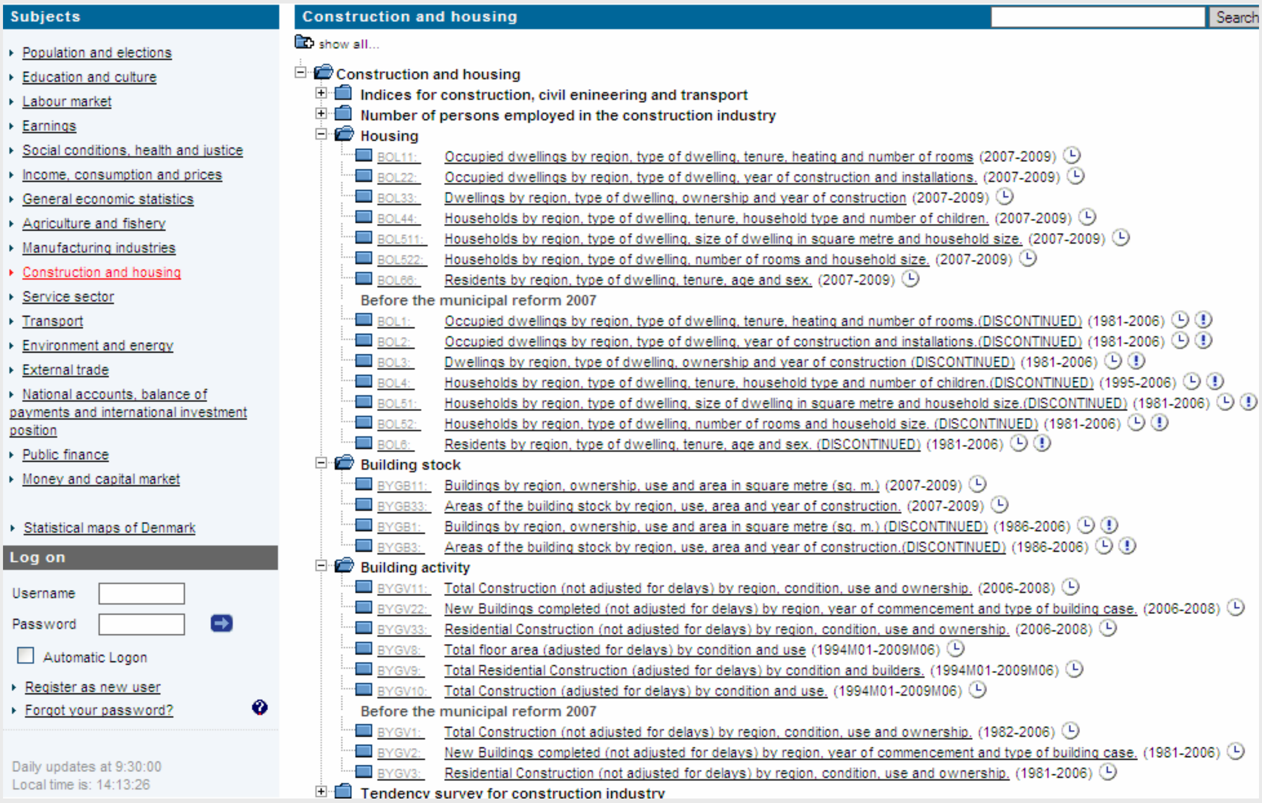


Having this information it is possible to create typical example buildings with information about the average energy performance of each construction (external walls, floors, roofs, windows and doors). From knowledge about the building stock it is further possible to identify the average building size (build up area and floor area) and make representative building models to calculate the energy performance for all buildings within a time period and a building category.

Statistics Denmark

Statistics Denmark provides all kind of statistical information about Denmark and the Danes. Some of the information is for free while other must be paid for. Among the free statistics is information about the Danish building stock as listed in Figure 39. Data are aggregated, but can be used for identifying building typologies.

Figure 39. Screen dump from Statistics Denmark (www.statistikbanken.dk) listing free statistics related to the Danish building stock. Any of the links can be expanded and filtered according to a number of fixed criteria and exported for further processing in a spread sheet tool.



Building typologies

Concerning the choice of representative building types with a high potential for improving their energy performance, a detailed description of the typical building is less crucial than the previous topics. Collection of detailed information may await the development of the renovation scenarios.

Information is needed regarding build up area and heated floor area, which will give the number of floors in the buildings. In addition to this the height of a typical storey is needed to estimate area of the thermal envelope. Last, but not least, there is a need for an estimate of the window area in the typical buildings.

This kind of information can be collected either from knowledge about building tradition or from registrations collected in the building energy certification schemes.

For Danish multi-storey residential buildings between 1850 until 1980 three main types can be identified: older masonry buildings, newer masonry buildings and large panel concrete buildings including different solutions regarding façade design, materials for facades and floors (of importance for thermal bridges and moisture challenges), inclusion of balconies etc. Surveys have been made to identify the most important renovation and retrofit needs, at least for the social housing sector.

Similar knowledge is established concerning Danish single family houses, for which a number of scenarios has been identified (Realea). The photos below illustrate Danish time typical single family detached houses.

Figure 40: Typical Danish detached single family houses constructed in different periods of time of the last century,

Building typologies

The tables below summarises the building typologies for five types (uses) of Danish buildings. From an energy savings calculation point of view these are the distinct typologies to use. Energy performance of the constructions is as registered by the energy performance certificate experts when issuing certificates for these kinds of buildings in the years 2005 to 2008. The typologies are thus representative for the average building and not for the building as it was originally constructed. Relevant U-values for the original buildings can be derived from the handbook for energy experts in the energy certification scheme. The typologies shown in the tables below can thus not be found as a single Danish building with respect to energy performance of constructions, but represents the average of all certified buildings. Regarding areas, the buildings can be considered archetypes for typical Danish buildings.

Table 46: Building typologies for the average Danish single family detached houses (Wittchen, 2009).

Const. per.	1850-1930	1931-1950	1951-1961	1961-1972	1973-1978	1979-1998	1999-2003	Unit
Roof	0.39	0.39	0.32	0.26	0.26	0.20	0.16	W/m²K
Floor	0.37	0.38	0.36	0.30	0.28	0.24	0.21	W/m²K
Windows	2.56	2.50	2.50	2.52	2.48	2.40	1.68	W/m²K
Ext. walls	0.86	0.85	0.84	0.65	0.50	0.37	0.32	W/m²K
Foundation	0.7	0.7	0.7	0.5	0.4	0.3	0.25	W/m²K
Window rebbat	0.2	0.2	0.2	0.2	0.15	0.1	0.03	W/m²K
Window factor	0.15	0.15	0.15	0.15	0.15	0.15	0.22	m²/m²
Air change	0.45	0.45	0.45	0.4	0.4	0.35	0.35	1/h
Avg. dwelling								
Avg. area	109	97	109	141	147	140	153	m²
Floors	1,37	1,37	1,18	1,06	1,09	1,1	1,1	-
Total area	27,720,494	13,715,583	12,984,106	58,239,171	24,662,363	19,954,023	3,295,260	m²

Table 47: Building typologies for the average Danish terraced houses (Wittchen, 2009).

Const. per.	1850-1930	1931-1950	1951-1961	1961-1972	1973-1978	1979-1998	1999-2003	Unit
Roof	0.42	0.57	0.25	0.31	0.30	0.20	0.15	W/m²K
Floor	0.42	0.45	0.37	0.30	0.25	0.24	0.22	W/m²K
Windows	2.58	2.46	2.49	2.47	2.46	2.50	2.08	W/m²K
Ext. walls	1.02	1.00	0.99	0.65	0.54	0.34	0.32	W/m²K
Foundation	0.7	0.7	0.7	0.5	0.4	0.3	0.25	W/m²K
Window rebbat	0.2	0.2	0.2	0.2	0.15	0.1	0.03	W/m²K
Window factor	0.15	0.15	0.15	0.15	0.15	0.15	0.22	m²/m²
Air change	0.45	0.45	0.45	0.4	0.4	0.35	0.35	1/h
Avg. dwelling								
Avg. area	126	136	141	161	170	190	190	m²
Floors	1.58	1.48	1.34	1.17	1.24	1.18	1.14	-
Total area	4,274,696	2,158,505	2,496,762	5,295,321	4,345,944	15,058,172	1,395,602	m²

Table 48: Building typologies for the average Danish farm houses (Wittchen, 2009)

Const. per.	1850-1930	1931-1950	1951-1961	1961-1972	1973-1978	1979-1998	1999-2003	Unit
Roof	0.34	0.42	0.32	0.36	0.26	0.26	0.18	W/m²K
Floor	0.41	0.34	0.37	0.35	0.27	0.33	0.25	W/m²K
Windows	2.59	2.61	2.52	2.70	2.47	2.43	1.57	W/m²K
Ext. walls	0.85	0.88	0.86	0.74	0.51	0.46	0.45	W/m²K
Foundation	0.7	0.7	0.7	0.5	0.4	0.3	0.25	W/m²K
Window rebbat	0.2	0.2	0.2	0.2	0.15	0.1	0.03	W/m²K
Window factor	0.15	0.15	0.15	0.15	0.15	0.15	0.22	m²/m²
Air change	0.45	0.45	0.45	0.4	0.4	0.35	0.35	1/h
Avg. dwelling								
Avg. area	177	163	158	175	200	195	202	m²
Floors	1.25	1.38	1.38	1.21	1.26	1.28	1.27	-
Total area	18,742,799	2,447,616	844,046	905,720	720,323	1,081,746	1,081,746	m²

Table 49: Building typologies for the average Danish blocks of flats (Wittchen, 2009).

Const. per.	1850-1930	1931-1950	1951-1961	1961-1972	1973-1978	1979-1998	1999-2003	Unit
Roof	0,45	0,54	0,37	0,44	0,30	0,18	0,15	W/m²K
Floor	0,45	0,48	0,51	0,39	0,27	0,24	0,20	W/m²K
Windows	2,72	2,68	2,69	2,48	2,58	2,41	1,80	W/m²K
Ext. walls	1,10	1,16	1,00	0,93	0,52	0,36	0,20	W/m²K
Foundation	0,7	0,7	0,7	0,5	0,4	0,3	0,25	W/m²K
Window rebbat	0,2	0,2	0,2	0,2	0,15	0,1	0,10	W/m²K
Window factor	0,15	0,15	0,15	0,2	0,2	0,25	0,25	m²/m²
Air change	0,7	0,7	0,7	0,7	0,7	0,6	0,60	1/h
Avg. dwelling								
Avg. block area	403	623	1272	1918	2155	1071	1093	m²
Floors	2.56	2.55	2.77	2.96	2.73	2.47	2.60	-
Total area	25,853,236	15,524,999	8,343,348	14,934,299	4,759,225	8,413,509	397,889	m²

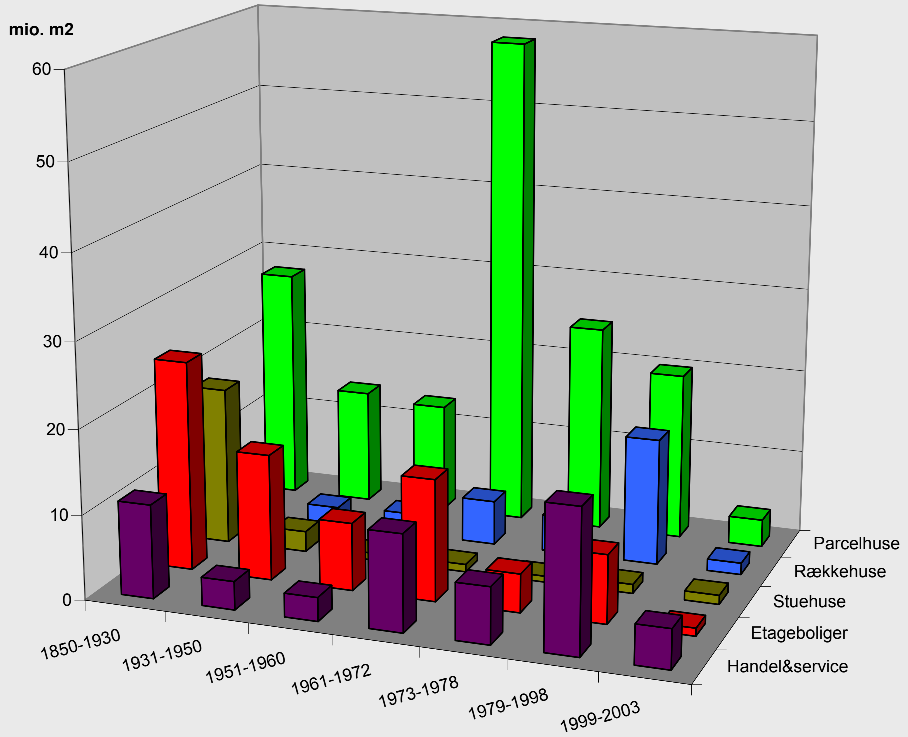
Table 50: Building typologies for the average Danish office and trade buildings (Wittchen, 2009).

Const. per.	1850-1930	1931-1950	1951-1961	1961-1972	1973-1978	1979-1998	1999-2003	Unit
Roof	0,40	0,29	0,33	0,37	0,29	0,25	0,15	W/m²K
Floor	0,56	0,49	0,51	0,42	0,55	0,55	0,20	W/m²K
Windows	2,60	2,62	2,51	2,62	2,46	2,54	1,80	W/m²K
Ext. walls	1,04	1,17	1,08	0,69	0,50	0,39	0,20	W/m²K
Foundation	0,7	0,7	0,7	0,5	0,4	0,3	0,25	W/m²K
Window rebbat	0,2	0,2	0,2	0,2	0,15	0,1	0,10	W/m²K
Window factor	0,15	0,15	0,15	0,2	0,2	0,25	0,25	m²/m²
Air change	0,7	0,7	0,7	0,7	0,7	0,6	0,60	1/h
Total floor area	11,094,000	3,351,000	2,788,000	11,406,500	6,668,100	16,881,400	4,634,000	m²

Floor areas

The floor areas for the different building types can be summarised as in the figure below.

Figure 41: Floor areas in Danish buildings constructed in time-typical periods for five different building types (trade and service; blocks of flats; farm houses, terraced houses; detached houses).



Building materials

Knowledge about building materials used as exterior coverage of the thermal envelope can give an indication on the cost for improving the thermal proper-ties of a building element. The used building material can also give an idea about which refurbishment measure would be the most applicable for the building. This information can in Denmark be found in the Building and Dwelling stock Register - at least for the materials used when the building was constructed.

Energy systems

Having established a common knowledge about the building envelope, in-formation about the technical installations is the buildings is essential to be able to evaluate the energy performance of the building stock and suggest applicable energy saving measures. Among the energy systems we need to collect information about are ventilation and heating systems incl. energy supply and available space for installations and ductworks.

In Denmark, information about energy supply for buildings is found in the Building Stock register where information about the primary and the secondary energy source for a property are available. In addition to this the Danish Energy Agency collects information about energy consumption in Denmark and divides it into consumptions in different categories of buildings summarised for each energy carrier (natural gas, fuel oil, district heating etc.).

Information on the national policy for energy supply is needed including scenarios including the expected CO_2 emissions from the future supply of electricity and district heating; e.g. for the Copenhagen area, the CO_2 emission for district heating is expected to be reduced to 10-25 kg CO_2/GJ in 2025 compared to 31 kg CO_2/GJ in 2007.

Table 51: Literature / sources Denmark

[Wittchen, K.B. 2009]	Survey of potential energy savings in 5 types of Danish buildings (in Danish).	Wittchen K.B. (2009) Potentielle energi-besparelser i det eksisterende byggeri. SBi 2009:05. Statens Byggeforskningsinstitut, Aalborg Universitet.
[Wittchen, K.B. 2004]	Survey of potential heating savings in 4 residential building types in Denmark (In Danish, with draft English translation).	Wittchen K.B. (2004). Vurdering af potentialet for varmebesparelser i eksisterende boliger. Dokumentation 057. ISBN: 87-563-1202-4. Statens Byggeforskningsinstitut, Hørsholm.
[Wittchen, K.B. et. al. 2009]	Identification of potential building typologies in Nordic countries (Draft).	Wittchen K.B. (ed), (2009). Building typologies in the Nordic countries. Danish Building Research Institute, Aalborg University, Hørsholm.
[Aude et. al.]	Identification of time-typical Danish detached houses (In Danish).	Danskernes huse. Aude B. Lundgaard B. Rotne G. & Sørensen P. Danskernes huse. Energispare-udvalget.
[Engelmark, 1983]	Description of old blocks of flats in the major cities of Denmark (In Danish).	Engelmark (1983).Københavnsk etagebolig-byggeri 1850-1900. Danish Building Research Institute, Hørsholm.
[Munch J, 2008]	Examples on how to improve the insulation level in older blocks of flats (In Danish).	Munch J. (2008). Efterisolering af etageboliger. SBi direction 221. Danish Building Research Institute, Aalborg University, Hørsholm.

3 Experiences in Non-Participating Countries

In the last chapter the TABULA partners described the experiences with building typologies in their own countries. In the following the view will be extended to countries not directly involved in TABULA. The necessary enquiries have been performed by distinct TABULA partners on the basis of personal contacts, available literature, brochures, websites etc.:

for Cyprus by NOA, for Estonia by STU-K, for Finland by POLITO, for Hungary by AEA, for Latvia by SBi, for Lithuania by NAPE, for Luxembourg by IWU, for Portugal by NOA, for Romania by SOFENA, for Spain by Energy Action, for the Netherlands by VITO, for the United Kingdom by ADEME/IWU and for Switzerland by IWU.

3.1 Cyprus

The main source of information on the building stock in Cyprus is the National Statistics Institute (www.mof.gov.cy/mof/cystat) where data are gathered on an annual basis (construction and housing statistics) and after the Censuses (1992 and 2001 currently available in electronic format).

The latest report on the Census 2001 includes data on the residential building sector regarding building types, size and amenities of dwellings, tenure status as well as types and sizes of households. Results are given comparatively to the Census of 1992 for the five main districts of Cyprus, namely: Nicosia, Larnaka, Ammochostos, Lemesos and Paphos. For each of the above districts results are given for urban and rural areas (Table 32 [1]).

Table 52: Extract from the Census 2001 report of the National Statistics Institute of Cyprus [1]

ΠΙΝΑΚΑΣ II. ΚΑΤΟΙΚΙΕΣ, ΚΑΤΟΙΚΗΜΕΝΕΣ ΚΑΤΟΙΚΙΕΣ, ΚΑΝΟΝΙΚΕΣ ΚΑΤΟΙΚΙΕΣ ΚΑΙ ΚΑΤΟΙΚΗΜΕΝΕΣ ΚΑΝΟΝΙΚΕΣ ΚΑΤΟΙΚΙΕΣ ΚΑΤΑ ΕΠΑΡΧΙΑ ΚΑΙ ΑΣΤΙΚΗ/ΑΓΡΟΤΙΚΗ ΠΕΡΙΟΧΗ, ΣΤΙΣ ΑΠΟΓΡΑΦΕΣ 1992 ΚΑΙ 2001

TABLE II. HOUSING UNITS, OCCUPIED HOUSING UNITS, CONVENTIONAL DWELLINGS AND OCCUPIED CONVENTIONAL DWELLINGS BY DISTRICT AND URBAN/RURAL AREA AS AT 1992 AND 2001 CENSUSES

Επαρχία District	1992				2001			
	Κατοικίες Housing units	Κατοικη-μένες κατοικίες Occupied housing units	Κανονικές κατοικίες Conventional dwellings	Κατοικη-μένες κανονικές κατοικίες Occupied Conventional dwellings	Κατοικίες Housing units	Κατοικη-μένες κατοικίες Occupied housing units	Κανονικές κατοικίες Conventional dwellings	Κατοικη-μένες κανονικές κατοικίες Occupied Conventional dwellings
Σύνολο - Total	**233.210**	**150.442**	**231.930**	**183.743**	**293.985**	**223.444**	**292.934**	**222.393**
Αστική - Urban	**149.363**	**75.221**	**148.567**	**124.312**	**189.258**	**155.687**	**188.649**	**155.078**
Αγροτική - Rural	**83.847**	**75.221**	**83.363**	**59.431**	**104.727**	**67.757**	**104.285**	**67.315**
Λευκωσία-Lefkosia	86.516	75.221	86.119	74.824	104.958	89.225	104.535	88.802
Αστική - Urban	60.855	54.941	60.582	54.668	75.341	66.977	75.070	66.706
Αγροτική - Rural	25.661	20.280	25.537	20.156	29.617	22.248	29.465	22.096
Αμμόχωστος-Ammochostos	14.532	8.944	14.444	8.856	18.975	11.602	18.899	11.526
Αγροτική - Rural	14.532	8.944	14.444	8.856	18.975	11.602	18.899	11.526
Λάρνακα-Lamaka	38.083	29.941	37.799	29.657	48.953	36.254	48.848	36.149
Αστική - Urban	23.829	18.445	23.644	18.260	30.317	22.810	30.257	22.750
Αγροτική - Rural	14.254	11.496	14.155	11.397	18.636	13.444	18.591	13.399
Λεμεσός-Lemesos	69.626	53.898	69.358	53.630	85.898	64.232	85.637	63.971
Αστική - Urban	50.821	41.839	50.596	41.614	62.389	51.183	62.222	51.016
Αγροτική - Rural	18.805	12.059	18.762	12.016	23.509	13.049	23.415	12.955
Πάφος-Pafos	24.453	17.019	24.210	16.776	35.201	22.131	35.015	21.945
Αστική - Urban	13.858	9.883	13.745	9.770	21.211	14.717	21.100	14.606
Αγροτική - Rural	10.595	7.136	10.465	7.006	13.990	7.414	13.915	7.339

The total number of residential dwellings is 292,934 of which 75.9% are occupied [1]. Data on the year of construction of the current conventional dwellings, illustrate that only 15% have been constructed prior to 1960, while most of the existing dwellings (75%) have been constructed between 1971-2001. A total of 21,692 buildings (7.4%) date before 1945, thus their age exceeds 56 years [2]. About 35,829 conventional dwellings were built from 1996–2001 [3]. During the inter-census period 1992-2001 the stock of conventional dwellings increased by 26.3%, 27.0% in urban areas and 25.1% in rural.

Residential buildings are classified in six categories, specifically:

- single detached houses (124,526 or 42.5% of the total),
- semi detached houses (47,752 or 16.3%),
- row houses (28,605 or 9.8%),
- back yard houses (9,519 or 3.2%),
- apartment blocks (60,042 or 20.5%),
- partly residential buildings (21,844 or 7.5%).

Apartment blocks recorded the highest inter-censal increase (52.8%) followed by semi detached (34.5%) and single detached houses (24.0%). Back-yard houses recorded decrease [1].

Comparing the type of dwellings in urban and rural areas shows that the percentage of single detached houses is by far higher in rural than in urban areas, whilst the percentage of apartment blocks is greater in urban than in rural areas. In urban areas the number of apartments is very close to the number of the single detached houses [1].

The **typical housing construction** system in Cyprus comprises the use of reinforced concrete for the load bearing part of the building, which is completed by masonry walls. Reinforced concrete, from foundations to the roof is mandated due to the high seismic activity of the region. Detailed construction regulations were adopted in the beginning of the 90´s. The typical filling of multi-story family houses comprises of brick walls (20 or 25 cm for the outer walls and 10 cm for the inner walls) that are plastered with 2-2,5 cm on either side [4].

The roofs are usually flat concrete slabs, which are covered with light concrete or screed of 50-100 mm for thermal insulation and on top with an asphalt layer of 2-5 mm, for moisture insulation. The last 5-10 years some multi-storey family houses appeared to form a different top finish with a complete or partial pitched roof. The vast majority of windows are single glazed (4-5 mm) with aluminium frames whereas a considerable proportion of multi-story family houses, especially after 1980 have double glazed windows [4].

