NATIONAL SCIENTIFIC REPORT - SLOVENIA

IEE TABULA - Typology Approach for Building Stock Energy Assessment

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Authors

Andraž Rakušček
Dr. Marjana Šijanec Zavrl
Gašper Stegnar

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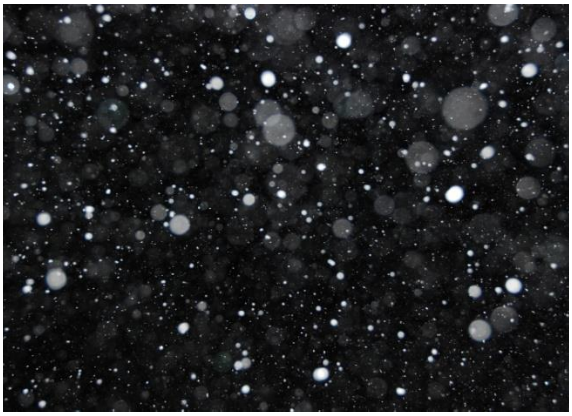
4 Introduction to building typology and IEE Tabula

Every building is unique. Like snowflakes. No snowflake is like another. But if we look from a distance we can say that snowflakes are alike. Same goes for buildings. We can say that some buildings are very alike. With some assumptions and for some specific observations we can even say that a group of buildings are the same. And a single representative of those buildings is 1 typical building.

One of those specifics fields is energy performance of a building. Different building characteristics have different impact on building energy performance. For example, colour of the building does not affect energy performance, thickness of insulation layer does. So, two buildings with same shape, same thermal insulation layers and different colours are not so different when we are observing only energy performance. On the other hand two buildings of same colour and different roof insulation may look the same, but have much different thermal characteristics. When we construct energy building typology we neglect colour of the building. If one would make a landscape building typology one would take colour of the building into account.

Energy building typology is grouping buildings with similar energy performances into groups. Creation of such typology was the core task in IEE Tabula.



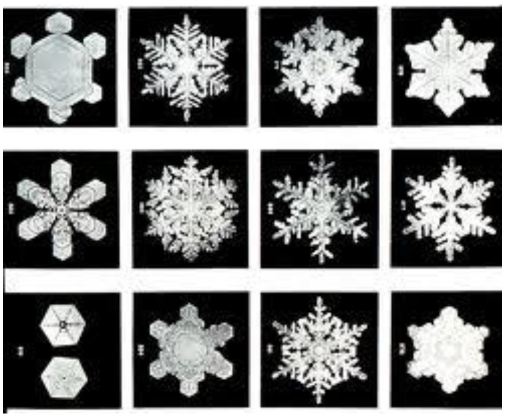


Figure 1: Snowflakes: same but different

This scientific report is the final paper evidence of Slovenian project work in IEE Tabula. Intelligent Energy Europe TABULA project (2009-2012) was a project where we created a building typology in each of the member states participating in the project. The participating countries are Germany, France, Italy, Denmark, Sweden, Belgium, Poland, Austria, Czech Republic, Greece, Slovenia, Ireland and Bulgaria. Associated partners from Spain and Serbia are also participants. The project was co-ordinated by IWU (Institut Wohnen and Umwelt GmbH – the Institute for Housing and Environment) based in Darmstadt, Germany.

Building typologies in project partner’s countries have a common structure. In order to exchange information between countries uniform definitions are necessary. Therefore the TABULA consortium has agreed on a number of settings concerning the classification systematics, the data structure and the energy balance calculation to be applied to all National Building Typologies.

Energy building typology has several uses two being: assessing representative building and calculation of national energy balance. In Slovenia we have done both. After developing

Tabula building typology we applied energy calculation on national level and calculated national energy balance (Chapter 0). Furthermore we compered this calculated values with statistical measured national energy consumption.

At the vary and of the project we developed Ensos application for assessing a single representative building and to make quick energy calculations.

Figure 2: Two buildings, one in Ljubljana, one in Jesenice. Different, but much alike.

5 Existing building typologies

Some attempts to assemble building typologies have been made in the past. First there was a study in mid-90. 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 latter 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.

5.1 Analysis of existing residential building stock

Building stock was divided according to different architectural design. Typology was build according to architectural criterion:

- Ground plan shape, the shape of floor area of the building (from perfect squar to irregular shapes)
- Volume of the building, from ideal cubic shape to prismatic shapes
- Compactness of the building site, from single standing buildings to terraced buildings

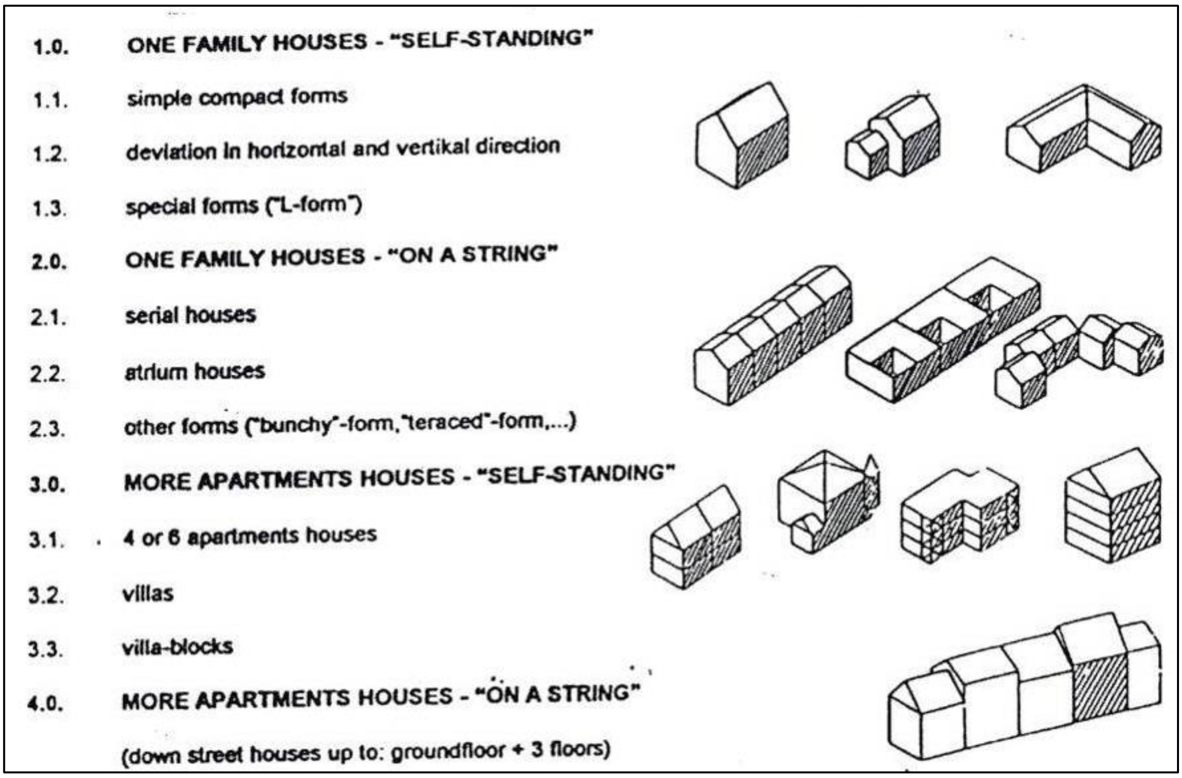


Figure 3: Residential buildings typology according to architectural criteria

In next step frequencies of each building type were documented. Bases for the frequencies were census from 1991.

Table 1: frequencies of each building type

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

For each building type representative building was assigned.

Then only buildings erected until 1980 were taken into further analyses. Year 1980 corresponds to the nation standard with stricter conditions regarding thermal properties of building components and building energy efficiency.

