Typology Approach for Building Stock Energy Assessment. Main Results of the TABULA project

– Final Project Report –

TABULA Project Team
October 2012

(Deliverable D2)

www.building-typology.eu

Supported by INTELLIGENT ENERGY EUROPE

Contract N°: IEE/08/495
Coordinator: IWU Institut Wohnen und Umwelt, Darmstadt / Germany
Project duration: June 2009 - May 2012

04-11-2012

Authors:

Tobias Loga (ed.) Nikolaus Diefenbach (ed.) Britta Stein (ed.)	IWU	Institut Wohnen und Umwelt / Institute for Housing and Environment	Darmstadt, Germany
Elena Dascalaki Constantinos A. Balaras Kalliopi Droutsa Simon Kontoyiannidis	NOA	National Observatory of Athens	Athens, Greece
Marjana Šijanec Zavrl Andraž Rakušček	ZRMK	Building and Civil Engineering Institute ZRMK	Ljubljana, Slovenia
Vincenzo Corrado Stefano Corgnati Ilaria Ballarini	POLITO	Politecnico di Torino - Department of Energy	Torino, Italy
Charles Roarty Michael Hanratty Bill Sheldrick	Energy Action	Energy Action Limited	Dublin, Ireland
Marlies Van Holm Nele Renders	VITO	Flemish Institute of Technological Research	Mol, Belgium
Małgorzata Popiołek Jerzy Kwiatkowski	NAPE	Narodowa Agencja Poszanowania Energii SA / National Energy Conservation Agency	Warszawa, Poland
Maria Amtmann	AEA	Austrian Energy Agency	Wien, Austria
Tomáš Vimmr Otto Villatoro	STU-K	STU-K	Prague, Czech Republic
Kim B. Wittchen Jesper Kragh	SBi	Danish Building Research Institute, AAU	Hørsholm, Denmark
Hubert Despretz	ADEME	Agence de l'Environnement et de la Maîtrise de l'Energie (ADEME)	Valbonne, France
Zdravko Georgiev	SOFENA	Sofia Energy Agency	Sofia, Bulgaria
Karin Spets	MDH	Mälardalens University	Västerås, Sweden
Leticia Ortega Begoña Serrano Lanzarote	IVE	Instituto Valenciano de la Edificación	Valencia, Spain
Milica Jovanovic Popovic Dusan Ignjatovic	Univ. Belgrade	University of Belgrade - Faculty of Architecture	Belgrade, Serbia

published by
Institut Wohnen und Umwelt GmbH
Rheinstr. 65 / D-64295 Darmstadt / GERMANY
www.iwu.de

October 2012

TABULA website: www.building-typology.eu

Contents

Abstract

In the last decades building typology approaches have been used in several European countries. In the framework of the IEE Project TABULA these experiences have been evaluated and on this basis a common concept has been developed. It resulted in the creation of national residential building typologies in 13 European countries. Each national typology consists of a classification scheme according to building size, age and further parameters and a set of exemplary buildings representing these building types. They have been published and disseminated by the project partners in national "Building Typology Brochures", demonstrating for each building the effect of conventional and of ambitious measures including passive house components.

For information exchange on the European level the "TABULA WebTool" provides an online calculation of the exemplary buildings from all countries. It is based on a simple and transparent reference procedure for calculating the energy need, the energy use by energyware and the energyware assessment (primary energy, carbon dioxide, costs). To enable a realistic assessment of energyware and heating costs savings an option to calibrate the calculated energy use to the typical levels of actual consumption is being provided.

Based on the residential building typologies building stock models have been created for seven countries which enable a projection of the actual national building stock consumption and the energy saving potentials.

Building typologies seem to be a good means to combine communication about refurbishment measures for single buildings with the overall building stock scope. The basic concept developed during TABULA can in the future be applied in different countries not only on the national level, but also for the assessment of regional and local housing stock subsets.

1 Introduction

Due to the needs of climate protection and energy saving the residential building sector in Europe will have to meet great challenges in the coming years and decades. Decisions will have to be made on European, national and local level concerning energy saving policies and measures which must be based on reliable information sources. Also house owners (private persons or housing companies) must be provided with information about the state and the energy saving potentials of their building. Models of the building portfolio are needed which enable detailed analysis of future scenarios and which at the same time must be based on up-to-date and reliable data. The success of the introduced strategies must be evaluated regularly to improve the models and the analysis.

Looking at residential building stocks there is a large variety of buildings and building characteristics according to the national architectural history and different builing types. Against that background the TABULA project aimed at laying a basis for models of the building portfolio by handling this variety and providing a public data source of the building sector. This was achieved by the making of building typologies which classify the national residential building stocks and provide information of typical building characteristics with regard to thermal quality of the building envelope and the applied heating systems.

Figure 1: Building stock models as a basis of decision making

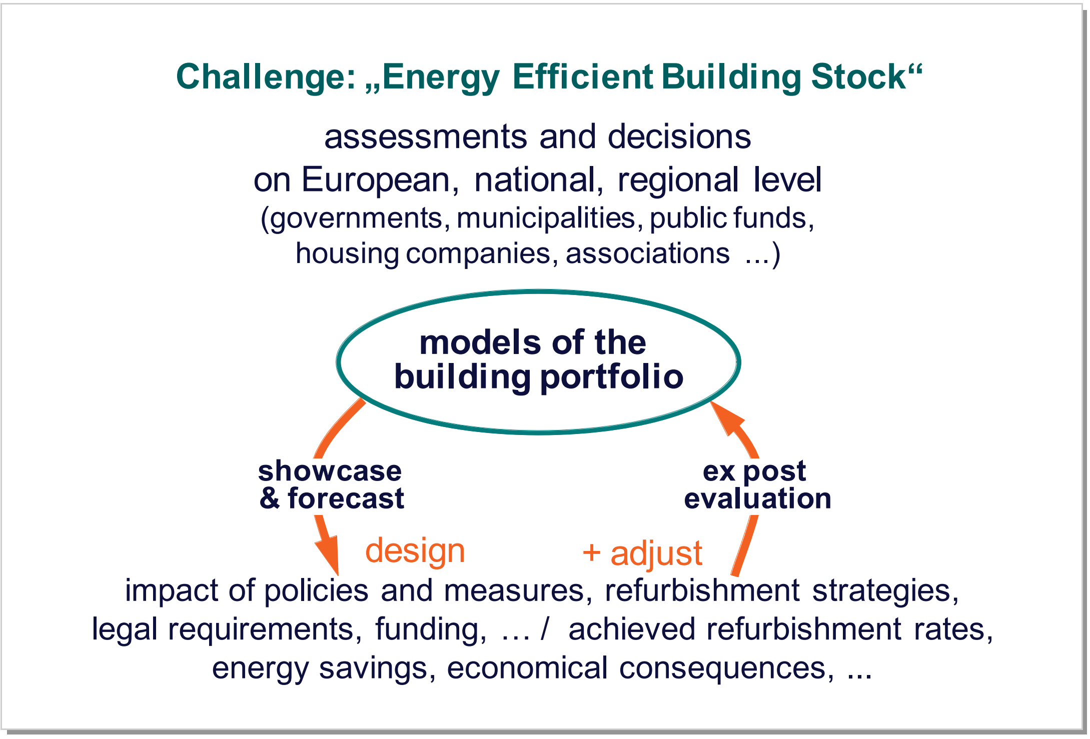
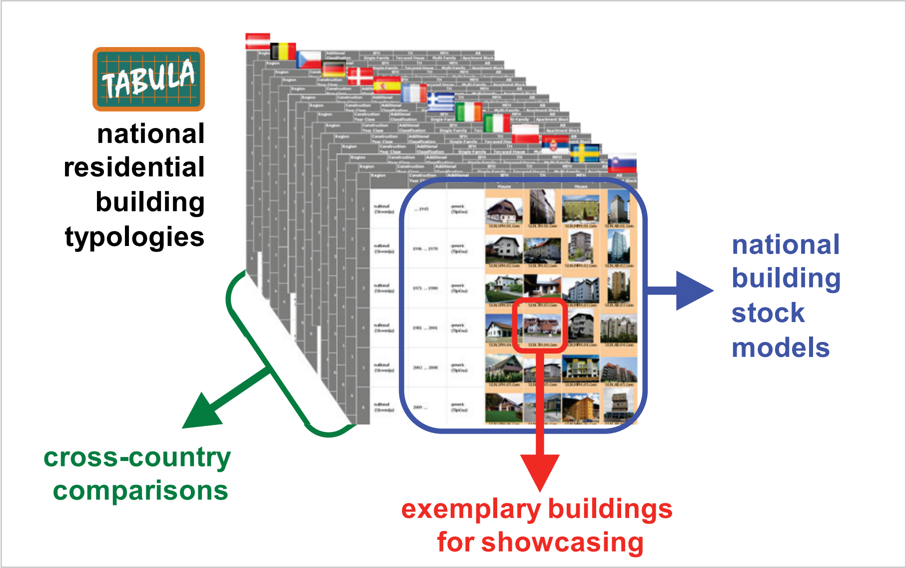


Figure 2: General idea of TABULA Building Typologies



2 Building Typologies in the Context of Energy Saving Strategies

The energy performance of buildings correlates with a number of parameters including the year of construction, the building size and the 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 description of the criteria for the definition of typical buildings as well as to a set of exemplary buildings representing the building types.

In the past few decades different experiences with building typologies have been made in European countries. The idea of the IEE project TABULA was to examine them and to come to a concerted approach for the field of residential buildings. A focus was placed on the energy consumption for space heating and hot water. The overall objective was to enable an understanding of the structure and of the modernisation processes of the building sector in different countries and – in the long run – to learn from each other about successful energy saving strategies.

The residential building typologies elaborated during TABULA form a data pool of the countries' residential building stocks. They offer different opportunities of application: Single exemplary buildings can be used as showcase examples to give a first estimation of energy saving potentials of real buildings. The set of exemplary buildings – complemented with statistical data about the national building stocks – can be applied for modelling the energy demand of the countries' residential building sectors and form a basis for further scenario analyses. From a European point of view the harmonised approach of the TABULA project provides a framework for cross-country comparisons of residential building stocks against the background of energy efficiency.

3 The TABULA Typology Concept

3.1 Classification of the National Residential Building Stock

An overview of the national building typology is given by the "Building Type Matrix" (Figure 3). The columns of the matrix represent four building size classes (single-family houses, terraced houses, multi-family houses, apartment blocks), the rows a certain number of construction year classes. The start year and end year of the construction year classes are individually defined for each country. The single cells of the matrix form the generic "Building Types" of a country.

3.2 Exemplary Buildings

To each generic building type of a country (cell of the classification grid) an exemplary building is assigned which is represented by a photo and the data of the thermal envelope. This building is supposed to be a typical representative of the building type, meaning that it has features which can commonly be found in houses of the respective age and size class. The envelope area and the heat transfer coefficients of the exemplary building are not necessarily representative in a statistical sense.

In addition heat supply systems for space heating and domestic hot water are defined which can commonly be found in the housing stock differentiated by energy carrier, heat generator type and energy efficiency level.

Building Type Matrix Slovenia

	Region	Construction Year Class	Additional Classification	SFH Single-Family House	TH Terraced House	MFH Multi-Family House	AB Apartment Block
1	national (Slovenija)	... 1945	generic (Tipična)	SI.N.SFH.01.Gen	SI.N.TH.01.Gen	SI.N.MFH.01.Gen	SI.N.AB.01.Gen
2	national (Slovenija)	1946 ... 1970	generic (Tipična)	SI.N.SFH.02.Gen	SI.N.TH.02.Gen	SI.N.MFH.02.Gen	SI.N.AB.02.Gen
3	national (Slovenija)	1971 ... 1980	generic (Tipična)	SI.N.SFH.03.Gen	SI.N.TH.03.Gen	SI.N.MFH.03.Gen	SI.N.AB.03.Gen
4	national (Slovenija)	1981 ... 2001	generic (Tipična)	SI.N.SFH.04.Gen	SI.N.TH.04.Gen	SI.N.MFH.04.Gen	SI.N.AB.04.Gen
5	national (Slovenija)	2002 ... 2008	generic (Tipična)	SI.N.SFH.05.Gen	SI.N.TH.05.Gen	SI.N.MFH.05.Gen	SI.N.AB.05.Gen
6	national (Slovenija)	2009 ...	generic (Tipična)	SI.N.SFH.06.Gen	SI.N.TH.06.Gen	SI.N.MFH.06.Gen	SI.N.AB.06.Gen

Figure 3: Example of a "Building Type Matrix" - Classification of the residential building stock of Slovenia

"Building Type Matrices" are available for 15 countries, see <CountryPages>.

Building Type Matrix Belgium

	Region	Construction Year Class	Additional Classification	SFH Single-Family House	TH Terraced House	MFH Multi-Family House	AB Apartment Block
1	national (Belgie)	... 1945	generic	BE.N.SFH.01.Gen	BE.N.TH.01.Gen	BE.N.MFH.01.Gen	
2	national (Belgie)	1946 ... 1970	generic	BE.N.SFH.02.Gen	BE.N.TH.02.Gen	BE.N.MFH.02.Gen	BE.N.AB.02.Gen
3	national (Belgie)	1971 ... 1990	generic	BE.N.SFH.03.Gen	BE.N.TH.03.Gen	BE.N.MFH.03.Gen	BE.N.AB.03.Gen
4	national (Belgie)	1991 ... 2005	generic	BE.N.SFH.04.Gen	BE.N.TH.04.Gen	BE.N.MFH.04.Gen	BE.N.AB.04.Gen
5	national (Belgie)	2006 ...	generic	BE.N.SFH.05.Gen	BE.N.TH.05.Gen	BE.N.MFH.05.Gen	BE.N.AB.05.Gen

Figure 4: Example of a "Building Type Matrix" - Classification of the residential building stock of Belgium

"Building Type Matrices" are available for 15 countries, see <CountryPages>.

3.3 Refurbishment Measures

The collected sets of real buildings serve as showcase examples to demonstrate the effect of refurbishment measures. For each building three stages of refurbishment were considered:

1. **"Existing State":** Typical state of a non-refurbished building.
2. **"Standard Measures"** (usual refurbishment): Package of measures for upgrading the thermal envelope and the heat supply system which are commonly realised during refurbishment; typically reflecting the national requirements in case of renovations.
3. **"Advanced Measures"** (ambitious refurbishment): Package of measures for upgrading the thermal envelope and the heat supply system which are usually only realised in very ambitious renovations or research projects; typically reflecting the level of passive house components.