For heating, the majority (33.4%) of conventional dwellings use gas stoves. Gas, electric or kerosene stoves are used in half of the dwellings. The percentage of dwellings with central heating has more than doubled since 1992 and has reached 27.3%. Also popular is the use of heat pump split units for urban areas and fireplaces for rural areas. Storage heaters are used mainly in urban (6.8%) compared to rural areas (2.9%). About 1.9% of the dwellings have no heating facilities of any type, 1.7% in urban and 1.8% in rural areas [1].

Solar water heating is very common in Cyprus. In 87.6% of the dwellings solar energy is used for hot water production (88.3% in urban and 86.1% in rural areas) and 0.6% of the dwellings use solar energy for both space heating and hot water production [1].

Data on the evolution of the building stock after the census of 2001 can be drawn from the annual reports of Construction and Housing statistics regularly published by the National Statistics Institute. In the most recent one [5], it is reported that by the end of 2008 the number of new dwellings completed increased by 10.3% to 18,195 dwelling units compared to 16,501 in the previous year. By district, the number of new dwellings is distributed as follows: Nicosia 4,788, Ammochostos

1,847, Larnaka 3,575, Limassol 3,981 and Paphos 4,004. The average area per dwelling completed in 2008 was 199 m^2 for houses and 118 m^2 for apartments, compared to 191 and 117 respectively in 2007. The dwelling stock at the end of the year amounted to 374,000 dwelling units, of which 63.1% were in the urban areas [5].

The harmonization of Cyprus with the Directive 2002/91/EC - Energy Performance of Buildings (EPBD) began with Law N142(I)/2006 and a number of regulations. The application of the thermal insulation regulation became mandatory in December 2007 and is regarded as a prerequisite for issuing a new building permit. The Ministry of Commerce, Industry and Tourism of the Republic of Cyprus (MCIT, www.mcit.gov.cy) has the overall responsibility to implement and monitor the national EPBD implementation. The Department of Energy of the Ministry is responsible for the organisation, management and control of the system for the energy certification of buildings.

The enactment of the legislation concerning the minimum energy requirements for all new buildings and existing buildings exceeding 1000 m^2 total useful floor area undergoing major renovation was introduced in December 2007. Enforcement was initiated in January 1st 2010 for residential buildings. Accordingly, when submitting the final design drawings, the designer should submit to the local authorities a set of the energy performance calculations proving compliance with the minimum requirements published by the Ministry [6] and an Energy Performance Certificate (EPC) that certifies the building is rated as B class or higher. Buildings with construction permits applied for before December 31, 2009 are excluded. The requirement of issuing EPCs during financial transactions (selling or renting of buildings) although mandatory is not officially monitored, thus actual progress is limited for the time being. About 200 auditors/energy experts have been certified for issuing EPCs of residential buildings. Certification of energy experts for non-residential buildings is still pending.

A total of 100 EPCs for residential buildings have been issued during the first two months of 2010. Among these, 95% concerns new constructions. No EPCs have been issued yet for non-residential buildings. All EPCs are submitted to the Department of Energy at MCIT.

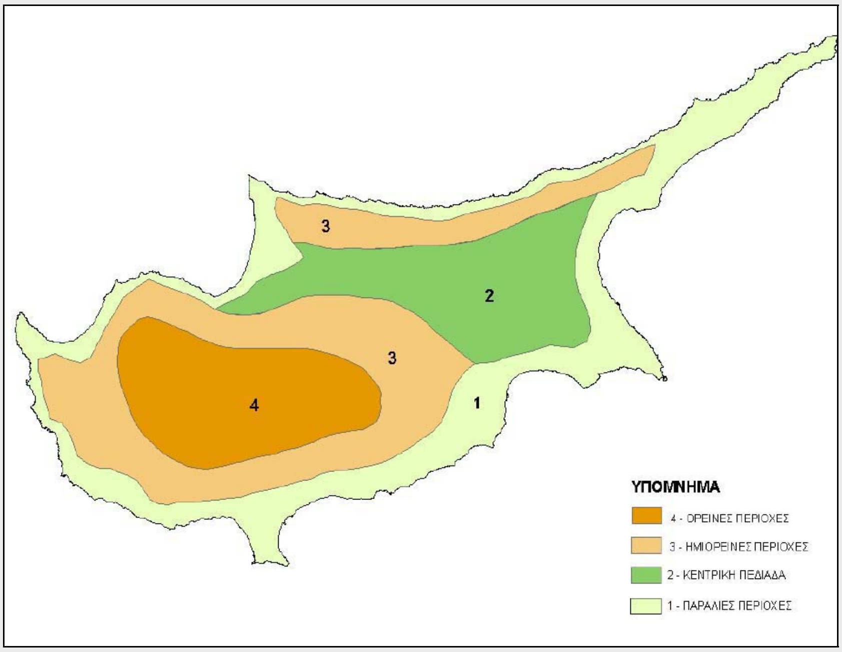
A relevant research project "Classification of buildings in Cyprus based on their energy performance" (www.epbd-project.com) is currently underway and it will be concluded by June 2010. It is funded by the Research Promotion Foundation of Cyprus. The main targets of the project are:

- To record and evaluate the energy performance (energy demand) of the residential building stock of Cyprus and the correlation of the energy demand with various parameters (age, zone, size etc)
- To suggest the number of the energy classes in the EPC and the upper and lower limits (kWh/m^2.y) of these classes
- To give specific proposals and a timeframe for the re-establishment of these limits
- To suggest cost effective measures or targeted actions for the improvement of the energy performance of buildings.

Analysis of data from Census 2001 permitted the classification of the Cypriot residential building stock according to four parameters, specifically: climatic zone, building type, age and size.

The Dept. of Energy of MCIT has defined 4 climatic zones in Cyprus, covering different regions of the island (Figure 72).

Figure 42: Climatic zones in Cyprus [7]



1. Coastal area
2. Low land area
3. Semi mountainous area
4. Mountainous area

Table 53 summarizes the main building categories per key-parameter and the corresponding share of the building stock.

Table 53: Preliminary results of the project "Classification of buildings in Cyprus based on their energy performance", Report 1: Characteristics of the 500 housing units sample (in Greek), WP3, Deliverable 1 (www.epbd-project.com)

<table>
<tr><th colspan="60">CLASSIFICATION OF RESIDENTIAL BUILDING STOCK</th></tr>
<tr><th colspan="60">Climatic zone</th></tr>
<tr><th colspan="15">1 (coastal)</th><th colspan="15">2 (low land)</th><th colspan="15">3 (semi Mountain-ous)</th><th colspan="15">4 (mountainous)</th></tr>
<tr><td colspan="15">54%</td><td colspan="15">27%</td><td colspan="15">16%</td><td colspan="15">3%</td></tr>
<tr><th colspan="60">Building type</th></tr>
<tr><th colspan="12">Single Family</th><th colspan="12">Duplex</th><th colspan="12">Apartment</th><th colspan="12">Multi use</th><th colspan="12">Row Houses</th></tr>
<tr><td colspan="12">44%</td><td colspan="12">17%</td><td colspan="12">21%</td><td colspan="12">8%</td><td colspan="12">10%</td></tr>
<tr><th colspan="60">Construction period</th></tr>
<tr><th colspan="20">prior to 1960</th><th colspan="20">1961-1990</th><th colspan="20">1990 -2010</th></tr>
<tr><td colspan="20">14%</td><td colspan="20">61%</td><td colspan="20">25%</td></tr>
<tr><th colspan="60">Building size (number of rooms)</th></tr>
<tr><th colspan="20">< 3</th><th colspan="20">3 to 6</th><th colspan="20">>6</th></tr>
<tr><td colspan="20">12%</td><td colspan="20">68%</td><td colspan="20">20%</td></tr>
</table>

References

[1] A. Census of population 2001 – Vol III: Households and Housing Units

[2] Pancyprian Welfare Council, National Report on Homelessness and Housing exclusion in Cyprus, prepared for FEANTSA, April 2004.

[3] http://www.nationsencyclopedia.com/Asia-and-Oceania/Cyprus-HOUSING.html

[4] Lapithis P., C. Efstathiades and G. Hadjimichael, State of the art: Cyprus, Cost C16 project “Improving the quality of existing urban building envelopes, 2002, TU Delft Faculty of Architecture dept. of Restoration and Renovation, www.CostC16.org

[5] CYSTAT, “Construction and Housing Statistics, 2008″. http://www.news.cyprus-property-buyers.com/2010/02/12/construction-housing-statistics-2008/id=003905

[6] Constantinos Xichilos, Implementation of the EPBD in Cyprus: Status June 2008, Ministry of Commerce, Industry & Tourism (MCIT), P130 18/7/2008, www.buildingsplatform.eu

[7] C.N Maxoulis, S. A. Kalogirou, G. Panayiotou, G. A. Florides, A.M Papadopoulos, M. Neophytou, P. Fokaides, G. Georgiou, A. Symeou, G. Georgakis, Classification of residential buildings in Cyprus based on their energy performance Renewable Energy Sources and Energy Efficiency Conference, 22&23/10/2009, Nicosia, Cyprus

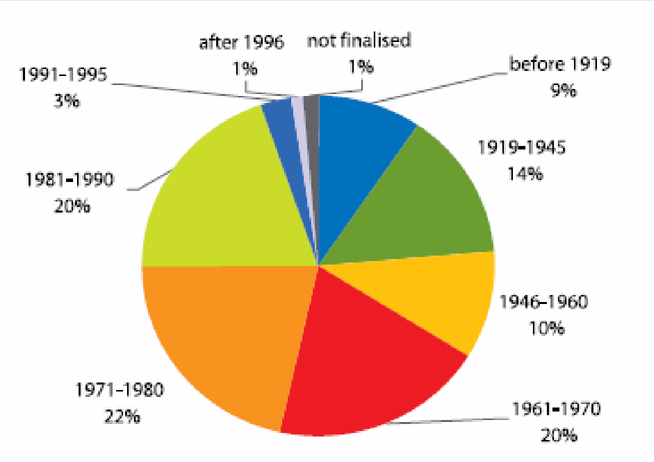
3.2 Estonia

Estonia presents the following housing situation for its 1.330.000 inhabitants (2006).

- 633'100 dwellings (38.4 mio m²)
- 28.5 m² per inhabitant
- 21'000 apartment buildings
- 136'000 single family houses
- over 95% privately owned

From the age point of view, the housing stock is structured as follows:

Figure 43



So far, it looks that a national residential building typology as it is defined in the TABULA project has not been developed in Estonia. There is however a national database of buildings with their year of completion and living area, in Estonian language on the following website: http://www.ehr.ee/

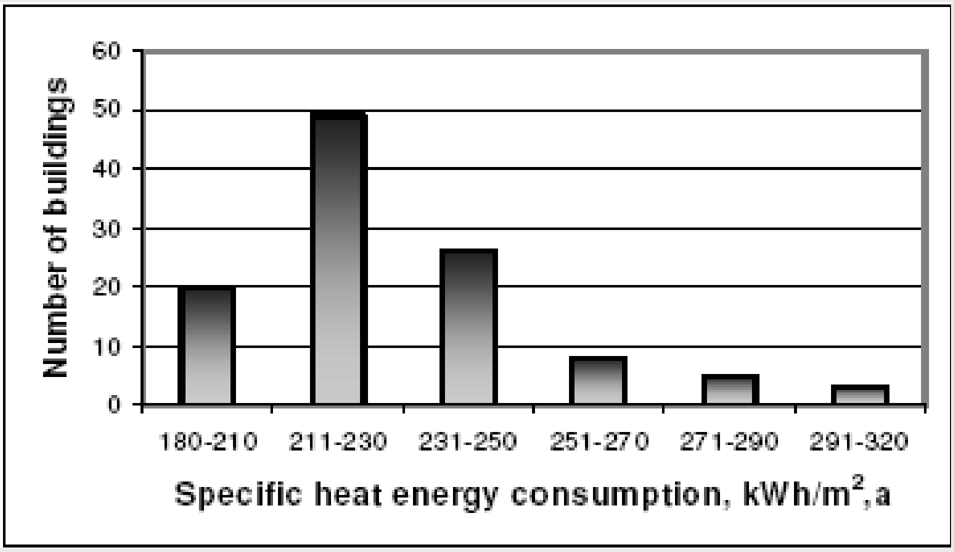
In December 2007, the Government approved the regulation on minimum energy performance requirements of buildings. This was the first time mandatory criteria for efficient use of energy in buildings were applied in Estonia since the restoration of independence in 1991. Until the end of 2007, energy efficiency criteria were used on a voluntary basis. The regulation on minimum energy performance requirements applies to new buildings as well as existing buildings, and it transposes articles 3 – 6 of the EPBD. This new regulation should help to classify any building according to its energy performance level.

Apartment blocks:

About 2/3 of people in Estonia live in apartment buildings. The majority (84 %) of Estonian apartment buildings have been constructed during the years 1945-1990. First apartment buildings composed of precast concrete elements were constructed at the beginning of 1960 when the production technology was imported from France and the design was made by a central designing institute in Moscow. The same solutions were widely used in many parts of the Soviet Union, with only few local changes made. So this important share of the housing stock is quite well documented. But low requirements for thermal performance in construction standards, poor quality of construction materials and technologies and neglected maintenance are the main reasons why most of these buildings fail to meet today's energy performance standards and why it is hard to classify them.

Following data were received from Tallinn University who made an assessment of some 5 storey apartment buildings in different conditions.

Figure 44: Dispersion of annual specific heating energy consumption in Estonian multi-storey apartment buildings connected to district heating networks



Solutions of different structure and building systems are calculated to find out the reliability of energy performance values for apartment buildings:

Version A. Existing validated building (envelope not corresponding to contemporary requirements – walls, roof; non-insulated basement floor; windows, balcony doors partly replaced; external doors replaced; no thermostatic valves installed to heating radiators; natural ventilation);

Version B. Partly renovated building in standard-use conditions (insulated side walls, roof; windows, balcony doors replaced; thermostatic valves installed to heating radiators; mechanical exhaust ventilation);

Version C. Fully renovated building in standard-use conditions (insulated walls, roof; windows, balcony doors replaced; thermostatic valves installed to heating radiators; de-centralized mechanical ventilation with heat recovery of exhaust air);

Version D. Building structures meet the requirements according to the Estonian standard EVS 837-1:2003.

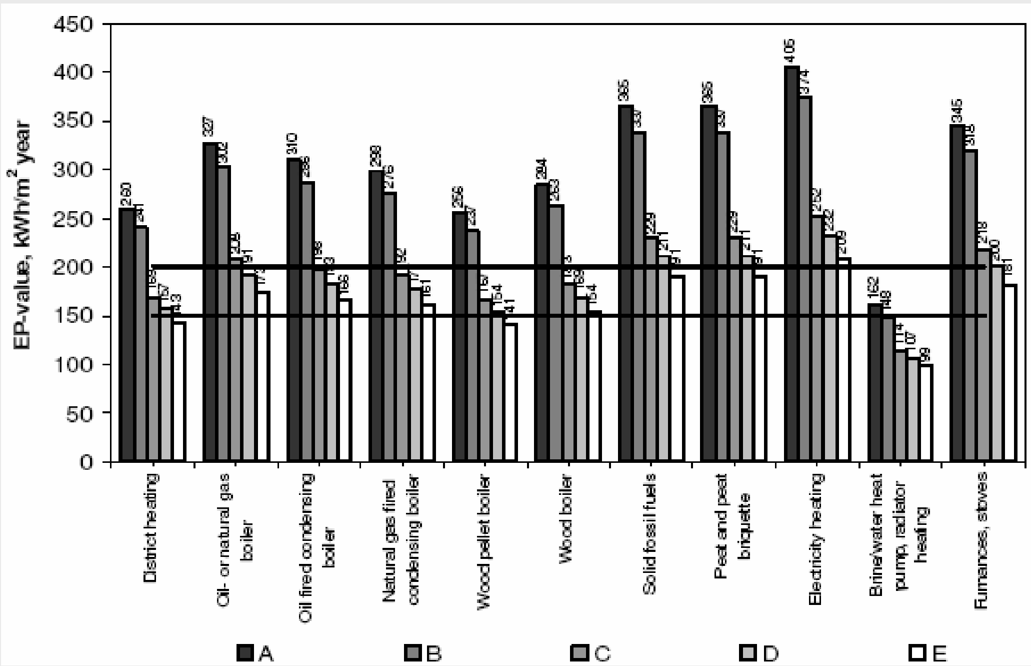
Version E. Low energy consuming building in standard-use conditions.

The annual specific energy consumption was calculated for each version. The calculations of the EP-values were based on efficiencies of heating systems and coefficients for primary energy consumptions.

Table 54

	Version				
	A	B	C	D	E
Thermal conductivity U, W/(m²·K)					
External wall	1,0	0,3	0,3	0,24	0,1
Roof	0,8	0,27	0,27	0,19	0,08
Floor	0,6	0,6	0,6	0,31	0,13
Windows	2,5	1,7	1,7	1,2	0,6
Exterior doors	0,8	0,8	0,8	0,6	0,4
Balcony doors	1,7	1,7	1,7	1,7	0,6
Air tightness of building envelope q_{50}, m³/(h·m²)	4	3	3	3	0,6
Ventilation air change rate, 1/h	0,3	0,42	0,42	0,42	0,42
Heat recovery temperature efficiency	0	0	0,6	0,6	0,85
Exhaust air min temperature, °C	-	-	5 °C	5 °C	0 °C

Figure 45



Results of EP-value for apartment building (horizontal lines represent EP requirements for new and existing buildings: 150 and 200 kWh/m²year

An overview of the housing in Rakvere, 7th biggest city of Estonia, 100km from Tallinn, is available about the apartment building over the 1960-1990 period.

<u>Period 1960-1970</u> – Silicate bricks houses, (Koidula, Küti, Jaama str,)

- Specific energy consumption: 271 kWh/m2
- The exterior walls are made with silicate bricks, precast concrete slabs are used for the floors,
- Non-bearing walls are made of bricks with concrete elements

- Buildings have flat roofs with 50 mm of sand or stone dust, sawdust or glass wool insulation.
- Buildings are standardized "blocks" without elevator with a number of floors limited to 2 - 5.



<u>Period 1971-1980</u> –Prefabricated small block apartment buildings

- Specific consumption: 279,5 kWh/m2
- The exterior walls are prefabricated smaller blocks and the floors are concrete panels,
- Non-bearing walls are in concrete block or silicate bricks
- Buildings have mostly flat roofs with 50 mm of stone dust or sand insulation layer.
- Buildings are standardized “blocks” without elevator with a number of floor limited to 5



<u>Period 1981-1990 1st type</u> – 3 floors small panel houses. Prefabricated small blocks apartment buildings

- Specific energy consumption: 294,5 kWh/m2
- The exterior walls and the floors are prefabricated smaller panels
- Non-bearing walls are small plocks and brick
- Buildings have flat roofs or roofs terraces with insulation (5m mm of glas fiber or flat roof covered with waterproofing felts).
- Buildings are standardized "blocks" without elevator with a number of floors limited to 3.

1981-1990 2nd type – Narva 5 floors large panel houses - Apartment buildings

- Specific energy consumption: 267 kWh/m2
- The exterior walls and the floors are in prefabricated panels,
- Non-bearing wall are in smaller plocks
- Buildings have flat roofs covered with 50 mm insulation and waterproofing layer..
- Buildings are standardized "blocks" without elevator with a number of floors limited to 5.

Detached Houses:

Information about 1990's detached houses are available from the analysis provided by the Technical University of Tallinn.

Scenarios of different building envelope and HVAC systems were simulated to define the reliability of energy performance values for detached houses:

Scenarios A: Typical detached house from the early 1990-s: sufficient thermal transmittance and air tightness of the building envelope; exhaust ventilation;

Scenarios B: Typical detached house from the end of the 1990-s: building envelope meets the requirements according to the Estonian standard EVS 837-1:2003; exhaust ventilation;

Scenarios C: Typical detached house from the end of the 1990-s with improved ventilation: building envelope meets the requirements according to the Estonian standard EVS 837-1:2003; supply-exhaust ventilation with heat recovery;

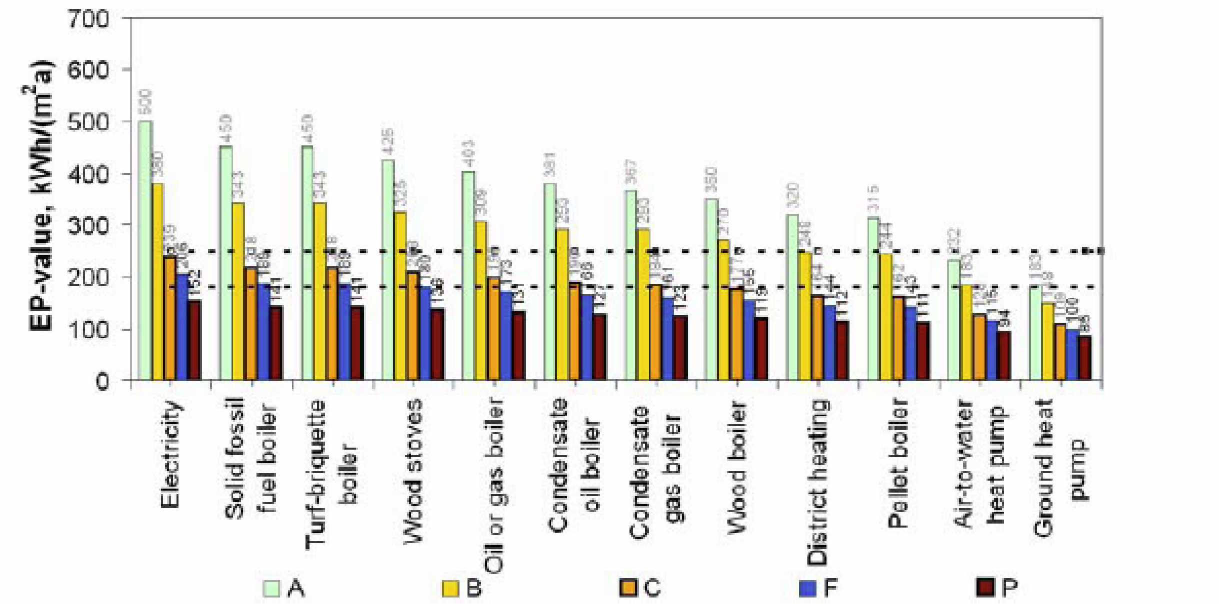
Scenarios F: Thermal transmittance of the building envelope represents the requirements of the Finnish building regulations 2010; supply-exhaust ventilation with heat recovery;

Scenarios P: Ultra-low energy detached house; supply-exhaust ventilation with heat recovery.

Table 55

	Building envelope and HVAC system scenarios				
	A	B	C	F	P
	Thermal transmittance U, W/(m^2·K) of the building envelope				
External walls	0.36	0.23	0.23	0.17	0.07
Roof	0.28	0.18	0.18	0.09	0.06
Floor (slab on ground)	0.28	0.18	0.18	0.16	0.08
Doors	1.0	0.7	0.7	0.7	0.4
Window: glazing / frame	2.7 / 2.0	1.2 / 1.4	1.2 / 1.4	1.0 / 1.1	0.5 / 1.1
	Solar properties of the windows				
Solar heat gain coefficient of windows, g	0.76	0.58	0.58	0.53	0.50
Solar transmittance, T	0.69	0.53	0.53	0.46	0.40
	Air tightness of the building envelope				
Air leakage value q_{50}, m^3/h m^2	9.0	3.0	3.0	3.0	0.6
	Properties of the ventilation systems				
Ventilation heat recovery efficiency	0	0	0.8	0.8	0.8
Specific fan power (SFP), W/(l/s)	1	1	1.5	1.5	1.5
Min. achievable leaving air temperature, °C	-	-	0	0	0
Supply/exhaust airflow ratio	1	1	1	1	1

Figure 46



EP-values for different building envelope and HVAC system scenarios (A-P) combined with 12 heating solutions. Primary energy factor for electricity: 1.5

As a general observation, in Estonia, most of the buildings are private ownership (each apartment has a different owner), so even if old buildings are far from the EPBD it seems hard to demolish them. Therefore a huge number of prefabricated buildings should be renovated in Estonia, even though the renovation process is hard because all owners have to agree before.