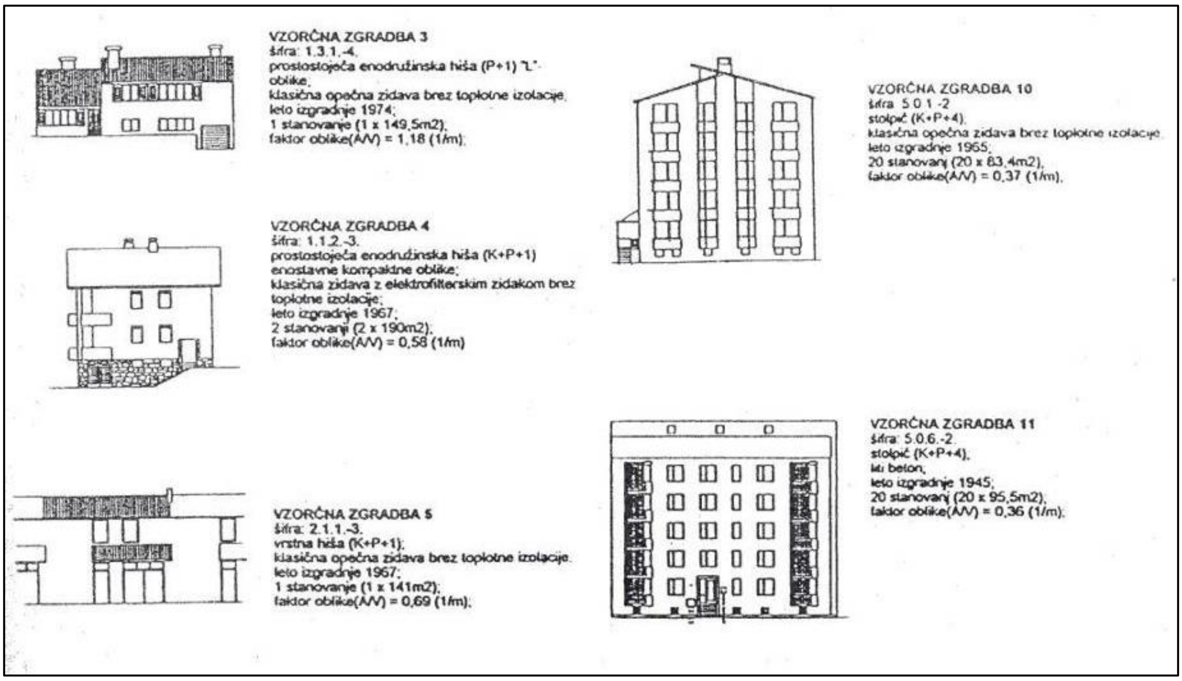


Figure 4: Representatives of building typology

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 (existing state and refurbishment state) correspond to energy savings which were then calculated on national bases.

Comparison of calculated energy savings and renovation costs was the bases for decision about cost effective measures.

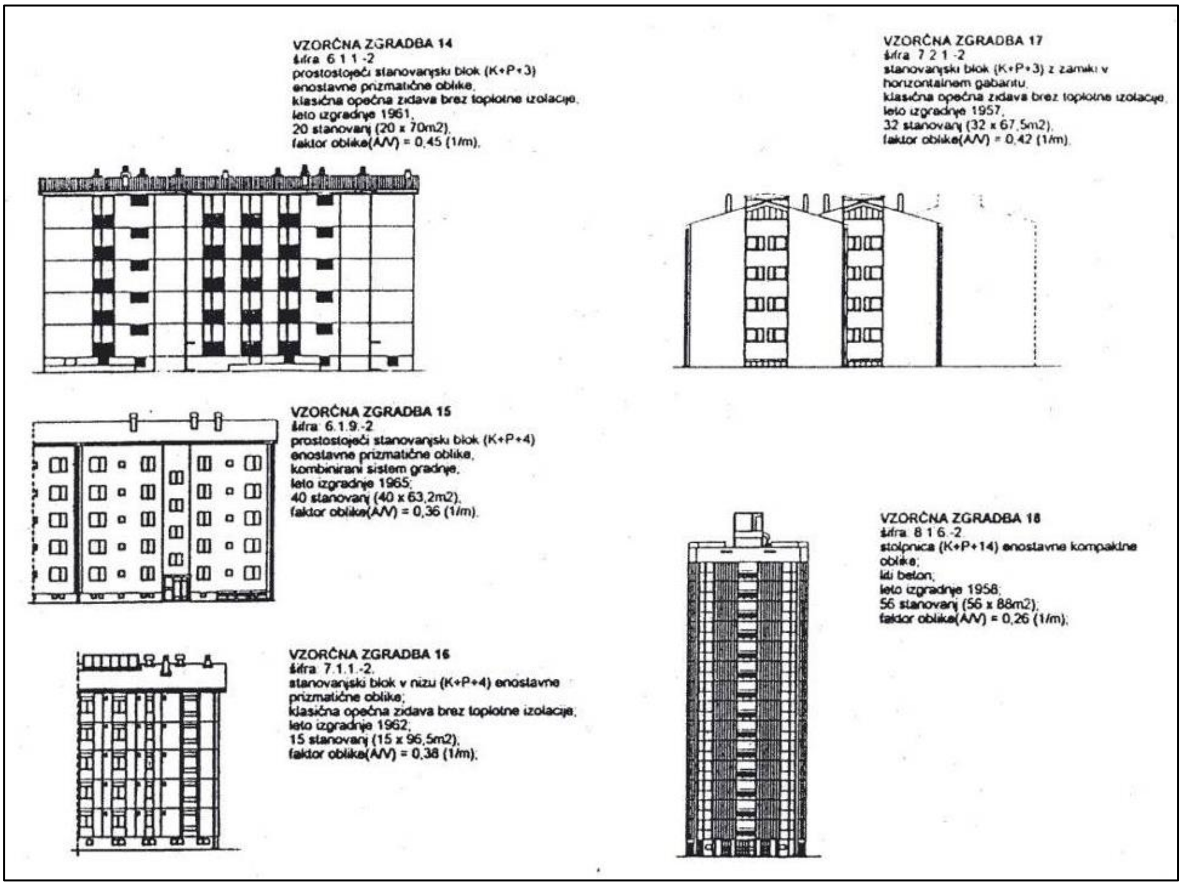


Figure 5: Representatives of each building typology

5.2 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.

In Table 2 on page 9 building frequencies according to statistical categories are shown. This typology represents period from 1962 to 1979.

Table 2: Building frequencies according to statistical categories 1962 - 1979

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

In years 2010 around 5.200 buildings ware erected. This is aroud 300 buildings less then in 2009. This is shown on next table.

Table 3: Frequencie of new building construction in years 2009 and 2010

	Skupaj		Nove stavbe		Sprememba namembnosti stavb	
	število	m²	število	m²	število	m²
2009						
Stavbe skupaj	5448	2711602	5300	2645706	148	65896
Stanovanjske stavbe	4.235	1.626.025	4.162	1.594.008	73	29.017
enostanovanjske stavbe	3.645	929.000	3.596	917.396	49	11.604
večstanovanjske stavbe	571	667.350	550	651.647	21	15.703
stavbe za posebne namene	19	29.675	16	27.965	3	1.710
Nestanovanjske stavbe	1.213	1.085.577	1.138	1.048.698	75	36.879
2010						
Stavbe skupaj	5.182	2.243.707	5.040	2.186.725	142	56.892
Stanovanjske stavbe	4.090	1.331.875	4.021	1.309.109	69	22.766
enostanovanjske stavbe	3.715	934.186	3.663	921.987	52	12.199
večstanovanjske stavbe	358	349.107	343	339.675	15	9.432
stavbe za posebne namene	17	48.582	15	47.447	2	1.135
Nestanovanjske stavbe	1.092	911.832	1.019	877.616	73	34.216

Source: [SURS]

The Statistical Office of the Republic of Slovenia records number of building permits issued each year and project costs. Project costs of new contracts ware in January 2012 lower for 38% when compared to year before. This includes buildings and other constructions (bridges, dams, roads, etc.). Contractual costs for buildings alone dropped for 73%. There were 3635 building permits issued in 2011 of which 2633 (72%) for residential buildings. This residential building will be built by private investors (89%). This sort of typology is useful in predicting building activity and construction costs in near future.