Figure 5: Proposals for building envelope refurbishment on the two levels "Standard and "Advanced"
Example from the German "Building Typology Brochure"

Modernisierungspaket 1: "konventionell" Maßnahme	U-Wert W/(m²K)	Modernisierungspaket 2: "zukunftsweisend" Maßnahme	U-Wert W/(m²K)
Dämmung im Sparren-Zwischenraum 12 cm (bei Bedarf Aufdopplung der Sparren und Freiräumen des Zwischenraums)	0,41	Dämmung im Sparren-Zwischenraum 12 cm + zusätzliche Dämmlage 18 cm	0,14
Dämmung 12 cm + Verputz (Wärmedämmverbundsystem), alternativ: hinterlüftete Fassade (z.B. Zellulose zwischen Traghölzern)	0,23	Dämmung 24 cm + Verputz (Wärmedämmverbundsystem), alternativ: hinterlüftete Fassade (z.B. Zellulose zwischen Traghölzern)	0,13
Einbau von Fenstern mit 2-Scheiben-Wärmeschutz-Verglasung	1,3	Einbau von Fenstern mit 3-Scheiben-Wärmeschutz-Verglasung und gedämmtem Rahmen	0,8
Dämmung 8 cm unter der Decke / alternativ: auf der Decke (im Fall einer Fußbodensanierung)	0,31	Dämmung 12 cm unter der Decke (bei ausreichender Kellerraumhöhe) / alternativ: auf der Decke (im Fall einer Fußb.-sanierung) oder Kombin. unter/auf	0,23

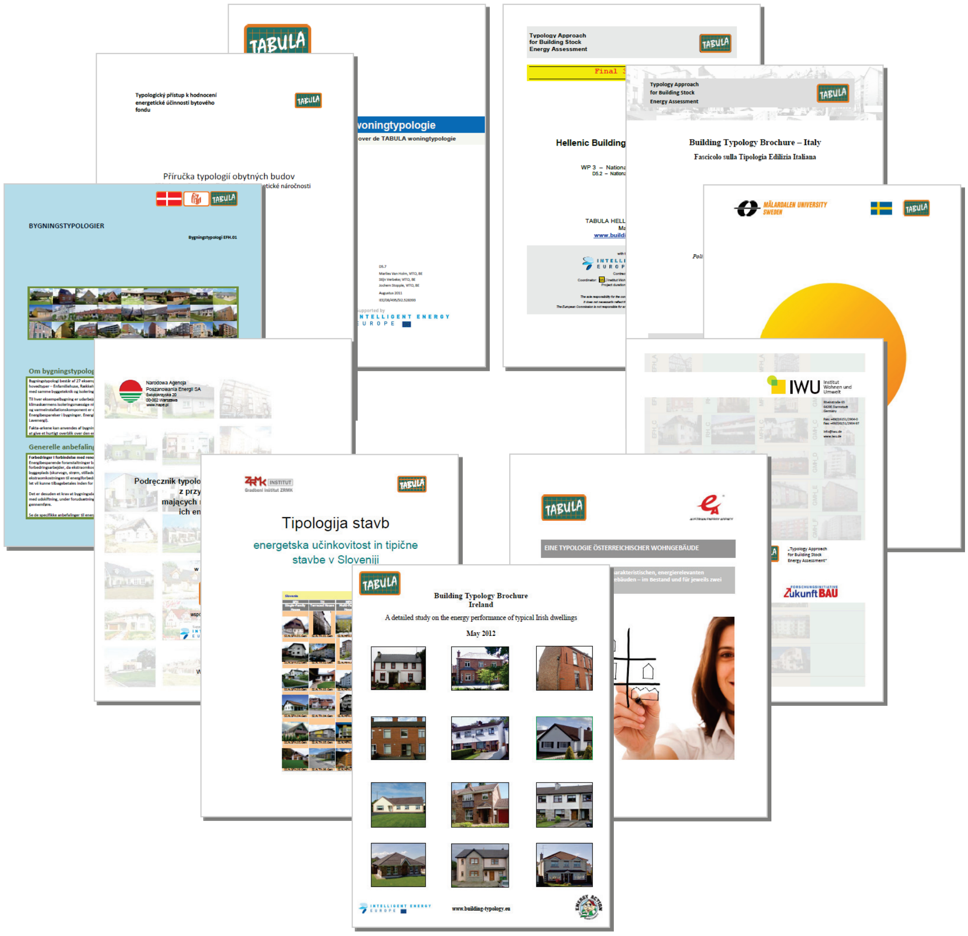
3.4 National Typology Brochures

For each country a brochure has been elaborated which contains the different elements of a residential building typology (Figure 6):

- the classification of the national building stock / display of the building type matrix;
- frequencies of the building types (see below, section 7);
- typical energy consumption values of exemplary buildings (see below, section 4.4);
- definition and description of refurbishment measures and the energy saving potential;
- "Building Display Sheets:
  A double page showing the existing state of the building and the possible energy savings by distinct measures (see examples in Figure 7);

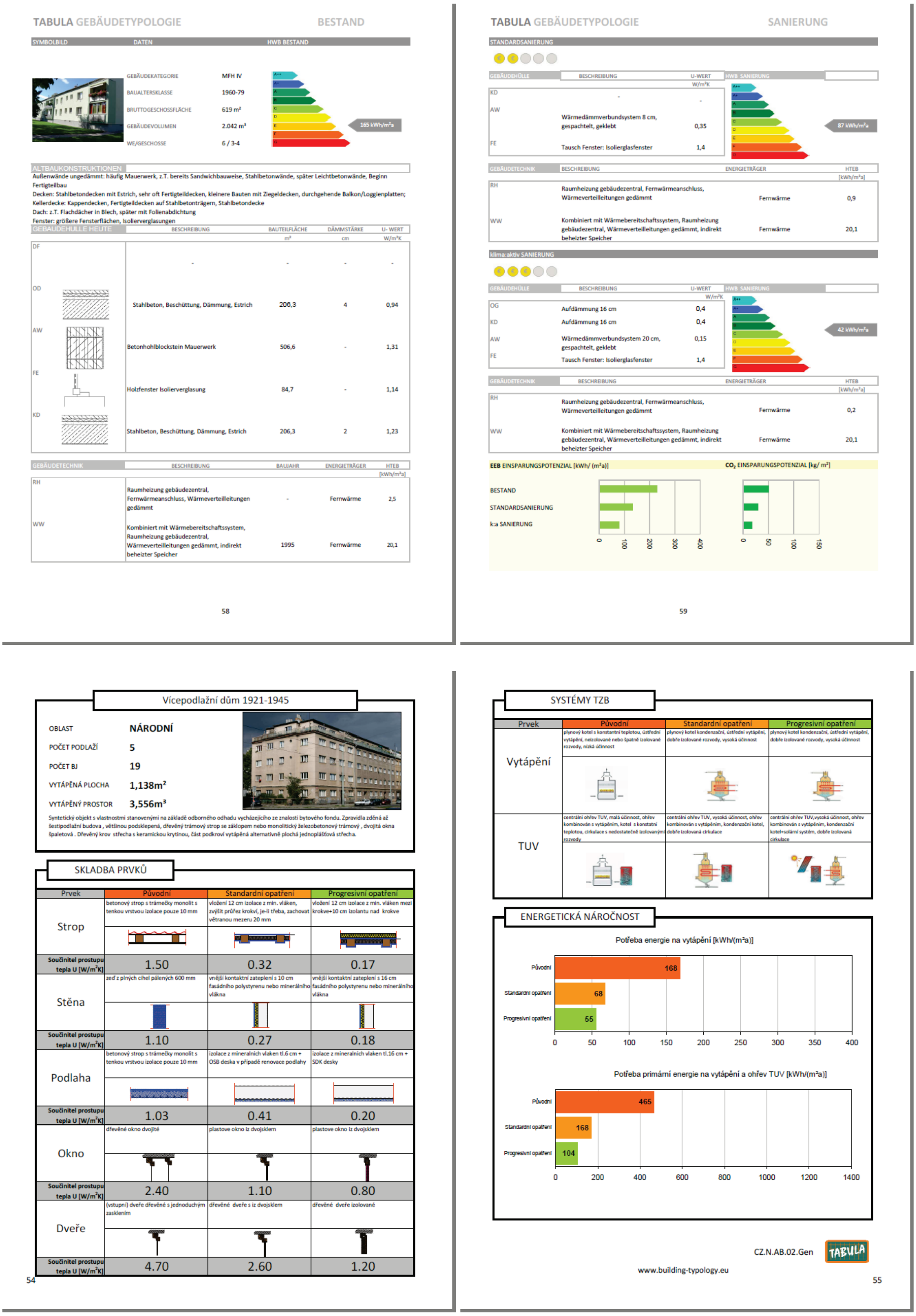
Each national brochure addresses key actors of the respective country and supplies them with information and material for energy advice activities. In some cases, the "Building Display Sheets" are also disseminated separately. The brochures are written in the respective national languages.

Figure 6: Individual "Building Typology Brochure" in each country



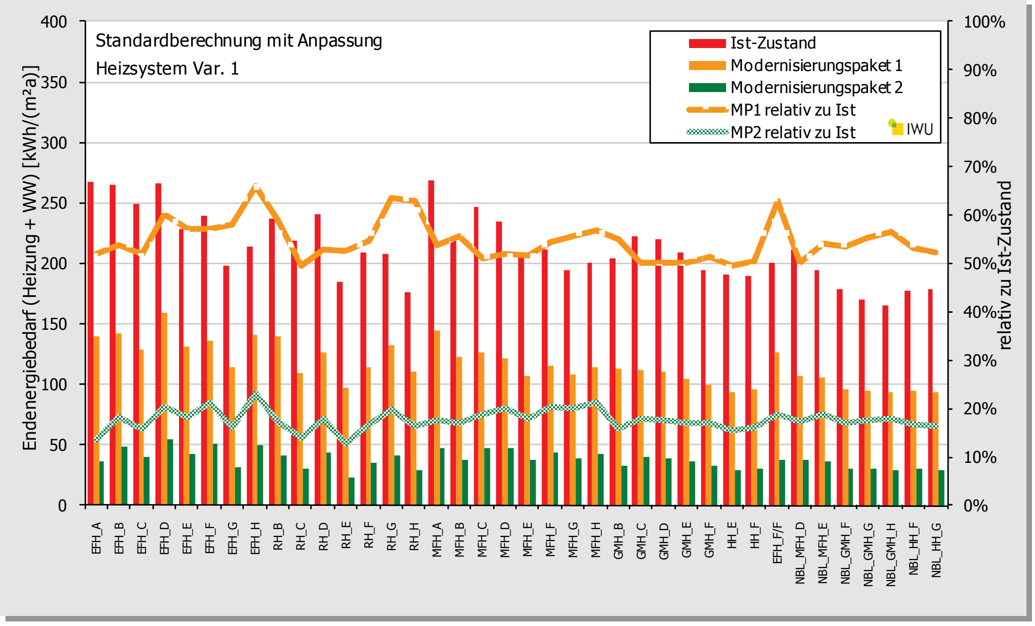
Download of the brochures at <NatTypBrochures>.

Figure 7: "Building Display Sheets" as part of a national "Typology Brochure"
Example from Austria and from the Czech Republic



Left side: Description of existing state / Right side: Energy savings achieved by two different packages of modernisation measures

Figure 8: Calculation of the energy use for all exemplary buildings
Example from the German typology brochure



Delivered energy per m² reference area (calibrated to the typical level of measured consumption) for three variants: (1) existing state = red, (2) standard measures = yellow; (3) advanced measures = green)

4 TABULA Calculation Method

4.1 Data Structure

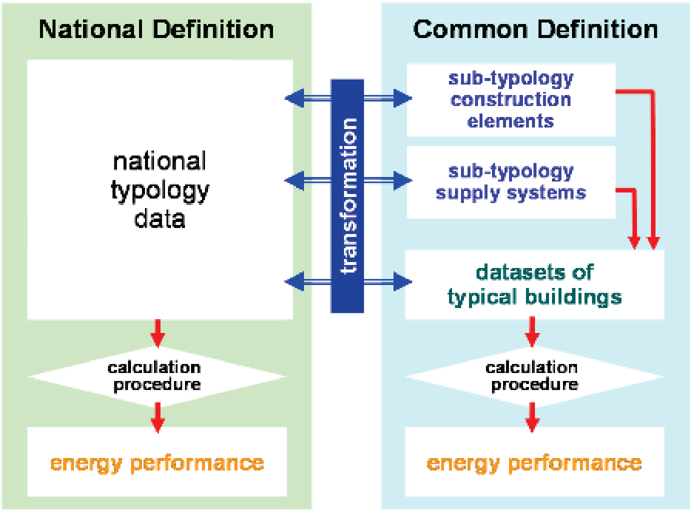
Since a comparable energy balance calculation for the exemplary buildings is needed the respective datasets of construction elements, envelope areas and different supply systems were collected in a common database for all countries. In case national definitions differ from this concerted data structure a data transformation had to be applied by the respective partner.

In consequence, always two versions of the example building and supply system data were produced (Figure 9):

- **National Definition:** Data according to the relevant national energy balance procedure (usually the national procedure for issuing energy performance certificates EPC), used in the national context for analyses, typology brochures (see section 3.4), default datasets in energy advice and EPC software, ...
- **Common Definition:** Data according to the TABULA data structure, used to understand and compare the energy performance and refurbishment measures of buildings from different countries, e.g. for showcase analyses (TABULA WebTool, see section 5) or cross-border building stock models.

Both definitions are describing the same physical properties. They constitute two sides of the same coin. All TABULA partners are responsible for the consistent transformation between their national and the common definition.

Figure 9: Two-track approach for definition of exemplary buildings and heat supply systems



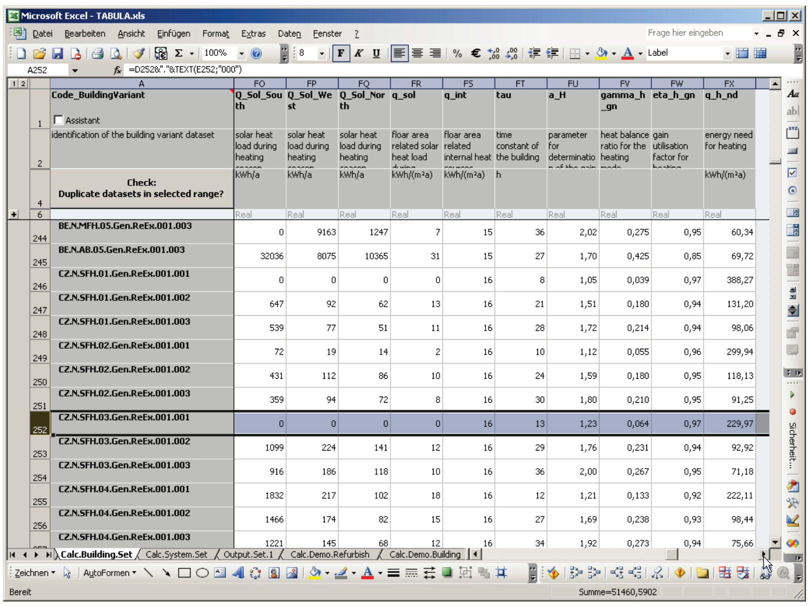
4.2 Common Calculation Procedure

The energy demand of the exemplary buildings is determined by use of a simple energy performance calculation procedure based on the respective CEN standards. The basics of the procedure are described in the first TABULA Synthesis Report <SR1>. The formulas and standard values are documented in a special report <CalcProc>.

Calculation sheets to show the formulas and interim values and thus to enable a tracking of the calculation for a given building and system have been elaborated (Figure 11).

Due to the low number of calculation formulas an implementation in form of a simple spreadsheet for buildings and for systems was also possible (1 row per dataset). In consequence, a large number of building and system variants can be calculated in a fast and transparent way.

Figure 10: Simple row-by-row calculation table of different building variants
Example: last columns of the energy need for heating calculation spreadsheet "Calc.Building.Set" (workbook <TABULA.xls> and <tabula-calculator.xls>)


Microsoft Excel - TABULA.xls

A252 =D252&"."&TEXT(E252;"000")

	A	FO	FP	FQ	FR	FS	FT	FU	FV	FW	FX
1	Code_BuildingVariant Assistant	Q_Sol_South	Q_Sol_West	Q_Sol_North	q_sol	q_int	tau	a_H	gamma_h_gn	eta_h_gn	q_h_nd
2	identification of the building variant dataset	solar heat load during heating season	solar heat load during heating season	solar heat load during heating season	floor area related solar heat load during	floor area related internal heat sources	time constant of the building	parameter for determination of the gain	heat balance ratio for the heating mode	gain utilisation factor for heating	energy need for heating
4	Check: Duplicate datasets in selected range?	kWh/a	kWh/a	kWh/a	kWh/(m²a)	kWh/(m²a)	h				kWh/(m²a)
6		Real	Real	Real	Real	Real	Real	Real	Real	Real	Real
244	BE.N.MFH.05.Gen.ReEx.001.003	0	9163	1247	7	15	36	2,02	0,275	0,95	60,34
245	BE.N.AB.05.Gen.ReEx.001.003	32036	8075	10365	31	15	27	1,70	0,425	0,85	69,72
246	CZ.N.SFH.01.Gen.ReEx.001.001	0	0	0	0	16	8	1,05	0,039	0,97	388,27
247	CZ.N.SFH.01.Gen.ReEx.001.002	647	92	62	13	16	21	1,51	0,180	0,94	131,20
248	CZ.N.SFH.01.Gen.ReEx.001.003	539	77	51	11	16	28	1,72	0,214	0,94	98,06
249	CZ.N.SFH.02.Gen.ReEx.001.001	72	19	14	2	16	10	1,12	0,055	0,96	299,94
250	CZ.N.SFH.02.Gen.ReEx.001.002	431	112	86	10	16	24	1,59	0,180	0,95	118,13
251	CZ.N.SFH.02.Gen.ReEx.001.003	359	94	72	8	16	30	1,80	0,210	0,95	91,25
252	CZ.N.SFH.03.Gen.ReEx.001.001	0	0	0	0	16	13	1,23	0,064	0,97	229,97
253	CZ.N.SFH.03.Gen.ReEx.001.002	1099	224	141	12	16	29	1,76	0,231	0,94	92,92
254	CZ.N.SFH.03.Gen.ReEx.001.003	916	186	118	10	16	36	2,00	0,267	0,95	71,18
255	CZ.N.SFH.04.Gen.ReEx.001.001	1832	217	102	18	16	12	1,21	0,133	0,92	222,11
256	CZ.N.SFH.04.Gen.ReEx.001.002	1466	174	82	15	16	27	1,69	0,238	0,93	98,44
	CZ.N.SFH.04.Gen.ReEx.001.003	1221	145	68	12	16	34	1,92	0,273	0,94	75,66