Sources:

[1] Proceedings of Healthy Buildings 2009 – Paper 409 – Determination of energy performance require for apartment buildings in Estonia – Allan Hani, Targo Kalamees, Teet-Andrus Koiv – Tallinn University of Technology.

[2] Evaluation of thermal bridges of prefabricated concrete panal apartment buildings in Estonia – S.Ilomets, T.Kalamees, L.Paap – Tallinn University of Technology and Tallinn University of Applied Sciences.

[3] Analysis of energy use in detached houses to determin energy performance requirements in Estonia - S.Ilomets, T.Kalamees, Teet-Andrus Koiv – Tallinn University of Technology

[4] Implementation of the EPBD in Estonia: Status and planning – May 2008 - Madis Laaniste Ministry of Economic Affairs and Communications

[5] ESAM reports n°2 in November 2007 – Esam pilot sites Czech Republic and Estonia.

3.3 Finland

Considering the experience in building constructions and energy efficiency, and the involvement in data-bases of existing buildings and national building typologies, the following bodies have been contacted in Finland:

Body	Internet address
Association of Finnish Architects' Offices	www.atl.fi
Finnish Population Register Centre	www.vaestorekisterikeskus.fi
Finnish Union of Municipalities	www.kunnat.net
MEVISION Group	www.mevisiongroup.fi
Ministry of Employment and the Economy	www.tem.fi
Ministry of the Environment	www.ymparisto.fi
Motiva (Centre for promoting energy saving)	www.motiva.fi
Tampere University of Technology	www.tut.fi
VTT (Technical research centre of Finland)	www.vtt.fi

In Finland, the main source of data for building typology analysis is the "Population Register Centre" that provides information on the basis of data contained in the Population Information System. The Population Information System is the most used national base register in Finland and it has been designed specifically to serve both government information needs and for academic research. It shows not only information about persons. In fact, the Population Information System also contains data on buildings. In particular, it stores information about more than three million buildings and nearly three million residences. Building information, commonly referred to as the Building and Dwelling Register (BDR), is maintained and checked in close cooperation with municipal building supervision authorities and local register offices.

Figure 47: Web site of the "Population Register Centre"

The continuous up date of the building information is guaranteed but the activities of the local authorities: the local register offices maintain residence details related to persons and their respective residences and they are also responsible for various changes and corrections to building information.

With reference to the information about buildings and their construction projects, the following data are recorded:

- Real estate and building code
- Addresses of the building
- Location coordinates
- Municipal sub-area
- Name and address of the owner
- Type of owner (for example person, housing corporation, municipality or the state)
- Planning situation when building permit was granted (for example master plan, building plan or no plan)
- Site ownership status (owner-occupied or rented)
- Size (for example gross floor area and number of storeys)
- Facilities (for example lift, sauna or swimming pool)
- Year of construction
- Purpose of use (for example detached house, terraced house, block of flats, summer cottage or school)
- Network connections (incl. sewerage, water and electricity)
- Building permits granted
- Contact details of those granted building permits
- Construction and facade material (for example wood, concrete or glass)
- Method of heating (for example oil, electric or wood heating)
- Fuel (for example oil, electricity, wood or geothermal energy)
- Number of apartments
- Residents in the building

Referring specifically to residential buildings, the following data are registered in the Population Information System:

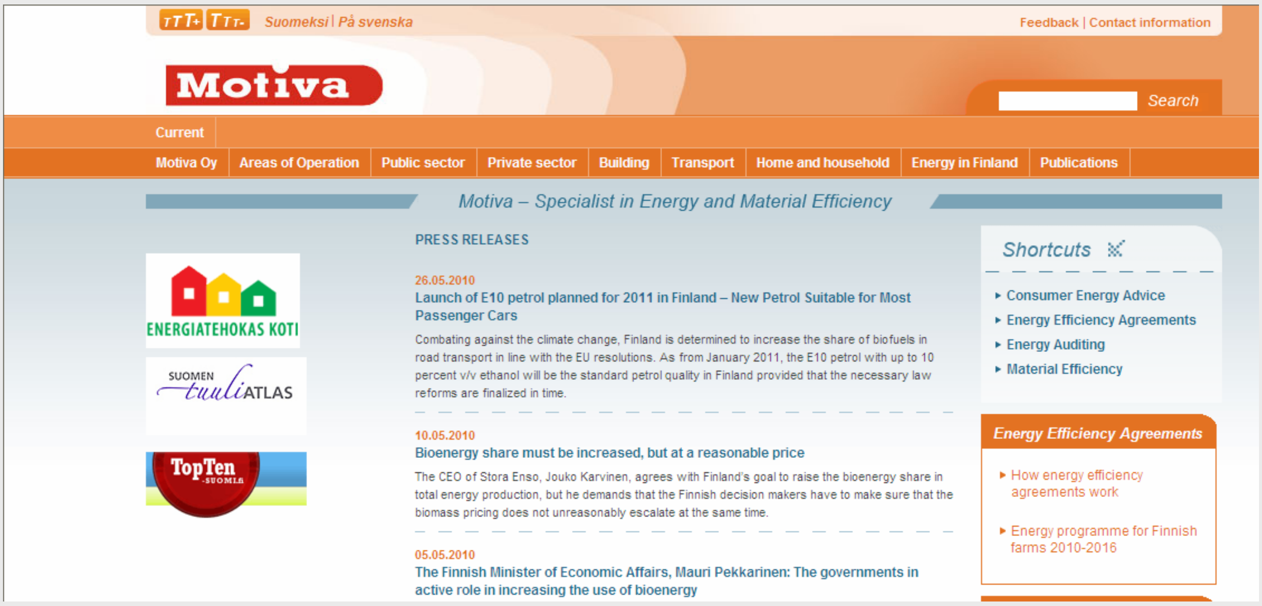
- Apartment code
- Floor area
- Tenure status (owner-occupied or rented)
- Occupancy status (for example inhabited or uninhabited)
- Number of rooms and type of kitchen
- Facilities (for example sauna or balcony)
- Habitants of the apartment

In addition to this database managed by a public body, other information taken from companies on efficient use of energy in buildings could be of interest for the definition of building typologies.

Among the others, the company “Motiva Oy” operates as an affiliated Government agency (an in-house unit) promoting efficient and sustainable use of energy and materials, and in particular:

- Development of energy audit and analysis activity
- Influencing attitudes and consumer habits
- Monitoring and impacts assessment

Figure 48: Web site of “Motiva Oy”



The developed activity on energy audit is aimed at assessing the energy efficiency of a building. This activity is crucial because an energy audit is needed when a building or its rooms are sold or rented, with the exception of small dwellings built before 2008. The typical approach to express the building energy performance by dividing the overall energy consumption (heating and cooling energy, energy for hot water and the energy for electrical appliances is included) of a building by gross area is used.

3.4 Hungary

The status quo is, that previously there are no building typologies set up in Hungary.

The Hungarian Central Statistical Office collects data on dwelling stock on the basis of the census data (repeated every 10 years) as well as dwelling construction and cessation data. Buildings are divided for the following categories: Family house, Multi-storey multi-dwelling buildings, Buildings in residential parks, Dwelling cluster, Housing estate buildings. Based on these data, building matrix with building age classes containing the total floor space of different building types can be set up.

There are several technical literatures (e.g. the “The new Hungarian building energetic regulation”) that contains database on building constructions with their physical parameters. The constructions are categorized on age classes therefore they can be assigned to the building types.

The Hungarian decree 7/2006 (V. 24.) contains database and calculation methodology for the determination of energy performance of buildings. This methodology can be used for the calculation of the energy performance of different building types equipped with different HVAC systems. Computer programmes have also been developed based on the calculation methodology set up in the decree of 7/2006 (V. 24.).

A typology like it is planned to create within the TABULA project would be very useful for the Energy Centre and they would be very appreciated if they could study the common typology and the method being developed during the project. If there is the possibility to find a financing possibility for the additional work needed, the Energy Centre is very interested in installing a harmonised typology in Hungary.

3.5 Lithuania

Statistics

About 45 % of total final energy consumption is used in housing sector. Whereas more than 60 % of the Lithuanian population resides in multi-apartment buildings constructed during 1961-1990, which are not complied with the effective requirements, this sector has great energy saving potential.

Table 56: Residential building statistics

Country	Population in millions	Total housing stock (number of flats)	Of these in prefabricated housing	Occupants per flat
Lithuania (LT)	3.5	1,295,000	**790,000**	**2.70**

A large number of standard series residential buildings was developed and constructed in the regions these countries are located in. Three main types can be identified in relation to energy refurbishment needs:

Table 57: Main building types in Lithuania

Type	Construction years	Construction features	Typical heating	Annual heat consumption kWh/m²
Type 1	1950 to approx. 1965	Masonry construction (bricks), modular construction (blocks)	Stove heating	approx. 150 to 180
Type 2	1962 to approx. 1980	Exterior walls constructed of one-storey, single-layer concrete slabs	Central heating (district heating), usually one-pipe system	approx. 140 to 170
Type 3	from 1975	One-storey, triple-layer concrete slabs (sandwich panels) with a thermal insulation core (approx. 5 cm)		approx. 100 to 140
New Buildings	from 1990	Usually individual constructions rather than prefabricated housing	Central heating (two-pipe system)	approx. 75 to 90

The next table shows percent of the three different types of prefabricated housing:

Table 58: Percent of the three different types of prefabricated housing

Type	Lithuania
Type 1 - masonry construction and modular construction	**35,0%**
Type 2 - exterior walls constructed of one-storey, single layer concrete slabs	**50,0%**
Type 3 - triple-layer concrete slabs with a thermal insulation core	**15,0%**

Table 59: Degree days in Lithuania (HDD)

Climate-related figures during heating period5	Lithuania
Duration of heating period in days	197
Average outdoor temperature in °C	0,20
Average room temperature in °C	19,00
Heating-Degree-days-number (HDD-index)	**3 704**
Ratio of HDD-indexes	**97%**
Heat demand for an assumed identical prefabricated building	150,86

Based on provisional data of Statistics Lithuania, in 2009, 3964 new residential buildings were recognized as suitable for use. In the residential buildings, 9400 dwellings were equipped, which is by 2429 dwellings or 21% less than in 2008. Their useful floor area made 1075 thous. m^2, which is by 89 thous. m^2 or 8% less than in 2008.

In 2009, in 4002 dwellings were equipped in 1–2 dwelling buildings; their useful floor area made 688 thous. m^2 (64% of the useful floor area of all new dwellings). In the blocks of flats, 5398 dwellings were equipped, i.e. by 2408 dwellings or 31% less than in 2008. The average useful floor area of a dwelling made 114 m^2.

Table 60: Residential buildings recognized as suitable for use by country

	Number of buildings	Dwellings			
		Number	Against 2008, growth, drop (-), per cent	useful floor area, thous. m^2	Average useful floor area, m^2
Total	**3964**	**9400**	**-20.5**	**1075.0**	**114.4**
1–2 dwelling buildings	3836	4002	-0.5	688.0	171.9
3 and more dwelling buildings (blocks of flats)	128	5398	-30.8	387.0	71.7

In 2009, 58 per cent of dwellings were recognized as suitable for use[1] in Vilnius county, more than 15% – in Kaunas county, 12% – in Klaipėda county. Against 2008, the number of dwellings recognized as suitable for use decreased in almost all counties. As in the previous year, the bulk of dwellings recognized as suitable for use fall within Vilnius city.

Table 61: Residential buildings recognized as suitable for use

Counties	Total			of which 1–2 dwelling buildings		
	number of buildings	number of dwellings	useful floor area, thous. m²	number of buildings	number of dwellings	useful floor area, thous. m²
Total	**3964**	**9400**	**1075.0**	**3836**	**4002**	**688.0**
Alytus	191	442	42.6	184	185	26.2
Kaunas	852	1454	194.2	832	856	156.5
Klaipėda	313	1098	111.7	296	315	53.6
Marijampolė	108	131	16.3	107	107	14.5
Panevėžys	119	191	22.3	118	119	17.4
Šiauliai	174	301	32.6	171	174	25.6
Tauragė	48	49	7.6	48	49	7.6
Telšiai	73	73	10.8	73	73	10.8
Utena	124	224	23.9	122	122	16.0
Vilnius	1962	5437	613.0	1885	2002	359.8

Possible changes in construction of residential buildings in the short run can be estimated according to the number of building permits and intended building area. Based on provisional data of Statistics Lithuania, in 2009, 5994 building permits for the construction of 6021 residential buildings were issued (of which, only 56 – for the construction of blocks of flats), which is by 2195 building permits, or 27 per cent, less than in 2008.

In 2009, building permits were issued for the construction of 7.5 thousand dwellings, i.e. by 8.4 thousand dwellings or 53% less than in 2008. Not only decrease in number of dwellings having building permits was observed but their structure has also essentially changed – the number of building permits for the construction of dwellings in blocks of flats decreased by 82%..

[1] Recognition of building as suitable for use – inspection carried out by the appropriate commission and its confirmation that building is built according to the building project and building project decisions, which determine conformity to the essential requirements for building set by the Law on Construction, are properly implemented.

Table 62: Buildings permits for the construction of residential buildings

	Granted permits	Construction authorized by building permits				
		buildings	dwellings	number of dwellings, against 2008, growth, drop (-), per cent	useful floor area, m²	average useful floor area, m²
Total	**5994**	**6021**	**7553**	**-52.6**	**1077.1**	**142.6**
1–2 dwelling buildings	5938	5964	6232	-28.2	979.1	157.1
3 and more dwelling buildings (blocks of flats)	56	57	1321	-81.8	98.0	74.2

Energy performance and saving potential

Heat consumption depends on building design, construction quality and materials, indoor installations, energy management (or absence of that), indoor comfort level and householder's response to a set of incentives. Therefore, the same type of buildings can consume different quantities of energy. Space heating varied from 107 to 275 kJ/m^2/degree-day (18^{0}C base) and did not demonstrate clear dependence on building age, height, or construction materials.

The heat insulation characteristics of these buildings do not comply with the contemporary standards. Compared to the other EU countries with similar climate conditions, energy consumption for residential heating is about 1,8 times bigger. The majority of residential buildings are physically worn and their condition does not satisfy the resident's needs. The tendency of decrease of energy consumption in buildings is reflected in the new technical regulations on construction in Lithuania.

On the base of energy audits, the local renovation programs determine energy saving measures and economically feasible decisions can be elaborated. It would allow energy efficiency increasing as well as improving the quality and value of buildings.

Figure 49

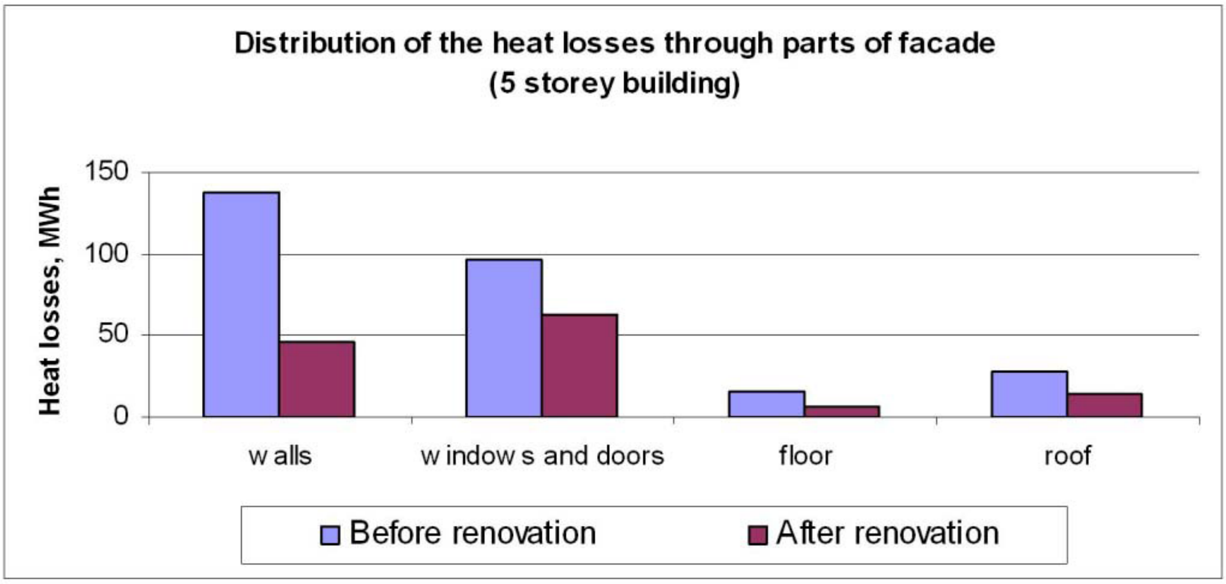


Figure 50

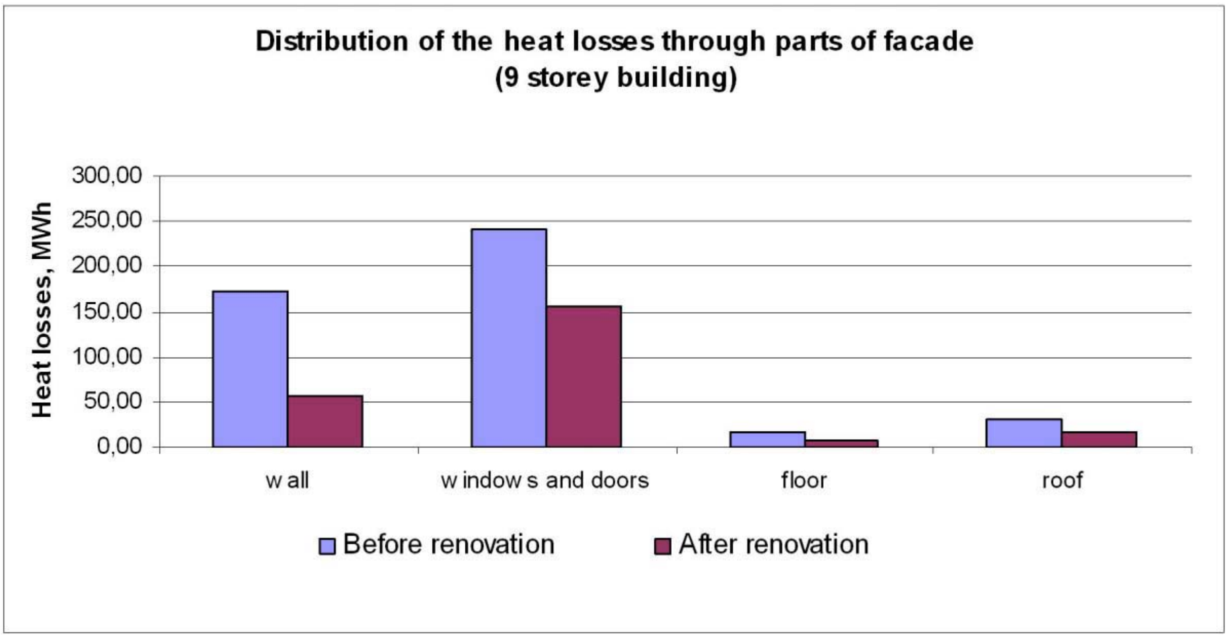


Table 63

Heat characteristics of five storey building before and after the renovation			
Characteristics	Before renovation	After reno-vation	Dimensions
Heat consumption for heating	381,38	193,53	MWh/year
Heat consumption for heating of total 1m^2 area	171,02	86,79	kWh/m^2
Heat consumption for heating of total 1m^3 area	61,079	30,99	kWh/m^3
Number of heating degree days	3507	3507	
Heat consumption in heating degree days	108,75	55,18	kWh/DL
Heat consumption for heating of total 1m^2 area in heating degree days	48,77	24,746	Wh/m^2×DL
Heat consumption for heating of total 1m^3 area in heating degree days	17,42	8,84	Wh/m^3×DL
Specific heat losses of building envelopes	4531,63	2299,56	W/K
	2,03	1,03	W/K/m^2
	0,73	0,37	W/K/m^3

Table 64

Heat characteristics of nine storey building before and after the renovation			
Characteristics	Before renovation	After reno-vation	Dimensions
Heat consumption for heating	747,89	444,65	MWh/year
Heat consumption for heating of total 1m^2 area	156,66	93,14	kWh/m^2
Heat consumption for heating of total 1m^3 area	55,95	33,26	kWh/m^3
Number of heating degree days	3507	3507	
Heat consumption in heating degree days	213,26	126,79	kWh/DL
Heat consumption for heating of total 1m^2 area in heating degree days	44,67	26,56	Wh/m^2×DL
Heat consumption for heating of total 1m^3 area in heating degree days	15,95	9,49	Wh/m^3×DL
Specific heat losses of building envelopes	8886,72	5283,51	W/K
	1,86	1,11	W/K/m^2
	0,66	0,40	W/K/m^3

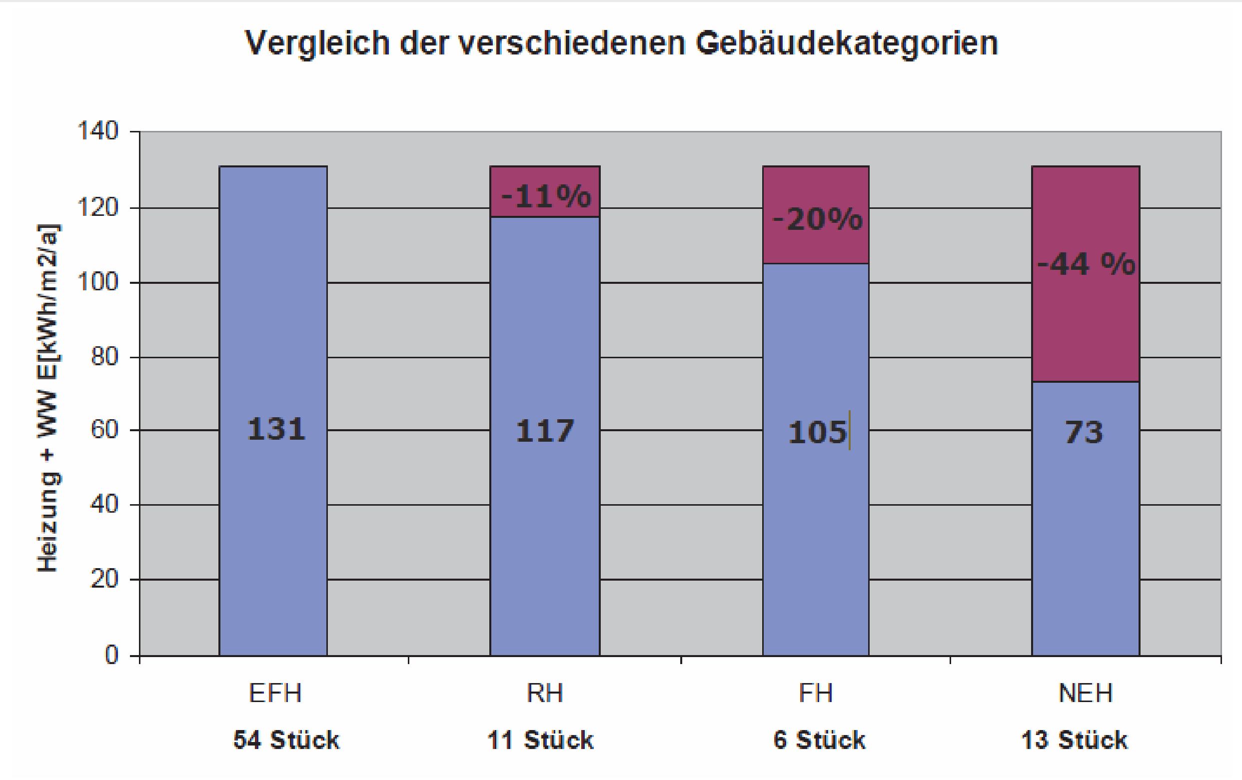
3.6 Luxembourg

In Luxembourg typological aspects of the building stock's energy performance have been considered in different fields.