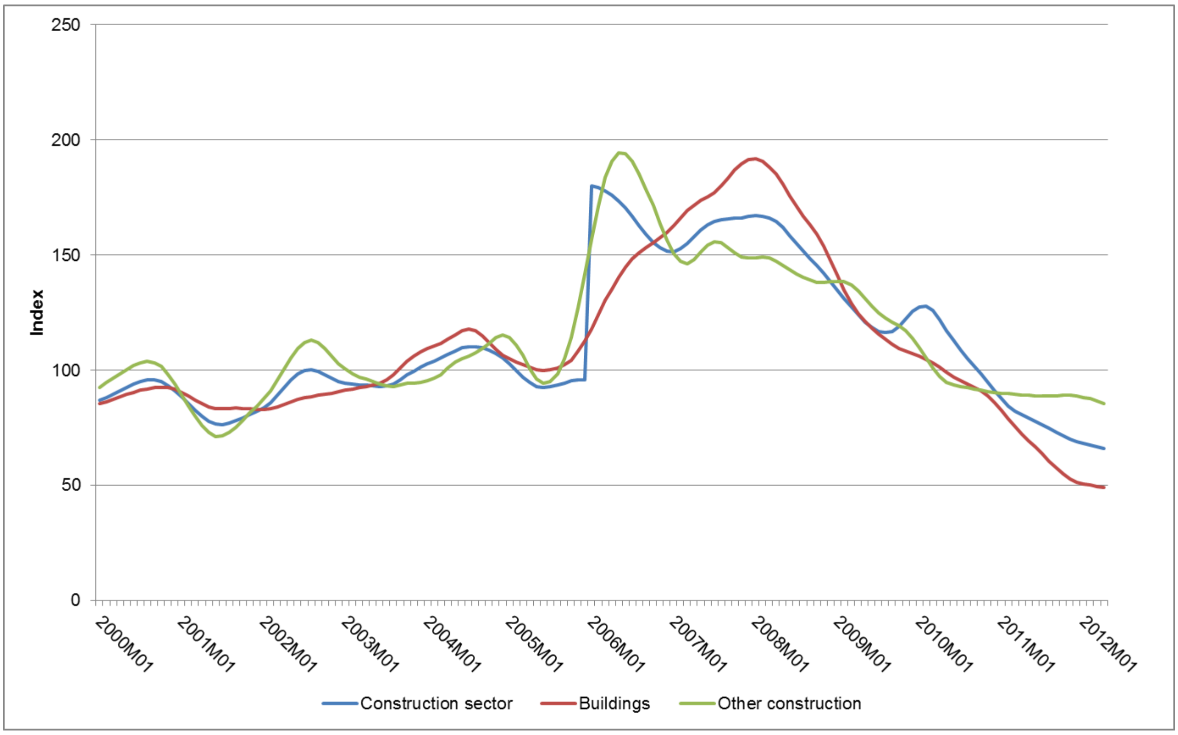


Figure 6: Construction contractual costs. Slovenia, 2000 – 2012 (Source: [SURS])

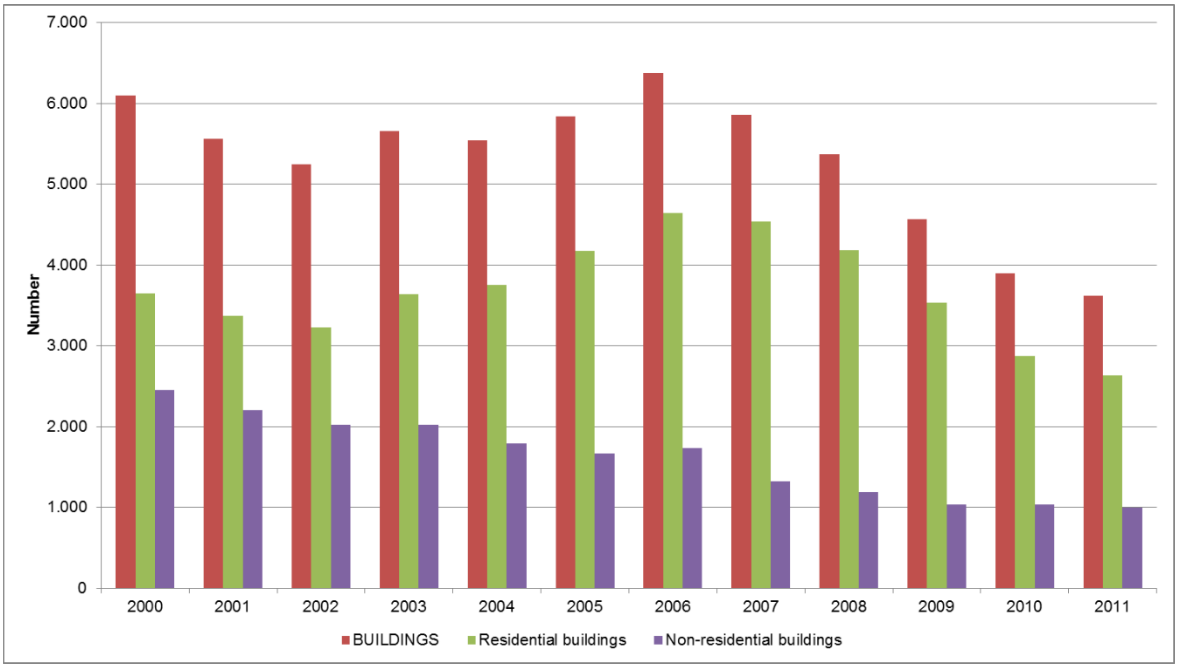


Figure 7: Number of builing permits, Slovenia, 2000 – 2011 (Source: [SURS])

5.3 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 has been assessed. According to the changes in thermal insulation regulative correspondent thickness of thermal insulation layer was added to the building envelope.

Table 4: Typology sub categories of construction principles

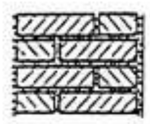
TECHNOLOGICAL GROUP	CONSTRUCTION PRINCIPLES (TECHNOLOGY)
1	classical brick construction without thermal insulation
2	classical construction with other (non-brick) materials
3	classical brick construction with thermal insulation
4	cast concrete construction in lost panelling
5	reinforced concrete frame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

Table 5: Number of residential buildings according to construction principles

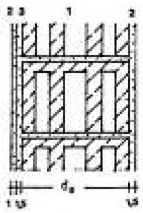
ARCH. GROUP		TECHNOLOGICAL GROUP										
		1	2	3	4	5	6	7	8	9	10	TOTAL
1.1.	build.	84339	42169	48193	1000	-	-	470	-	7205	3374	186750
	apart.	92528	44577	50601	1024	-	-	482	-	7229	3374	199815
1.2.	build.	21685	3614	6626	30	-	-	48	-	1325	422	33750
	apart.	23010	3855	6745	30	-	-	48	-	1325	422	35437
1.3.	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

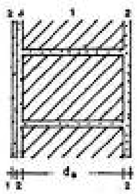
In a separate study a common building construction types ware analysed. No frequencies ware proposed. A study was a part of the Manual for Energy Advisors.

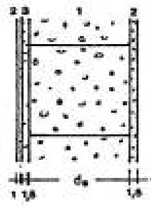
Figure 8: Common building construction types in old buildings (Manual for Energy Advisors)



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

5.4 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 6: Building floor area according to typology categories

Building groups according to the year of construction and thermal insulation level, respectively	Total energy consumption (kWh/m^{2}a)	Total floor area 1997 (m^2)	Increment in residential floor area in 1998, 1999 (m^2)	Switch between categories due to energy restoration in years 1998, 1999 (m^2)	Total (m^2)
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

Source: (Statistical yearbook 2001, 31.12.99 and ZRMK analyses)

5.5 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 IEE DATAMINE project)

6 Statistical data

Slovenia was lacking the information on the typical systems in the buildings.

A different approach had to be taken and we established co-operation with a group of national experts working on an energy efficiency pole in residential sector.

We developed some specific survey [REUS] questions for TABULA needs. Finally based on the obtained results and findings on existing building stock we were able to develop the national building typology (not only on the architectural level but also on the level of systems in existing buildings).

Second source for statistical analyses was Registry of Buildings.