Calc.Building.Set / Calc.System.Set / Output.Set.1 / Calc.Demo.Refurbish / Calc.Demo.Building

Bereit Summe=51460,5902

Figure 11: Demo-calculation sheet "Building Performance"

Energy Balance Calculation — **Building Performance**

Standard Reference Calculation - based on: EN ISO 13790 / seasonal method

building	DE.N.MFH.05.Gen.ReEx.001 (1958...1968)	reference area	$A_{C,ref}$	3129,1	m²
climate	DE.N (Germany)	(conditioned floor area)			

code construction element	original U-value $U_{original,i}$ W/(m²K)	measure type	applied refurbishment measure	actual U-value $U_{actual,i}$ W/(m²K)		area (basis: external dimensions) $A_{env,i}$ m²		adjustment factor soil $b_{tr,i}$		$H_{tr,i}$ W/K
Roof 1					×		×		=	
Roof 2	0,60			0,51	×	971,1	×	1,00	=	493,8
Wall 1	1,20			1,20	×	2039,0	×	1,00	=	2446,8
Wall 2					×		×		=	
Wall 3					×		×		=	
Floor 1	1,60			1,08	×	971,1	×	0,50	=	524,9
Floor 2					×		×		=	
Window 1	3,50			3,50	×	507,5	×	1,00	=	1776,2
Window 2					×		×		=	
Door 1	3,00			3,00	×	2,0	×	1,00	=	6,0
thermal bridging: surcharge on the U-values				ΔU_{tb} 0,10	×	$\Sigma A_{env,i}$ 4490,7	×	1,00	=	$H_{tr,tb}$ 449,1

Heat transfer coefficient by transmission H_{tr} sum **5697**

	volume-specific heat capacity air $c_{p,air}$ Wh/(m³K)		air change rate by use $n_{air,use}$ 1/h		by infiltration $n_{air,infiltration}$ 1/h		$A_{C,ref}$ m²		room height (standard value) h_{room} m		W/K
Heat transfer coefficient by ventilation H_{ve}	0,34	× (	0,40	+	0,20	) ×	3129,1	×	2,50	=	**1596**

		internal temp. ϑ_i °C		external temp. ϑ_e °C		heating days d_{hs} d/a		Kd/a
accumulated differences between internal and external temperature	(	20,0	−	4,4	) ×	222	=	3463

		H_{tr} W/K		H_{ve} W/K		temperature reduction factor F_{red} (h_{tr} = 1,82 W/(m²K))		x 0,024 kKh/a		kWh/a
Total heat transfer Q_{ht}	(	5697	+	1596	) ×	0,92	×	83,1	=	**559250**

window orientation	reduction factors: external shading F_{sh}		frame area fraction F_F		non-perpendicular F_W		solar energy transmittance $g_{gl,n}$		window area $A_{window,i}$ m²		solar global radiation $I_{sol,i}$ kWh/(m²a)		kWh/a
1. Horizontal	0,80	× (1 -	0,30	) ×	0,90	×	0,75	×		×	403	=	
2. East	0,60	× (1 -	0,30	) ×	0,90	×	0,75	×	22,2	×	271	=	1709
3. South	0,60	× (1 -	0,30	) ×	0,90	×	0,75	×	243,2	×	392	=	27032
4. West	0,60	× (1 -	0,30	) ×	0,90	×	0,75	×	22,2	×	271	=	1709
5. North	0,60	× (1 -	0,30	) ×	0,90	×	0,75	×	219,8	×	160	=	9968

Solar heat load during heating season Q_{sol} sum **40418**

	kh/d		internal heat sources φ_i W/m²		heating days d_{hs} d/a		$A_{C,ref}$ m²		kWh/a
Internal heat sources Q_{int}	0,024	×	3,00	×	222	×	3129,1	=	**50015**

internal heat capacity per m² $A_{C,ref}$	c_m	45	Wh/(m²K)	
time constant of the building	$\tau = \frac{c_m \cdot A_{C,ref}}{H_{tr} + H_{ve}}$ =	19	h	
parameter	$a_H = a_{H,0} + \frac{\tau}{\tau_{H,0}}$ =	1,44		
heat balance ratio for the heating mode	$\gamma_{h,gn} = \frac{Q_{sol}+Q_{int}}{Q_{ht}}$ =	0,162		
gain utilisation factor for heating	$\eta_{h,gn} = \frac{1-\gamma^{a_H}}{1-\gamma^{a_H+1}}$ =	0,94		

Energy need for heating $Q_{H,nd}$ $Q_{ht} - \eta_{h,gn} \times (Q_{sol} + Q_{int})$ = **474344** kWh/a

Standard reference calculation of the energy need for heating determined by applying standard boundary conditions and relevant national climate data; based on: EN ISO 13790 / seasonal method; for details see <CalcProc>.

Figure 12: Demo-calculation sheet "System Performance"

Energy Balance Calculation — System Performance

Standard Reference Calculation - based on: EN ISO 15316 / level B (tabled values)

	code		$A_{C,ref}$	
building	DE.N.MFH.05.Gen.ReEx.001.001	conditioned floor area	3129,1	m²
system	DE.<Oil.B_NC_LT.MUH.01>.<El.E_IWH.Gen.01>.<-.Gen.01>.<Gen>			

Domestic Hot Water System

	code
system	DE.El.E_IWH.Gen.01

	code		value	thereof recoverable for space heating:	value
energy need hot water		$q_{nd,w}$	15,0		
+ losses distrib.	DE.D.Gen.02	$q_{d,w}$	1,4	$q_{d,w,h}$	0,8
+ losses storage		$q_{s,w}$	0,0	$q_{s,w,h}$	0,0
		$q_{g,w,out} = q_{nd,w} + q_{d,w} + q_{s,w}$	16,4	$q_{w,h} = q_{d,w,h} + q_{s,w,h}$	0,8
			kWh/(m²a)		kWh/(m²a)

energyware for domestic hot water

	code	heat generator code	$\alpha_{nd,w,i}$		heat generator output $q_{g,w,out}$		expenditure factor $e_{g,w,i}$		delivered energy $q_{del,w,i}$		combined heat and power: expenditure factor electricity generation $e_{g,el,w,i}$		electricity production $q_{prod,el,w,i}$
1	El	DE.E_IWH.Gen.01	100%	x	16,4	x	1,00	=	16,4	:	0,00	=	0,0
2			0%	x		x	0,00	=	0,0	:	0,00	=	0,0
3			0%	x		x	0,00	=	0,0	:	0,00	=	0,0
					kWh/(m²a)				kWh/(m²a)				

auxiliary energy

		code	$q_{del,w,aux}$
aux	el	DE.D.Gen.01	0,0
			kWh/(m²a)

Heating System

	code
system	DE.Oil.B_NC_LT.MUH.01

	code		value	unit	gain utilisation factor for heating $\eta_{h,gn}$		ventilation heat recovery $\eta_{ve,rec}$		$q_{ht,ve}$
energy need space heating		$q_{nd,h}$	151,6	kWh/(m²a)					
– usable contribution of hot water system		$q_{w,h}$	0,8	kWh/(m²a)	94%	x			
– usable contribution of ventilation heat recovery		$q_{ve,h,rec}$	0,0	kWh/(m²a)	94%	x	0%	x	39,1
+ losses distribution and heat emission	DE.C_Ext.MUH.03	$q_{d,h}$	15,1	kWh/(m²a)					kWh/(m²a)
+ losses storage		$q_{s,h}$	0,0	kWh/(m²a)					
		$q_{g,h,out} = q_{nd,h} - q_{w,h} - q_{ve,h,rec} + q_{d,h} + q_{s,h}$	165,9	kWh/(m²a)					

energyware for space heating

	code	heat generator code	$\alpha_{nd,h,i}$		heat generator output $q_{g,h,out}$		expenditure factor $e_{g,h,i}$		delivered energy $q_{del,h,i}$		combined heat and power: expenditure factor electricity generation $e_{g,el,h,i}$		electricity production $q_{prod,el,h,i}$
1	Oil	DE.B_NC_LT.SUH.03	100%	x	165,9	x	1,23	=	204,1	:	0,00	=	0,0
2			0%	x		x	0,00	=	0,0	:	0,00	=	0,0
3			0%	x		x	0,00	=	0,0	:	0,00	=	0,0
					kWh/(m²a)				kWh/(m²a)				

auxiliary energy

		code	
heating system			$q_{del,h,aux}$
aux	el	DE.C.MUH.01	1,8
ventilation system			$q_{del,ve,aux}$
aux	el	DE.-.Gen.01	0,0
			kWh/(m²a)

Standard reference calculation of the energy use for heating and DHW determined by applying standard boundary conditions and relevant national climate data; based on: EN ISO 15316 / level B (tabled values), for details see <CalcProc>.

These calculation sheets form part of <TABULA.xls>, <tabula-calculator.xls> and <WebTool> (see clauses below).

4.3 Heating System Typology and Assessment of Energywares

Basis of the heat supply calculation procedure are tabled values for heat generation, storage, distribution and auxiliary energy – each for space heating and domestic hot water. The respective values for these system components have been determined for each country by use of the relevant national EPC methods, converted and entered into the TABULA database.

As a further step an assessment of the energywares used is performed by multiplying the delivered energy per energy carrier with the respective national or European factors. It includes the determination of the quantities:

- total primary energy demand,
- non-renewable primary energy demand,
- carbon dioxide emissions,
- energy costs.

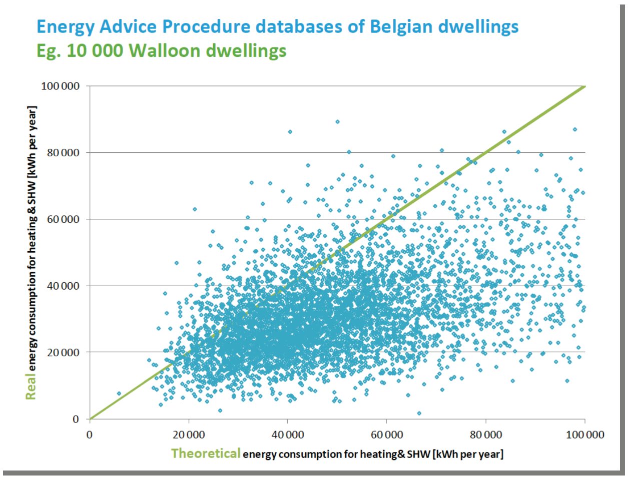
4.4 Calibration to the Typical Level of Measured Consumption

In order to enable realistic statements about the energy use and the possible energy savings, the TABULA concept includes the option of calibrating the calculated results to the typical level of measured consumption.

A precondition for such an adaptation is the knowledge about the average energy consumption of buildings for different levels of their theoretical energy performance. Some of the TABULA partners already performed respective correlation analyses (see example in Figure 13), in other cases only estimations are available. In case of estimations the calibration to the typical level of consumption is deemed preliminary – up to the time when more detailed information is available and reliable statistical analysis have been performed.

The TABULA WebTool (see section 5) takes account of this calibration. It offers an option to change all displayed results from "standard calculation, not adapted" to the status "adapted to typical level of measured consumption" (menu item "settings").

Figure 13: Measured vs. calculated energy consumption for space heating and DHW
Example from Belgium: Analysis for 10 000 dwellings



4.5 TABULA Database and Calculation Workbook

An MS Excel workbook <TABULA.xls> has been designed containing the example building datasets of all countries and enabling own calculations, modifications and variations of refurbishment measures and supply systems. The idea of this workbook is to perform the following tasks:

A. **“Data Base”:**
   Frame for collecting and merging typology data from different countries;

B. **“Programming Template”:**
   Structure template and data source for the TABULA WebTool (see section 5);

C. **“Showcase Calculation”:**
   Display of the common energy performance procedure / check of input data;

D. **“Operative Analyses”:**
   Energy performance calculation of sets of buildings/systems (row by row calculation sheets).

A simplified version of the workbook has been extracted from "TABULA.xls" for easy use by third parties. This workbook "tabula-calculator.xls" provides an easy access to the data of exemplary buildings and systems, offers own calculations and variations on a row by row spreadsheet basis (<tabula-calculator.xls>).

Within the workbook there are data tables of construction elements, refurbishment measures, heat generation systems for space heating and hot water supply, heat distribution and storage systems and ventilation systems. The database of TABULA.xls includes:

- 1267 building construction elements (walls, roofs, upper floor ceilings, basements, windows),
- 455 insulation measures
- 1205 types of supply system components.

Figure 14: Data Sheet of "TABULA.xls"
Example: datasets of exemplary buildings

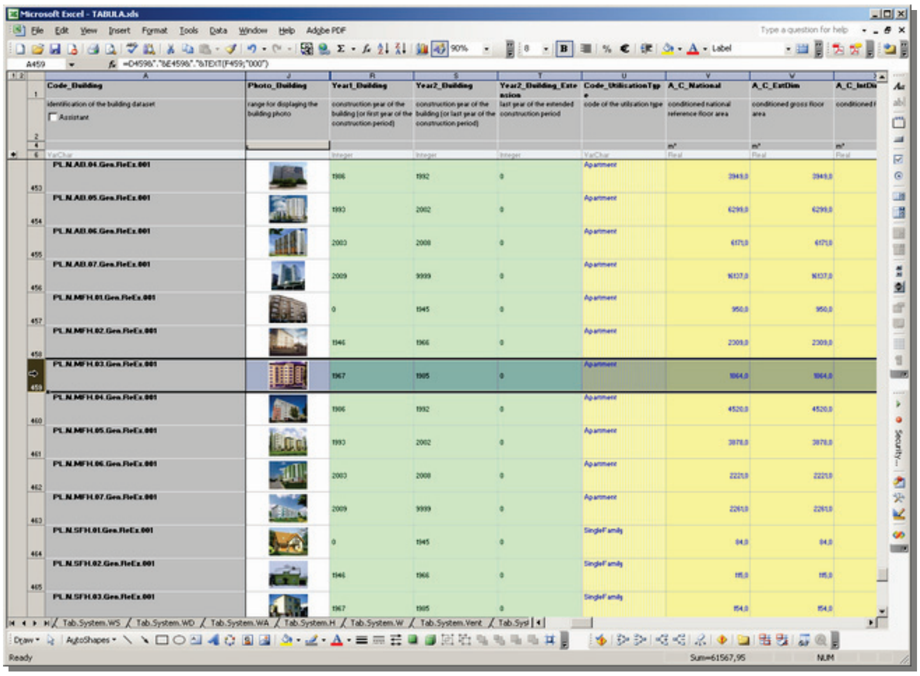


Figure 15: Data Sheet of "TABULA.xls"
Example: datasets of construction elements

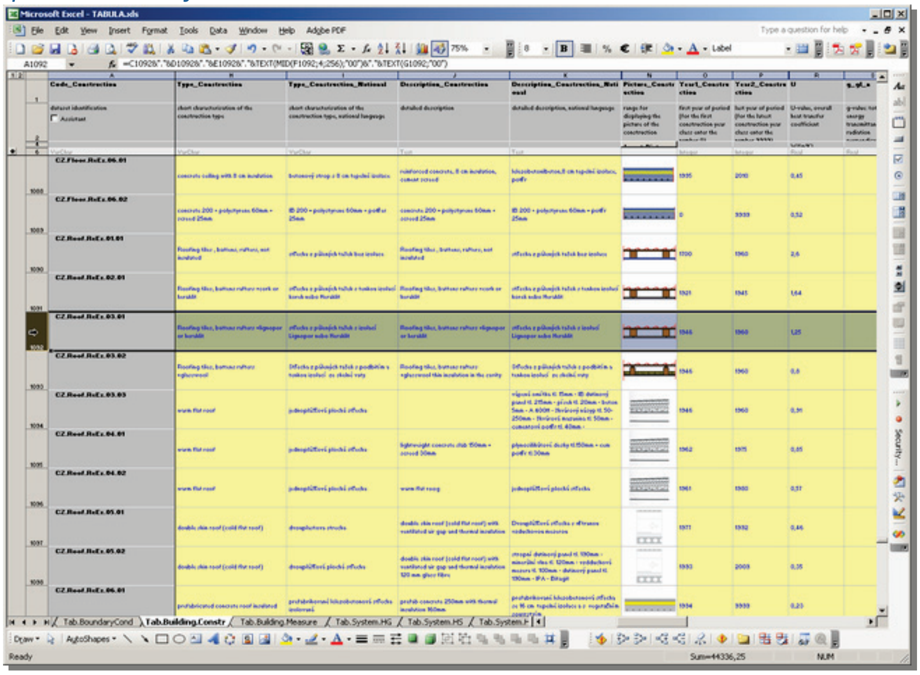
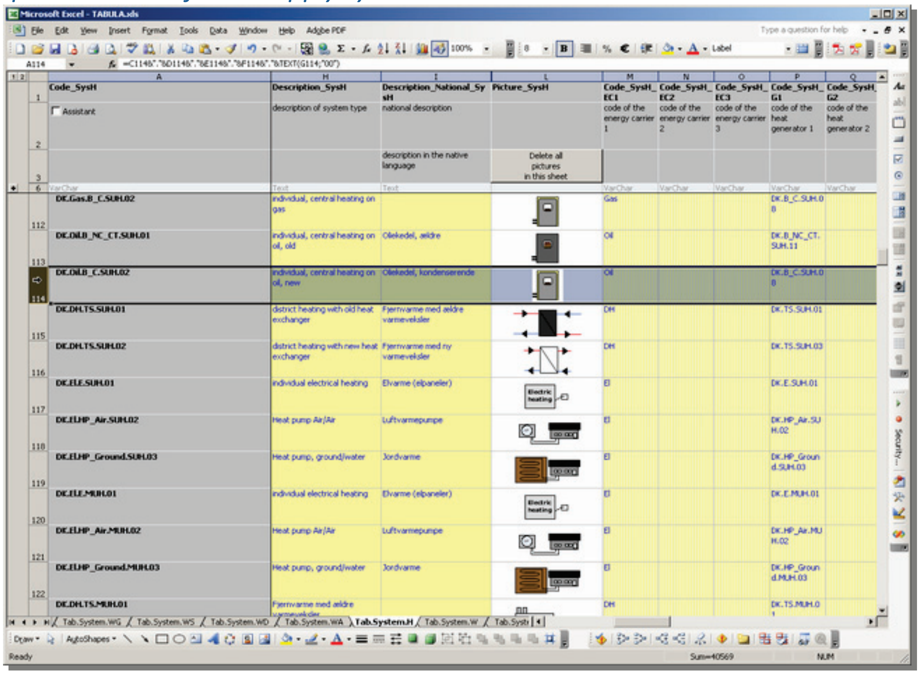