The government has introduced an energy passport for buildings, called "carnet de l'habitat". It provides a kind of radiogram of the building made by an expert who analyses stability, hygiene, comfort, ecology and energy efficiency. This audit proposes concrete measures to correct possible defaults. The carnet de l'habitat is issued by use of a special software [Katalyse 2007]. The procedure is based on a building typology with typical construction elements differentiated by construction year and building size. However, detailed data of the building typology are not published.

In a study of the University of Luxembourg the energy consumption of single family houses built between 1997 and 2007 was investigated. This was done by means of a selected set of typical buildings which were deemed as representatives for the entity of new single family houses. The measured consumption was compared with the calculated energy consumption for these representatives and the discrepancies were discussed. [Maas et al. 2007] / [Maas et al. 2008]

Figure 51: Comparison of the consumption of different building types (new buildings) [Maas et al. 2007]



As regards the energy performance of typical supply systems tabled values have been published by the government in the annex of the EPBD regulation for residential buildings [Lux PE 2007]. The table below shows as an example the energy expenditure coefficient of heat generators by building size and installation period.

Table 65: Tabled energy performance values of typical supply system components / example: expenditure coefficients of heat generators for different installation year periods [Lux PE 2007]

Anlagenaufwandszahl für Heizwärmeerzeugung $e_{E,H}$ bei Installationen mit mäßigem Wärmeschutz der Rohrleitungen

spezifischer Heizwärmebedarf q_H in kWh/m²a			EFH					MFH				
			≤50	100	150	200	≥250	≤50	100	150	200	≥250
Zentralheizungen	Konstanttemperatur- & Pelletskessel	bis 1986	1,99	1,72	1,61	1,54	1,50	1,73	1,52	1,43	1,37	1,34
		ab 1986	1,93	1,67	1,56	1,49	1,45	1,68	1,47	1,39	1,33	1,30
		ab 1995	1,87	1,62	1,51	1,45	1,41	1,63	1,43	1,35	1,30	1,26
	Niedertemperaturkessel	bis 1986	1,84	1,59	1,49	1,42	1,39	1,68	1,48	1,39	1,33	1,30
		ab 1986	1,76	1,52	1,42	1,36	1,32	1,61	1,41	1,33	1,27	1,24
		ab 1995	1,67	1,45	1,35	1,29	1,26	1,55	1,36	1,27	1,23	1,20
	Gas-Brennwertgerät	bis 1995	1,61	1,39	1,30	1,24	1,21	1,49	1,31	1,23	1,18	1,15
		ab 1995	1,58	1,37	1,28	1,22	1,19	1,48	1,29	1,22	1,17	1,14
	Holzkessel		1,93	1,67	1,56	1,49	1,45	1,68	1,47	1,39	1,33	1,30
	Elektrowärmepumpe	Außenluft	0,75	0,62	0,57	0,54	0,53	0,72	0,61	0,56	0,54	0,52
		Erdreich	0,57	0,48	0,44	0,42	0,41	0,55	0,46	0,43	0,41	0,40
	Fernwärme / KWK		1,52	1,32	1,23	1,18	1,15	1,46	1,28	1,20	1,16	1,13

References

[Katalyse 2007] Carnet de l'habitat. Entwicklung eines ganzheitlichen Gebäudeerfassungs- und Bewertungssystems zur Subventionierung von Sanierungs- und Renovierungsmaßnahmen für Gebäude im Bestand (Gebäudepass inkl. Anwendungssoftware); Wohnungsbauministerium Luxemburg, 1999 - 2008 (Artikel 2003); unpublished; overview at: http://www.katalyse.de/sites/cms.katalyse.de/files/file/Bauen_und_Wohnen/Lux2007.pdf

[Lux PE 2007] Règlement grand-ducal du 30 novembre 2007 concernant la performance énergétique des bâtiments d'habitation / Verordnung über die Gesamtenergieeffizienz von Wohngebäuden / Annexe; Journal Officiel du Grand-Duché de Luxembourg; 14. December 2007

[Maas et al. 2007] Maas, Stefan; Waldmann, Danièle; Zürbes, Arno; Scheuren, Jean-Jacques: Wie viel Energie der Luxemburger wirklich verbraucht; Revue Technique Luxembourgeoise 4/2007 www.aliai.lu/rt/rt20074/rt20074e.pdf

[Maas et al. 2008] Maas, Stefan; Waldmann, Danièle; Zürbes, Arno; Scheuren, Jean-Jacques; Heinrich, Hermann: Der Energieverbrauch von Einfamilienhäusern in Luxemburg; Gesundheitsingenieur 129 (2008) Heft 4 http://www.baufachinformation.de/zeitschriftenartikel.jsp?z=2008089000045

3.7 The Netherlands

In the Netherlands there are about 6,5 million existing dwellings where like in most other European countries the energy saving potential is very large. Senter Novem (agency from the ministry of economic affairs) acknowledged the demand for a more theoretical approach to set up their policy measures with respect to energy advice, etc. Therefore they developed in 2001 a first version of 16 reference buildings to represent the existing building stock build before the year 2001. In 2007 this version was updated and extended to 27 example buildings. Each example building represents a specific part of the Dutch building stock.

The energy performance characteristics of the dwellings are calculated based on the calculation method for EPC's for existing residential buildings ("EI-certificaatrekenmethodiek") and energy advice for existing residential buildings ("EPA-adviesberekeningsmethodiek"). All the information is made public available under the form of a brochure and a CD-ROM with lots of extra detailed information.

Figure 52: Brochure with the 27 example buildings for the Netherlands.

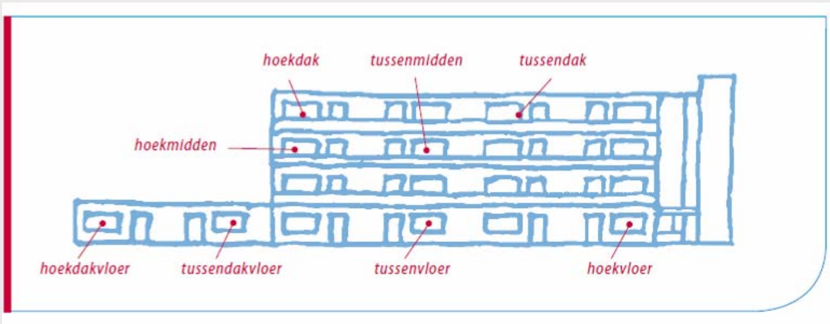
The development of the 27 example dwellings is based on a research called qualitative dwelling registration (KWR – Kwalitatieve Woning Registratie) were data sets from 15.000 of existing dwellings build until 2000 were collected. This research had the intention to describe the quality of the Dutch dwelling stock and was initiated by the ministry of housing, spatial planning and the environment (VROM). In total there are 8 dwelling types and 6 building periods.

Figure 53: Subdivision of the 27 example buildings according to dwelling type and building period

	BOUWPERIODE					
	T/M 1945	1946-1965	1966-1975	1976-1979	1980-1988	1989-2000
Vrijstaande woning > 150m²	1		2			3
Vrijstaande woning ≤ 150m²	4		5			6
Twee-onder-één-kapwoning	7		8			9
Rijwoning	10	11	12	13	14	15
Maisonette	16		17			18
Galerijflat	19		20			21
Portiekflat	22		23			24
Overige flat	25		26			27

Those 27 example buildings form the main types of the typology. For some main dwelling types there are subdivisions made e.g. a “Rijwoning” contains both the terraced as semi-detached dwellings and all main types of flats like “Maisonette”, “Gelerijflat”, Portiekflat” and “Overige Flat” have another subdivision according the number of free surfaces to the outer environment. In total there are 117 subtypes available.

Figure 54: Subdivision of the multi-family houses into 8 subtypes



For each subtype they have elaborated 4 situations with corresponding levels of energetic comfort; the initial state (oorspronkelijk niveau), the current state (=huidig niveau), a renovated state (=comfort niveau) and an advanced renovated state (=comfort+ niveau). All the example buildings were calculated and labelled for those 4 comfort situations by means of the calculation method for EPC’s.

Figure 55: Classification of the dwelling types according to the energy performance index for EPC's

WONINGEN VAN VOOR 1966	A	B	C	D	E	F	G
Oorspronkelijk niveau					x	x	x
Huidig niveau				x	x	x	
Comfort/ comfort+ niveau	x	x	x				

WONINGEN 1966 – 1988	A	B	C	D	E	F	G
Oorspronkelijk niveau					x	x	x
Huidig niveau			x	x	x		
Comfort/ comfort+ niveau	x	x	x				

WONINGEN 1989 – 2000	A	B	C	D	E	F	G
Oorspronkelijk niveau			x				
Huidig niveau		x	x				
Comfort/ comfort+ niveau	x						

In the main brochure for each of the 27 example building there are information sheets published. An information sheet is describing the characteristics of a dwelling for a given building type and construction period. The values are based on a weighted average. The sheet is composed with separate parts discussing the envelop caracteristics, the technical installations for heating and domestic hot water, potential energy saving measures with respect to their estimated cost, the calculated energy performance and the average energy savings.

Figure 56: Parameters related to the building envelop in current and renovated state

BOUWKUNDIGE KENMERKEN

Gebruiksoppervlakte (m^2)	182,7
Aantal bewoners	3,2

		U-WAARDE (W/m^2K)		RC WAARDE (m^2 K/W)	
BOUWDEEL	OPP. (m^2)	HUIDIG	COMFORT	HUIDIG	COMFORT
Begane grondvloer	96,0	1,10	0,34	0,65	2,65
Dak hellend	135,8	0,68	0,68	1,30	1,30
Dak plat	-	-	-	-	-
Voorgevel gesloten	31,8	0,65	0,44	1,36	2,11
Voorgevel glassoort 1	3,3	5,10	2,00	-	-
Voorgevel glassoort 2	10,3	3,10	2,00	-	-
Achtergevel gesloten	31,8	0,65	0,44	1,36	2,11
Achtergevel glassoort 1	3,3	5,10	2,00	-	-
Achtergevel glassoort 2	10,3	3,10	2,00	-	-
Zijgevel gesloten	113,3	0,65	0,44	1,36	2,11
Zijgevel glassoort 1	2,7	5,10	2,00	-	-
Zijgevel glassoort 2	8,5	3,10	2,00	-	-

Figure 57: Parameters related to the technical installations in current and renovated state

INSTALLATIE

	HUIDIG	COMFORT
Ruimteverwarming	Centrale verwarming met VR ketel	Centrale verwarming met HR 107 ketel
Tapwater	VR Combitapketel (met bad)	HR Combitapketel (met bad)
Ventilatie	Natuurlijk ventilatiesysteem	Natuurlijk ventilatiesysteem

Figure 58: Parameters related to the calculated energy saving measures and corresponding costs

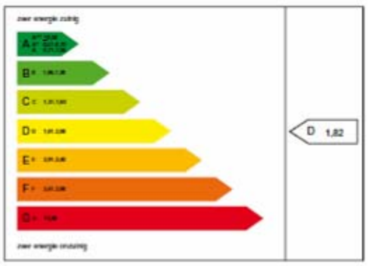
ENERGIEBESPARINGSPAKKETTEN EN KOSTEN VOOR DE PROFESSIONELE GEBRUIKER/INVESTEERDER

MOGELIJKE MAATREGELEN	PAKKET VAN HUIDIG NAAR COMFORT	INVESTERING PER m² OF STUKS EXCL. BTW	INVESTERING PER MAATREGEL EXCL. BTW
Vloerisolatie	*x*	*€ 20*	*€ 1.920*
Dakisolatie (plat)			
Dakisolatie (hellend)			
Gevelisolatie (spouw)	*x*	*€ 15*	*€ 2.652*
HR++ glas	*x*	*€ 33*	*€ 1.268*
Combitapketel (HR107)	*x*	*€ 2.139*	*€ 2.139*
Collectieve ketel (HR107)			
Kosten pakket prof. gebruiker/investeerder			***€ 7.979***

Figure 59: Energy performance of the building in current and renovated state according to the EPC calculation method

ENERGIEPRESTATIE

	HUIDIG	COMFORT
Berekend gasverbuik (m³ gas/jaar)	*3309*	*1964*
Berekend hulpenergiegebruik (kWh/jaar)	*297*	*399*
EI (-)	*1,82*	*1,16*
Energielabel	*D*	*B*



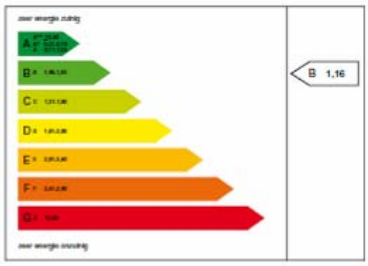


Figure 60: Summary of the energy savings when moving up from current situation to renovated situation

BESPARINGEN

	BESPARING VAN HUIDIG NAAR COMFORT
Besparing gasverbuik (m³ gas/jaar)	*1345*
Besparing hulpenergiegebruik (kWh/jaar)	*-102*
Besparing energiekosten (euro/jaar)	*731*

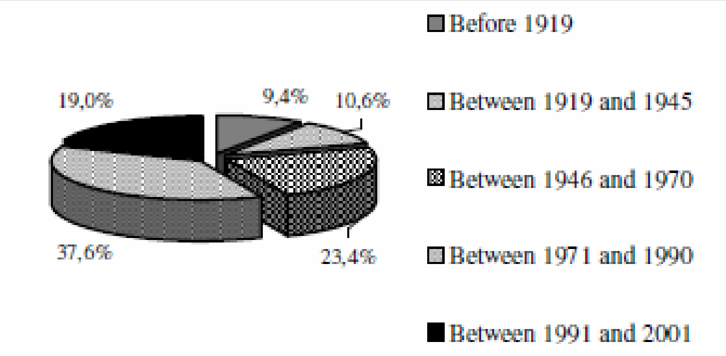
3.8 Portugal

The main source of information on the building stock in Portugal is the National Statistics Institute (www.ine.pt) where data are gathered on an annual basis (new building construction records) and on a ten-year basis (Censuses of 1991, 2001 and the next scheduled for 2011).

The results of the 1991 and 2001 Censuses, published by the National Statistics Institute, highlight some features of the resident population, households, buildings and housing, according to several spatial breakdowns. According to the Census 2001 there are almost 5.1 millions of residential units in Portugal for a total of 3.7 millions of families which represents a ratio of 1.34 residential units per family. From this, 18% correspond to seasonal residences while 11% are unoccupied. This means that Portugal has about 3.9 millions of permanent residential units [1].

Figure 61 shows that the period of major growth of the building stock was between 1971 and 1990 [1].

Figure 61: Evolution of the building stock in Portugal [1]



The number of dwellings has practically doubled over the last three decades and the growth rate is consistently higher than that of number of households, which in 2001 placed Portugal at the second highest housing ratio per household (1.38) within the EU, only surpassed by Spain (1.44). In regional terms, the number of dwellings exceeds the number of households in the North, Centre and Algarve regions in the 1990s, whereas the ratio is more balanced in the other regions, as listed in Table 66 [2].

Table 66: Conventional Dwellings and Resident Households, 1991 and 2001 [2]

NUTS 2	Conventional Dwellings 1991	Households 1991	Conventional Dwellings 2001	Households 2001
North	1,278,948	1,009,594	1,605,157	1,203,226
Centre	812,433	566,771	945,322	566,771
Lisbon and V.T.	1,422,198	1,108,205	1,701,426	1,286,765
Alentejo	267,289	192,694	304,539	200,884
Algarve	211,288	117,015	276,093	147,014
Madeira	79,001	64,911	94,271	72,938
Azores	83,810	62,886	92,617	71,389
Portugal	4,154,967	3,315,708	5,019,425	3,619,528

Source: National Statistics Institute, 1991 and 2001 Censuses.

Regarding the age of the housing stock, only 14% of the existing dwellings were built before 1945. During the last three decades, construction rates and rates of land occupation were very high, as about 63% of the conventional housing in 2001 had been built between 1971 and 2001. In territorial terms, all regions experienced intense real estate development in the last few decades before 2001, as listed in Table 67 [2].

Table 67: Conventional Dwellings by construction period (%), 2001 [2]

NUTS 2	Dwellings before 1945	Dwellings 1945–1970	Dwellings 1971–2001
North	14%	20%	66%
Centre	16%	24%	60%
Lisbon and V.T.	10%	30%	60%
Alentejo	28%	22%	50%
Algarve	11%	18%	71%
Madeira	16%	20%	64%
Azores	20%	20%	60%
Portugal	14%	23%	63%

***Source*: Computations based on data available from the National Statistics Institute, 2001 Census [2]**

In terms of regional distribution, Table 68 lists the average age of the housing stock is higher in the Alentejo, and Lisbon and Tagus Valley, while the Algarve, North, Madeira and the Azores have a more recent stock, a result of a more intense construction dynamic in the last few decades.

Table 68: Average Age of Buildings [2]

NUTS 2	Average Age of Buildings
North	38.4
Centre	40.8
Lisbon and V.T.	42.9
Alentejo	46.5
Algarve	40.3
Madeira	35.6
Azores	38.5
Portugal	38.5

Source: Computations based on data available from the National Statistics Institute, 2001 Census [2].

The first legal document concerning the building thermal performance was published in 1990. Its name, RCCTE (Decree-Law 40/90 from the 6th February) is the acronym for the Portuguese name "Regulamento das Características de Comportamento Térmico dos Edifícios" that means Regulation of Thermal Building Behaviour Characteristics. The RCCTE intended to impose the improvement of the thermal quality of the buildings envelopes as a strategy to improve the indoor comfort without increasing the energy consumption. To improve the buildings behaviour during winter, the reduction of the overall thermal coefficient (U) of walls and roofs was imposed through the definition of a maximum Uvalue. Since that time, the use of insulation materials and double glazing in widows started to become common in building construction. Besides the thermal insulation improvement, it also promoted the use of efficient solar energy collection strategies [1] .

As nearly 80% of the building stock was built before the publication of the RCCTE,
therefore without any thermal demands, its thermal performance is inadequate in almost all cases. In spite of this reality, thermal rehabilitation is not yet a common practice. Therefore, there is still a great effort to be done in this context in Portugal in the near future [1].

In 2006, following Rio agreements and the necessity of reducing greenhouse gases emissions (Kyoto protocol), but mainly due to the European Directive 2002/91/CE of the European Parliament and of the Council of December 16, 2002 on the energy performance of buildings, the Portuguese government revised the thermal regulation to improve the quality level of the buildings [1].

The new regulation envisages the reduction of the building energy consumption in nearly 50% and the main changes are the following [1]:
- improve the reference thermal characteristics of the building envelope;
- double the envelope insulation thickness, in general;
- mandatory use of double glazing in the coldest zones and for the orientations without significant solar gains;
- take into account the contribution of passive solar systems;
- take into account the energy spent in heating the sanitary hot water;
- mandatory use of solar panels for hot water production.

The implementation process of building energy performance certification in Portugal was made step-wise [3]:
– 3 July 2006: Revised technical regulations in force for new residential and non-residential buildings,
– 1 July 2007: Certification of new large (> 1000 m²) residential and non-residential buildings for which construction permit is requested,
– 1 July 2008: Certification of all new residential and non-residential buildings (independently of size) for which construction permit is requested,
– 1 January 2009: Certification of all buildings, new and existing, residential and non-residential.

About 66 % of the Portuguese population live in multi family houses. There are 1.3 million multifamily buildings and 2.1 million single family buildings. Most of these have individual heating systems, so distribution of heating bills is not a general problem in Portugal. Certification of multi family buildings is done by the individual flat and it is done by asset rating only. A centralised computer system creates the certificate with the information provided by the qualified expert. Data is entered in an electronic form at the internet and stored in a central database of Energy Certificates. Based on the information available in the database some important patterns were observed [4]:
a) The estimated level of private investment to transform the energy classification from the current level of 40% to 85% of the Portuguese dwellings to be at least in the class B - is €235.00 millions. In this sense, an important private investment is required.
b) There is a significant proportion of low efficiency dwellings (classified between C to G) in buildings constructed during the twentieth century. On the contrary, those buildings constructed during the periods 2000-2009 are predominantly high efficiency buildings (the regulation being in force since 2007). Table 4 presents the results per decade.

Table 69: Distribution of level of energy efficient class of Portuguese dwellings per year of construction [4]

Year Range	High Efficiency Dwellings (classified from A+ to B-)	Low Efficiency Dwellings (classified from C to G)
1950-1959	4.67%	95.33%
1960-1969	5.62%	94.38%
1970-1979	5.00%	95.00%
1980-1989	5.98%	94.02%
1990-1999	16.26%	83.74%
2000-2005	46.08%	53.92%
2006-2009	62.83%	37.17%

ADENE, as the Agency in charge of the management and operation of the certification process in Portugal, has been able to collect information over the past two years on the current energy efficiency conditions of residential buildings, their location, distribution and most important the recommended measures the implementation of which will lead to substantial improvements in the energy efficiency grading of each dwelling, among others. In the end of 2009 the database included a total of about 200,000 records. [3]. An indicative example of the database exploitation communicated to NOA after contacting ADENE included a breakdown of the certified new and/or existing flats (or single family houses) per construction period and typology. There are 9 different typologies according to the number of bedrooms per flat or single family residence. There is also a classification according to whether the installed systems serve the purpose of heating, cooling or both.

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[2] Fátima Loureiro de Matos, Housing Conditions in Portugal, DOI:10.2478/v10089-008-0020-8, Bulletin of Geography Socio–economic Series no. 11/2009, pp.49-60.

[3] Paulo Santos, Certification of flats and blocks of flats in Portugal, Concerted Action EPBD II Prague, 1/12/2008

[4] Dionis Arvanitakis, Financial incentives for the adoption of residential energy efficient products: An analysis of European programmes and best practices, CasA+ Building Codes project, ADENE, Nov. 2009

3.9 Romania

National Institute of Statistics in Romania carried out Population and Housing Census in March 2002. After 2002 the data on the building stock are actualized annually and limited aggregated data are published in the Romanian Statistical Yearbook, chapter Dwellings and Public Utilities (last edition-2008). The statistical surveys include:

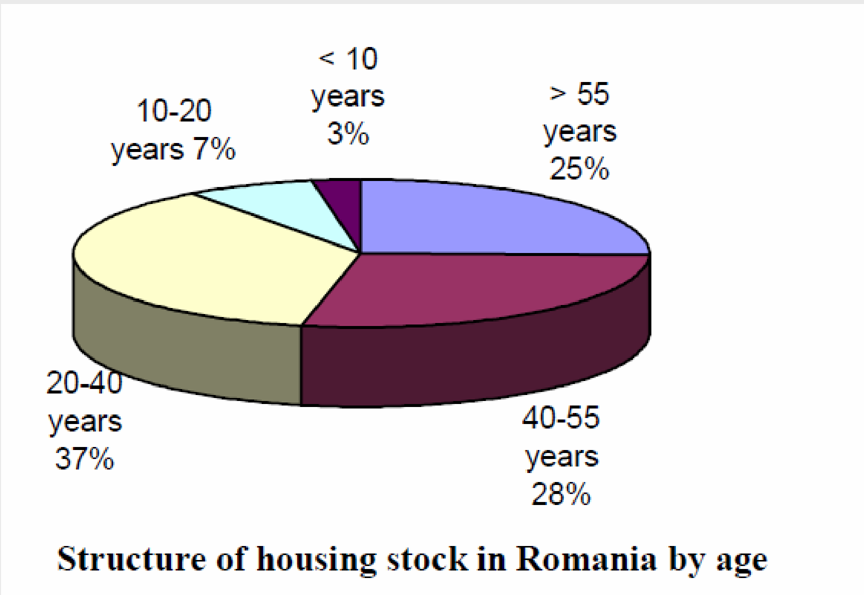
- Statistical survey on the changes in dwellings stock;
- Statistical survey on finished dwellings;
- Statistical surveys on water supply, public sewerage and green spaces, sanitation and distribution of electric energy, naturalgas and other statistical surveys in urbanistic field.