Table 7: 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
SI.N.SFH.01.Gen	140.605	150.283	13.474	14.822
SI.N.SFH.02.Gen	91.163	99.013	8.996	9.895
SI.N.SFH.03.Gen	82.684	88.604	8.919	9.811
SI.N.SFH.04.Gen	114.561	118.970	12.043	13.247
SI.N.SFH.05.Gen	21.567	22.093	2.571	2.828
SI.N.SFH.06.Gen	99	102	9	10
SI.N.TH.01.Gen	12.974	14.897	1.214	1.336
SI.N.TH.02.Gen	11.383	12.800	1.108	1.218
SI.N.TH.03.Gen	7.505	8.354	799	879
SI.N.TH.04.Gen	8.301	9.078	939	1.032
SI.N.TH.05.Gen	2.394	2.575	273	300
SI.N.TH.06.Gen	47	56	4	5
SI.N.MFH.01.Gen	10.693	60.531	3.647	4.011
SI.N.MFH.02.Gen	5.142	39.591	2.031	2.235
SI.N.MFH.03.Gen	2.105	16.238	866	953
SI.N.MFH.04.Gen	2.248	18.320	1.010	1.111
SI.N.MFH.05.Gen	1.152	9.233	562	618
SI.N.MFH.06.Gen	14	84	5	6
SI.N.AB.01.Gen	930	43.683	2.184	2.402
SI.N.AB.02.Gen	885	35.085	1.482	1.630
SI.N.AB.03.Gen	1.060	50.667	2.350	2.585
SI.N.AB.04.Gen	826	38.962	1.899	2.089
SI.N.AB.05.Gen	256	12.397	712	784
SI.N.AB.06.Gen	4	1.077	66	72
Building Stock total	518.598	852.693	67.164	73.881

Source: [REN] Registry of buildings, 2009, http://e-prostor.gov.si/?id=601

Table 8: Percentage of thermally refurbished envelope areas

Building classes	walls	roofs	upper floor ceilings	basement/ cellar ceiling	windows
Single Unit Houses					
SUH.01	38%	74%	38%	no data	84%
SUH.02	45%	74%	48%	no data	74%
SUH.03	38%	58%	49%	no data	46%
SUH.04	35%	34%	31%	no data	31%
SUH.05	20%	7%	9%	no data	0%
SUH.06	0%	0%	0%	no data	0%
Multi Unit Houses					
MUH.01	14%	55%	17%	no data	77%
MUH.02	16%	56%	21%	no data	52%
MUH.03	14%	38%	20%	no data	49%
MUH.04	26%	34%	18%	no data	27%
MUH.05	17%	0%	0%	no data	0%
MUH.06	0%	0%	0%	no data	0%

Source: REUS survey, 2011

Table 9: Information on insulation level of walls

	Thickness of exterior wall insulation layer (eg. mineral wall, polystyrene)				
Building classes	no insulation	less then 5 cm	from 6 to 10 cm	more then 10 cm	no data
Single Unit Houses					
SUH.01	53%	20%	14%	7%	7%
SUH.02	45%	16%	29%	7%	3%
SUH.03	34%	24%	34%	7%	2%
SUH.04	19%	24%	40%	13%	4%
SUH.05	10%	5%	52%	22%	11%
SUH.06	46%		17%	37%	
Multi Unit Houses					
MUH.01	73%	10%	3%	8%	7%
MUH.02	51%	17%	6%		26%
MUH.03	48%	15%	16%		21%
MUH.04	12%	28%	28%	5%	27%
MUH.05		34%	52%	14%	
MUH.06				100%	

Source: REUS survey, 2011

Table 10: Information on window types

Building classes	Windows type							
	Casement single glassing window	box window (2 Casement single window, between gap more then 10	box window (2 Casement single window, between gap less then 10	Casement double glassing window	Casement double low E glassing window	Casement triple low E glassing window	other	no data
Single Unit Houses								
SUH.01	13%	29%	18%	34%	1%	2%	1%	3%
SUH.02	8%	26%	14%	37%	10%	3%		2%
SUH.03	5%	24%	19%	35%	12%	4%		1%
SUH.04	5%	16%	19%	44%	11%	4%	1%	1%
SUH.05	2%	12%		23%	37%	15%		11%
SUH.06		37%		46%		17%		
Multi Unit Houses								
MUH.01	5%	33%		31%	21%	3%		7%
MUH.02	5%	40%	18%	30%	4%	2%	1%	
MUH.03	12%	11%	6%	63%	7%	1%		
MUH.04	15%	18%	12%	48%	8%			
MUH.05	17%			50%	17%		17%	
MUH.06					100%			

Source: REUS survey, 2011

Table 11: Information on insulation level of roof

	Thickness of roof insulation layer (eg. mineral wall, polystyrene)					
Building classes	no insulation	less then 5 cm	from 6 to 15 cm	from 16 to 30 cm	more then 30 cm	no data
Single Unit Houses						
SUH.01	50,80%	13%	17%	11%	1%	8%
SUH.02	44,60%	9%	29%	11%	1%	6%
SUH.03	27,50%	13%	39%	14%	2%	6%
SUH.04	34,50%	9%	31%	16%	3%	7%
SUH.05	11,40%	6%	25%	29%	10%	18%
SUH.06	45,70%		17%	37%		
Multi Unit Houses						
MUH.01	74,00%		7%	4%		15%
MUH.02	42,40%	4%	11%	5%	5%	34%
MUH.03	42,00%	8%	16%	2%		33%
MUH.04	8,30%	22%	26%	9%	1%	34%
MUH.05	16,80%	17%	27%	14%		25%
MUH.06				100%		

Source: REUS survey, 2011

Table 12: Centralization of the heat supply (for space heating)

percentage of buildings per building class	Single Unit Houses						Multi Unit Houses					
	SUH.01	SUH.02	SUH.03	SUH.04	SUH.05	SUH.06	MUH.01	MUH.02	MUH.03	MUH.04	MUH.05	MUH.06
local heating, room heating	26%	9%	5%	5%	6%	0%	25%	10%	3%	7%	16%	0%
floor heating	12%	12%	6%	7%	3%	0%	27%	15%	14%	20%	33%	100%
central heating for building	61%	78%	87%	87%	91%	100%	33%	37%	37%	47%	42%	0%
district heating	0%	1%	3%	1%	1%	0%	14%	38%	46%	26%	9%	0%
total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: REUS survey, 2011

percentage of buildings per building class	Single Unit Houses						Multi Unit Houses					
	SUH.01	SUH.02	SUH.03	SUH.04	SUH.05	SUH.06	MUH.01	MUH.02	MUH.03	MUH.04	MUH.05	MUH.06
other heating	28%	15%	10%	8%	7%	11%	28%	27%	12%	8%	7%	6%
central heating	55%	78%	85%	85%	77%	84%	57%	53%	62%	67%	78%	72%
district heating	1%	2%	1%	1%	1%	3%	10%	16%	25%	23%	12%	17%
no heating	16%	5%	4%	6%	15%	1%	5%	3%	2%	2%	2%	6%
no data	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%
total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: Registry of buildings, 2009, http://e-prostor.gov.si/?id=601

Table 13: Heat generation of space heating systems

percentage of buildings per building class	Single Unit Houses						Multi Unit Houses					
	SUH.01	SUH.02	SUH.03	SUH.04	SUH.05	SUH.06	MUH.01	MUH.02	MUH.03	MUH.04	MUH.05	MUH.06
old wood or coal boiler	45%	30%	35%	25%	20%	50%	26%	9%	2%	14%	0%	0%
old oil or gas boiler	32%	42%	42%	49%	37%	17%	53%	58%	84%	69%	86%	100%
low energy boiler	1%	0%	2%	2%	3%	0%	0%	3%	2%	0%	0%	0%
condensation boiler	0%	0%	1%	0%	6%	0%	0%	0%	0%	1%	0%	0%
new biomass boiler	4%	2%	4%	5%	11%	0%	7%	1%	2%	0%	0%	0%
electric heater	0%	2%	0%	0%	3%	17%	0%	3%	4%	2%	0%	0%
heat pump air-water	2%	2%	1%	1%	3%	0%	0%	0%	2%	0%	0%	0%
heat pump water-water	0%	0%	1%	1%	3%	0%	3%	0%	0%	7%	0%	0%
heat pump water-water	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%
combined wood oil boiler	8%	18%	10%	10%	11%	0%	2%	6%	2%	4%	0%	0%
solar panels	1%	1%	1%	2%	0%	0%	0%	0%	0%	0%	0%	0%
other	8%	2%	3%	2%	3%	17%	9%	17%	2%	4%	0%	0%
no data	1%	0%	0%	0%	0%	0%	0%	3%	1%	0%	14%	0%
total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: REUS survey, 2011