Figure 16: Data Sheet of "TABULA.xls"
Example: datasets of heat supply systems



5 Building Typology WebTool

The mentioned Excel workbooks are working tools offering many possibilities to calculate energy balances and saving potentials for a set of buildings. Of course, before an expert can use it, he/she has to spend some time to understand the structure of the workbook itself and the different calculation sheets.

With the intention to enable an intuitive easy access to the TABULA concept and its possible benefits an online application has been created. The TABULA <WebTool> is addressing energy experts in all European countries. It offers them to interactively explore the different aspects of residential building typologies and to easily track and understand the common calculation procedure.

For a typical building of a selected country the energy related features, the energy consumption in the existing state and the effect of energy saving measures on the two levels "Standard" and "Advanced" can be viewed. The data structure and calculation formulas are identical with the above mentioned Excel workbooks <TABULA.xls> and <tabula-calculator.xls>.

In addition, an expert version provides an online access to all datasets including those of synthetical average buildings (if available for a country, see section 9) and enables a calculation of arbitrary combinations of buildings and systems <WebToolExpertVersion>.

Figure 17: Screenshot of the TABULA Building Typology WebTool <WebTool>
Example: *Country and building selection*

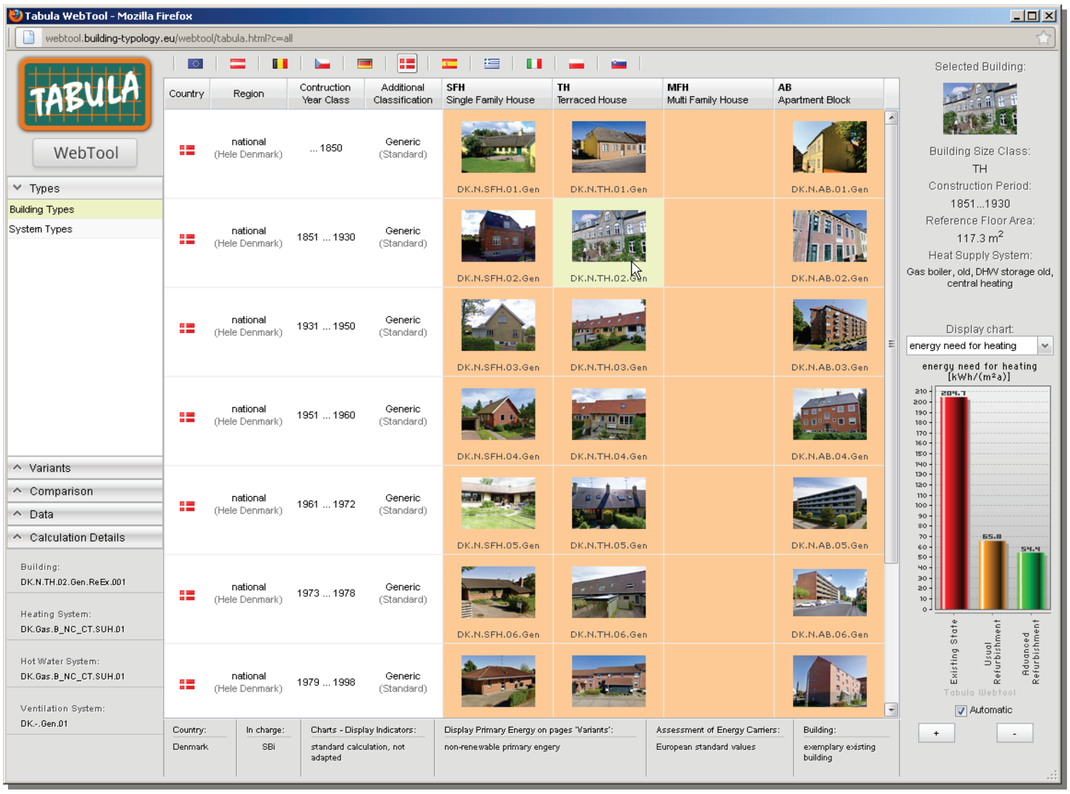


Figure 18: Screenshot of the TABULA Building Typology WebTool <WebTool>
Example: *Energy balance for building and supply system*

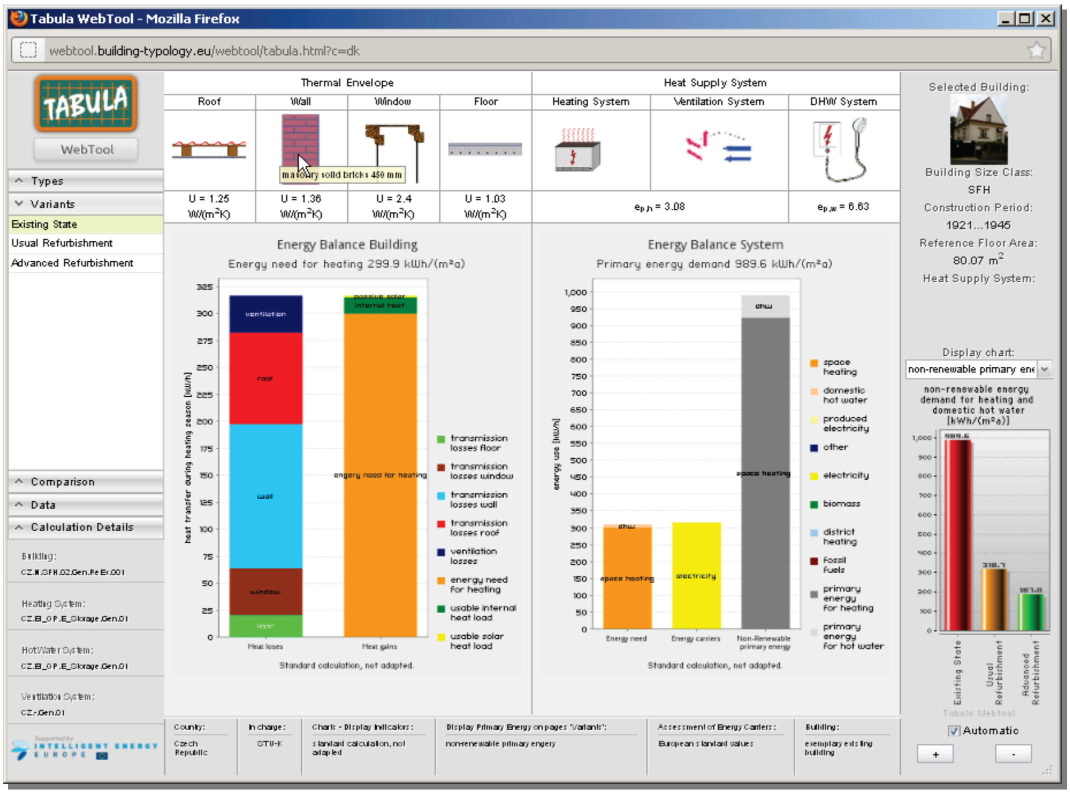
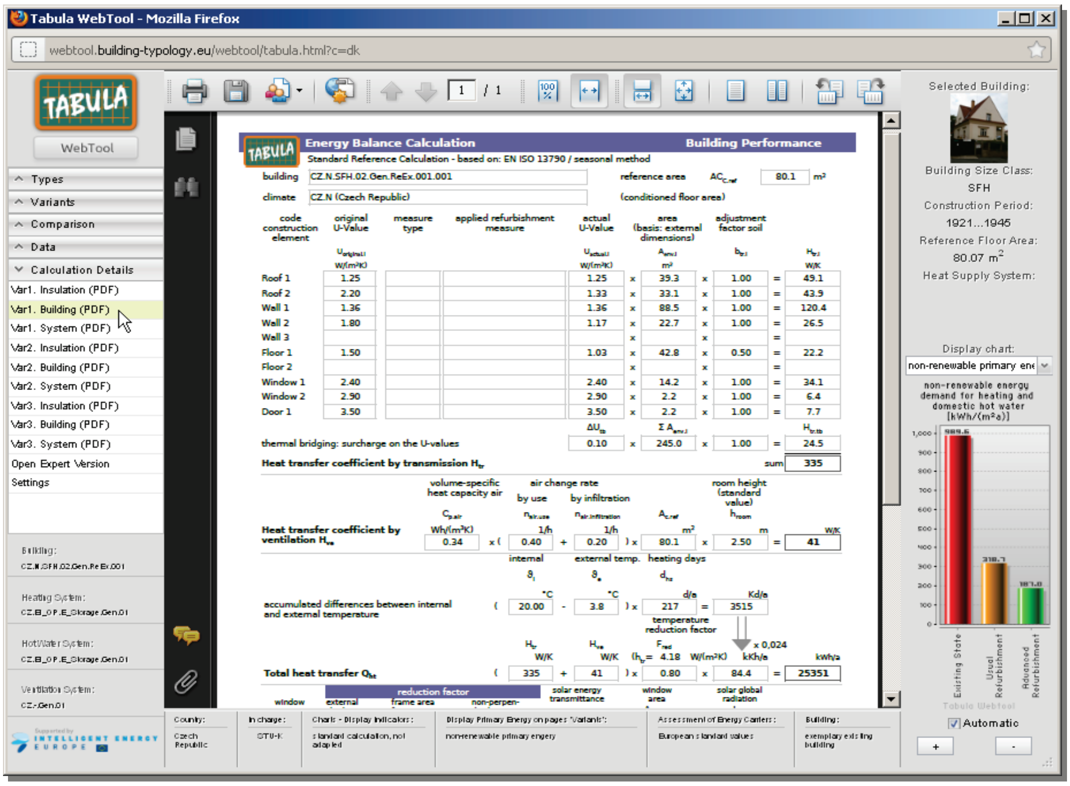


Figure 19: Screenshot of the TABULA Building Typology WebTool <WebTool>
Example: *Transparent and traceable online calculation*



6 Cross-Country Comparison of Building and System Data

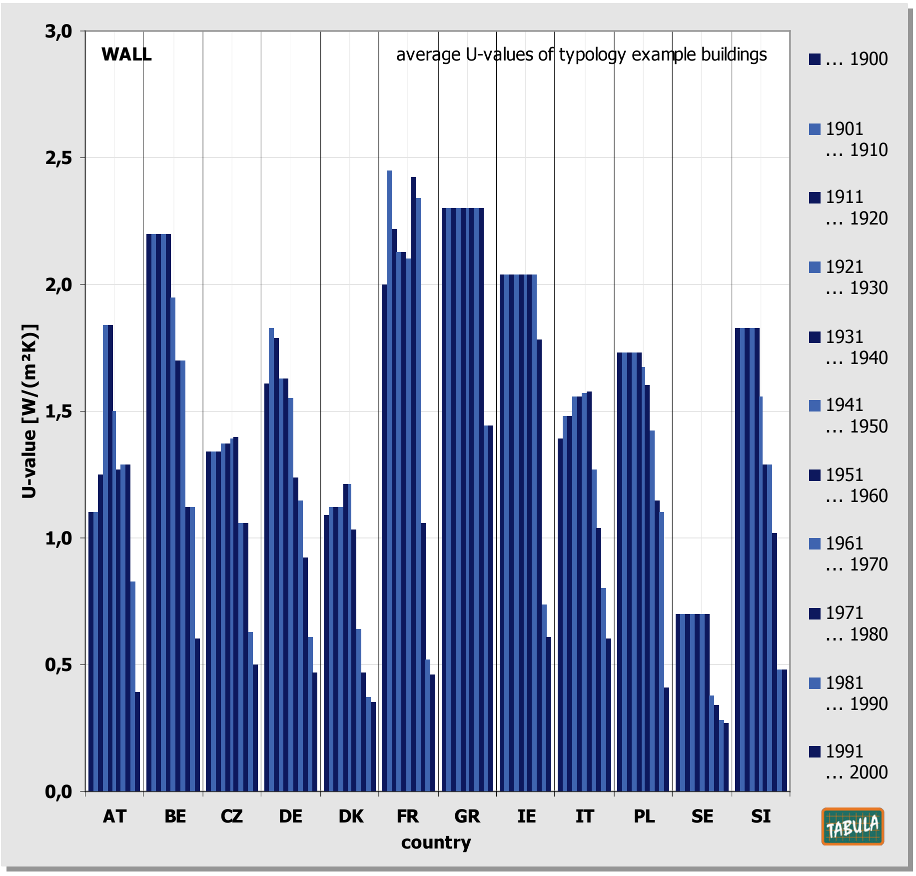
To compare the energy related properties of buildings between the different countries an analysis of typological data included in the TABULA database (MS Excel workbook <TABULA.xls>) has been performed <DataEval>. An overview of the results is given in Apendix B. Depending on the type of data the evaluations can in the future be useful for different aspects mentioned in the following clauses.

6.1 Construction Elements and Insulation Measures

An evaluation of the U-values of roofs, walls, windows and floors of the exemplary buildings provides indications about the development of thermal quality standards in the participating countries during the last century (Figure 20). Of course, since the transfer coefficients by transmission were not exactly measured the comparison is not reflecting the actual but the assumed performance relying on individual national assessment methods.