Romanian housing stock includes 4.846.572 buildings (8.110.407 dwellings), from which 23.5% are located in urban area. 97% of the total number of buildings is privately owned (2002).

Residence buildings are classified by the **year of construction**, as Figure 62 presents the structure of building stock in Romania by age:

-before 1910 – 245375 buildings
-1910-1929 – 330352
-1930-1944 – 498910
-1945-1960 – 1280927
-1961-1970 – 1005711
-1971-1980 – 635677
-1981-1989 – 266397
-1990-1994 - 218727
-1995-1999 - 234419
-2000 or later - 101609

Figure 62: Structure of housing stock in Romania by age



Source: Analysis of the local situations in the Eastern European partner countries", Romania, project EAST-GSR

The other typology is by **the construction material of outer walls**:

- Reinforced concrete, precast concrete panels or steel skeleton framed concrete
- Brick masonry, stones masonry or panels substitutes, made of
  - reinforced concrete (steel, beams)
  - wood
- Wood (beams, logs etc.)
- Sampling plastered with wet clay, adobe, other materials (wood pressed panels, rolled mud bricks, etc.)

Residential buildings are also divided into 3 types by their **structure**:

- One-dwelling houses
- Two-or-more dwelling houses
- Blocks

The share of buildings with one dwelling (monofamiliar house), is well above 95% from the total

number of housing stock. Block of flats represents only 1,8% from the total numebr of buildings but shelter 39% (2.984.577 apartaments) from the total number of dwellings in Romania (1992 census).

Other classification is by **macroregion, development region, county and by type of ownership** (private, public, private group (cooperative/associations), religious cults).

Building energy performance and installations

The great majority of these dwellings are situated in old buildings, between 15 and 55 years of age, with poor insulation. The global thermal isolation coefficient in the period 1950-1985 had a level of about 1,0 - 1,3 W/m3K. Higher requirements for the specific thermal resistances are set in 1984 by the Decree 256-84 and of the normative NP 15-84. The necessary of heat have been reduced with about 20% (from about 1,0 W/m3K, to about 0,8 W/m3K). Further regulation changes obtained in 1989 and 1998. [3]

Main characteristics of the Romanian situation concerning block of flats are:

- 37-49% of the total final energy consumption in Romania is used for heating and hot water of the blocks connected to the centralized heating system;

- the blocks of flats represent 72% of the existing dwellings in the urban area, about 58% of the existing block of flats (2.4 million apartments) build before 1985, would need rehabilitation and thermal modernization. [3]

Romania is divided into four climate zones (national regulations - STAS 1907/1-97).The number of degrees-days of the heating/cooling season is calculated for each region according with a statistical algorithm (STAS 4839-97) where the average monthly temperatures are also mentioned, as well as the average monthly intensity of solar radiation by each locality. The heating season lasts for about 180 days, with the number of degree-days ranging from 2,900 to 5,150. [3]

Table 70 represents the finished dwelling by type of installations.

Table 70: Finished dwellings by type of installations (extract)

număr / number

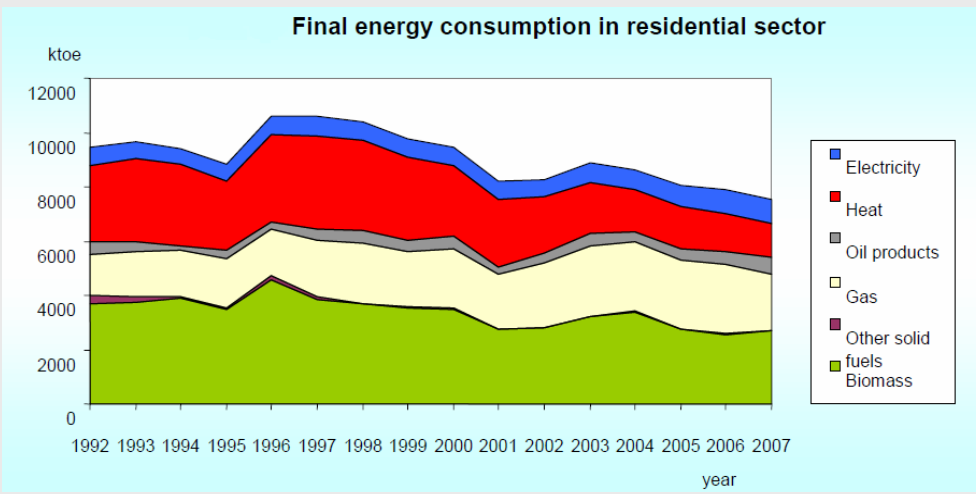
Tipul instalaţiei / *Type of installation*	Total 1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total	**29460**	**29921**	**29692**	**29517**	**26376**	**27041**	**27722**	**29125**	**30127**	**32868**	**39638**	**47299**
Electrică / *Electric*	28217	29001	28342	28291	25301	25833	26963	28500	29403	32258	39268	46755
De alimentare cu apă potabilă / *For supply with drinking water*	12774	12903	12843	12593	11684	12611	15259	18014	19599	21374	25394	34101
De canalizare / *For sewerage*	9928	9860	9805	9660	8591	9907	12830	16046	16275	17438	21351	27717
De încălzire, din care: / *For heating, of which:*												
Centrală termică (inclusiv termoficare) / *Steam-generating station (including central heating)*	6522	6774	6584	6253	5632	6883	9554	13037	14005	15100	20259	28150
Sobe cu gaze / *Gas stoves*	1653	1848	2340	2531	2730	1921	1995	1683	1558	1522	1486	1442
Sobe cu combustibil solid şi lichid / *Stoves with solid and liquid fuel*	21069	21037	20427	20399	17792	18030	16014	14277	14412	16065	17709	17328

Source: Romanian Statistical Yearbook, National Institute of Statistics in Romania, 2008

In 2005 there was registered an energy final consumption of about 7,97 toe or 32% of total energy final consumption in Romania.
By source of energy:
- electricity (9,2%);
- thermal energy (34,7%);
- petroleum (19%);
- natural gas (35,2%);
- coal (0,1%);
- others (renewable resources or offal – 1,8%).

Figure 63 represents the final energy consumption in residential sector in Romania over the period 1992-2007.

Figure 63: Final energy consumption in residential sector



Source: Energy Efficiency Policies and Measures in Romania, Odyssee-Mure project

In the residential sector, thermal energy is used for heating, preparing warm water and food cooking. Speaking in general, the efficiency of this thermal energy use is only 43% (63% in Bucharest – the capital of Romania).

Because of poor conditions of some centralized heating systems and the lack of metering systems at all block of flats or at individual levels, many consumers, especially from towns areas, preferred individual heating systems using natural gas. [5]

Table 71 represents the installation facilities in residential buildings.

Legal framework

The main regulations in the field of residential building stock are as follows:

- Law No 199/2000 regarding the efficient use of energy, amended and updated by Law No56/2006, which aims to create the necessary legal framework for the development and implementation of national policies for the efficient use of energy.
- Emergency Government Ordinance No 174/2002 regarding the taking of measures to thermally insulate multi-storey residential buildings, approved by Law No 211/2003.
- Government Decision No 163/2004 regarding the approval of the National Strategy for Energy Efficiency.
- Government Decision No 1535/2003 regarding the "Strategy for the Promotion of Renewable Sources of Energy" and Government Decision No 443/10.04.2003 concerning the promotion of the production of electrical energy from renewable energy sources.

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Table 71: Dwellings by actual destination of the building, type of residential building, installation facilities, dependencies and areas (part of the table)

ACTUAL DESTINATION OF THE BUILDING TYPE OF RESIDENTIAL BUILDING INSTALLATIONS FACILITIES AND DEPENDENCIES	TOTAL			URBAN AREA			RURAL AREA		
	Number of dwell-ings	Number of house-holds	Number of persons	Number of dwell-ings	Number of house-holds	Number of persons	Number of dwell-ings	Number of house-holds	Number of persons
A	1	2	3	4	5	6	7	8	9
ROMANIA									
DWELLINGS - TOTAL	8107114	7315891	21345033	4259574	3956426	11152099	3847540	3359465	10192934
INSTALLATIONS FACILITIES									
a) Dwellings with water-supply installation	5724125	5298414	15282655	4078180	3802635	10649788	1645945	1495779	4632867
- inside dwelling	4297065	3990721	11291690	3744665	3486739	9654698	552400	503982	1636992
- public network	3948678	3669811	10231948	3679079	3425471	9453791	269599	244340	778157
- own system	348387	320910	1059742	65586	61268	200907	282801	259642	858835
- outside dwelling	1427060	1307693	3990965	333515	315896	995090	1093545	991797	2995875
- inside building	88443	81452	246212	42595	39868	119544	45848	41584	126668
- public network	56224	52128	155908	34268	32049	95078	21956	20079	60830
- own system	32219	29324	90304	8327	7819	24466	23892	21505	65838
- outside building	1338617	1226241	3744753	290920	276028	875546	1047697	950213	2869207
- public network	406143	381662	1173179	158117	152417	480931	248026	229245	692248
- own system	932474	844579	2571574	132803	123611	394615	799671	720968	2176959
b) Dwellings with hot-water	3516812	3280733	9154699	3247476	3035060	8344771	269336	245673	809928
- inside dwelling	3477054	3244844	9058223	3213534	3004499	8265774	263520	240345	792449
- public network	2604525	2419326	6540205	2580330	2399012	6475405	24195	20314	64800
- own system	872529	825518	2518018	633204	605487	1790369	239325	220031	727649
- outside dwelling, but inside building	39758	35889	96476	33942	30561	78997	5816	5328	17479
c) Dwellings with sewerage installation	4297065	3990721	11291690	3744665	3486739	9654698	552400	503982	1636992
- public network	3619037	3358248	9247272	3513216	3267140	8960893	105821	91108	286379
- own system	638284	595234	1927007	214069	203225	643181	424215	392009	1283826
- other situation	39744	37239	117411	17380	16374	50624	22364	20865	66787
d) Dwellings with electric installation	7871201	7170168	20890177	4225365	3932542	11069517	3645836	3237626	9820660
e) Dwellings by cooking fuel									
- gas	5850268	5419431	15626170	4019769	3753950	10505868	1830499	1665481	5120302
- public network	3282776	3071557	8541179	3012358	2820863	7773795	270418	250694	767384
- gas cylinder (liquefied gas)	2567492	2347874	7084991	1007411	933087	2732073	1560081	1414787	4352918
- solid fuel	2154626	1824871	5521282	202515	175646	577697	1952111	1649225	4943585
- electricity	29887	24721	59783	21137	18208	42390	8750	6513	17393
- other	72333	46868	137798	16153	8622	26144	56180	38246	111654
f) Dwellings by type of energy used for heating									
- thermal heating (public or local network)	2485295	2312927	6229793	2464898	2295804	6175643	20397	17123	54150
- own thermal station with:	462858	436287	1296877	416093	395364	1162893	46765	40923	133984
- gas	417529	395322	1165439	390776	371803	1088937	26753	23519	76502
- solid fuel	35362	32614	106439	18693	17553	56232	16669	15061	50207
- liquid fuel	9967	8351	24999	6624	6008	17724	3343	2343	7275
- stoves with:	4961559	4407935	13373932	1210258	1125102	3424310	3751301	3282833	9949622
- gas	692754	653259	1891006	471676	446883	1269639	221078	206376	621367
- solid fuel	4249747	3737460	11430994	728691	668888	2126691	3521056	3068572	9304303
- liquid fuel	19058	17216	51932	9891	9331	27980	9167	7885	23952
- other means of heating	197402	158742	444431	168325	140156	389253	29077	18586	55178
g) Dwellings with air conditioning	39129	36262	99478	34190	32186	87282	4939	4076	12196

Source: Population and Housing Census, National Institute of Statistics in Romania, 2002

3.10 Spain

Spain has approximately 25 million existing dwellings. The table below, provided by the Spanish Ministry for Housing shows the growth in dwellings on a geographical basis from 2001 through to 2008.

Table 72

	2001	2004	2008
TOTAL NACIONAL	21,033,759	22,623,443	25,129,207
Andalucía	3,554,198	3,922,607	4,408,278
Aragón	657,555	699,563	759,921
Asturias (Principado de)	524,336	556,612	607,620
Balears (Illes)	504,041	539,826	587,918
Canarias	855,022	937,084	1,045,184
Cantabria	286,901	311,303	345,145
Castilla y León	1,455,050	1,543,748	1,695,579
Castilla-La Mancha	988,555	1,045,585	1,214,458
Cataluña	3,328,120	3,571,897	3,923,033
Comunidad Valenciana	2,558,691	2,767,763	3,123,236
Extremadura	575,284	606,080	651,406
Galicia	1,312,496	1,405,098	1,544,625
Madrid (Comunidad de)	2,482,885	2,635,616	2,890,229
Murcia (Región de)	595,319	646,435	778,815
Navarra (Comunidad Foral de)	261,147	278,103	310,175
País Vasco	892,009	936,935	997,294
Rioja (La)	156,769	169,612	193,904
Ceuta y Melilla	45,381	49,576	52,387

*Total viviendas= vivienda libre+ vivienda protegida.

The Spanish census (2001) gives a breakdown of dwellings by age band by region as indicated in the table below. The 2001 census data was gathered from the website of the Spanish National Statistics Institute www.ine.es .

Table 73

Año de construcción (agregado) *CC.AA. de la vivienda*	TOTAL	Antes de 1920	1921-1940	1941-1960	1961-1980	1981-1990	1991-2001	No es aplicable
TOTAL	**20,946,554**	2,050,462	905,612	2,975,327	8,662,208	2,882,535	3,383,677	86,733
Andalucía	3,531,124	237,278	115,696	433,398	1,466,850	606,682	655,429	15,791
Aragón	654,483	96,741	28,374	99,910	233,486	94,728	99,240	2,004
Asturias (Principado de)	523,616	78,363	22,148	90,238	197,897	57,811	75,565	1,594
Balears (Illes)	501,840	54,804	20,489	75,428	208,220	78,720	61,827	2,352
Canarias	851,463	44,808	30,439	123,106	363,114	137,740	148,033	4,223
Cantabria	284,235	43,070	13,295	43,085	93,801	35,186	53,793	2,005
Castilla y León	1,449,415	196,783	74,786	234,299	502,561	206,639	228,793	5,554
Castilla-La Mancha	986,051	99,743	46,278	145,469	332,692	171,924	187,183	2,762
Cataluña	3,314,155	390,224	161,257	465,210	1,487,955	335,789	459,118	14,602
Comunidad Valenciana	2,547,775	197,907	104,609	365,002	1,127,189	344,204	398,565	10,299
Extremadura	573,796	80,419	33,405	98,626	162,521	91,058	105,751	2,016
Galicia	1,308,363	179,302	63,340	173,588	475,719	194,278	217,069	5,067
Madrid (Comunidad de)	2,478,145	120,672	101,458	336,084	1,212,735	299,641	397,966	9,589
Murcia (Región de)	592,613	34,639	20,083	71,197	236,850	114,013	113,964	1,867
Navarra (Comunidad Foral de)	258,721	39,273	8,612	33,782	99,117	27,701	49,062	1,174
País Vasco	889,560	122,304	47,429	156,470	395,494	65,888	97,827	4,148
Rioja (La)	155,931	28,829	8,020	20,670	55,970	15,662	25,426	1,354
Ceuta	22,776	3,580	1,961	4,835	6,894	2,342	2,937	227
Melilla	22,492	1,723	3,933	4,930	3,143	2,529	6,129	105

The 2001 Census also provides detailed data on heating systems for all Spanish buildings. The table below shows the numbers of dwellings with different heating systems for each main fuel type for principal residences.

Table 74

	With individual heating	With central heating	Room heaters only	Without any means	Total
Gas	436,546	3,008,857	1,263,317	-	4,708,720
Electricity	49,906	1,085,537	3,352,637	-	4,488,080
Petroleum or derivates	756,129	1,125,112	108,968	-	1,990,209
Wood	9,202	95,468	253,858	-	358,528
Coal or derivatives	77,272	140,047	316,447	-	533,766
Others	9,464	12,977	24,518	-	46,959
Not applicable	-	-	-	2,057,764	2,057,764
Total	1,338,519	5,467,998	5,319,745	2,057,764	14,184,026

Source: Census 2001

The 2001 census data also shows the proportion of heating system types within the main age band.

Table 75

	Before 1900	1900-1920	1921-1940	1941-1950	1951-1960	1961-1970	1971-1980	1981-1990	1991-2001
With individual heating (single family house)	2.89%	3.68%	6.33%	6.33%	7.16%	9.88%	15.22%	10.03%	6.18%
With central heating (multi family house)	29.53%	28.92%	30.42%	31.99%	33.51%	34.60%	34.86%	44.71%	56.23%
Room heaters only	47.98%	48.93%	45.60%	43.93%	43.11%	41.08%	35.97%	32.16%	26.43%
Without any means	19.59%	18.47%	17.66%	17.75%	16.21%	14.44%	13.95%	13.10%	11.17%
	100.00%	100.00%	100.01%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

For dwellings built in the 1991-2001 period, 56% had central heating systems and 26% had room heaters only.

The Dpto. Doméstico y de Edificios, Instituto para la Diversificación y Ahorro de la Energía (IDAE),Ministerio de Industria, Turismo y Comercio has indicated additional reports and research relating to building typologies in Spain.

The Valencian Institute of Building (Institut Valencia de L'Edificacio or IVE) has developed a whole system of procedures for the **Energy Assessment** of existing buildings, to analyse both the current state and the improved status of the building after refurbishment (for more information visit: http://www.five.es/).

This comprehensive energy assessment system is composed of the following procedures:

ICE
INFORME DE CONSERVACIÓN Y EVALUACIÓN ENERGÉTICA

- **Conservation Report and Energy Assessment**

  This report is based on a preliminary inspection of the existing building, which purpose is not only to achieve an understanding of the overall maintenance status of the building but also to carry out an energy assessment.

  It is a technical document designed to achieve an understanding of the overall maintenance status of the building on its security, functionality and energy efficiency aspects and analyzing deficiencies in order to adopt the necessary measures and priorities for action at a future refurbishment. The registry of the maintenance status of Buildings enables recording of the current state of existing buildings and provides a management system to establish the best criteria for the adaptation and rehabilitation of buildings.

- **Constructive Elements Catalog for Building Renovation**

  The Constructive elements Catalog of energy building renovation arises as a tool to help engineers to deal with building renovations. In order to propose actions to improve existing buildings it is necessary to become familiar with the constructive solutions used in the past. In this regard, the catalog contains a wide range of constructive elements which make up the thermal envelope of buildings, used in building constructed in Spain from the 40s to the 80s. The catalog also includes typologies resulting from energy improvements of previous historic solutions, with information on the thermal performance achieved, including construction details and giving criteria for the selection of each proposed solution, not only from a technical point of view but also from an economic, and sustainability point of view.

- **CERMA Rehabilitación**

  CERMA is an IT Tool which quantifies the energy demand and CO_2 emissions generated by the inspected building in its current state. The tool can guide the engineer/architect quantifying the future energy demand and future CO_2 emissions of a future envelope or systems intervention.

  The final report issued by the tool is an aid for the engineers/ architects when they have to justify the intervention proposal for renovation works to be financed by the authorities.

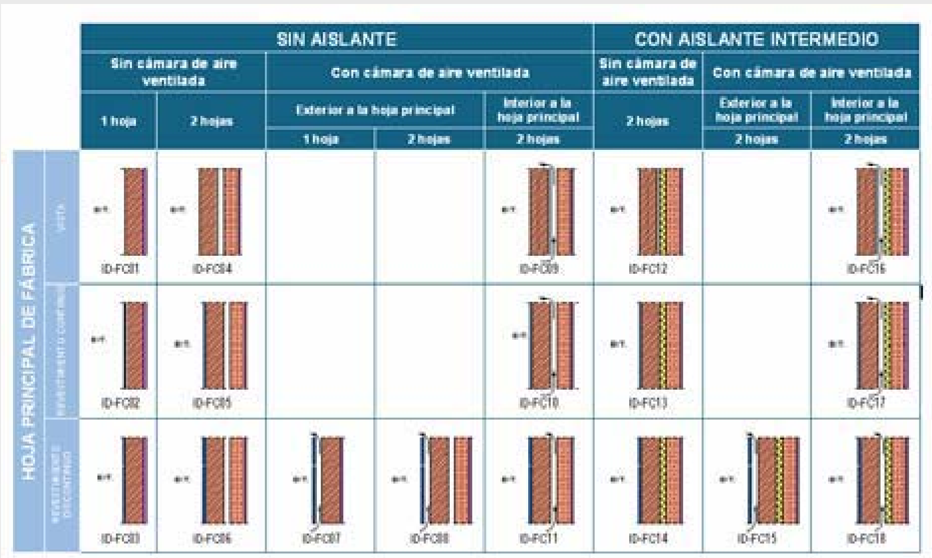
The Constructive Elements Catalog for Building Renovation is divided into two parts:

- **PART 1:** Typological classification of existing and improved building materials

- **PART 2:** Characteristics of existing and improved construction solutions

Part 1 is divided into different sections that correspond to the constructive elements constituting the building thermal envelope. From the "Constructive elements catalog for building renovation", the engineer/architect can choose the construction element typology under consideration, in this case, facades. The appropriate subtype can then be selected.

Figure 64: Typological classification of pre-existing walls



Once the initial inspection of the building has been completed, the internal calculation engine CERMA+ will generate a supporting certificate of energy savings arising from the renovation of the building.