Table 14: Centralization of the heat supply (for domestic hot water)

percentage of buildings per building class	Single Unit Houses						Multi Unit Houses					
	SUH.01	SUH.02	SUH.03	SUH.04	SUH.05	SUH.06	MUH.01	MUH.02	MUH.03	MUH.04	MUH.05	MUH.06
local	32%	15%	8%	9%	9%	13%	51%	44%	27%	24%	0%	0%
floor central	12%	11%	8%	10%	9%	0%	25%	16%	20%	27%	69%	100%
central	56%	72%	81%	80%	82%	88%	14%	14%	11%	32%	31%	0%
district heating	0%	1%	3%	2%	0%	0%	5%	25%	42%	17%	0%	0%
no data	0%	0%	0%	0%	0%	0%	5%	0%	0%	0%	0%	0%
total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: REUS survey, 2011

Table 15: Heat generation of domestic hot water systems

percentage of buildings per building class	Single Unit Houses						Multi Unit Houses					
	SUH.01	SUH.02	SUH.03	SUH.04	SUH.05	SUH.06	MUH.01	MUH.02	MUH.03	MUH.04	MUH.05	MUH.06
heat pump air-water	9%	7%	6%	8%	11%	0%	12%	0%	6%	11%	0%	0%
solar panels	5%	2%	5%	2%	6%	0%	0%	0%	0%	0%	0%	0%
electric heater	7%	6%	10%	8%	6%	33%	8%	27%	16%	4%	0%	0%
fow-through gas boiler	11%	5%	9%	8%	6%	0%	16%	7%	23%	28%	19%	0%
same as heating	65%	77%	69%	72%	72%	67%	52%	66%	55%	52%	81%	100%
other	2%	2%	2%	2%	0%	0%	12%	0%	0%	4%	0%	0%
no data	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: REUS survey, 2011

Table 16: Ventilation systems

percentage of buildings per building class	Single Unit Houses						Multi Unit Houses					
	SUH.01	SUH.02	SUH.03	SUH.04	SUH.05	SUH.06	MUH.01	MUH.02	MUH.03	MUH.04	MUH.05	MUH.06
natural ventilation	100%	100%	100%	100%	92%	100%	100%	100%	99%	99%	100%	100%
mechanical ventilation (no heat recovery)	0%	0%	0%	0%	3%	0%	0%	0%	1%	1%	0%	0%
mechanical ventilation (with heat recovery)	0%	0%	0%	0%	5%	0%	0%	0%	0%	0%	0%	0%
total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: REUS survey, 2011

Table 17: Air conditioning systems

percentage of buildings per building class	Single Unit Houses						Multi Unit Houses					
	SUH.01	SUH.02	SUH.03	SUH.04	SUH.05	SUH.06	MUH.01	MUH.02	MUH.03	MUH.04	MUH.05	MUH.06
Cooling device installed	10%	13%	12%	20%	20%	22%	18%	11%	10%	32%	54%	0%
Cooling device not installed	90%	87%	88%	80%	80%	78%	82%	89%	90%	68%	46%	100%
total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: REUS survey, 2011

Table 18: Control of central heating systems

percentage of buildings per building class	Single Unit Houses						Multi Unit Houses					
	SUH.01	SUH.02	SUH.03	SUH.04	SUH.05	SUH.06	MUH.01	MUH.02	MUH.03	MUH.04	MUH.05	MUH.06
no regulation	38%	24%	22%	20%	21%	0%	30%	51%	40%	35%	17%	0%
termostatic valves only	21%	18%	24%	23%	29%	0%	18%	23%	44%	22%	0%	0%
room termostat - temperature control	23%	35%	22%	24%	12%	21%	29%	12%	15%	21%	27%	100%
room termostat - temperature and time control	10%	14%	24%	24%	33%	17%	8%	8%	0%	14%	56%	0%
outside temperature control	2%	3%	4%	3%	5%	17%	15%	3%	1%	5%	0%	0%
other	6%	6%	4%	7%	0%	46%	0%	4%	0%	2%	0%	0%
no data	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: REUS survey, 2011

7 TABULA building typology

7.1 Building typology

Buildings can be classified into categories according to their typical physical characteristics (region, type and size) and construction period. This information together with statistical data of the frequency of each building type was gathered; relevant categories were identified and populated the main building typology.

Slovenian TABULA Typology was elaborated with 4 building size typologies and for whole country:

- SFH – single family house,
- TH – terraced house,
- MFH – multifamily house and
- AP – apartment block)

6 age classes ware elaborated.

- until 1945 (1) – pre WWII period
- 1945 – 1970 (2) – after WWII period, no thermal regulations
- 1971 – 1980 (3) – first national regulation on energy saving protection of buildings
- 1981 – 2002 (4) – revision of regulation
- 2003 – 2008 (5) – first energy performance calculation methodology based on European standards
- from 2009 (6) – latest energy performance regulations

Subdivision according to the time of construction can be found only for residential buildings, building in other subsectors have not been studied yet. The total residential building stock is sub-divided into suitable groups according to the regulation about thermal insulation in Slovenia.

Table 19: Groups according to the time of construction and thermal regulation changes

GROUP ACCORDING TO TIME OF CONSTRUCTION AND THERMAL REGULATION CHANGES	PERIOD
1	until 1945
2	1945 - 1970
3	1970 - 1980
4	1980 - 2002
5	post 2002

Each building type was described with the corresponding typical characteristics of the building envelope.

Figure 9: Slovenian Tabula Building Typology Matrix

Table 20: Thermal transmittance of building envelope U (W/m^2K), according to thermal insulation regulations

YEAR	REGULATION	BUILDING ELEMENT										
		CLIMATIC ZONE	OUTSIDE WALL	WALL BETWEEN APARTM.	WALL AGAINST GROUND	CEILING BETWEEN APARTM.	FLOOR ON THE GROUND	CEILING AGAINST UNHEATED ATTICS	CEILING ABOVE UNHEATED CELLAR	CEILING, OPEN PASSAGE	FLAT ROOF
1875	“Stavbni red za Vojvodino Kranjsko”		brick wall 45 cm (1,29) brick wall 38 cm (1,39)								

1958	Expert recommendation according to use of brick in construction of outside and inside walls and ceilings in residential building		brick wall 38 cm (1,39)								
1966	Recommendation for thermal insulation regulations in civil engineering	I II III	1,68 1,45 1,28	1,97 1,86 1,62	1,16	3,44	1,2	1,16	1,04	0,7 0,6 0,5	0,9
1967	“Pravilnik o minimalnih tehničnih pogojih za gradnjo stanovanj”	I II III	1,79 1,54 1,37			1,31		1,31	1,31		1,3
1970	“Pravilnik o tehničnih ukrepih in pogojih za toplotno zaščito stavb”	I II III	1,68 1,45 1,28	1,97 1,86 1,62		1,39 / 2,32	0,9	1,16	1,04	0,7 0,6 0,5	0,9
1980	“Tehnični pogoji za projektiranje in graditev stavb”	I II III	1,22 0,93 0,83		1,94 1,85 1,61	1,38	0,9 0,8 0,7	0,69	0,75 0,63 0,52	0,5 0,5 0,4	0,8 0,7 0,6
1987	“Tehnični pogoji za projektiranje in graditev stavb”	I II III	1,2 0,9 0,8	1,95 1,85 1,6	1,2 0,9 0,8	1,35	0,9 0,8 0,7	0,95 0,85 0,7	0,75 0,6 0,5	0,5 0,5 0,4	0,8 0,7 0,6
1998	Recommendation for new standard	I - II III	0,60 (0,70) 0,40 (0,50)	2 1,5	0,60 (0,70) 0,40 (0,50)	1,4 1,4	0,6 0,5	0,5 0,3	0,5 0,4	0,5 0,4	0,5 0,4
2002	"Pravilnik o toplotni zaščiti in učinkoviti rabi energije v stavbah - PTZURES"	all	0,6	1,6	0,7	1,35	0,5	0,35	0,5	0,4	0,3
2010	"Pravilnik o učinkoviti rabi energije v stavbah - PURES"	all	0,28	0,9	0,35	0,9	0,4	0,2	0,2	0,3	0,2

7.2 Building construction elements sub-typology

To further define typical buildings a common building element sub typology was elaborated. Sub-typology for roof elements, windows elements, floor elements, etc.