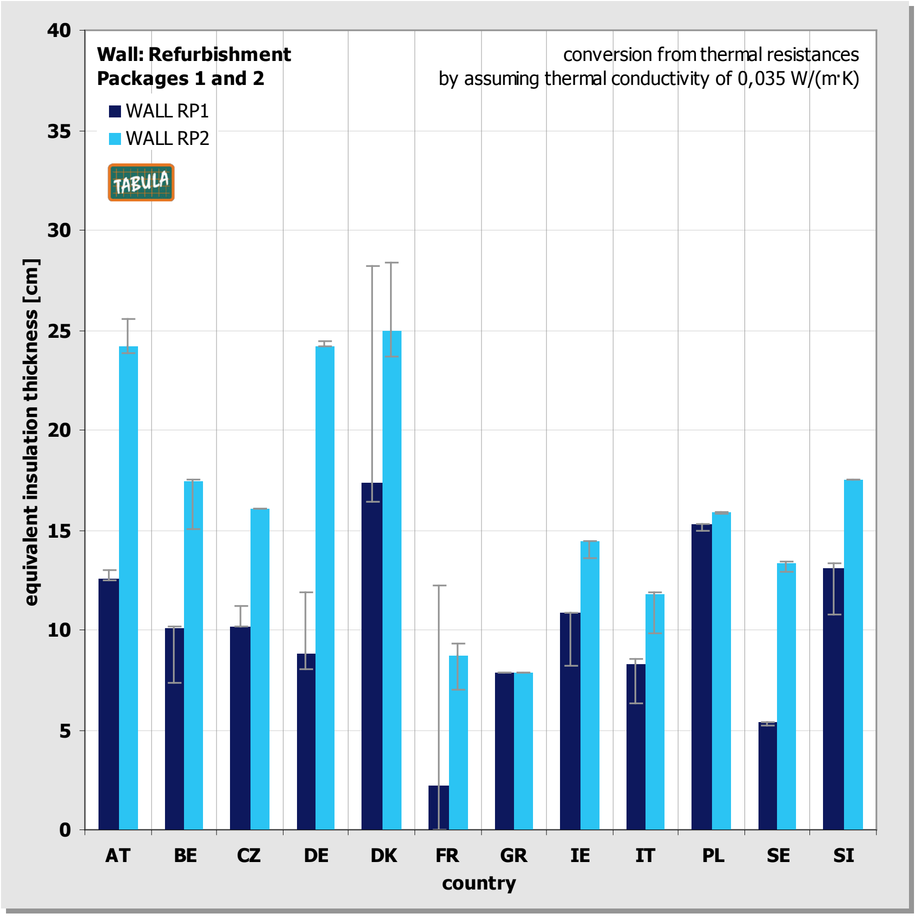
The evaluation of the refurbishment measures on the levels "Standard" and "Advanced", as proposed in different the typology brochures (see section 3.4), disclosed rather large differences – even between countries in similar climatic zones (Figure 21). Thus, the confrontation and discussion of energy upgrade qualities remains an important task for the future.

Figure 20: Analysis of "TABULA.xls" data – Comparison of features of exemplary buildings <DataEval>
Example: U-values of walls per country and decade



Evaluations of further envelope types ("roof", "window", "floor") are available at <DataEval>.

Figure 21: Analysis of "TABULA.xls" data – Comparison of insulation measures proposed in the national typology brochures (section 3.4) <DataEval>
Example: insulation thickness of wall refurbishment per country; "standard" (RP1) and "advanced" (RP2) measures



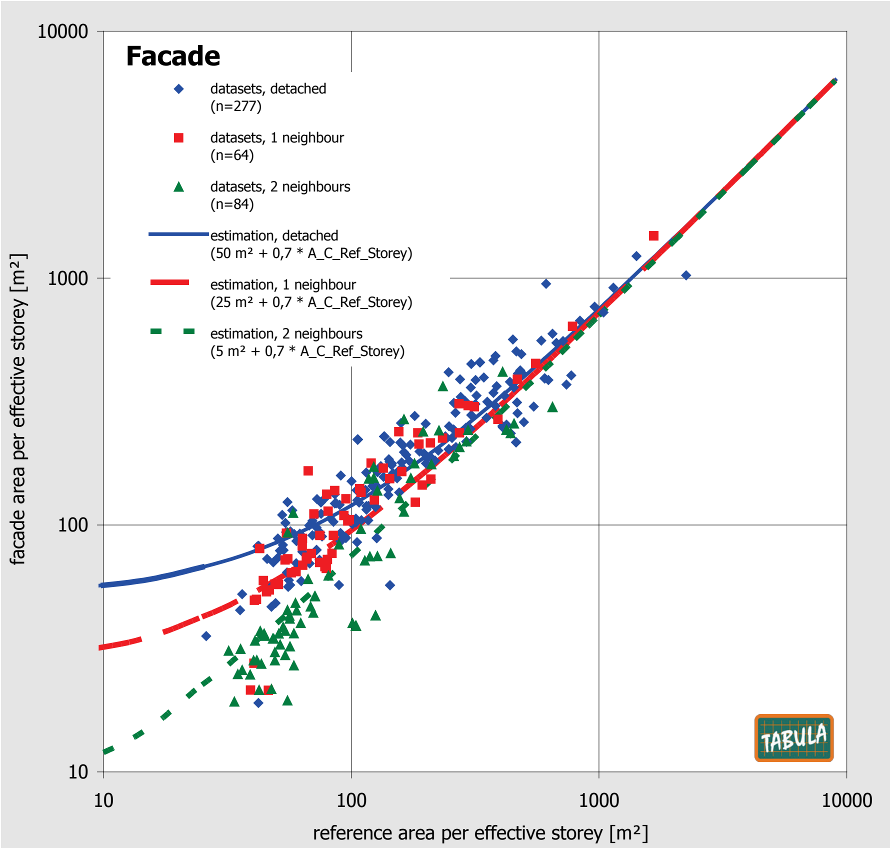
Evaluations of further envelope types ("roof", "window", "floor") are available at <DataEval>.

6.2 Thermal envelope areas

The analysis of the thermal envelope areas of exemplary buildings has resulted in typical values for the ratio of the surface area to the reference floor area per envelope type (roof, wall, window, and floor). The averages and the spreads may in the future support plausibility checks of data input. In addition, the mean envelope areas of the exemplary buildings are a possible basis for building stock models (see section 9) in case that more representative information about building stock surface areas is not available.

Figure 22: Analysis of "TABULA.xls" data – Dependency of the thermal envelope from basic parameters
<DataEval>

Example: Correlation of the facade area with the TABULA reference area per storey, differentiated by the number of directly attached neighbour buildings



Further in-depth analyses revealed a systematic correlation of the envelope areas with basic geometrical parameters like number of storeys, number of directly attached neighbour buildings, etc. (Figure 22). In the future, these functional dependencies may be useful to estimate the size of the thermal envelope of a given building in the context of housing stock surveys and portfolio assessments. Also a further development of the TABULA WebTool using model buildings which can be adapted to the basic geometrical features of a given real building seems possible.

6.3 Heat Supply Systems

Since commonly defined data are available for heat generators, storages and distribution systems a comparison of the energy performance of these components between the participating countries was possible (Figure 23). Generally the values turned out to be rather similar for a given component. In some cases larger deviations were found which may either reflect differences in technologies or in methods for the determination of standard values. In any case such comparisons can also in the future be useful for a quality check of the typology input data.

Figure 23: Analysis of "TABULA.xls" data – Comparison of system data between different countries
<DataEval>
Examples: energy expenditure factors of
a) boilers B_NC, B_C, B_WP (non-condensing, condensing and wood pellets) and
b) electrical heat pumps HP_Air, HP_Ground, HP_ExhAir (heat source: external air, ground, exhaust air)

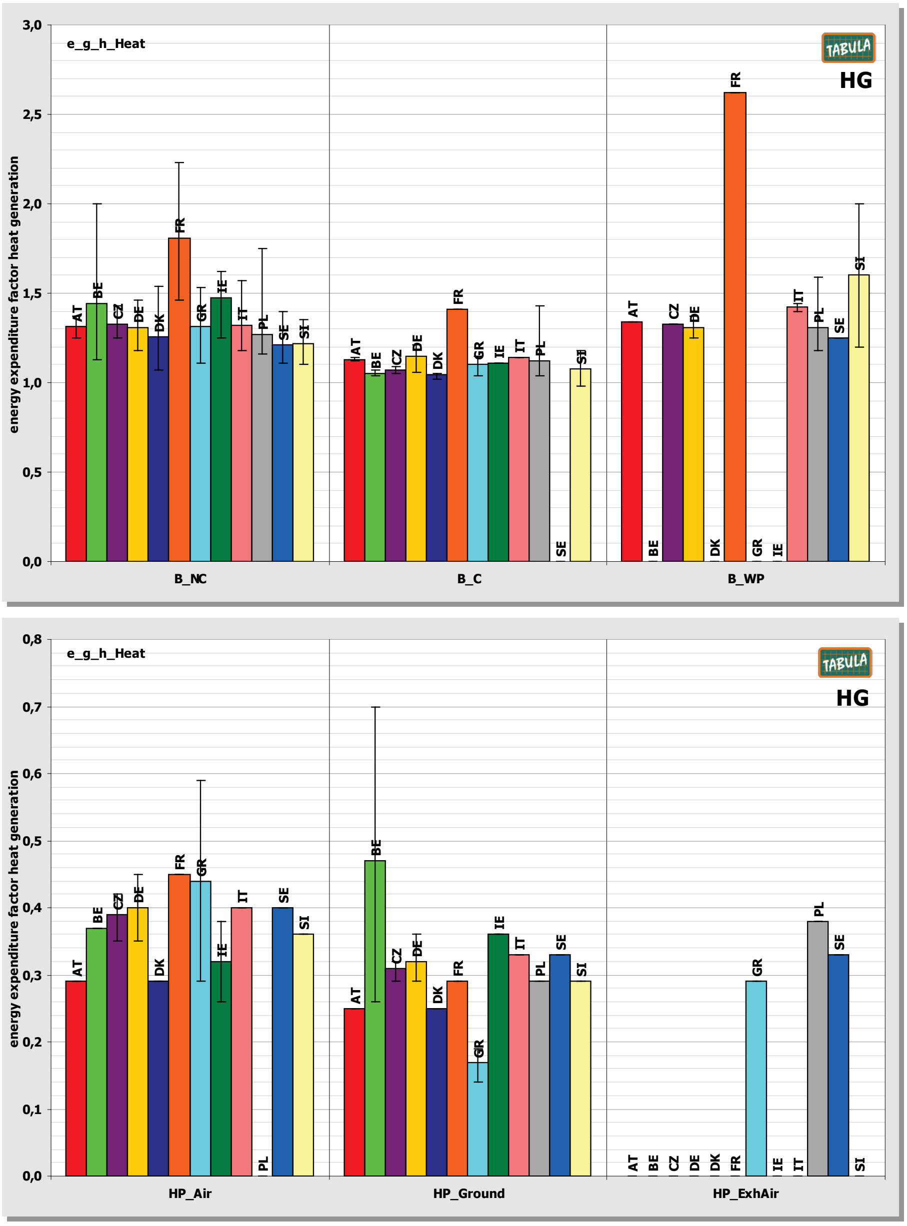


Table 1: Result of the comparative analyses of heating system data – derived default values (simplified common values) <DataEval>
Example: energy expenditure factors of heat generators

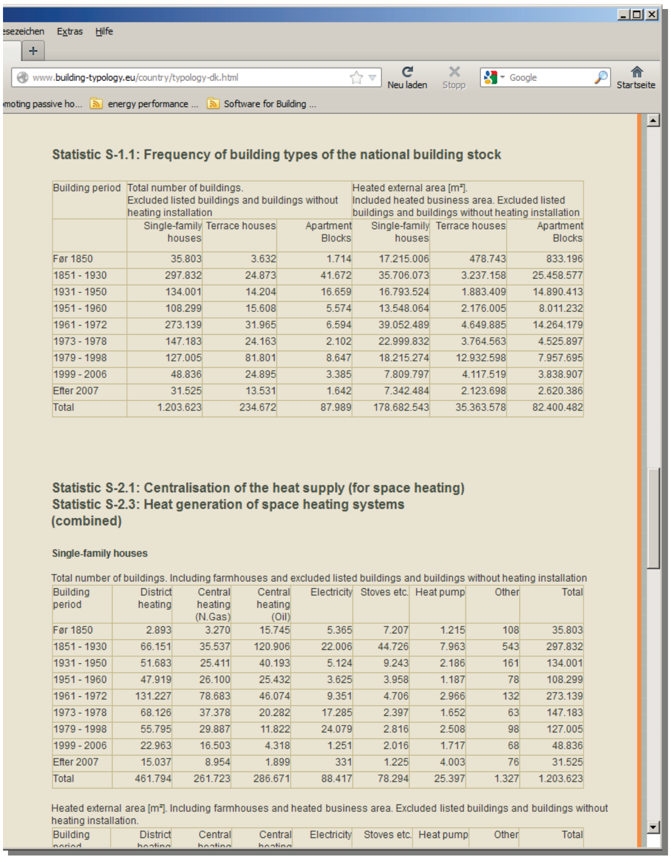
TABULA Code	Description	heat generation expenditure factor (heating systems) delivered energy demand (H_S) divided by produced heat $e_{g,h}$ [-]		
	energy efficiency	**poor**	**medium**	**high**
B_NC	boiler, non-condensing	1,92	1,36	1,13
B_C	boiler, condensing	1,31	1,13	1,06
B_WP	wood-pellets boiler	2,12	1,52	1,31
G_IWH_NC	gas-fired instantaneous water heater, non-condensing	1,27	1,24	1,20
G_IWH_C	gas-fired instantaneous water heater, condensing	1,17	1,13	1,10
G_SH	gas-fired space heater	1,50	1,41	1,29
E_Immersion	electric immersion heater	1,08	1,03	1,00
E	direct electric heat generator	1,25	1,02	1,00
HP_Air	heat pump, heat source external air	0,50	0,37	0,30
HP_Ground	heat pump, heat source ground	0,52	0,31	0,21
HP_ExhAir	heat pump, heat source exhaust air	0,36	0,33	0,31
Stove	stove	2,96	1,92	1,40
OpenFire	open fire	4,44	3,39	2,44
TS	district heating transfer station	1,34	1,13	1,06
CHP	combined heat and power generation	1,67	1,67	1,67
Solar	thermal solar plant	0,00	0,00	0,00

Furthermore, the averages of the available energy performance values of supply system components can be helpful in case that national values do not exist. In consequence, tables listing such default values have been determined for each supply system component (Table 1). The default values can also be utilised for the elaboration of transnational building stock models.

7 National Statistics of Buildings and Heat Supply Systems

In order to assess the relevance of the building types and as a pre-requisite for the design of building stock models the available statistics have been reported for each country. Basic statistics are the frequencies of building types and of supply system types. Further information about the energy related properties have been added – as far as available. It can be stated that there is a general lack of sufficiently detailed data about the energy performance of buildings in the participating countries, especially as regards the current refurbishment grades and annual refurbishment rates. More details about the concept and the structure of the statistical tables can be found in the TABULA Synthesis Report SR1 chapter 6 <SR1>.

Figure 24: National housing stock statistics at the "Country Pages" of the TABULA website <CountryPages>
Example: housing stock statistics of Denmark



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

Building period	Total number of buildings. Excluded listed buildings and buildings without heating installation			Heated external area [m²]. Included heated business area. Excluded listed buildings and buildings without heating installation		
	Single-family houses	Terrace houses	Apartment Blocks	Single-family houses	Terrace houses	Apartment Blocks
Før 1850	35.803	3.632	1.714	17.215.006	478.743	833.196
1851 - 1930	297.832	24.873	41.672	35.706.073	3.237.158	25.458.577
1931 - 1950	134.001	14.204	16.659	16.793.524	1.883.409	14.890.413
1951 - 1960	108.299	15.608	5.574	13.548.064	2.176.005	8.011.232
1961 - 1972	273.139	31.965	6.594	39.052.489	4.649.885	14.264.179
1973 - 1978	147.183	24.163	2.102	22.999.832	3.764.563	4.525.897
1979 - 1998	127.005	81.801	8.647	18.215.274	12.932.598	7.957.695
1999 - 2006	48.836	24.895	3.385	7.809.797	4.117.519	3.838.907
Efter 2007	31.525	13.531	1.642	7.342.484	2.123.698	2.620.386
Total	1.203.623	234.672	87.989	178.682.543	35.363.578	82.400.482

Statistic S-2.1: Centralisation of the heat supply (for space heating)
Statistic S-2.3: Heat generation of space heating systems (combined)

Single-family houses

Total number of buildings. Including farmhouses and excluded listed buildings and buildings without heating installation

Building period	District heating	Central heating (N.Gas)	Central heating (Oil)	Electricity	Stoves etc.	Heat pump	Other	Total
Før 1850	2.893	3.270	15.745	5.365	7.207	1.215	108	35.803
1851 - 1930	66.151	35.537	120.906	22.006	44.726	7.963	543	297.832
1931 - 1950	51.683	25.411	40.193	5.124	9.243	2.186	161	134.001
1951 - 1960	47.919	26.100	25.432	3.625	3.958	1.187	78	108.299
1961 - 1972	131.227	78.683	46.074	9.351	4.706	2.966	132	273.139
1973 - 1978	68.126	37.378	20.282	17.285	2.397	1.652	63	147.183
1979 - 1998	55.795	29.887	11.822	24.079	2.816	2.508	98	127.005
1999 - 2006	22.963	16.503	4.318	1.251	2.016	1.717	68	48.836
Efter 2007	15.037	8.954	1.899	331	1.225	4.003	76	31.525
Total	461.794	261.723	286.671	88.417	78.294	25.397	1.327	1.203.623

Heated external area [m²]. Including farmhouses and heated business area. Excluded listed buildings and buildings without heating installation.