Figure 65: Options for energy renovation

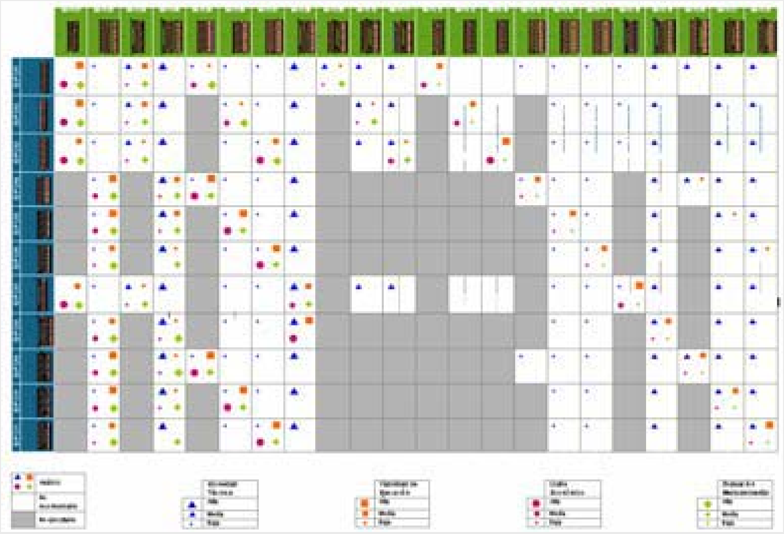


Figure 66: Typological classification of improvements

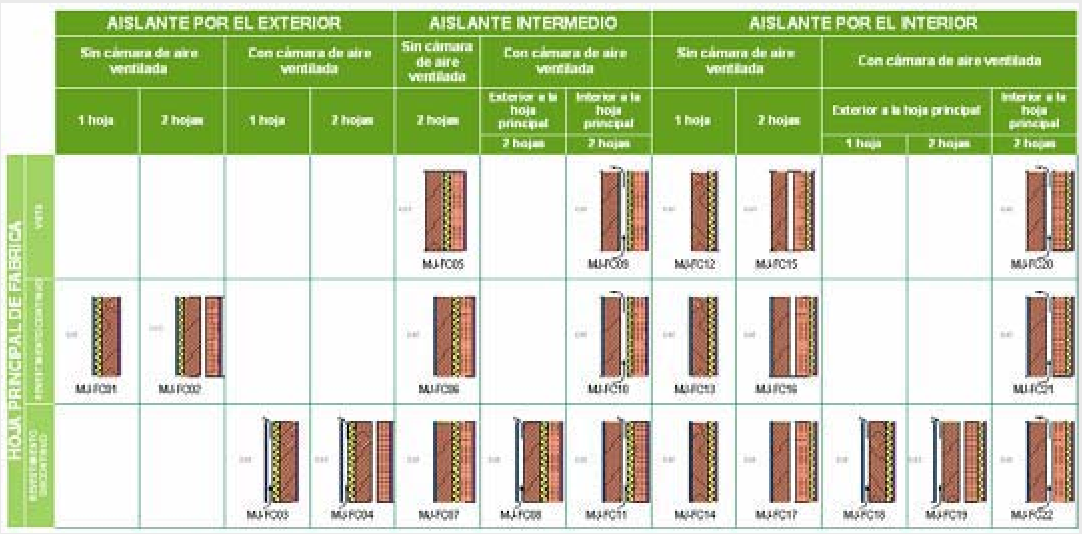


Figure 67: Technical specifications of the most common solutions

Pre-existing façade


CATÁLOGO DE SOLUCIONES CONSTRUCTIVAS DE REHABILITACIÓN

157

A proposal for an improved façade

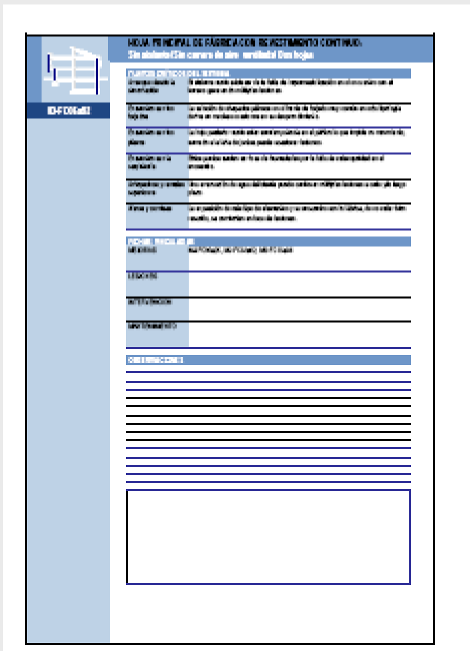

CATÁLOGO DE SOLUCIONES CONSTRUCTIVAS DE REHABILITACIÓN

195

Part 2 of the catalog delves into the technical characteristics of the specific constructive solutions, corresponding to the pre-existing constructive elements and to the improved solutions proposed from the catalog.

Figure 68: Technical characteristics of the constructive solution of an existing façade


IDENTIFICACIÓN



The blue filing cards contain information about the pre-existing elements giving their technical characteristics, including, the U value. It also describes the critical points of the solution that may be conflicting in a future intervention.

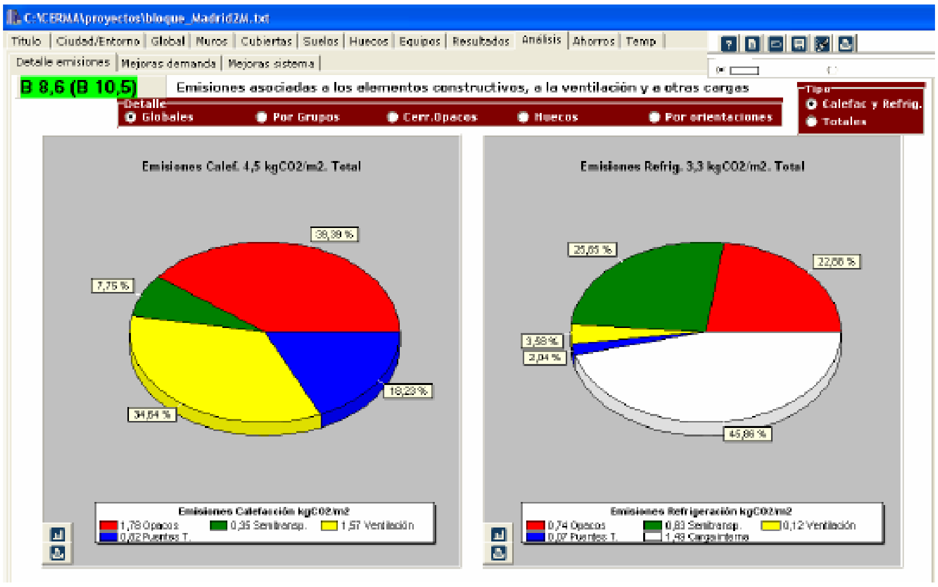
Figure 69: Technical characteristics of the improved facade solution

The Filing cards associated with improvement solutions incorporate technical features depending on the thickness of insulation. They include a graph that allows the technician to determine the insulation thickness required for the regulations in force depending on the thermal characteristics of insulating itself. Green filing cards also provide advantages and disadvantages of proposed solutions from not only a technical point of view but also economic, implementation and, of course, from the sustainability point of view.

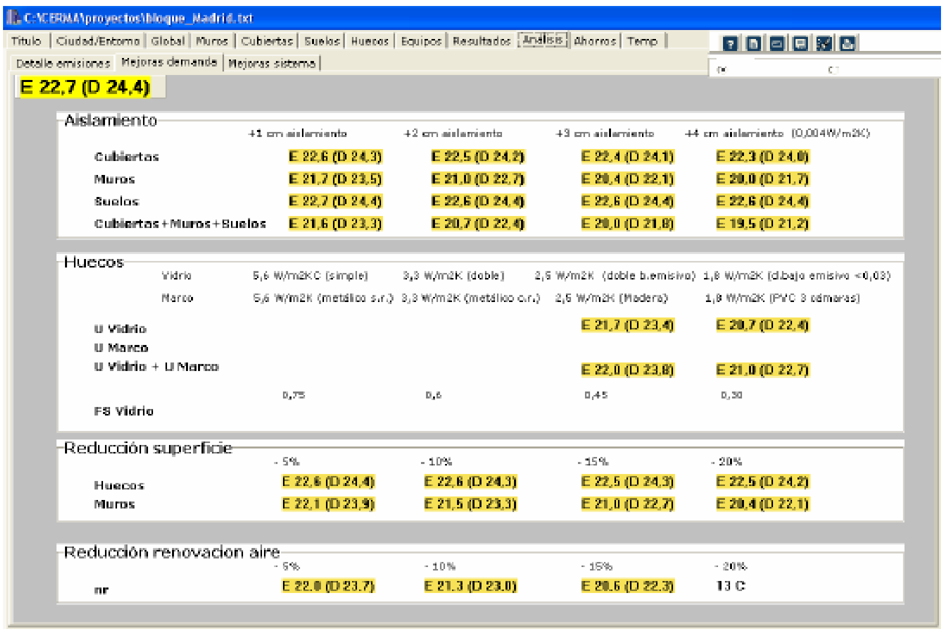
The computer tool CERMA+ allows estimation of existing residential buildings energy qualification. The aim of CERMA is, through a simple process of entering data, to make a quick estimation of the Energy Efficiency Rating letter. The letter of the Energy Efficiency Rating is obtained using tools provided by the Ministry of Industry. CERMA+ provides users with better solutions to efficiently reduce the energy consumption of the building.

The most outstanding result that this procedure provides is the detail of the building energy efficiency qualification estimation. Also obtaining qualification assigned to heating, cooling and hot water separately, monthly and annual energy demand for heating, cooling and hot water, consumption of final energy monthly and annual energy for heating, cooling and hot water; monthly and annual CO_2 emissions from heating, cooling and hot water, and information on reducing consumption that would be obtained using "standard" improvements in the constructive elements and systems provided by the building.

Figure 70: Results provided by the tool



The picture shows the screen "detail of emissions," which shows the emissions associated with the constructive elements, ventilation and other charges. This analysis is available globally, by group, by walls, by windows and by orientations, as well as by separate charges: heating, cooling or global.

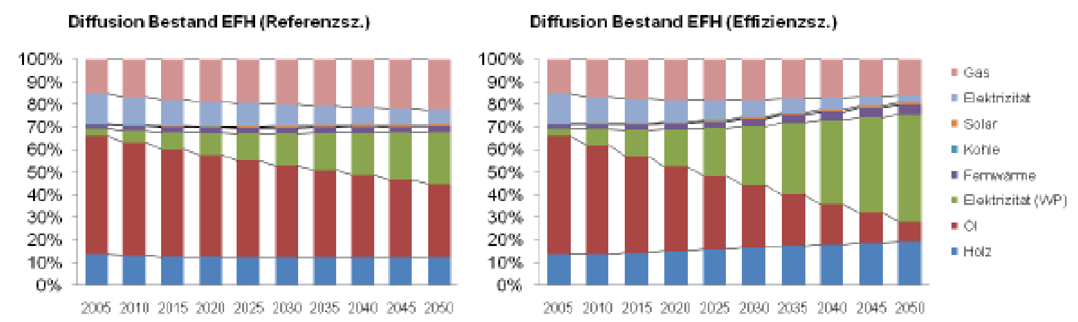


The picture shows the screen "Demand improvements", showing standard default scenarios for improvement and emissions resulting from the implementation of these improvements. CERMA + only shows the results when the results of the improvement are positive, i.e. when there is a reduction in emissions.

3.11 Switzerland

Different types of Swiss buildings were analysed in a comprehensive scenario study carried out by the Technical University of Zurich (ETH Zürich) and partners [Heeren 2009]: Single- and multi-family houses, office buildings and schools and 13 construction periods were considered. According to the given purpose – the making of a scenario analysis – the building types are mainly defined by U-values of the building elements and the heat supply structure. Architectural details of the building types are not considered and documented. The study makes use of statistical data of the Swiss building stock and the distribution of heat supply systems in Switzerland. Considering modernisation rates the analysis can build upon an earlier survey study [BFE2003].

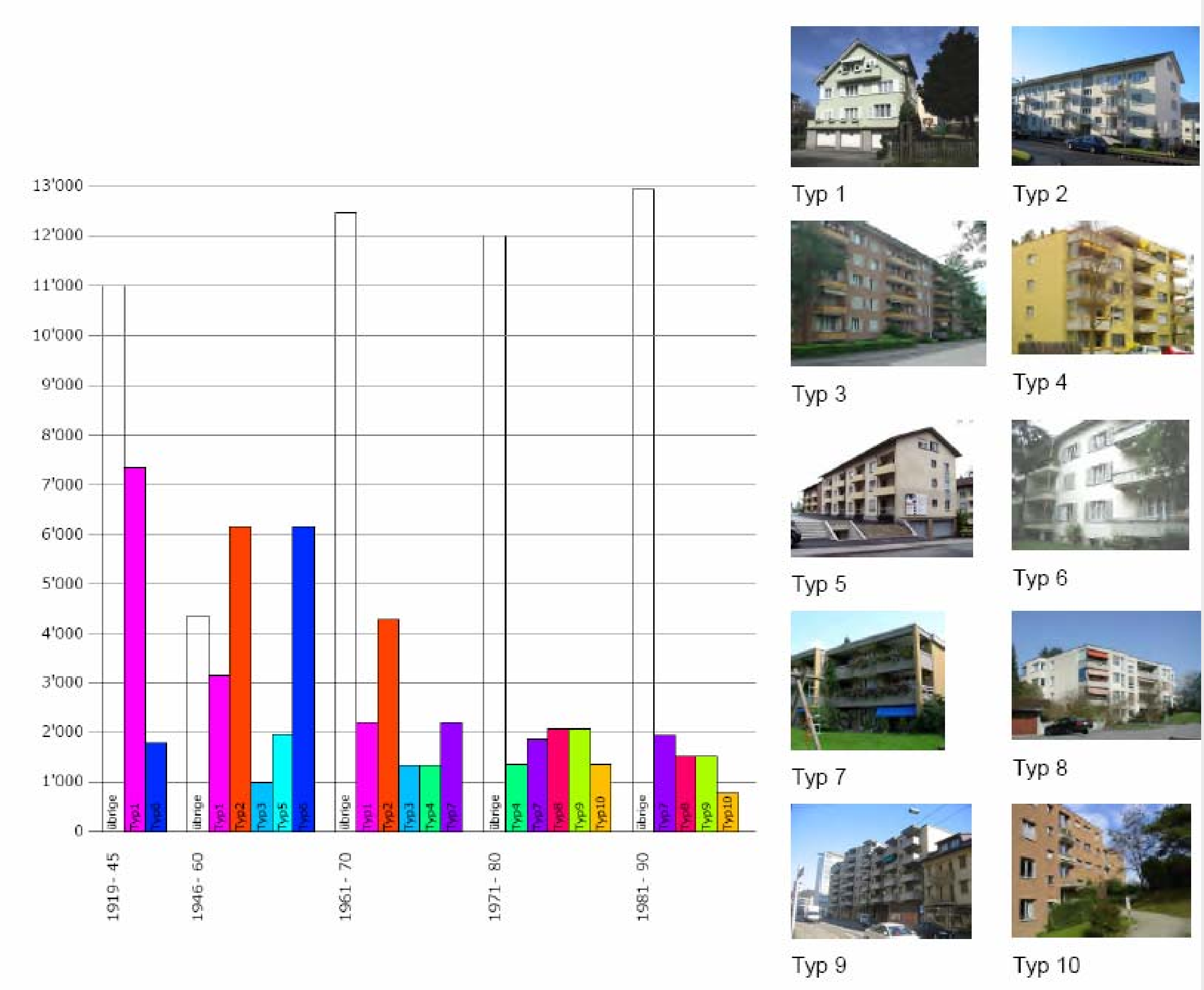
Figure 71: Energy carriers of space heating systems in the Swiss building stock (single family houses): 2005 and scenario values for 2035 and 2050 (from [Heeren 2009])



Diffusion [%]	2005	Referenz-Szenario 2035	Referenz-Szenario 2050	Effizienz-Szenario 2035	Effizienz-Szenario 2050
Holz	13,8%	12,4%	12,3%	17,3%	19,3%
Öl	52,5%	38,6%	32,4%	22,8%	8,9%
Elektrizität (WP)	3,0%	16,5%	22,9%	31,6%	47,2%
Fernwärme	1,9%	2,3%	2,5%	3,6%	4,4%
Kohle	0,2%	0,1%	0,0%	0,1%	0,0%
Solar	0,1%	0,8%	1,2%	0,8%	1,0%
Elektrizität	13,1%	8,5%	6,1%	6,4%	3,0%
Gas	15,4%	20,7%	22,6%	17,4%	16,1%

Building typology approaches are also developed the Lucerne University of Applied Sciences and Art in the “Competence Centre for Typology and Foresight Planning in Architecture”. Figure 72 shows a set of 10 representative buildings describing the section of multi-family houses in the Swiss building stock. The typology was developed in a research project aiming at a comprehensive modernisation strategy for the Swiss multi-family building stock using prefabricated elements.

Figure 72: Swiss multi-family house types (diagramme on the left: frequency depending on construction periods) [Fischer 2008][2]



References

[Heeren et al. 2009] N. Heeren (ETH Zürich), M. Jakob (TEP Energy GmbH) et al., „Gebäudeparkmodell – SIA Effizienzpfad Energie – Dienstleistungs- und Wohngebäude“, Vorstudie im Auftrag des Schweizerischen Bundesamtes für Energie, Schlussbericht 1. Oktober 2009

[BFE 2003] M. Jakob, E. Jochem: Erhebung des Erneuerungsverhaltens im Bereich Wohngebäude. CE-PE, ETH Zürich i.A. Bundesamt für Energie (BFE), Bundesamt für Wohnungswesen (BWO), Kantone ZH, AG, TG, BL und BE.2003

[2] R. Fischer, P. Schwehr (Hochschule Luzern, Kompetenzzentrum Typologie und Planung in Architektur) „Typenbasierte Evaluation – Chance für die ganzheitliche Wohnbauerneuerung“, in: 15. Schweizer Statusseminar „Energie- und Umweltforschung im Bauwesen“, 11./12. September 2008, Zürich

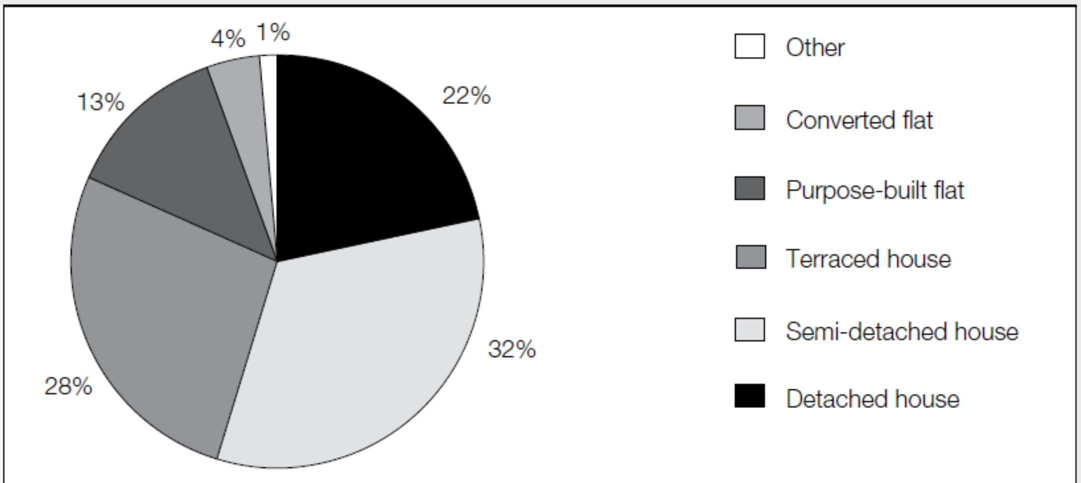
3.12 United Kingdom

UK National Statistics continuously publishes the relevant statistics at http://www.statistics.gov.uk/. As an example Table 76 shows the number of households by construction year and type of accommodation and tenure in England. Figure 73 shows the distribution of different building types.

Table 76: Year property built by type of accommodation and tenure, England, 2007-08
Source: [DCLG 2009]

Type of accommodation and tenure	Year property built: Before 1919	1919-1945	1946-1964	1965-1984	1985 or later	Total
						thousands
House or bungalow						
All owner-occupiers	2,571	2,759	2,796	3,096	2,040	13,262
All social renters	125	486	802	549	337	2,300
All private renters	489	328	256	237	233	1,542
All tenures	**3,184**	**3,574**	**3,853**	**3,882**	**2,610**	**17,104**
Flat or maisonette						
All owner-occupiers	264	90	153	244	277	1,029
All social renters	126	125	385	648	271	1,555
All private renters	267	144	97	173	171	853
All tenures	**657**	**360**	**636**	**1,065**	**719**	**3,437**
All types of accommodation[1]						
All owner-occupiers	2,870	2,859	2,968	3,368	2,346	14,413
All social renters	255	612	1,196	1,205	613	3,881
All private renters	797	493	367	415	416	2,488
All tenures	**3,923**	**3,964**	**4,531**	**4,988**	**3,375**	**20,782**

Figure 73: Type of accommodation, England, 2007-08
Source: [DCLG 2009]

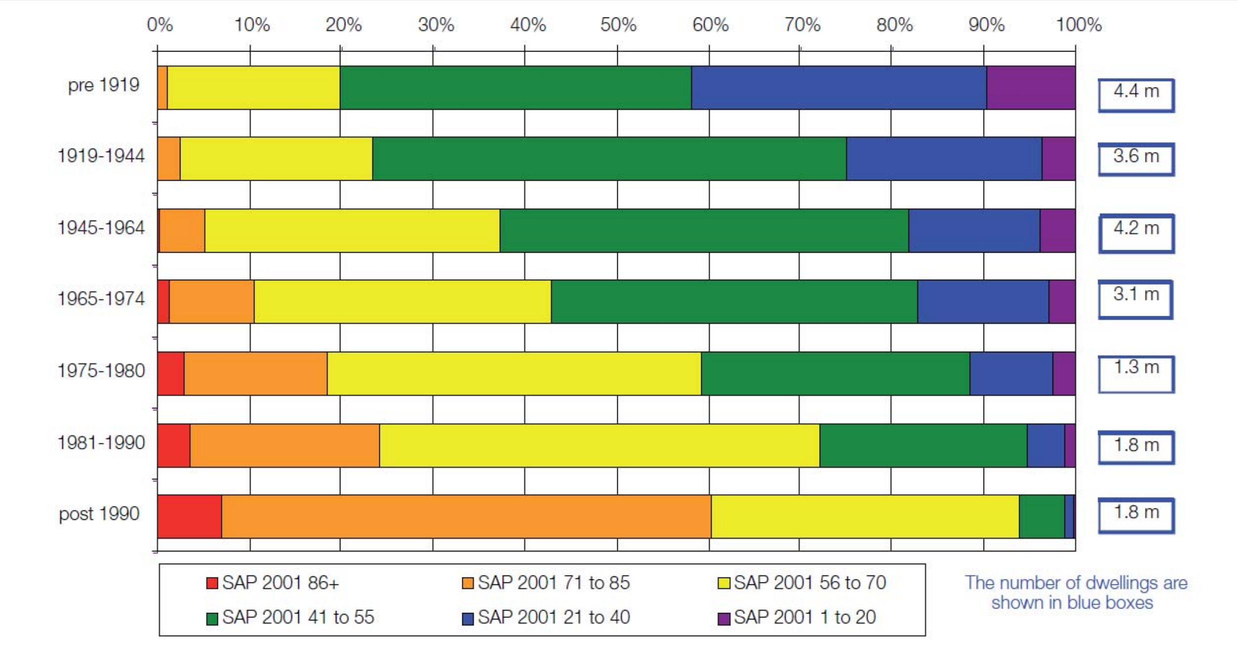


Source: Communities and Local Government, Survey of English Housing

An overview of the energy efficiency in the existing dwelling stock by typological criteria is given in [DCLG 2006]: According to this report the factors that have the greatest correlation with energy performance of the existing stock are age and dwelling type/size. Modern buildings are much more energy efficient and smaller buildings suffer less heat loss. Apart from these more or less immutable factors, the quality and amount of insulation and efficiency of heating systems also affect energy performance. Other factors that are taken into account in the SAP[3] calculations include building shape, orientation, window sizes and distribution.

Figure 74 clearly demonstrates a step change in the energy efficiency of post-1990 stock since when the building regulations have progressively raised the energy efficiency standards for new homes. Improvements in the energy performance of new build, combined with household improvements have led to an increase in the average energy efficiency of the stock. Two thirds of all properties have SAP values between 41 and 70.[3] There is a clear trend that older properties have much lower energy performance with over 40 per cent of properties built before 1919 with SAP less than 41. By contrast 60 per cent of properties built since 1990 have SAP ratings above 70.