Several sources for acquisition of building data were foreseen. As the official national energy certification data base (planned as preferable source of data) hasn’t been implemented yet the reserve plan was activated:

The relevant building data were collected from:

- National real-estate Registry by National Surveying and Mapping Authority of the Republic of Slovenia (includes: the registry of buildings and registry of flats with some additional technical and renovation in-formation),

- REUS survey – Energy use in households - (REUS from June 2010 is the 2nd annual survey of Sinergija group - public & commercial partnership of 40 partners) – the poll was made by exhaustive questionnaire on energy characteristics of building and user habits (1000 questions on energy-building-HVAC-electricity-renovation-behaviour-habits-values, in a representative sample for Slovenia N=1009, personal interviews – field survey), REUS also joined TABULA NAG

- Classification of whole building stock is based on the National Real-Estate Registry (building type, age). The energy characteristics of the particular class are modelled based on several sources: REUS data, existing database of pilot energy certificates and energy audits; energy saving studies, partner expertise and statistical data.

Elements thermal insulation corresponds to the time period. Due to the political system in the past not many different construction types were documented.

7.3 System elements sub-typology

Again several sources where used to get an overview about typical systems in typical buildings.

7.4 Geometry of real example buildings

Geometry of real example building was used to represent each building type. Envelope elements and systems installed where selected according to the period of building construction.

National energy balance

7.5 Building Typology Approach

Slovenian TABULA Typology was elaborated with 4 building typologies (SFH – single family house, TH – terraced house, MFH – multifamily house and AP – apartment block) and 6 age classes:

- until 1945 (1) – pre WWII period
- 1945 – 1970 (2) – after WWII period, no thermal regulations
- 1971 – 1980 (3) – first national regulation on energy saving protection of buildings
- 1981 – 2002 (4) – revision of regulation
- 2003 – 2008 (5) – first energy performance calculation methodology based on European standards
- from 2009 (6) – latest energy performance regulations

For calculation of national energy balance only 2 condensed building typologies (single unit buildings – SUB and multi-unit buildings – MUB) were used, thus combining SFH + TH into SUB and MFH + AB into MUB respectably. Furthermore first to age classes were grouped into single year class (until 1970) living us with 5 age classes. This gives us 10 primary building types.

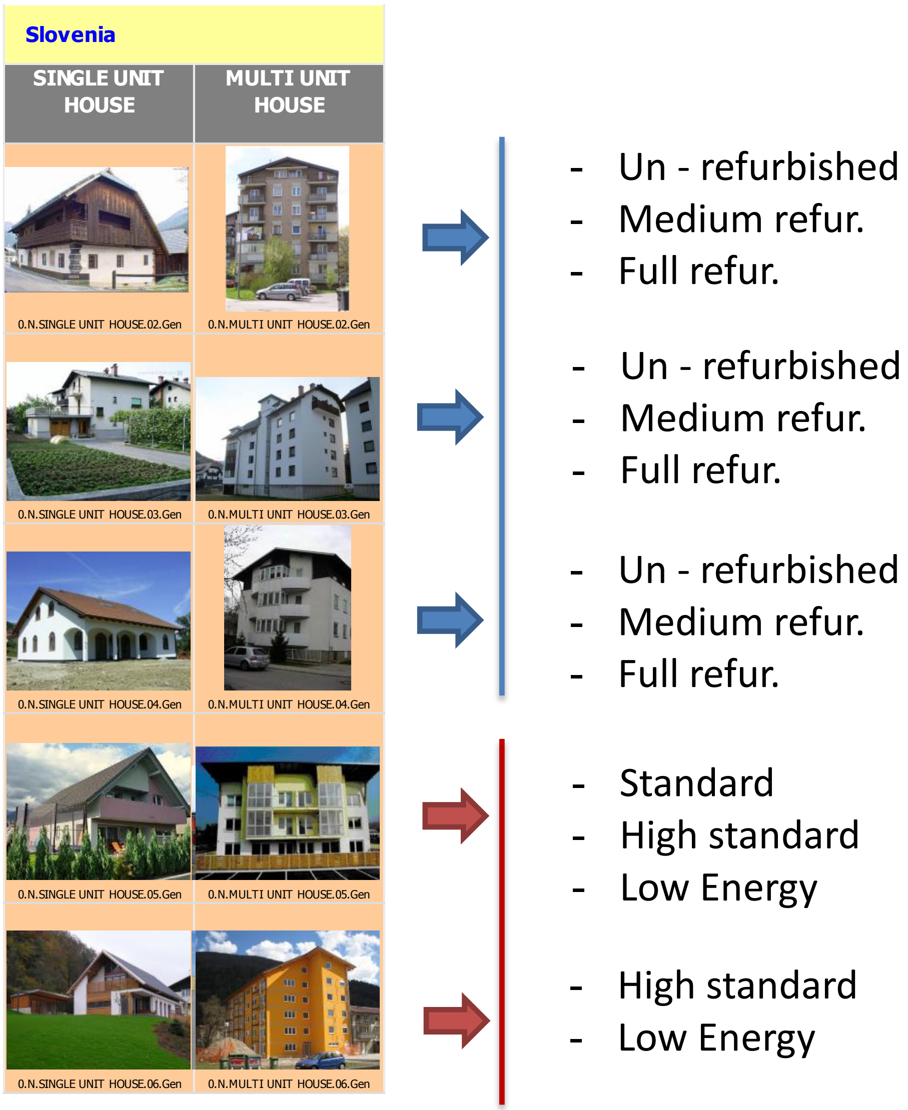
Table 21: Frequencies of 10 building types in 2009

Building type	number of buildings	number of apartments	living space in 1000 m2	TABULA reference area in 1000 m2	
SUH.01 (until 1970)	256.125	276.993	24.792	27.271	Single Unit Houses
SUH.02 (1971 – 1980)	90.189	96.958	9.718	10.690	
SUH.03 (1981 – 2002)	122.862	128.048	12.981	14.280	
SUH.04 (2003 – 2008)	23.961	24.668	2.844	3.129	
SUH.05 (from 2009)	146	158	14	15	
MUH.01 (until 1970)	17.650	178.890	9.344	10.278	Multi Unit Houses
MUH.02 (1971 – 1980)	3.165	66.905	3.216	3.538	
MUH.03 (1981 – 2002)	3.074	57.282	2.909	3.200	
MUH.04 (2003 – 2008)	1.408	21.630	1.274	1.401	
MUH.05 (from 2009)	18	1.161	71	78	
Building Stock total	518.598	852.693	67.164	73.881	

Source: Registry of buildings [REN]

Primary building types describe original state of buildings at the time of erection. Since then buildings have changed and for the calculation of current national balance we have to take into consideration changed, refurbished, present buildings. Thus we investigated sub typologies. Subdivisions ware made according to a) level of refurbishment (un-refurbished, medium or full refurbishment) or b) level of thermal protection of building at the time of erection (standard level, high standard level, or low energy level). Figure 10 on next page shows these subdivisions.

Figure 10: Division of primary building types into present state building types



28 building typologies where calculated in Slovenian national balance. Buildings representing this typology types where "real" example buildings (10 real geometries, ReEx) with assigned different "real" thermal insulation thickness and windows types to represent subdivisions.

7.6 Available Data

Registry of buildings of Slovenia [REN] is a large database. It includes all of the country buildings with some information interesting for energy calculations. This are: year of building erection, area and utilisation of building part (apartment)[1], year of windows, roof and wall

[1] Utilisation of building part(s) is the information from which we can assume about utilisation of a building as a whole (examples of utilisation types of building part: apartment in single family house with one apartment (stand-alone), apartment in an apartment building of 21 to 50 apartments).

refurbishment, number of storeys and type of heat generation. The database is constantly updating. For our calculation we used data from 2007.[2]

Combination of information about the year of refurbishment of wall, roof and windows with the knowledge about the level of refurbishment at that time gave us an insight into today state of those buildings. These steps where made with some assumptions:

- Roof: half of refurbishment with no thermal improvement, before 2002 → 10 cm of thermal insulation, after 2002 → 20 cm of thermal insulation,

- Walls: before 1996 → 5 cm of thermal insulation, after 1996 → 8 cm of insulation,

- Windows: before 1996 → U = 2,7 W/m^{2}K, after 1996 → U = 1,4 W/m^{2}K.