Building	District	Central	Central	Electricity	Stoves etc.	Heat pump	Other	Total

Available for 14 countries at the respective TABULA "Country Page" <**NatStat**>

8 Use of Energy Certicicate Databases as a Data Source

Different sources can be used to get information about the energy performance of national building stocks. Among these Energy Performance Certificates (EPC) are promising since the information is mainly relying on investigations by energy experts and the number of EPCs issued in the past years is rather large, due to implementation of EPBD. In a certain number of countries central databases are available which facilitate the data access. In the course of the the IEE project DATAMINE different ways of using EPC data for building stock monitoring were developed and applied.[1]

During the set-up of national residential building typologies eight TABULA partners checked the possibility to use EPC databases from their countries as information sources. The results are reported in a thematic report <EPCdatabases>. In some cases more detailed information is available in the national scientific reports of the respective partners.[2]

[1] see Final Report of the IEE Project DATAMINE: http://env.meteo.noa.gr/datamine/DATAMINE_Final_Report.pdf

[2] see http://www.building-typology.eu/tabulapublications.html

Table 2: Buildings with energy certificates compared to the total building stock
Example from Denmark

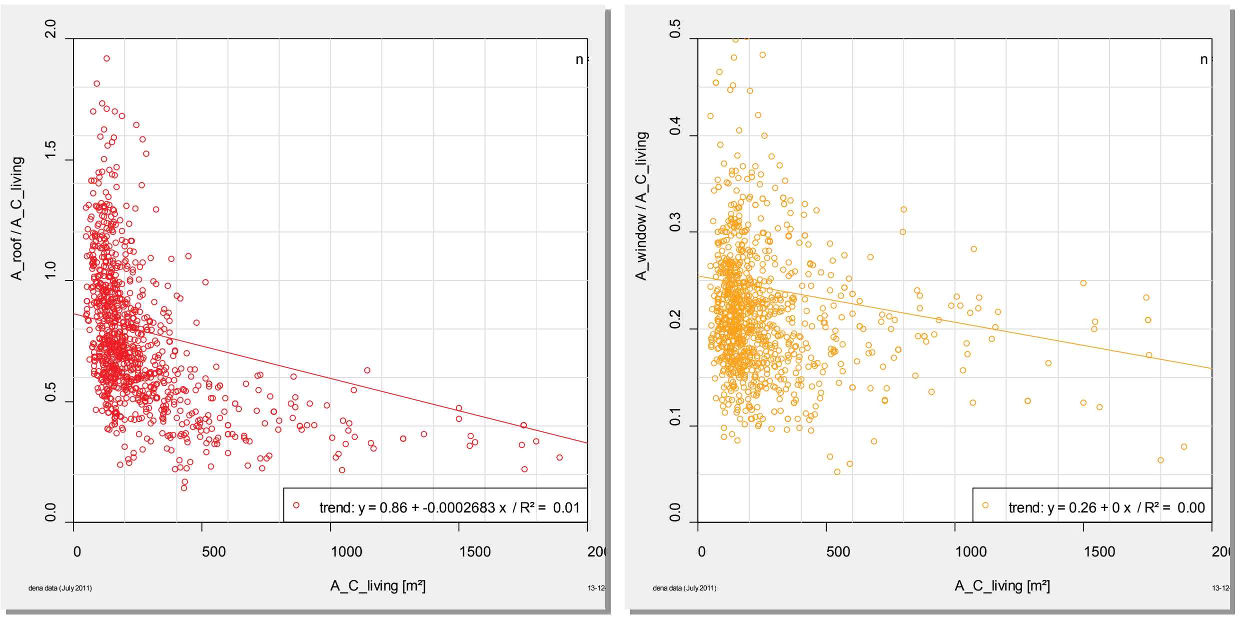
Building Type	No. of certificates [-]	Certificated area [m²]	Total building stock area [m²]	Certificated share [%]
Farm houses	3,125	601,525	22,288,805	2.7
Single-family houses	96,392	14,540,141	155,288,565	9.4
Terrace houses	22,395	4,876,719	35,191,925	13.9
Apartment blocks	7,370	9,849,870	78,087,914	12.6
Office and trade buildings	2,330	5,028,800	67,243,558	7.5

In general it can be stated that a precondition for the use of EPC data is that the database has a homogeneous structure containing not only general but also detailed information about buildings and supply systems. This was the case in all considered databases. As regards Austria, Belgium and Italy the existing databases are not covering the whole countries but only one or several regions. In case of Germany registration of EPCs is not mandatory, so only a certain subgroup was available which is part of a quality assurance scheme.

Summarised the databases turned out to be useful for defining model buildings, especially as regards the geometrical data. By averaging the envelope areas for the different national building types a basis for building stock models is formed.

The average U-values and the refurbishment state can in principle also be extracted. Nevertheless, the fact has to be considered that issuing of EPCs is only required at certain occasions as selling, renting or refurbishments. Since a systematic correlation of the refurbishment state and these occasions cannot be excluded this information of the EPC database cannot be assumed to be representative. In consequence, additional data sources like a supplemental random based survey (or a census in the best case) appear to be necessary to determine the implementation rates of energy saving measures.

Figure 25: Ratio of roof area / window area area to living space
Example: Analysis of a German EPC database



Nevertheless, further information not necessarily requiring a representative sample, can be drawn from the databases. In three of the evaluated databases the measured energy consumption was available in addition to the asset rating. So, TABULA partners from Belgium and from Denmark derived information about the correlation of measured and calculated consumption (see chapter 4.4.)

For the future the TABULA partners recommend to include all relevant typological aspects in the EPC databases in order to facilitate the quality assurance of input data and calculation results. The knowledge about the correlation of distinct quantities can especially be helpful to give indications about the plausibility of thermal envelope areas. An extension of EPC databases to also include the actual measured consumption would be an important means to derive factors for the adaptation of the calculated energy use to the typical level of measured consumption, as being part of the TABULA concept.

9 Models of the National Housing Stock

One important objective of the set-up of national building typologies is the elaboration of bottom-up models which enable a calculation of the energy consumption of the respective building stocks. A typical application field is the investigation of energy saving potentials for a national or regional building stock as well as the design and evaluation of instruments and political strategies.

The elaborated set of exemplary buildings, as shown above, can be directly used as a building stock balance model – as far as statistics are available for the frequencies of building and system types and for the refurbishment state. The example buildings are in this case considered as a small sample of the stock. It is also possible to merge several classes and derive a small number of "average buildings". As a consequence the implementation of scenario analyses – which implicates the variation of a large number of parameter combinations (e.g. different insulation measures, supply system changes and upgrades) – will be much easier.

Table 3: Result of a housing stock energy balance
Example: Belgian housing stock model – comparison of model results with national Energy balance <NatMod>

[TJ]	Model	Energy Balance	Deviation, related to: Single Value	Total Value
Natural gas	131 120	146 033	10,2%	4,5%
Fuel oil	149 082	156 684	4,9%	2,3%
Coal	10 190	5 833	-74,7%	-1,3%
LPG	3 321	5 336	37,8%	0,6%
Electricity	18 159	10 429	-74,1%	-2,3%
Wood	5 332	8 780	39,3%	1,0%
TOTAL	**317 205**	**333 095**	**4,8%**	**4,8%**

National Energy balance Belgium 2006 / final energy consumption in TJ

If respective statistical information is available an elaboration of "average buildings" is possible. Such synthetical buildings are usually based on random samples (or a census in the best case) collected by surveys or from EPC databases. For some countries such average buildings have been derived in the framework of the TABULA project. An access to these datasets is possible by means of the Expert Version of the TABULA WebTool[3].

[3] <WebToolExpertVersion>: The identification code contains "SyAv" for "Synthetical Average" in contrast to "ReEx" for real existing building).

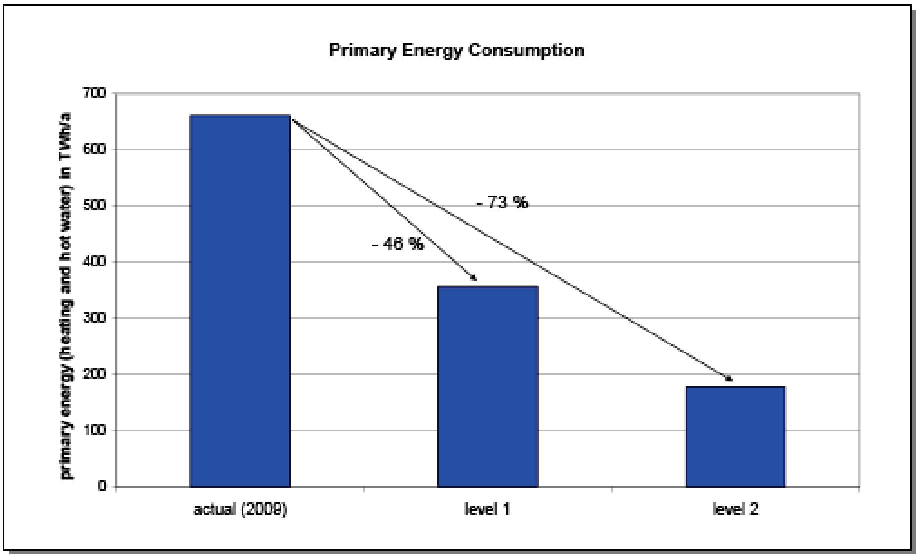
National building stock models have been elaborated by seven TABULA partners on the basis of the typology data. The results are available in a special report <NatModels>.

The partners were choosing different modelling approaches depending on the available statistical data. Some defined a set of synthetical buildings reflecting building stock averages, others were applying a set of generic example buildings from the national TABULA typologies.

The results show that the model calculations can provide plausible projections of the energy consumption of the national residential buildings stock. The fit of model calculations and national energy statistics is satisfactory (Table 3), deviations can often be explained and corrected by adapting standard boundary conditions of the applied calculation models to more realistic values.

Some partners made estimations of possible energy savings, e.g. by applying “standard” or “advanced” packages of energy saving measures to the whole building stock. In that way high potentials of energy savings and CO_2 reduction in the residential building sector could be documented (Figure 26, Figure 27).

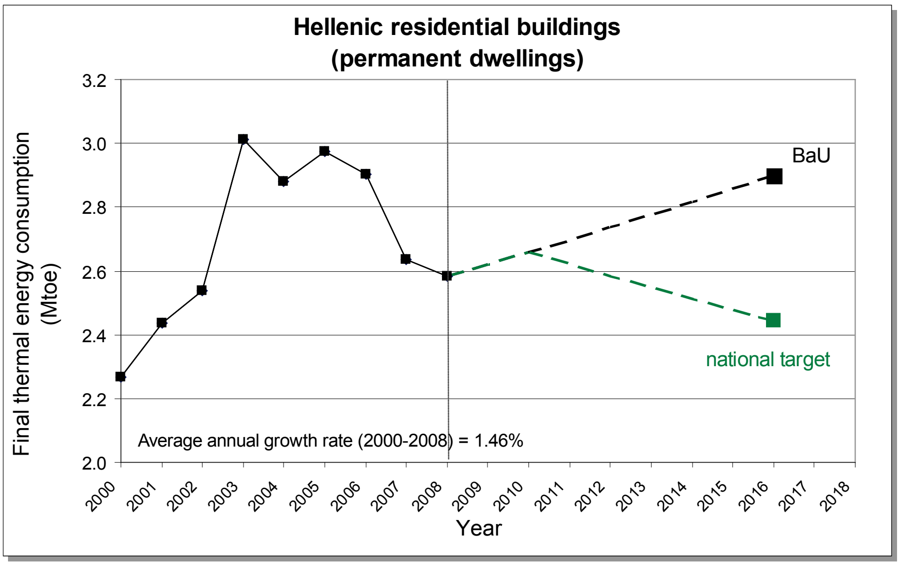
Figure 26: Energy saving potentials determined by use of a national building stock model
Example: German housing stock model – calculation of potential energy savings <NatMod>



Calculated primary energy consumption of non-renewable energy sources in the German residential building stock: actual value (2009) and reduced consumption after application of energy saving measures (in TWh/a)

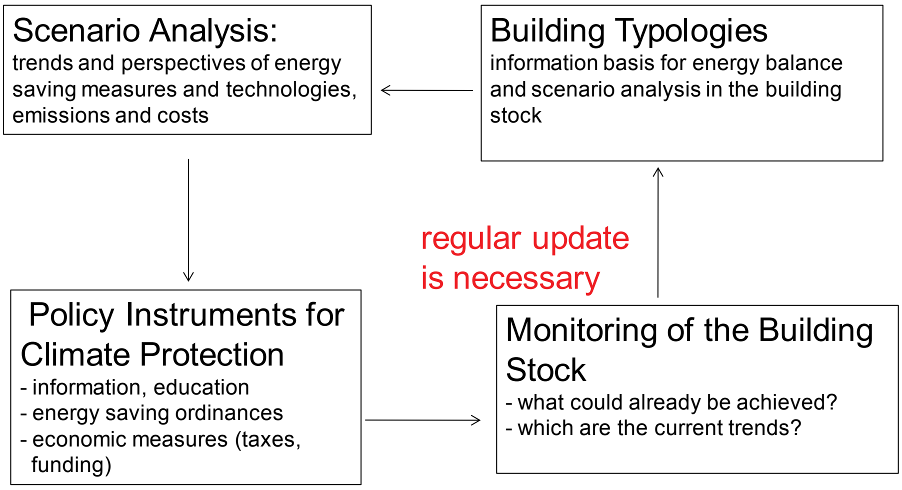
In general, the analysis shows that building typologies can be a helpful tool for modelling the energy consumption of national building stocks and for carrying out scenario analysis also beyond the TABULA project. The consideration of a set of representative buildings makes it possible to have a detailed view on various packages of measures for the complete buildings stock or for its sub-categories. The effects of different insulation measures at the respective construction elements as well as different heat supply measures including renewable energies can be considered in detail.

Figure 27: Example from Greece – Evolution of the thermal energy consumption in permanent dwellings since 2000 and estimated for 2016 to reach the national indicative energy savings target of 9% in Greece



The quality of future model calculations will depend very much on the availability of statistical data. For reliable scenario analysis information is necessary about the current state of the building stock (How many buildings and heating systems have been refurbished until now?) and about the current trends (How many buildings and heating systems are being refurbished every year?). The availability and regular update of the relevant statistical data will be an important basis for the development and evaluation of national climate protection strategies in the building sector (Figure 28).

Figure 28: The role of building stock monitoring and building typologies in the framework of energy saving and climate protection strategies for the housing sector



10 Country Overview

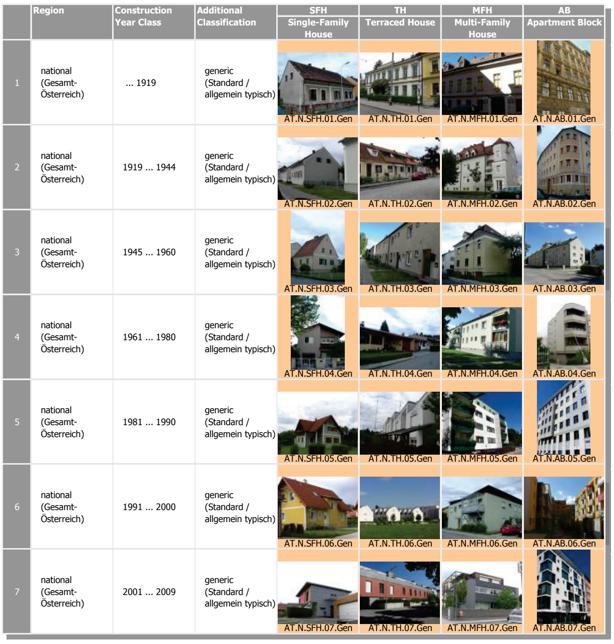
The following clauses provide a rough overview of the building typology approaches and the development of national energy balance models in the participating countries. A detailed documentation of the national activities is given in Appendix A and in the respective national scientific reports <NatSciRep>.

10.1 <AT> Austria

According to national architectural history and available statistical data seven construction periods and all four building size classes (single-family, terraced and multi-family houses, apartment blocks) were considered in the Austrian building typology which results in 28 building types.

Analysis with a national EPC database was carried out to deliver statistical average values of living space, heating demand and U-values which were used for the finding of the example buildings of the typology. In addition a national energy balance calculation and estimations of energy saving potentials were carried out.