Figure 74: Profile of energy performance in existing dwelling stock / dependence on construction age bands
Source: [DCLG 2006]



Further analyses have been done on methodical issues, e.g.:

- A current review of comprehensive building stock models describes bottom-up and top-down methods and gives an overview of common bottom-up modelling techniques (statistical and building physics based) [Kavgic et al. 2010]. The study inter alia compares five building physics based bottom-up models focusing on the same building stock (UK case study).
- A research team at Newcastle University School of Civil Engineering and Geosciences is working on a methodology that allows topographic building footprints to be classified to the level of residential spatial topological-building types and corresponding period of construction. The approach developed employs spatial structure and topology to first recognise residential spatial topological types of *Detached*, *Semi-Detached* or *Terrace*. Thereafter, morphological and spa-

[3] Energy performance of buildings is measured using the Standard Assessment Procedure (SAP), which measures the fuel efficiency of the heating systems and thermal efficiency of the building fabric i.e. how well it retains heat. It is measured on a scale of 1 (least efficient) to120 (most efficient).

tial metrics are employed with multinomial logistic regression to assign buildings to particular periods of construction for use within city-scale impact assessment studies. Overall the system developed performs well for the classification of residential building.

- Scotland has actually done a national energy model based on building typologies and published the model as an open source product so it can be updated over time.

References

[DCLG 2006] Review of Sustainability of Existing Buildings; Department for Communities and Local Government. The Energy Efficiency of Dwellings – Initial Analysis, London 2006

[DCLG 2009] Housing in England 2007–08. A report principally from the 2007– 08 Survey of English Housing; Department for Communities and Local Government: London; September 2009

[Kavgic et al. 2010] M. Kavgic, A. Mavrogianni, D. Mumovic, A. Summerfield, Z. Stevanovic and M. Djurovic-Petrovic: A review of bottom-up building stock models for energy consumption in the residential sector; Building and Environment Volume 45, Issue 7, July 2010, Pages 1683-1697

4 Application Fields and Target Groups

4.1 General Considerations

The collected examples from the different European countries show that typological aspects of the energy performance of buildings can be used for a large variety of purposes. In the following the different objectives and target groups in the respective application contexts are categorised on a general level. The special focus of the common approach of the TABULA project is indicated in chapter 4.2.

"Showcase Example": Demonstration of typically achievable energy savings

The basic form of a national building typology is a set of example buildings which are selected because they are very common in the respective country. An example building consists of a physical definition and a photograph of an actual existing building. The example buildings are classified by construction period and building size. Furthermore supply systems are defined which are common for the respective example building. The defined building types are used to demonstrate the possible energy savings by applying refurbishment measures.

The pre-calculated examples can be disseminated by brochures or by online information platforms. The primary target groups are house owners. Referring to the appearance and the details of an actual existing building proves the feasibility of the measures and creates the necessary confidence.

The "Showcase Examples" can also be used in energy advice or energy certificate software as pre-defined datasets in order to show typical energy savings without entering all the input data necessary for issuing an energy performance certificate. The availability of the same set of buildings in software applications also allows an easy comparison of the software features by the users.

Apart from the field of common information the showcase examples can also be used by key actors to present the impact of policies and measures in an illustrative manner.

"Typological Assessment": Simplified energy assessment of distinct buildings

In case of energy advice software applications the building types are usually just a starting point. They can easily be adapted to some basic features of the real building, for example to consider the variety of geometrical forms. But also in the case that the real building was already modernised by e.g. wall insulation of a certain thickness the typology "showcase" building may be modified in the same way (for energy balance calculation within the software) to draw a more realistic picture of the actual building.

Also the design of energy performance certificate procedures can be improved by typological aspects which allow simplifications of data acquisition: Instead of the investigation of a large number of building details (e.g. thicknesses and materials of construction layers, lengths and insulation of heat pipes) global values are used which represent typical cases.

"Building Stock Model": Imaging the energy consumption of the entirety of buildings

In case that frequencies of the above mentioned building types are known they can be used to model the energy performance of the building stock on a local, regional or national level:

The starting point is the existing building typology in form of "example buildings". In order to form a building stock model it is necessary to determine frequencies for each building type. Since the statistical information is not always available on the required level of detail (see chapter 6 "Statistical Data") an allocation on the basis of reasonable estimations is possible.

A typical application field is the investigation of energy saving potentials for a national or regional building stock and the ex post and ex ante evaluation of instruments and political strategies. Furthermore a building typology can be useful for the strategic planning of housing companies or other owners of building portfolios.

The elaborated set of example buildings can be used directly as a building stock balance model. But it is also possible to merge different classes and derive a small number of "average buildings". As a consequence the implementation of scenario analyses – which implicates the variation of a number of different parameters (e.g. insulation measures, supply systems) – is much more easy.

The quality of the building stock model can be improved by empirical enquiries or – if available – by analyses of a database containing datasets of all buildings of the considered building stock.[4] Possible analyses are the determination of average envelope areas, frequencies of construction types (materials, thicknesses), supply systems or frequencies of refurbishment measures by building type.

4.2 Focus of the TABULA project

The starting point for all these activities is the investigation and classification of the national building stock and the definition of the necessary construction periods and other energy-relevant parameters. This will be done in the framework of the TABULA project for all participating countries considering the available information documented in chapter 2. A further common task is to find at least one example building representing each building type and to calculate the possible energy savings for two types of measures (most common measures and advanced measures). In addition, the frequencies of building types and of supply system types will be indicated, as far as available (see chapter 6). Each partner will present the results in a "Typology Brochure" written in the respective national language addressing the above mentioned target groups. The methodical basis is to be documented in each case in a separate scientific report.

Some of the TABULA partners will use the building typology and the associated statistics also as a basis for defining a model of the national residential building stock. A further optional task will be to examine how to transfer the results achieved for the residential building stock to the non-residential buildings sector.

For a better involvement of the mentioned key actors the TABULA work programme is accompanied by a national advisory group in each participating country.

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[4] see IEE project DATAMINE www.meteo.noa.gr/datamine

Table 77: Application fields and target groups of building typologies in the context of energy performance assessment

Application Field / Objective		Context	Key Actors	Target Groups
Showcase Examples	**Initial Energy Advice Brochure**	use of brochures or building type sheets in consumer counselling interviews; demonstration of typically achievable energy savings, practical feasibility for typical buildings	consumer advisors, energy consultants, associations	consumers, house owners
	Illustration of Policies and Measures	illustrative presentation of the consequences of political instruments	energy / building experts, scientists	policy-makers, ministry departments, government agencies, other authorities, associations etc.
Single Building Assessment	**Simplified Energy Advice Software**	software applications which allow an adaptation of the typological assessment to distinct parameters of a given building	software companies, providers of online-information tools	consumers, house owners
	Simplified Issuing of Energy Performance Certificates	use of typological information instead of on-site acquired detailed data; reduction of effort for data enquiry	energy / building experts, scientists, standard setting organisations	EPC issuers, energy advisors
Building Inventory	**Portfolio Assessment**	example calculations, extrapolation to the whole portfolio, strategic decisions	energy consultants, building experts, expert staff of the different target groups	housing companies, municipalities, other owners of building portfolios
	Building Stock Modell	ex ante and ex post assessment of the impact of political strategies and instruments; scenario calculations	energy / building experts, scientists	policy-makers, ministry departments, government agencies, other authorities, associations etc.

5 Definition of the Common Typology Structure

5.1 Concept

As have been shown in chapter 2 a lot of information about the frequencies of existing buildings, typological criteria and the energy performance of existing buildings is available in the European countries. Nevertheless very different concepts have been implemented and the level of detail differs from country to country. Therefore it is not easy for a building expert to get a comprehensive overview of the appearance, the construction principles and the technical installations of typical buildings in other countries. This is not only a language problem but depends also on the different definitions and construction traditions.

The TABULA project aims at overcoming this problem by finding a common definition which serves as a platform for mutual understanding of the building stock's energy consumption and the measures taken to reduce it. The concept can be described in the following way:

1. Each partner develops, adapts or updates the building typology of his country. For this purpose he designs a classification system according to building age and size and finds example buildings representing the building classes. The respective data of these buildings (envelope areas, U-values, g-values etc.) together with the photographs constitute the building typology of the country. In an analogue manner a heat supply system typology is developed for the country. Then each partner defines refurbishment measures on the two different levels "typical" and "advanced". On this basis the energy saving potential and the achievable energy performance assessment according to the national regulations are calculated. The results will be documented in a brochure for each country in the respective national language.
2. Based on the existing experiences a harmonised approach for a structure of national typologies is developed by the project team. The project partners are supposed to transfer the national building data into the common typology structure. The result materialises in a database containing all model buildings from all participating countries. These well structured basic data will be available for all energy experts who want to analyse the residential building stock of different countries and carry out scenario analyses. Apart from the database a webtool is going to be developed which allows for a display of data of typical buildings from each country and showcase calculations for the original and the refurbished state.

The key principle of the TABULA approach is to follow both ways in parallel. Each partner is responsible for the transfer of the model building data between the national and the common data structure.

In the run up to the necessary harmonisation information about existing national building typologies was collected and analysed (see chapter 2). An overview of the agreed common typology structure is shown in Table 78. The details are outlined in the following sections.

Table 78: Main definitions of the TABULA typology structure (residential buildings)

1	**Parameters for Classification**		
	1	**Country**	country identifcation
	2	**Region**	> national > { region of the country, if necessary }
	3	**Construction Year Class**	for each country definition of periods: from { year }... to ... { year }
	4	**Building Size Class**	categories: > single family house > terraced house (single family) > multi-family house > apartment block > tower building
	5	**Additional Parameter**	optional / for example: > semi detached / end-terrace house > mid-terrace house > half timbered building > panel building > etc.
2	**Reference area**		floor area based on internal dimensions (see DATAMINE evaluation)
3	**Calculation method building**		Calculation of energy need for space heating: > seasonal method according to EN ISO 13790 > one-zone model
4	**Boundary conditions**		to be defined by partners for his country: > external temperature > solar radiation standard values: > room temperature > air exchange rate > internal heat gains > values for red. factors solar radiation (shading, ...)
5	**Thermal envelope**		external dimensions (DATAMINE convention)
6	**U-values**		table by each partner with explanations in national language and in English
7	**Consideration of thermal bridging**		categories (effect of constructional thermal bridges): > low > medium > high
8	**Calculation method supply system**		balance type: EN 15316, level B (tabled values)
			tabled values for subsystems determined by applying national procedures / standards: > heat generation: energy expenditure coefficients > heat storage: annual losses in kWh/(m²a) > heat distribution (including heat emission): annual losses in kWh/(> auxiliary energy: annual electric consumption in kWh/(m²a) (each for space heating systems and dhw systems)
9	**Delivered energy / fuel**		reference to gross calorific value

5.2 Common Classification

The agreed parameters for classification of buildings are:

- the country
- the region or climate zone, if available
- the construction year class
- the building size class
- an additional parameter

A code system for identification of the building types is going to be developed.

All partners have to classify their building types according to this system, considering the following points:

- If possible a single national building typology should be developed for a country. In this case the parameter “region” would be disregarded (standard value “national”).
- In case that in a country there are regions which significantly differ with regard to climate conditions and typical buildings (appearance, construction principles) the complete typology will be developed for each region separately (in consequence the classification “national” is not existing for this country).
- In case that only some special building types are existing in a distinct region of the country they can be considered as individually defined additional category using the Additional Parameter.
- The additional parameter can furthermore be used to define subtypes (e.g. mid-terrace, end-terrace) and special construction principles (half-timbered buildings, panel buildings, etc.) , if necessary.
- The construction year classes reflect shifts in building practice and energy requirements by building regulations. They are defined for each country separately.

5.3 Energy Performance Calculation

The common building typology structure of the TABULA project will in general be used for determining the energy use for space heating and domestic hot water of residential buildings. Cooling, air conditioning, lighting, electric appliances will not be considered in the general concept. Nevertheless, some partners will dedicate their work to the question of transferability of the typology concept to these energy uses at non-residential buildings. During this activity the TABULA partners will discuss which additional definitions will be necessary for non-residential buildings.

The general TABULA approach is that two independent calculation procedures will be applied to each building typology:

[A] National Calculation Procedures for each country

Each partner is applying the respective national energy balance procedure according to national EPBD implementation. The results will be used for the elaboration of the National Building Typology Brochures and other national applications.

[B] Common Calculation Procedure

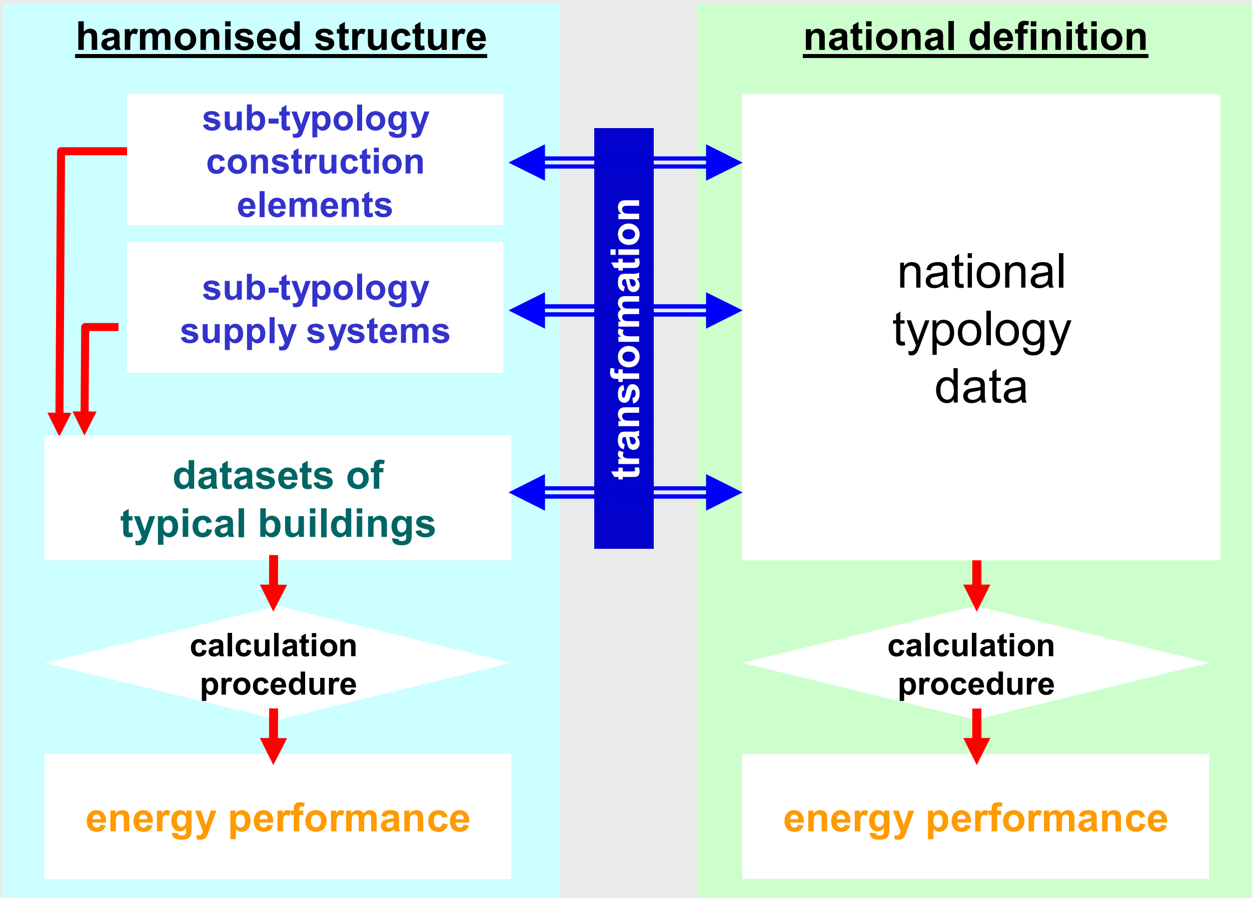
This is the harmonised approach for calculation of the energy use and the delivered energy by energy carriers. It will be used in the Typology Webtool and in the framework of cross-country comparisons. The common calculation is supposed to be a very simple procedure in order to ensure transparency of the calculation (understandable in each country / comprehensible online calculation) and easy handling (Excel calculation for a large number of buildings). The calculation procedure is as far as possible defined in accordance with the relevant CEN standards and takes into account standard values for climates and utilisation, fixed on a national level. In general already existing harmonised definitions (CEN, DATAMINE, ...) are taken into account, if applicable.

In the long run it is intended to develop a set of (empirical) factors for each country, representing the relation between

- the measured and the calculated consumption
- the energy performance indicators of the national and the common procedure

each determined for a large number of buildings

Figure 75: Relation of the common typology structure and the national definition



[A] National Calculation Procedures (National Context)

The calculation procedures which will be used by each project partner to develop the national building typology brochure are listed in the following table.

Table 79: Calculation methods intended to be used for the National Building Typology Brochures (later changes possible)

Partner N° Country	Method / Software	Explanation
1. Germany	Energieeinsparverordnung EnEV 2009 (Building: DIN V 4106-10 / System: DIN V 4701-10 / -12 + PAS 1027) Software Application: EnEV-XL	official method of the German Energy Saving Ordinance for residential buildings; additional application of adaption factors for calibration of calculated energy demand to typically measured consumption
2. Greece	Energy demand: EN-ISO 13790 (monthly method) and relevant TOTEE Heating Systems: EN 15378:2007 and relevant TOTEE Software Application: EPA-NR (as adapted for Greece by TEE)	The recently signed national regulation for the energy performance of buildings – KENAK is based on the official European standards (Common Ministerial Decision KYA 5825/9.4.2010), The Technical Chamber of Greece (TEE) is finalizing national technical guidelines (TOTEE) for the determination of the related factors on a national basis, along with a software based on EPA-NR
3. Slovenia	(not yet determined)	
4. Italy	(not yet determined)	
5. France	(not yet determined)	
6. Ireland	Dwelling Energy Assessment Procedure	official method for all dwellings in the Republic of Ireland
7. Belgium	(not yet determined)	
8. Poland	(not yet determined)	
9. Austria	"OIB-Richtlinie 6", incl. annexes and "ÖNORMEN H 5055 – H 5059" Software: ETU „Gebäudeprofi plus“ and xls-Tool granted by the OIB (Austrian Institute of Construction Engineering)	official methods and calculation factors for Austrian EPC´s for residential and non-residential buildings
10. Bulgaria	(not yet determined)	
11. Sweden	(not yet determined)	
12. Czech Republic	(not yet determined)	
13. Denmark	Building's energy demand (Bygningers Energibehov). Danish Building Research Institute, Direction no. 213.	Monthly method, primarily based on European standards adapted to Danish conditions: Heating and cooling demands are calculated according to prEN ISO 13790:2005. In addition use of solar shading, the length of the heating season, utilization of a share of the

	Software application: Be06	heatloss from installations is taken into account. Calculation of heat loss from installations is based on the Danish Standard DS 452. Heat loss from pipes is based on prEN 15316, part 2.3 and part 3.2. Losses in boilers and auxillary electricity are determined on monthly basis from the actual conditions according to prEN 15316 part 4.1 metode II og part 3.3. Eletricity consumption in heat pumps is determined from the overall efficiency and the choice of heat source and delivery according to relevant parts of prEN 15316 part 4.2 – given the fact that this method is developed for an annual calculation. Contribution from solar heating for domestic hot water is determined on monthly basis determined form the actual system layout. Calculations is based on prEN 15316, part 4.3. Electricity for lighting is calculated according to relevant parts of prEN 15193-1. Contribution from solar cells is calculated according to prEN 15316 part 4.6.

[B] Common Calculation Procedure (International Context)

The common energy balance calculation method is defined as follows:

Calculation of energy need for space heating

The energy need for space heating is calculated by applying the seasonal method according to EN ISO 13790 on the basis of a one-zone model. The external boundary conditions (air temperature, external temperature / solar radiation) are defined by each partner for his own country for a standard base temperature. In case of significant climatic differences between regions of a country several climate datasets are provided. Standard values are used for the utilisation conditions (room temperature, air exchange rate, internal heat sources) and for the solar radiation reduction factors (shading).

The basis of the envelope area calculation are the buildings' external dimensions, as already established in the DATAMINE project.[5] As regards the thermal transfer coefficient a table will be provided for each country with U-values of typical construction elements, differentiated by construction period, supplemented by explanations in national language and in English.

Thermal bridging will be considered by applying 3 categories (low / medium / high) depending on the effect of constructional thermal bridging. The assessment takes into account the amount of penetration of the thermal envelope by punctual or linear construction elements with significantly higher thermal conductivity not considered in the U-values. The respective additional losses will be incorporated in the common calculation procedure in the form of an addend on the heat transfer coefficient by transmission.

5 This convention has specific advantages in the case of simplified calculation procedures: The transmission losses of the undisturbed envelope areas (summarised product of areas and U-values) are for buildings without severe constructional thermal bridging roughly the same as the exact transmission losses including Ψ-values at the edges of the elements (summarised product of lengths and Ψ-values are approximately Zero). Therefore the possible energy saving by applying thermal insulation to the different construction elements can be determined in a simple way. Supplemental losses of severe constructional thermal bridging can be considered by applying an additional term to the transmission losses. In case of internal dimensions the geometrical thermal bridging must always be taken explicitly into account.

Most of the partners are using external dimensions in their countries, whereas the national methods of France and Ireland are based on internal dimensions. Conversion factors can be used to transform between internal and external dimensions.

Calculation of the delivered energy need

The energy performance of the supply system is calculated on basis of tabled values for the following subsystems (EN 15316 level B). In the case of heat generators energy expenditure coefficients are used which are defined as the ratio of delivered energy need to produced heat. As agreed in the DATAMINE project values for the delivered energy are always based on the gross calorific value. In case of heat storage and heat distribution, values for the annual losses in kWh/(m²a) will be listed in the respective tables. The auxiliary energy will be considered by values representing the annual electric consumption in kWh/(m²a). The above mentioned tables will be created for both space heating systems and dhw systems. The tabled values will be determined for typical supply systems according to the respective national standards.

Reference area

In order to compare different buildings it is convenient to relate the energy consumption to a quantity representing the size of the building, usually the floor area or the volume of the buildings. However, different types of reference areas or volumes are used in the partner countries and there is no type which is available for all countries. Therefore a reference area is defined which is used for the purpose of cross-country comparison and which is derived from the available reference quantities.

The definition of reference areas is based on the DATAMINE data structure. It contains the following types of floor areas (see [DATAMINE FR]):

Table 80: Definition of different reference quantity according to the DATAMINE data structure [DATAMINE FR]

Quantity	Data field name		Description
conditioned gross floor area	**A_C_extdim**	m²	conditioned floor area calculated on the basis of external dimensions (measured to the outside surface of external walls)
conditioned floor area	**A_C_intdim**	m²	conditioned floor area calculated on the basis of internal dimensions (measured to the inside surface of external walls) The floor area may be the gross internal area (= total building area measured inside external walls) or the net internal area (= total building area measured inside external and internal walls) - since the difference is small we don't distinguish between both. The conditioned area is generally equal with the heated area or with the air-conditioned area, dependent of which is the bigger one.
conditioned useful floor area	**A_C_use**	m²	section of the conditioned net floor area primarily dedicated to the utilisation of the building, excluding functional and circulation areas (excluding e.g. stair cases in all buildings, corridors in non-residential buildings). In office buildings the conditioned useful floor area is equivalent to the net lettable area.
conditioned living area	**A_C_living**	m²	section of the conditioned net floor area inside of the apartments of the building (only to be filled in for buildings which are completely or at least partly used as residential buildings)
conditioned building volume	**V_C**	m³	conditioned volume of the building (external dimensions)

The reference area used in the DATAMINE concept is the conditioned floor area based on internal dimensions. The reason for this choice is that the values are typically between A_C_extdim and A_C_use or A_C_living. In consequence the area related energy performance indicators are closer to those which are known in the different countries and can therefore be more easily compared with well-known values without converting.