One building could have several refurbishment measure taken in the past. Combination of those measures gives us possibility to define such building as one of subtypes (blue arrows in Figure 10).

To divide newer buildings (from 2003) that have not been refurbished into 3 thermal protection levels (red arrows) we made further assumptions based on our experience.

Table 22: Frequencies of sub – building types (% of number of buildings in building type)

<table>
<tr><td>Building Type</td><td>Distribution</td><td></td></tr>
<tr><td>SUH.04.Standard</td><td>55 %</td><td rowspan="5">Single Unit Houses</td></tr>
<tr><td>SUH.04.High_stand</td><td>40 %</td></tr>
<tr><td>SUH.04.Low_E</td><td>5 %</td></tr>
<tr><td>SUH.05.High_stand</td><td>95 %</td></tr>
<tr><td>SUH.05.Low_E</td><td>5 %</td></tr>
<tr><td>MUH.04.Standard</td><td>65 %</td><td rowspan="5">Multi Unit Houses</td></tr>
<tr><td>MUH.04.High_stand</td><td>35 %</td></tr>
<tr><td>MUH.04.Low_E</td><td>5 %</td></tr>
<tr><td>MUH.05.High_stand</td><td>99 %</td></tr>
<tr><td>MUH.05.Low_E</td><td>1 %</td></tr>
</table>

Less data is available regarding systems installed.

Table 23: Frequencies of different systems for heating (% of number of buildings of residential buildings)

[2] In 2008 there was a large scale survey to gather information about existing buildings. From 2008 until now only new buildings are imputed. This leaves us with no information about refurbishment measures from 2006 until present.

Building type	no heating	central heating	other heating	district heating	no data	**Total**	
SUH.01	5,7%	31,7%	11,4%	0,5%	0,1%	49%	**Single Unit Houses**
SUH.02	0,7%	14,8%	1,7%	0,2%	0,0%	17%	
SUH.03	1,4%	20,1%	2,0%	0,2%	0,0%	24%	
SUH.04	0,7%	3,6%	0,3%	0,0%	0,0%	5%	
SUH.05	0,0%	0,0%	0,0%	0,0%	0,0%	0%	
MUH.01	0,1%	1,9%	0,9%	0,4%	0,0%	3%	**Multi Unit Houses**
MUH.02	0,0%	0,4%	0,1%	0,1%	0,0%	1%	
MUH.03	0,0%	0,4%	0,0%	0,1%	0,0%	1%	
MUH.04	0,0%	0,2%	0,0%	0,0%	0,0%	0%	
MUH.05	0,0%	0,0%	0,0%	0,0%	0,0%	0%	
Building Stock total	9%	73%	16%	2%	0%	518.598	

Source: Registry of buildings [REN]

Data about Slovenian typology with its subtypes is dated in year 2007. To calculate energy balance for the year 2011 (Table 24) we had to take into consideration the average yearly rate of building modernisation (building moves from class SUH.01.Un_refur to class SUH.01.Med_refur), rate of building demolition (only in oldest year class) and rate of new buildings erection. Data for these trends was available from Registry of Buildings and National statistics.

Table 24: Frequencies of building types (% of useful floor area in 1.000 m^2) in 2011

Single Unit Buildings	Floor area in 1.000 m^2	Tabula reference area in 1.000 m^2	% of SUH	**Multi Unit Buildings**	Floor area in 1.000 m^2	Tabula reference area in 1.000 m^2	% of MUH
SUH.01.Un_refur	9.790	10.769	18,9%	MUH.01.Un_refur	4.070	4.477	23,2%
SUH.01.Med_refur	10.314	11.345	19,9%	MUH.01.Med_refur	3.803	4.183	21,7%
SUH.01.Full_refur	4.238	4.661	8,2%	MUH.01.Full_refur	1.201	1.322	6,8%
SUH.02.Un_refur	5.302	5.833	10,2%	MUH.02.Un_refur	1.752	1.927	10,0%
SUH.02.Med_refur	3.137	3.450	6,1%	MUH.02.Med_refur	1.094	1.203	6,2%
SUH.02.Full_refur	1.101	1.211	2,1%	MUH.02.Full_refur	293	322	1,7%
SUH.03.Un_refur	8.615	9.476	16,6%	MUH.03.Un_refur	1.866	2.052	10,6%
SUH.03.Med_refur	3.947	4.342	7,6%	MUH.03.Med_refur	985	1.084	5,6%
SUH.03.Full_refur	518	570	1,0%	MUH.03.Full_refur	123	135	0,7%
SUH.04.Standard	1.673	1.840	3,2%	MUH.04.Standard	894	984	5,1%
SUH.04.High_stand	1.216	1.338	2,4%	MUH.04.High_stand	522	574	3,0%
SUH.04.Low_E	152	167	0,3%	MUH.04.Low_E	75	82	0,4%
SUH.05.High_stand	1.668	1.835	3,2%	MUH.05.High_stand	864	950	4,9%
SUH.05.Low_E	88	97	0,2%	MUH.05.Low_E	9	10	0,0%
	51.758	56.934	100%		17.549	19.304	100%

Source: Registry of buildings [REN]

7.7 Energy Balance Method

For each of 28 building types total energy use and primary energy consumption was calculated with software according to National methodology based on CEN standards [PURES] (Heating and cooling demand is calculated with monthly method according to EN ISO 13790:2008). Internal temperature was set to 20 °C with intermitted heating where heat generator is off for 25% of time.

Systems installed in each of the real example buildings where heating system and DHW preparation system that are most probable (based on experiences and not on reliable statistical data). For example: old single unit building has an old real example boiler that is located in unheated room. Energy carrier was chosen according to national statistic about energy use in buildings.

7.8 Energy Balance of the Residential Building Stock

Energy balance model calculated energy performance indicators for each of the 28 subtypes. In Table 25 are summarized some of those indicators into building type (heating need, final energy for domestic hot water preparation, electrical energy for lightning). Primary energy was calculated with factors from [PURES] and CO_2 emissions from data from Statistical office [STAT].

Table 25: Heat consumption of the Slovenian residential building stock (2011) for space heating, hot water and lighting

Building type	Heating need (Qnh)	DHW final (Qf,w)	lightning final (W,f)	Final energy (Q,f)	Primary energy	CO_2 emissions
SUH.01	2.937 GWh	454 GWh	363 GWh	3.722 GWh	4.829 GWh	978 kt
SUH.02	2.094 GWh	113 GWh	209 GWh	2.538 GWh	3.085 GWh	956 kt
SUH.03	1.285 GWh	323 GWh	202 GWh	1.534 GWh	2.004 GWh	684 kt
SUH.04	154 GWh	57 GWh	36 GWh	199 GWh	264 GWh	71 kt
SUH.05	88 GWh	64 GWh	20 GWh	116 GWh	155 GWh	47 kt
MUH.01	1.262 GWh	145 GWh	290 GWh	1.767 GWh	2.363 GWh	792 kt
MUH.02	356 GWh	64 GWh	40 GWh	410 GWh	517 GWh	151 kt
MUH.03	280 GWh	57 GWh	36 GWh	325 GWh	436 GWh	162 kt
MUH.04	95 GWh	28 GWh	16 GWh	133 GWh	181 GWh	68 kt
MUH.05	28 GWh	15 GWh	9 GWh	45 GWh	64 GWh	25 kt
Total	8.580 GWh	1.320 GWh	1.219 GWh	10.791 GWh	13.898 GWh	3.934 kt

Table 26 shows primary energy consumption and CO2 emissions by energy carrier.

Table 26: Primary energy consumption and CO_2 emissions of the Slovenian residential building stock (2011) for space heating, hot water and lighting by energy carrier

Energy carrier	Primary energy	Co2 emissions
Oil	4.506 GWh	1.194 kt
Gas	1.066 GWh	213 kt
District heating	1.254 GWh	414 kt
Electricity	3.986 GWh	2.113 kt
Other RES	2 GWh	0 kt
Biomass	3.084 GWh	0 kt
Coal	0 GWh	0 kt
Total	13.898 GWh	3.934 kt

7.9 Comparison to National Statistical Data of the Residential Building Stock

National energy balance calculated with TABULA tool was cross checked with the statistical fuel consumption data and the data calculated in the basis of draft national energy balance.