Figure 29: The Austrian Building Type Matrix



	Region	Construction Year Class	Additional Classification	SFH Single-Family House	TH Terraced House	MFH Multi-Family House	AB Apartment Block
1	national (Gesamt-Österreich)	... 1919	generic (Standard / allgemein typisch)	AT.N.SFH.01.Gen	AT.N.TH.01.Gen	AT.N.MFH.01.Gen	AT.N.AB.01.Gen
2	national (Gesamt-Österreich)	1919 ... 1944	generic (Standard / allgemein typisch)	AT.N.SFH.02.Gen	AT.N.TH.02.Gen	AT.N.MFH.02.Gen	AT.N.AB.02.Gen
3	national (Gesamt-Österreich)	1945 ... 1960	generic (Standard / allgemein typisch)	AT.N.SFH.03.Gen	AT.N.TH.03.Gen	AT.N.MFH.03.Gen	AT.N.AB.03.Gen
4	national (Gesamt-Österreich)	1961 ... 1980	generic (Standard / allgemein typisch)	AT.N.SFH.04.Gen	AT.N.TH.04.Gen	AT.N.MFH.04.Gen	AT.N.AB.04.Gen
5	national (Gesamt-Österreich)	1981 ... 1990	generic (Standard / allgemein typisch)	AT.N.SFH.05.Gen	AT.N.TH.05.Gen	AT.N.MFH.05.Gen	AT.N.AB.05.Gen
6	national (Gesamt-Österreich)	1991 ... 2000	generic (Standard / allgemein typisch)	AT.N.SFH.06.Gen	AT.N.TH.06.Gen	AT.N.MFH.06.Gen	AT.N.AB.06.Gen
7	national (Gesamt-Österreich)	2001 ... 2009	generic (Standard / allgemein typisch)	AT.N.SFH.07.Gen	AT.N.TH.07.Gen	AT.N.MFH.07.Gen	AT.N.AB.07.Gen

10.2 <BE> Belgium

With five construction age bands the Belgian typology considers 19 generic types. In addition there are 10 special types (e.g. for semi-detached houses or small multi-family houses). Analysis pf EPC databases from the Flemish and the Walloon region provided input for the definition of typical buildings. Moreover, a comparison of measured and calculated energy consumption was carried out. Starting from an existing energy balance model for the Flemish housing stock a national approach could be realised during TABULA by integrating building stock data from the Walloon and Brussels region.

Figure 30: "Building Display Sheet" – Extract from the Belgian building typology brochure

2. Type 2 - Halfopen bebouwing pre 1946

2.1 Beschrijving

Deze woningfiche heeft betrekking op driegevelwoningen daterend uit de periode voor 1946.

2.2 Details

Woningtype: Halfopen bebouwing
Bouwperiode: Voor 1946
Bruto vloeroppervlakte (m^2): 237 m^2
Beschermd volume (m^3): 652 m^3
Totale verliesoppervlakte (m^2): 447 m^2

2.3 Huidige situatie

(1) Bouwkundige kenmerken (HS)

Component	Beschrijving	U-waarde (W/m²K)
Dak	Ongeïsoleerde dakconstructie pre 1946	1,7
Gevel	Ongeïsoleerde massieve buitenmuur pre 1946	2,2
Vloer	Ongeïsoleerde vloer op volle grond pre 1991	0,85
Raam	Houten raamprofielen - enkele beglazing - pre 1971	5
Deur	Buitendeur - ongeïsoleerd deurblad - pre 1991	4

(2) Systeemeigenschappen (HS)

Component	Beschrijving
Verwarming	Plaatselijke gaskachel pre 1985 - rendement 0,75
Warm water	Individuele doorstroom gasgeiser - leidinglengtes > 5 m
Ventilatie	Géén gecontroleerde ventilatie

Supported by INTELLIGENT ENERGY EUROPE

Pagina | 9

2.4 Standaard renovatie (EPB 2010)

(1) Bouwkundige kenmerken (EPB 2010)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 15 cm	0,3	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 8 cm	0,4	Renovatiemaatregel
Vloer	Vloerisolatie - 5 cm	0,4	Renovatiemaatregel
Raam	Geïsoleerde raamprofielen - verbeterde isolerende beglazing Ug 1,1 - na 2005	2	Vervangingsmaatregel
Deur	Buitendeur - geïsoleerd deurblad	2,9	Vervangingsmaatregel

(2) Systeemeigenschappen (EPB 2010)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas – leidinglengtes > 5m	Vervangingsmaatregel
Ventilatie	Ventilatiesysteem C - natuurlijke toevoer en mechanische afvoer	Nieuwe installatie

2.5 Lage energierenovatie

(1) Bouwkundige Kenmerken (LE)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 30 cm	0,15	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 15 cm	0,25	Renovatiemaatregel
Vloer	Vloerisolatie - 10 cm	0,25	Renovatiemaatregel
Raam	Verbeterde geïsoleerde raamprofielen Uf 2 - verbeterde isolerende beglazing Ug 1,1	1,6	Vervangingsmaatregel
Deur	Verbeterd geïsoleerde deurprofielen Uf 2 - verbeterd geïsoleerd deurblad	1,6	Vervangingsmaatregel

(2) Systeemeigenschappen (LE)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas – leidinglengtes > 5m	Vervangingsmaatregel
Warm water	Thermische zonnepanelen - 5 m^2 - onbeschaduwd	Nieuwe installatie
Ventilatie	Balansventilatie met warmterecuperatie met volledige bypass - rendement 0,8	Nieuwe installatie

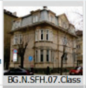
Pagina | 10

Supported by INTELLIGENT ENERGY EUROPE

10.3 <BG> Bulgaria

A building type matrix with 6 age bands and all in all 21 generic types was defined. Five additional types represent special historical, high-rise and panel buildings.

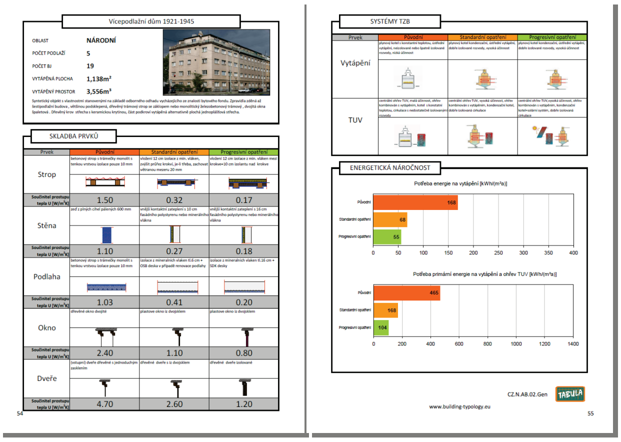
Figure 31: Additional Bulgarian building types

7	national (Bulgarian)	1919 ... 1929	Neobaroque, Neoclassicism, Secession (Необарок, неокласицизъм и сецесион)	 BG.N.SFH.07.Class	 BG.N.TH.07.Class	 BG.N.MFH.07.Class	
8	national (Bulgarian)	1960 ... 1998	Prefabricated Elements (Pannels) (Сглобяеми елементи (панелни сгради))				 BG.N.AB.08.PrefEl
9	national (Bulgarian)	1960 ... 1998	High-rised buildings (Високи сгради изпълнени по метода "пълзящ кофраж" или "едроплощен кофраж")				 BG.N.AB.09.HRis

10.4 <CZ> Czech Republic

24 builing types constitute the Czech housing typlogy which considers six construction periods. The national energy balance model was created using six synthetical average buildings. The applied statistical data sources were considered to be reliable in case of multi-family houses (especially panel buildings) whereas in case of single-family houses estimations had to be made. A comparison of the TABULA common calculation method and the Czech national method (NKN) was carried out showing comparable results.

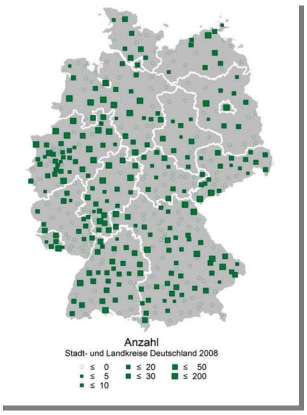
Figure 32: Documentation of a building type in the Czech typology brochure



10.5 <DE> Germany

The elaboration of the German typology started from existing approaches. In the course of an update and a partly reorganisation the number of generic types was reduced (now: 36 buildings assigned to nine age bands) and additional sub-types (e.g. for panel buildings in East Germany) were introduced. Considering the results of a countrywide survey of residential buildings (completed in 2010) and the analysis of an EPC database a set of six synthetical average buildings was defined as a basis for the national building stock model. The model was applied to give estimations of energy saving potentials in the German residential housing stock.

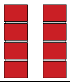
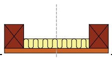
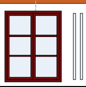
Figure 33: Return of questionnaires from German urban and rural districts in a representative survey which delivered basic data for the building stock model



10.6 <DK> Denmark

In the Danish typology nine age bands are reflecting shifts in building tradition and (later) the introduction and tightening of energy requirements. Considering single-family houses, multi-family houses and apartment blocks 27 building types were introduced. According to Denmark's tradition of issueing energy certificates and the establishment of EPC databases there were good information sources available for the selection of typical real example buildings and for the definition of synthetical average buildings as a basis for the national energy balance model. With this model comparative analysis of the TABULA standard methodology with a calculation according to Danish boundary conditions and with the Danish energy statistics were carried out showing a good overall compliance. Moreover, energy saving potentials of the Danish building stock were analysed.

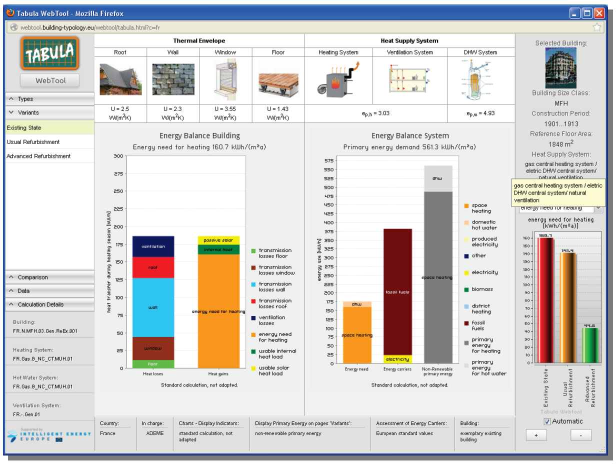
Figure 34: Examples of Danish envelope construction types

Description	Illustration	U-value, [W/m²K]
30 cm brick (cavity wall), not insulated		1.60
Boards / rafter, 50 mm insulation		0.60
Farm-house window, wood profiles, glazing bars, double glazing		2.8

10.7 <FR> France

The French typology considers all four building size classes (single-family, terraced and multi-family houses, apartment blocks) and six construction periods resulting in 24 generic types.

Figure 35: Energy Balance of an examplary building of the French typology in the TABULA webtool



10.8 <GR> Greece

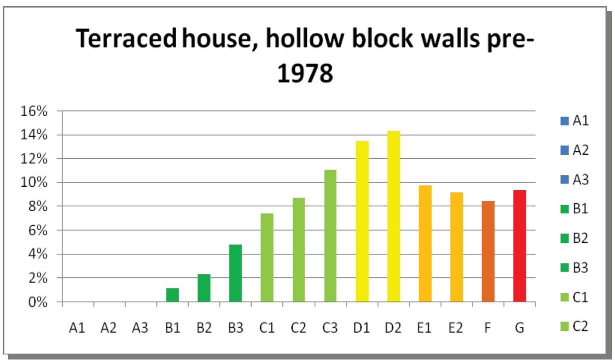
The Hellenic typology considers two size classes (single- and multi-family houses), three construction periods and four climate zones resulting in 24 generic building types. On this basis a web-based mulitmedia tool was developed addressing Greek home owners who whish to have a first assessment of the energy performance of their houses. An energy balance model of the national residential building stock was established and applied for a comparison of the current "business as usual" energy refurbishment trends with the government's climate protection targets.

Figure 36: eKIA: a Greek web-based multimedia tool (www.energycon.org/ekia.html)

10.9 <IE> Ireland

The five construction age bands of the Irish typology were defined according to a national energy assessment procedure by clustering age bands with the same default U-values. Three size classes (single-family houses, terraced houses and apartment blocks) were used so that 15 generic building types were defined. In addition 19 special building types were introduced to consider particular construction methods (like hollow block or timber frame). Analysis of a national EPC database was carried out. Energy balances were compared to the results of the TABULA common calculation method. Deviations in the two older age bands can at least partly be explained by the energy refurbishment progress which has already been achieved in the old Irish building stock.

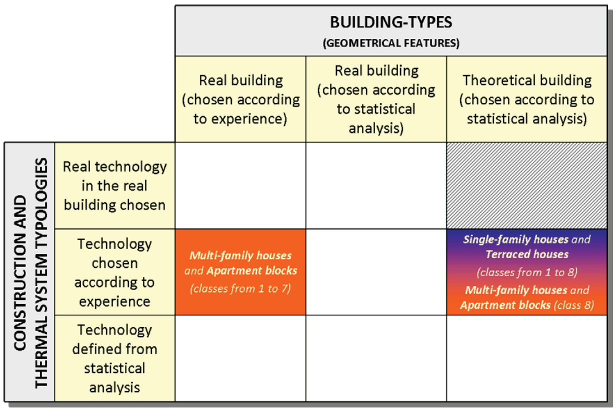
Figure 37: Analysis of national EPC ratings of type No. 11 of the Irish residential building typology (BER Scores from NAS, October 2011)



10.10 <IT> Italy

The Italian housing typology focuses on the middle climate zone comprising the highest portion of the Italian residential building stock . It is classified according to eight characteristic construction periods defining 32 building types. An EPC database was used for deriving average values of geometrical building properties. The building stock energy balance model was established on the basis of six reference buildings which were chosen on the basis of statistical analysis. Potentials of energy savings and CO_2 emission reductions were analysed.

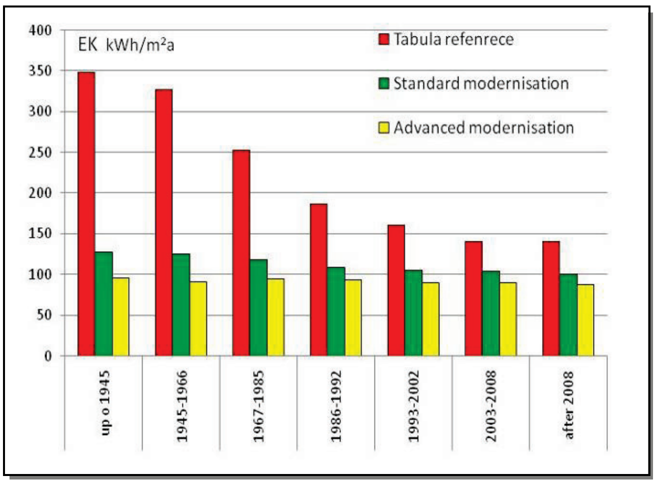
Figure 38: Approaches used for defining Italian building-types



10.11 <PL> Poland

26 generic Polish building types were defined according to seven construction periods (five periods for apartment blocks). Real example buildings representing the generic types were chosen to be similar with statistical average buildings. Those had been derived before by statistical analysis of a national EPC database.

Figure 39: Reduction potential of the energy consumption of Polish single-family houses according to the calculation made by the TABULA Tool

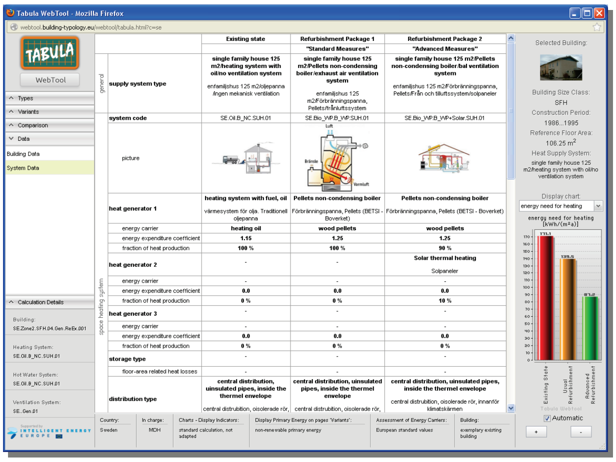


construction period	reduction potential SFH	
	standard modernisation	advanced modernisation
up to 1945	63,2%	72,7%
1945-1966	61,8%	72,2%
1967-1985	53,4%	62,8%
1986-1992	41,9%	50,0%
1993-2002	34,4%	43,8%
2003-2008	25,7%	35,7%
after 2008	29,1%	38,3%

10.12 <SE> Sweden

Single- and multi-family houses are considered with three climatic zones and five age bands so that altogether 30 generic building types were defined in the Swedish typology.