If this area is available for a building the reference area A_C_ref will be derived directly from A_C_intdim. If it is not available, A_C_ref is estimated by use of the available reference quantities using the following adaptation factors (and the given sequence of queries):

Table 81: Derivation of the reference area used for cross-country comparison [DATAMINE FR]

available quantity	A_C_ref
conditioned floor area based on internal dimensions	= A_C_intdim
conditioned floor area based on external dimensions	= 0,85 · A_C_extdim
conditioned living area	= 1,1 · A_C_living
conditioned useful floor area	= 1,4 · A_C_use
conditioned building volume	= 0.85/3.0 · V_C = 0,283 · V_C

5.4 Actual Consumption

Due to a number of reasons systematic discrepancies between the calculated and measured energy consumption can be found in practice: There are always uncertainties regarding the actual transmission losses of a building, since the thermal conductivity of the construction materials can usually not be measured and the heat transfer on external and internal surfaces varies depending on different influences (neighbouring buildings, greened facades, wind protection, furniture near the walls, …) which are difficult to determine. Further uncertainties result from unknown details of the supply system (length, insulation and average temperature of heat pipes, …).

Apart from technical properties of the building envelope and the supply system a further cause for discrepancies of calculated and measured consumption is the user behaviour. An indicator for this influence is the broad spread of consumption values which can be discovered in thermally identical buildings. The variation is caused by the wide range of thermal comfort levels. But the conditions can also depend systematically on the building or system type. A large single family house with for example 2 inhabitants in 6 rooms is more likely to have a lower average indoor temperature due to the fact that some rooms are not directly heated during winter. Completely different indoor conditions can be assumed for an apartment in which 5 persons share 3 rooms. Apart from a higher average temperature also the demand for fresh air will typically be higher.

In practice also the type of heating system can influence systematically the relation between actual and calculated consumption. Usually, dwellings heated by wood or coal stoves have a lower average temperature than centrally heated buildings as the effort to heat it is much higher (buy and carry the heating fuel, start a fire) and there is no thermostat to control the temperature. It can also be assumed that the comfort traditions are different from country to country.

It is difficult to include all these aspects in the assessment of buildings and in the calculation of the possible energy savings. Therefore the energy performance is usually calculated by use of a number of simplifications regarding the technical building properties and by determining standard boundary conditions – in order to keep the effort for data acquisition acceptable. The use of standard values for indoor conditions can also be justified by the need for comparability. The energy performance and heating costs of different buildings should be compared by assuming the same thermal comfort.

On the other hand one of the main objectives of the creation of national building typologies is to image the actual energy consumption of the building stock and to develop and evaluate strategies for possible reductions. In consequence, the actual consumption of the buildings has to be taken into account. Information is needed regarding the typical relationship of asset to operational rating – for all national methods as well as for the common calculation method. This knowledge constitutes an important pre-condition for a reliable determination of energy savings, in case of energy advice (typically achievable savings) and in case of building stock modelling (total or average energy savings). Each TABULA partner will face this challenge and will – as far as possible – try to determine the correlation by use of the available information. Nevertheless, statistically well-founded and differentiated values can in most cases only be found in the long run by future investigations.

References Chapter 5

[DATAMINE FR] Loga, Tobias / Diefenbach, Nikolaus (ed.): DATAMINE – Collecting Data from Energy Certification to Monitor Performance Indicators for New and Existing Buildings; Final Report of the EIE project DATAMINE; IWU Darmstadt, January 2009 http://env.meteo.noa.gr/datamine/

http://www.iwu.de/fileadmin/user_upload/dateien/energie/DATAMINE_Public_Final_Report.pdf

executive summary:
http://www.iwu.de/fileadmin/user_upload/dateien/energie/DATAMINE_Executive_Summary.pdf

6 Statistical Data

One of the benefits of building typologies is to provide a basis for the analysis of the national building stocks, e.g. for energy balance and scenario calculations. In order to fulfil this task the building typology has to be accompanied by statistical data describing the frequency of building and heating system types. Thus, during TABULA statistical data of the national residential building stocks will be collected and documented. Since the making of comprehensive statistical analysis or even carrying out new surveys is beyond the scope of the project, all partners rely on the already available data in their countries which might be very different from case to case. Nevertheless, harmonisation of data is a major intention of the project and thus an attempt will be made to define a common approach for data presentation which is at the same time flexible enough to meet the individual needs. In this chapter a preliminary version of the TABULA statistical data structure is presented.

6.1 Statistical Data Structure

The data structure will be defined by data tables which will later be filled in by the TABULA partners in cases where the respective data is available for their countries. At the moment the tables are still empty but for clarification examples for the labelling of the rows and columns of the tables will be given. Just for a better illustration they sometimes reflect the situation of the German subproject. They only serve as examples and can always be adopted to the data availability in the respective country.

The tables S-1.1 to S-1.2.1 are related to the buildings, tables S-2.1 to S-2.10 provide the statistical information of the heat supply system (including ventilation and air conditioning, if applicable).

Table 82: Overview of the statistical table templates S-1.1 to S-2.10

Statistical Table	Item
S-1.1	Frequency of building types of the national building stock
S-1.2	State of envelope refurbishment
S-2.1	Centralisation of the heat supply (for space heating)
S-2.2	Heat distribution and storage of space heating systems
S-2.3	Heat generation of space heating systems
S-2.4	Heat distribution and storage of domestic hot water systems
S-2.5	Heat generation of domestic hot water systems
S-2.6	Solar thermal systems
S-2.7	Ventilation systems
S-2.8	Air-conditioning systems
S-2.9	Control of central heating systems
S-2.10	Correlation of envelope and heat supply modernisations

All tables which can be filled in by the project partners will have to be accompanied by documentation of the used information sources. It has to be considered that all the given data will have to be related to statistical surveys, either “official” national statistics or scientific investigations which are base on “real” statistical data acquisition. If estimations are made to fill in data gaps those numbers may not be documented here (even if the numbers can be quoted from scientific literature): This kind of data can also be collected but it will have to be documented separately.

Statistic S-1.1: Frequency of building types of the national building stock

Building TYPE	number of buildings	number of apartments	living space in 1000 m²	TABULA reference area in 1000 m²
SFH.01				
SFH.02				
SFH.03				
…				
MFH.04				
…	…			
AB.7.hr	…			
Building Stock total				

This is one of the most important statistical data tables because it is directly related to the building typology. Since very basic information of the residential building stock is considered which is available in most of the countries, usually a high level of detail will be achieved here. In the German case for example the data can be made available for each of the currently more than 40 building types.

Instead of the living space a different national reference area (e. g. the most common one) can be considered. Because of the different national definitions a common TABULA reference area was defined (see chapter 0) to make the numbers comparable.

In the following tables the building type will be combined with further data: In 1.2. information on the modernisation of the building envelope is provided, the tables S-2.1 to S-2.10 show the supply system. In considering all these additional characteristics one after the other the building stock would divide in more and more subtypes. To give an example:

44 building types x 4 levels of modernisation x 15 types of heating systems would result in 2640 classes. Because it can not be expected that statistical information will be available on that level of detail and for a clear arrangement of the data a simplified documentation will usually be necessary. Therefore it will be necessary to combine several building types in higher classes. In the German case it might be suitable to distinguish only between single-unit houses (SUH, including all buildings up to 2 apartments, single-family houses as well as terraced houses) and multi-unit houses (MUH, all buildings with 3 and more apartments, multi-family houses as well as apartment blocks). Moreover only four construction periods are considered: “Very old” buildings (until 1957), “old” buildings (1958 – 1978) and two further periods reflecting the introduction of the “thermal protection ordinances” for new buildings since the end of the 1970ies (1979 - 2001) and the improved “energy saving ordinances” (since 2002) [6]. In later tables the first two periods (building constructed until 1978) will be combined for further simplification.

[6] To be precise, the first German thermal protection ordinance came into force at the end of 1977.

Statistic S-1.2.1: Percentage of thermally refurbished envelope areas

Building classes	walls	roofs /upper floor ceilings	basement / cellar ceiling	windows
Single Unit Houses				
SUH.01-04 (until 1957)				
SUH.05-06 (1958 - 1978)				
SUH.07-09 (1979 - 2001)				
SUH.10-11 (since 2002)				
Multi Unit Houses				
MUH.01-04 (until 1957)				
MUH.05-06 (1958 - 1978)				
MUH.07-09 (1979 - 2001)				
MUH.10-11 (since 2002)				

This table indicates the level of how far thermal protection refurbishment measures that have been carried out in the building stock. Thermal protection at the time of building erection is not to be documented here because it is already considered in the description of building types.

Statistic S-1.2.2: Information on insulation level and window types

(no common template)

This table delivers supplementary information on the level of thermal protection (e.g. U-values, insulation layer thickness, window types like double glazing or thermal protection glazing). Because the type of available data may be quite different from case to case (if available at all) a suggestion for the design of the table is not given here.

Statistic S-2.1: Centralisation of the heat supply (for space heating)

percentage per building class	**single unit houses**				**multi unit houses**			
	SUH.01-04	SUH.05-06	SUH.07-09	SUH.10-11	MUH.01-04	MUH.05-06	MUH.07-09	MUH.10-11
	-1958	1959-78	1979-2001	2002 -	-1958	1959-78	1979-2001	2002 -
room heating systems								
building / apartment heating systems								
district heating								
	100%	100%	100%	100%	100%	100%	100%	100%

Statistic S-2.1 gives very basic information on the space heating system.

In the German case it is planned to consider just eight building classes, but for the reason of simplification this number is reduced to six in the next tables by combining the old buildings (constructed until 1978) in one class. This is based on the fact that the estimated average lifetime of heating generators is only 20 – 25 years so that in those old buildings at least one exchange of the heat generator will probably have taken place breaking up the coupling of building age and the type of heat generator. At the same time those old buildings can be considered as “similar” because they were erected before the first German thermal protection ordinances came into force.

Most of the tables in this chapter show percentage numbers, so that it will be necessary to tell which quantity they are referring to. For example if the numbers in the table for MUH.05-06 would show 10 % for district heating – what does it mean? Are 10 % of the buildings of class MUH-05-06 supplied by district heating or are 10 % of the apartments (or the living space) in those buildings supplied by district heating? This is not the same because within MUH.05-06 there are buildings with only 3 or 4 apartments but also those with 10 and more apartment. And if the percentage of district heating supply is different within those subgroups then also the numbers will be different. So it is always important to provide the information on which quantity the percentage numbers are based. Here we do not give a certain definition because the choice to be made will depend on data availability and in this chapter only examples are shown.

Statistic S-2.2: Heat distribution and storage of space heating systems

heat distribution and storage (for space heating)	**single unit houses**			**multi unit houses**		
(related to building / apartment heating systems and district heating)	until 1978	1979-2001	since 2002	until 1978	1979-2001	since 2002
"type 1" (e.g. high heat losses, distribution pipes not insulated)						
"type 2" (e.g. medium heat losses, distribution pipes insulated)						
"type 3" (e.g. low heat losses, distribution pipes well insulated)						
"type 4" (e.g. very low heat losses, distribution inside the apartment)						
	100%	100%	100%	100%	100%	100%

The four levels of insulation just serve as an example for classifying the available information.

The numbers in the table only relate to buildings with building / apartment heating systems (stoves) or district heating. This is because in the case of room heating systems there is usually no separate heat supply and storage system so there is no such table necessary or it can be dealt with separately[7].

In many cases, also in the following tables, it will be sensible to consider the degree of centralisation of the heating system (given in Statistic S-2.1) as a second classification criterion beside the main criterion of building types (with its six classes in the example) – as it has been done here. In such a case it is important that the table always shows clearly which type of heating systems (according to Statistic S-2.1) the numbers are related to.

Statistic S-2.3: Heat generation of space heating systems

heat generation (for space heating): main system						
numbers related to: building and apartment heating systems	**single unit houses**			**multi unit houses**		
	until 1978	1979-2001	since 2002	until 1978	1979-2001	since 2002
very old gas boilers (until 1978)		…				
old gas boilers (1979-1994)		…				
new gas boilers (non-condensing, since 1995)						
new gas boilers (condensing, since 1995)						
very old oil boilers						
….						
old electric heat pumps (until 1994)						
new electric heat pumps (since 1995)						
….						
(about 15 systems)						
	100%	100%	100%	100%	100%	100%

Statistic S-2.3 gives quite important data for the energy balance of the national building stock: The distribution of heat generators for space heating among the (six) building classes. It includes three different characteristics which could in principle also be counted separately:

The energy carrier (2.3.1), the installation year (2.3.2) and the type (2.3.3) of the heat generator. Usually this information should be combined as in the example table so that the relationship between these quantities is considered (for example the installation years of gas boilers are different from oil boilers or heat pumps).

It has to be noted that again – like in 2.2 – the centralisation of the heating system is used as second classification criterion: The example Statistic S-2.3 only relates to houses with building or

[7] In case of electric night storage heaters the storage system is usually interpreted as a part of the heat generation system to be considered in table 2.3.

apartment heating systems. Room heating systems should be considered in a separate part of Statistic S-2.3 (not shown in this example), whereas buildings with district heating supply do not have a separate (main) heat generator so that for them there is no additional information necessary.

The table should be related to the main heat generation system. If there is an additional solar system it will be considered in Statistic S-2.6

Statistic S-2.4: Heat distribution and storage of domestic hot water systems

(similar to Statistic S-2.2)

In principle the same as Statistic S-2.2 but for hot water instead of space heating.

Statistic S-2.5: Heat generation of domestic hot water systems

(similar to Statistic S-2.3)

In principle the same as Statistic S-2.3 but for hot water instead of space heating.

Statistic S-2.6: Solar thermal systems

solar thermal systems	single unit houses			multi unit houses		
	until 1978	1979-2001	since 2002	until 1978	1979-2001	since 2002
no solar thermal system						
solar system for hot water						
solar system for heating and hot water						
	100%	100%	100%	100%	100%	100%

The example table shows a simple way of considering solar thermal systems.

Statistic S-2.7: Ventilation systems

ventilation systems (building/appartment systems)	single unit houses			multi unit houses		
	until 1978	1979-2001	since 2002	until 1978	1979-2001	since 2002
no ventilation system						
exhaust air ventilation						
ventilation system with heat recovery						
	100%	100%	100%	100%	100%	100%

Only ventilation systems for complete apartments or buildings should be considered here (no ventilation systems only for the toilet or exhaust hoods in the kitchen).

Statistic S-2.8: Air conditioning systems

cooling / air conditioning systems	single unit houses			multi unit houses		
	until 1978	1979-2001	since 2002	until 1978	1979-2001	since 2002
there is no cooling / air conditioning system						
there is a cooling / air conditioning system						

Here small systems for the cooling of single rooms should also be considered.

Statistic S-2.9 Control of central heating systems

control of central heating sytems *numbers related to: building / apartment and district heating systems*	**all (single and multi unit) houses**		
	until 1978	1979-2001	since 2002
no valves (at the radiators)			
non-thermostatic valves			
thermostatic valves			

In this example it is assumed that for single and multi-unit houses separate statistical data is available is not available.

Statistic S-2.10 Correlation of envelope and heat supply modernisations

The tables S-1.2 and S-2.3 deal with building insulation and heat generators separately, but it can be assumed that there is a relationship: It appears quite probable that the fraction of modern energy-saving heating systems is higher in well insulated buildings than in non-modernised houses of the same age. If statistical data is available it can be presented here. A possible way of doing this might be to subdivide building classes like (SUH.01-04 erected until 1978) in at least two new categories “modernised” and “not modernised” and to document the results of Statistic S-2.3 separately.

6.2 Availability of Data

A pre-check of data availability for the tables S-2.1 to S-2.7 was carried out among the TABULA project partners. In order to describe the level of detail of statistical data, three rough levels were introduced with level 3 being the highest one considering building size classes (at least single- and multi-unit houses) as well as building age classes. As additional information the number of climate zones, building size classes and age classes are given which will prospectively be considered in the statistical data at levels 2 and 3 (if applicable). The following table shows the results of the availability check: It can be expected that the statistical data of the most important issues (highlighted yellow: frequency of building types, centralisation of heat supply and heat generator) will be made available on a satisfying level of detail in most of the countries. As expected, statistical information on many other characteristics which are usually not in the focus of national statistics will often not be available, for example about the modernisation of building elements.

Table 83: Pre-check of the availability of statistical data by the TABULA partners

Planned level of detail	Germany	Greece	Slovenia	Italy	France	Ireland	Belgium	Poland	Austria	Bulgaria	Sweden	Czech Rep.	Denmark
number of climate zones / regions in the typology	1	4	3-4	3	not yet clear	1	3	1	7 / 2	not yet clear		4	1
Levels of Detail *(climate zones x size classes x age classes)*	***L3a 1x4x10 L3b 1x2x(3-4)***	***L3 4x2x3***	***L3 (3-4)x5x5***	***L3 3x3x7***	***L3a 46 types L3b 1x2x7***	***L3 1x4x10***	***L3 3x6x6***	***L3 1x2x6***	***L3 2x3x6***	***L3 1x2x8***		***L3 (1x2x7) L2 (1x1x3)***	***L3 (1x4x7)***
Remarks	*most of the data available in autumn 2010 (survey)*	*sometimes not official statistics but estimates*	*4 data sources >1000 build. each*	*difficulty: assign regional data to climat zones*	*details to be clarified, 2011 detailed study*	*later: analysis of national En.Certificate Database*	*some old data (2001) must be extrapolated*	*official statistics only 1x1x6 perspective: EPC database -> detailed information*	*national survey: measures of last 10 years, but not considering older measures*				
1.1 Frequency of Building Types	**L3a**	**L3**	**L3**	**L3**	**L3a**	**L3**	**L3**	**L3**	**L3**	**L3**		**L3**	**L3**
1.2 State of Modernisation	L3b	(--)	L3	some data available	--(2011)	L1 (estimates	L1 (Flandres	--	L3	--		--(estimation	L3
1.2.1 Modernised Building Elements	L3b	(glasing)	L3					--	partly L 3 (e.g. external walls)				L3
1.2.2 Modernisation Quality	L3b		L3 (year)					--	--				L3
2.1 Centralisation of Heating System	**L3b**	**L3**	**L3**	**L3**	**L3b**	**L 2.2 (age)**	**L3**	**L3**	**L3**	**L1**		**L2**	**L3**
2.2 Heat Distribution (Space Heating)	L3b	?	L3		-- (2011)	--	L1	--	L3	--		--	L3
2.3 Heat Generation (Space Heating)	**L3b**	**L3**	**L3**	**L3**	**L3b**	**L1**	**(L3)**	**L3 (study, simplified**	**(L3)**	**--**		**--**	**L3**
2.1.1 energy carrier	**L3b**	**L3**	**L3**	**L3**	**L3b**	**L1**	**L3**	**(L3)**	**L3**	**--**		**--**	**L3**
2.1.2 installation year	**L3b**	**L3**	**L3**	**L3**	**--**	**L1**	**?**	**(L3)**	**--**	**--**		**--**	**L3**
2.1.3 type of heat generator	**L3b**	**L3**	**L3**	**L3**	**L3b**	**L1**	**?**	**(L3)**	**L 3**	**--**		**--**	**L3**
2.4 Heat Distribution / Storage (Hot Water)	L3b	--	--	--	-- (2011)	L1	L1	--	--	--		--	L3
2.5 Heat Generation (Hot Water)	L3b	L3	(year)	L3	L2	L1	L1 (?)	--	--	--		--	L3
2.6 Solar Thermal Systems	L3b	L3	L3 (area)	L3 (later)	L2	L1	-- (but new h	--	L1	--		--	L3
2.7 Ventilation Systems	L3b	-- < 1%	--	-- <1%	-- <1%	-- <1%	--	--	-- <1%	--		--	L3

Levels of detail
indicating on which level of detail statistical information is available and will be documented

Level 3 2 characteristics will be considered at the same time (but not as detailed as in the building typology)
- building size classes (at least 2): suh / muh (single unit houses <= 2 appartments)
- building age classes

Level 2.1 only distinguishing between building size (e.g. suh / muh)
Level 2.2 only distinguishing between building age
Level 1 only information for the whole building stock is available
- - no information is available

additional information: climate zones or regions x size classes x age classes
(related to building classes)

7 Guidance for the Elaboration of a National Building Typology according to the TABULA Scheme

In the following you find a short overview of the tasks necessary to elaborate a national building typology, consisting of a set of example buildings for showcase analyses and building stock modelling. These tasks constitute the main work programme of the IEE project TABULA Work Package 3. Beyond this running project it is intended to extend the approach to other European countries and to develop it in the direction of a continuously working information system. In consequence experts not participating at the IEE project are invited to apply the steps of the following guidance for their country in the same manner and to supplement the common database and the planned Typology Webtool by a further national set of typical buildings.

1. **Define building types for your country.**

   The first task is the definition of construction periods for your country. You should select the border years of these periods by considering changes in construction materials, construction principles and architecture (geometrical shape, groundplan design, appearance of the building) but also changes in the legal requirements for the thermal properties of the envelope. It can also be useful to take into account the building age criteria which are used in the available national buildings' statistics.

   The TABULA building size classes (see chapter 5.2) and the construction periods of your country define a raster with different building types to which the individual residential buildings from your national stock can be assigned to.

2. **Find example buildings representing the different building types.**

   The next step is the search for example buildings, which are – as regards appearance and structure – very common in your country. You should acquire the data and photographs of at least one example building for each existing building type. Possible sources are the databases of energy advice activities and energy certificate issuing, but also model projects, research projects etc.. It is of course not easy to find "ideal example buildings": Many buildings which appear to be very common at first glance have minor individual details which are not typical. Therefore small modifications or simplifications of datasets can be applied, if reasonable.

3. **Differentiate between regions and other parameters, if necessary.**

   It may be the case that there are important regional differences between the existing buildings of your country due to climatic or cultural differences. Then the national typology can be subdivided in two or more regions and different building types can be defined for each. Also a special group of buildings with energy-related properties that considerably differ from the most common structure can be considered in the typology (e.g. panel buildings). In this case an additional parameter is introduced as indicator (see Table 78).

4. **Define typical supply systems.**

   Identify the supply systems for heating and domestic hot water which are most common for your country. Calculate the energy performance for these typical systems assuming an installation in a most common single-family house and in a most common multi-family house. Create specific performance indicators according to the TABULA scheme which can be applied to supply systems in different building types (see Table 78).

5. **Enter your data into the common database.**

   The energy-related data of the building and system types will usually be defined by use of the national definitions for energy performance calculation procedures. You should now transform these datasets to the common TABULA data definitions and enter them into the TABULA database (Excel workbook). On this basis the typology data of your country can later be incorporated in the planned TABULA Webtool.

6. **Publish your national "Typology Brochure".**

   The national typology data can be used in your country for different purposes by applying the national energy performance certificate procedures. One basic publication would be a "Typology Brochure" that describes the typology approach and presents each building type on a double page showing on the left side the photograph and typical energy-related properties and on the right side the possible energy saving which can be achieved by refurbishment measures.

7. **Supplement the typology with statistical data.**

   Examine the available statistics of residential buildings and collect them by use of the structure shown in chapter 6.1. On the basis of the building types, the assigned frequencies and the knowledge about already implemented thermal protection measures and installed supply systems a model can be created that is able to image the national building stock. In case that empirical information is missing today try to find ways to collect them in the future, e.g. by convincing the responsible institutions to collect the missing data in planned surveys, in the frame of energy certificate implementation (EPC database) etc..

8. **Try to image the buildings' energy consumption of your country by use of the building stock model.**[8]

   In order to assess the imaging quality of the model you should be able to compare the calculation results with information about the actual consumption of buildings. The basis should be the empirical analysis of the measured annual consumption and its correlation with asset rating results or – as an alternative – with typological criterion of the buildings (building size class, construction period, supply system type, already implemented refurbishments).

8 additional task, performed only by a limited number of TABULA partners