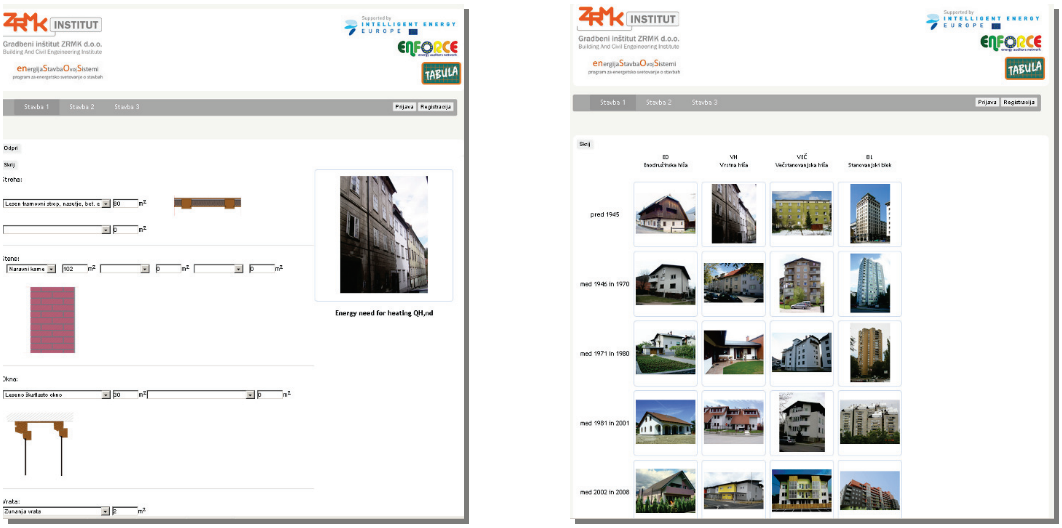
Figure 40: Data of heat supply systems (existing state and refurbishment packages) of a Swedish examplary building in the TABULA WebTool



10.13 <SI> Slovenia

According to six construction periods the Slovenian typology comprises 26 types. For the definition of the types and for the making of an energy balance model of the building stock the data of a survey and of national registries could be used. Two scenarios for the development of energy use in the Slovenian residential building stock until 2020 were calculated. Two webtool applications adressing home owners and energy advisors were developed – one based on the TABULA webtool concept, the other with a separat approach using typology data. Recommendations for the planned establishment of a national EPC database were derived from the TABULA experiences.

Figure 41: Screenshots from the Slovenian “EnSos” webtool



10.14 <SP> Spain

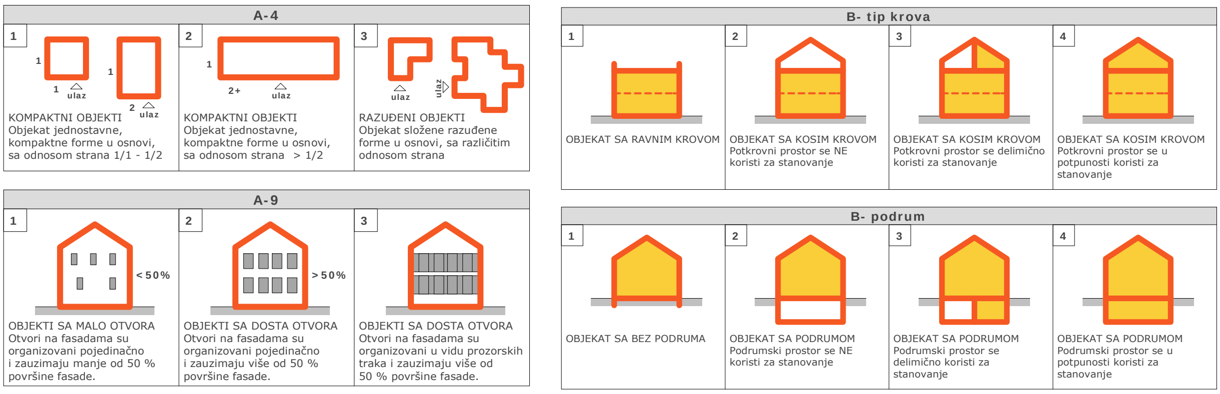
The Spanish partners – in their role as associated partners to the project without EU funding – defined the building type matrix for the country with regard to three main climatic zones and six construction periods resulting in 72 building types. Six example buildings were defined for the Mediterranean zone and integrated into the TABULA webtool. Besides, statistical data of the Spanish residential building stock was analysed and documented at the TABULA website.

Figure 42: Spanish climatic zones. (Source: ISFTIC Images banc)

10.15 <RS> Serbia

Serbia is also an associated partner of the project without EU funding. The Serbian building type matrix shows a structure considering 26 generic building types. A systematic approach of typology development was carried out starting with a countrywide representative survey of residential houses to attain basic statistical data for the definition of the representative buildings. The further elaboration of the typology is still in progress.

Figure 43: Excerpts from the questionnaire of the Serbian representative survey of residential buildings



11 Consideration of Non-Residential Buildings

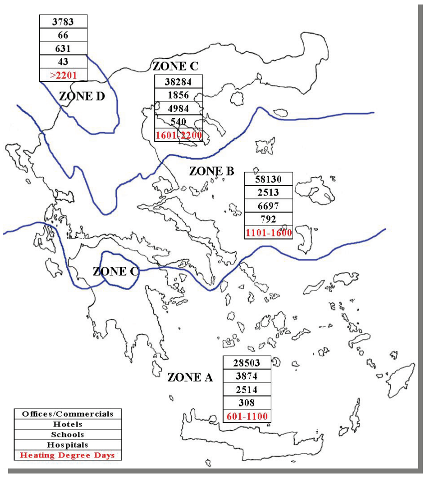
Because of the broad variety of uses and associated characteristics, setting up a typology for the non-residential sector is rather complex. It is therefore important to consider both, practicability of and data availability for such a structure. During the TABULA project a review of existing national approaches and statistical data has been elaborated for five countries <NonRes>.

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

Table 4: National statistics of the non-residential building stock
Example: Number of non-residential buildings and gross floor areas in Austria, differenztiated by Building category and construction year class **<**NonRes**>**

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

Figure 44: Assesment of non-residential buildings.
Example: Distribution of Hellenic non-residential building stock **<**NonRes**>**



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

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

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

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

In summary, it can be stated that further research on various issues is needed to be able to set up national non-residential building typologies at the same level as those for residential buildings.

Table 5: Example. Suggestion for a consolidated structure of building categories for public and private non-residential buildings in Germany <NonRes>

No.	Description of the Building Category
1	**Public Facilities** Parliament Buildings, Courthouses, Prisons, Facilities for emergencies
2	**Education and Research** Lecture Halls, Institute Buildings, Laboratories
3	**Schools** Grammar Schools, Vocational Schools, Special Schools, Nursery Schools, Schools for further education
4	**Hotel, Accommodation** 1- and 2-star Hotels, 3-star Hotels, 4- and 5-star Hotels, Youth Hostels/Guest Houses/Holiday Accommodations/Hostels/Club Houses/Communal Accommodations
5	**Public Houses/Restaurants** Bars, Restaurants, Canteens/Refectories
6	**Buildings used for events and cultural purposes** Cinemas, Opera Houses/Theatres, Roofed Halls/Civic Centres, Exhibition Buildings, Recreation Centres, Youth Clubs, Community Halls
7	**Sports Facilities** Sports Halls, Multipurpose Halls, Indoor swimming Pools, Leisure Pools, Club houses, Gyms
8	**Retail and Services** Retail Non-Food/other Services up to 300 m², Retail Non-Food more than 300 m², Retail Food up to 300 m², Retail Food more than 300 m², Stores, Malls, Shopping Centre (Food and Non-Food), closed Warehouses/Shipping Company, self-employed Health Care/Surgeries, Beauticians/Hair dressers
9	**Health Care** Hospitals with less than 250 beds, Hospitals with 251 to 1000 beds, Hospitals with more than 1000 beds
10	**Transport Infrastructure** Airport/Terminal, Airport Cargo Buildings, Airport maintenance/Hangar, Airport Workshops, Private Underground Parking, Public Underground Parking, Train Station < 5000 m², Train Station > 5000 m²
11	**Office Buildings** with Space heating only, Temperate/Ventilated, Completely air conditioned/Conditioning independent from outside temperature

12 Conclusions and Outlook

Residential building typologies have proved to be a good means to combine communication about refurbishment measures and their benefit for single buildings with the overall perspective on the building stock.

The main lessons learnt from the development of the TABULA typologies are:

- The data situation regarding building structure and heat supply system as well as energy performance of the housing stock is different in each country. However, an elaboration of the basic elements of a TABULA building typology, a building type matrix and exemplary buildings, was possible in each country.
- Despite the differences of building traditions and calculation standards in the participating countries the TABULA partners could exchange and compare the information about shapes, construction elements, heat supply systems and energy performance of typical residential buildings. The cross-country comparision was facilitated by the prior definition of a "common typology language".
- During the development and the application of energy balance models of national residential building stocks a lack of knowledge about some important characteristics was stated in most of the countries – especially concerning the attained progress and the annual rates of energy refurbishment in the building stock. Systematic data collection, e.g. by means of representative surveys, will in the future be necessary to close the information gaps.
- Statistical analysis of mean values of measured and calculated building energy consumption (which could be carried out by some of the partners with the help of building and energy performance certificate data bases) showed considerable deviations. This resulted in the definition of approximate calibration factors which can optionally be used in the TABULA webtool. In general, more systematic research about this question will be necessary in the future.

The TABULA partners are determined to preserve and disseminate the elaborated national typologies and to further develop certain aspects. In their role as „Caretaker“ of the typologies of their countries the partners will also in the future be responsible for the maintenance and update of typology data as defined during the project[4]. They understand the TABULA approach as a public concept open for attaching additional themes and research items – elaborated by themselves but also by third parties.

In the following a number of recommendations for the future development are given and options for the extension towards possible fields of application are discussed.

- **Inclusion of further countries:** An extension towards further countries or regions is desirable. Interested institutions are invited to become national caretaker and to commit themselves to the elaboration of a building type matrix, a typology brochure, datasets of exemplary buildings and statistics according to the common TABULA concept. This may be possible within the framework of individual national projects or – in a joint approach of several countries – on the basis of projects funded by the European Union.
- **Downscaling:** The set-up of similarly structured building typologies for regional and local housing stocks or portfolios of housing companies is a further option including tasks similar to those of the national level and providing benefits in an analogue way.
- **Inclusion of newly built homes and NZEB:** The current TABULA concept is focusing on refurbishments. An extension towards new buildings is in principle desirable but needs some further development, because the thermal envelope standards are in many countries depending on the type of heating system. Nevertheless, an inclusion of new constructions in the TABULA WebTool would result in the possibility to directly compare the requirements for new buildings between different countries. Such an extension should also include future standards, especially that of "Nearly Zero-Energy Buildings" (NZEBs).

---

[4] building type matrix, exemplary buildings, building stock statistics; if applicable: average buildings and building stock model

- **"Adaptable model buildings":** The potentials of the showcase concept could be enlarged if model buildings were used that offer a flexible adaptation to the features of a given real building. Such "adaptable model buildings" could take advantage of the statistical analyses of thermal envelope areas of the exemplary buildings (section 6). They would offer a modification of the envelope depending on the number of storeys, the number of directly attached neighbour buildings as well as the attic and cellar type. Also the flexible consideration of earlier implemented energy upgrades of envelope and supply systems should be possible. Implementing these typological adaptations as features in the TABULA WebTool would enlarge the application fields and would provide a blueprint for quick online energy advice applications.
- **Simplified assessment of building portfolios:** The utilisation of adaptable model buildings as mentioned above can also be valuable for a rough assessment and continuous monitoring of building portfolios and for the data acquisition in the context of representative surveys. A precondition is a standardised questionnaire for elevating typological data.
- **Demonstration buildings ("best practice examples"):** Already refurbished buildings could be assigned as sizable examples to the different national building types. The measure description would include photographs from the renovation phase and – after a period of utilisation – values for the measured consumption.
- **Non-residential buildings:** The next steps towards a national typology for non-residential buildings are the fixing of classification criteria, the determination of exemplary buildings, the definition of a set of refurbishment measures for envelope and supply system, the elaboration of building display sheets and the collection and processing of consistent statistical information. On the international level the task would be to prepare a common building database on the basis of a concerted calculation procedure.
- **Summer performance of buildings:** The current TABULA systematic is focusing on the energy use for space heating and domestic hot water. A simplified classification of the summer performance and the determination of the energy use for cooling / air-conditioning would provide benefits for the application in southern countries and in the field of non-residential buildings.
- **Building stock monitoring:** Typology based building stock models are a good basis to proceed towards comprehensive building stock monitoring activities. This comprises the elaboration and the testing of mechanisms for a continuous update of the relevant input quantities, scenario calculations identifying refurbishment targets, necessary annual refurbishment rates, the trend development and the gap to be overcome. Moreover, the development of models for the statistical correlation of the calculated and the real energy consumption can be enabled by surveying the relevant physical indicators (thermal insulation, heat supply systems) and the actual energy consumption (heating bills) in the same process.

13 References (TABULA Publications)

Reference Shortcut	Short Title and Link
<CalcProc>	TABULA Calculation Method – Energy Use for Heating and Domestic Hot Water. Reference Calculation and Adaptation to the Typical Level of Measured Consumption; TABULA documentation; IWU, Darmstadt 2012 http://www.building-typology.eu/tabulapublications.html#Download_Data_Tool
<CountryPages>	"Country Pages" of the TABULA Website http://www.building-typology.eu/country.html
<DataEval>	Evaluation of the TABULA Database – Comparison of Typical Buildings and Heat Supply Systems from 12 European Countries; TABULA Work Report; IWU, Darmstadt 2012 http://www.building-typology.eu/tabulapublications.html#Download_Data_Tool
<EPCdatabases>	Use of Energy Certificate Databases for National Building Typologies; with contributions by: AEA / Austria; VITO / Belgium; IWU / Germany; ADEME / France; Energy Action / Ireland; POLITO / Italy; NAPE / Poland; TABULA Thematic Report N° 1; IWU, Darmstadt 2012 http://www.building-typology.eu/tabulapublications.html
<NatModels>	Application of Building Typologies for Modelling the Energy Balance of the Residential Building Stock. Models for the national housing stock of 8 countries; by Vito / Belgium, STU-K / Czech Republic, SBi / Denmark, IWU / Germany, NOA / Greece, POLITO / italy, ZRMK / Slovenia; TABULA Thematic Report N° 2; IWU, Darmstadt 2012 http://www.building-typology.eu/downloads/public/docs/report/TABULA_TR2_D8_NationalEnergyBalances.pdf
<NatSciRep>	http://www.building-typology.eu/tabulapublications.html#Download_ScientificReports
<NatStat>	National Statistics at the respective TABULA "Country Pages" http://www.building-typology.eu/country.html
<NatTypBrochures>	"National Typology Brochures" at the respective TABULA "Country Pages" http://www.building-typology.eu/tabulapublications.html
<NonRes>	Typology Approaches for Non-Residential Buildings in Four European Countries. Existing Information, Concepts and Outlook; with contributions by AEA / Austria, IWU / Germany, NOA / Greece, NAPE / Poland; TABULA Thematic Report N° 3; IWU, Darmstadt 2012 http://www.building-typology.eu/downloads/public/docs/report/TABULA_TR3_D9_NonResidentialBuildings.pdf
<SR1>	Use of Building Typologies for Energy Performance Assessment of National Building Stocks. Existent Experiences in European Countries and Common Approach; First TABULA Synthesis Report; with contributions by NOA / Greece, ZRMK / Slovenia, POLITO / Italy, ADEME / France, Energy Action / Ireland, VITO / Belgium, NAPE / Poland, AEA / Austria, SOFENA / Bulgaria, STU-K / Czech Republic, SBi / Denmark; IWU, Darmstadt 2010 http://www.building-typology.eu/downloads/public/docs/report/TABULA_SR1.pdf
<TABULA.xls>	Excel workbook "TABULA.xls", master file containing all building, construction and system data and used as a template for programming the TABULA WebTool http://www.building-typology.eu/tabulapublications.html#Download_Data_Tool
<tabula-calculator.xls>	Excel workbook "tabula-calculator.xls", extract from the master file "TABULA.xls" http://www.building-typology.eu/downloads/public/calc/tabula-calculator.xls
<WebTool>	Building Typology WebTool / Standard Version http://webtool.building-typology.eu/
<WebToolExpertVersion>	Expert version of the TABULA WebTool; gives access to the underlying data http://webtool.building-typology.eu/