For comparison purposes different statistical data for different time periods were investigated. These data includes also energy use for cooking and other home appliances that is not calculated in energy balance model. Methodology for energy performance calculation uses climatic data averages for last 30 years. To compare results of our model and national statistical data we took average of three available sources (Table 27).

There is large deviation in electricity and biomass consumption. This originates in DHW preparation (electricity, model calculates not realistic energy needs for DHW) and cooking (biomass is used in Slovenia for stoves for cooking).

Gas is used for cooking, but this is not evident from the results. Total energy consumption is very close to calculated results but considering the roughness of the model one can conclude that this is more of coincidence.

Table 27: Comparison of model results with national energy statistics

Energy carrier	National Action Program 2001 – 2005 (average) [AP]	Final energy consumption by energy source, households 2002 [STAT]	Energy balance households 2007 – 2009 (average) [STAT]	Average	Calculated	Deviation
Oil	4.943 GWh	5.462 GWh	3.477 GWh	4.627 GWh	4.506 GWh	-3%
Gas	1.049 GWh	805 GWh	1.268 GWh	1.041 GWh	1.066 GWh	2%
District heating	1.203 GWh	1.339 GWh	1.120 GWh	1.221 GWh	1.254 GWh	3%
Electricity	2.873 GWh	2.821 GWh	3.117 GWh	2.937 GWh	3.986 GWh	36%
Other RES	0 GWh	0 GWh	0 GWh	0 GWh	2 GWh	-
Biomass	3.847 GWh	3.770 GWh	3.768 GWh	3.795 GWh	3.084 GWh	-19%
Coal	58 GWh	219 GWh	0 GWh	92 GWh	0 GWh	-
Total	13.972 GWh	14.415 GWh	12.750 GWh	13.713 GWh	13.898 GWh	1%

7.10 Calculation of Energy Saving Potentials

Energy balance models are especially useful for calculation of energy savings. Slovenian model was used for designing different refurbishment scenarios of external wall. For these purpose new subtypes were defined (letter F was added). This new subtypes represent existing buildings with refurbished façade. Only buildings from 01, 02 and 03 year class would undergo refurbishment in upcoming years.

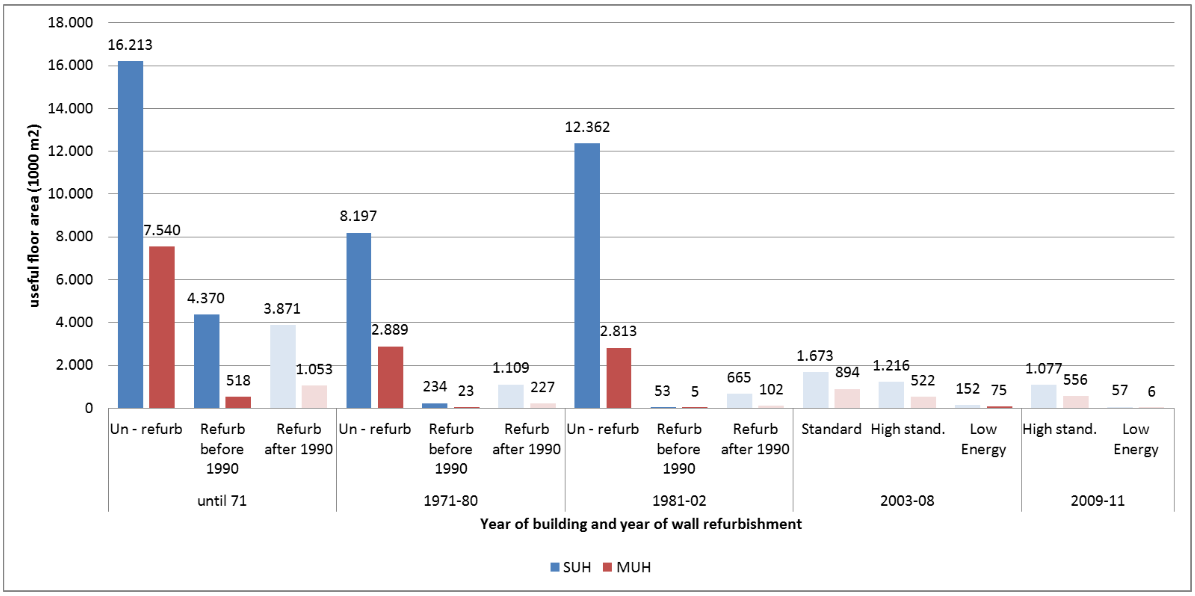


Figure 11: Potential for wall refurbishment (end of 2010), only buildings in first three year classes will undergo external wall refurbishment until 2020

Refurbishment measure was realistically set (8 cm of new thermal insulation if there was some kind of thermal insulation already present and 15 cm of new thermal insulation for building with no thermal protection). For example: SUH.01.Un_refur with no thermal insulation will be insulated with 15 cm and this will become new sub type SUH.01.Un_refur.F.

Then 2 scenarios where investigated: normal scenario and ambitious scenario. In 2010 1,9 % of residential building stocks walls where insulated (only 0,14 % with national subsidies). This was taken as a normal scenario. On the other hand more ambitious rate of 6 % was proposed. Algorithm based on past experiences and National Energy Program was built that describes fluctuation of buildings between building sub types.

Erection of new building, old buildings demolition and other type of refurbishment where taking into account as well.

Table 28 shows heated area of first SUH year class for present state and for two different scenario. One can observe big difference between numbers of old SUH that are still unrefurbished (first row of data, this buildings where build before 1971 and will be at least 50 years old in 2020).

Table 28: Example of total floor area per building type in 2011 and for two scenarios in 2020

Building sub type	**Area 2011 (1.000 m2)**	**Area 2020, 1,9% (1.000 m2)**	**Area 2020, 6% (1.000 m2)**
SUH.01.Un_refur	9.790	5.128	415
SUH.01.Un_refur.F		2.885	8.144
SUH.01.Med_refur	10.314	6.178	1.264
SUH.01.Med_refur.F		2.884	8.141
SUH.01.Full_refur	4.238	6.501	4.615
SUH.01.Full_refur.F		547	1.545
…	…	…	…

For both scenarios in 2020 energy balance was calculated as for 2011.

Table 29: Example of total floor area per building type in 2011 and for two scenarios in 2020

Energy carrier	2011	2020 1,9%	2002 6%
Oil	4.506 GWh	3.889 GWh	3.453 GWh
Gas	1.066 GWh	1.186 GWh	1.120 GWh
District heating	1.254 GWh	1.463 GWh	1.346 GWh
Electricity	3.986 GWh	3.913 GWh	3.864 GWh
Other RES	2 GWh	10 GWh	10 GWh
Biomass	3.084 GWh	2.812 GWh	2.491 GWh
Coal	0 GWh	0 GWh	0 GWh
Total	13.898 GWh	13.272 GWh	12.284 GWh
	0,0%	-4,5%	-11,6%

Analyse of saving potentials related to refurbishment of existing buildings external walls showed that we can achieve up to 11 % of savings. For these we would have to refurbish 6% of residential building stock each year. In other words until 2020 more than 54 % of building stock would have a new façade. This could only happen with large scale subsidies. It is an ambitious goal which should be considered, since refurbishments not only bring energy savings, but also economic growth, employment and lower CO_2 emissions thus lower emission penalties.

8 Slovenian Tabula application

8.1 EnSoS Web Tool

EnSos Web Tool is an online application at http://gi-zrmk.eu/ensos/. Its users are energy advisors and home owners. They can in a few quick steps calculate energy consumption for their house and apply different refurbishment measures. Basic idea for the application was developed in Tabula project (Tabula Web Tool) with further modifications. In EnSos user first picks a building from Slovenian Tabula Typology that is similar to his own. In next step, he can change envelope elements and modify element envelope areas. There is a restricted list of envelope elements and systems installed from which a user can choose from. They are typical. Calculation is done according to Tabula methodology. User can save the building and then modify it and so make two different variations, different refurbishment scenarios.

By compression of existing state and refurbishment state, user can observe the impact of different measures and thus make preliminary decisions. Using Tabula developed typology for buildings, elements and systems enables a tool that doesn’t require expert knowledge and extra time thus appropriate for general population. It’s main outcome is a dissemination of refurbishment measures on existing buildings.

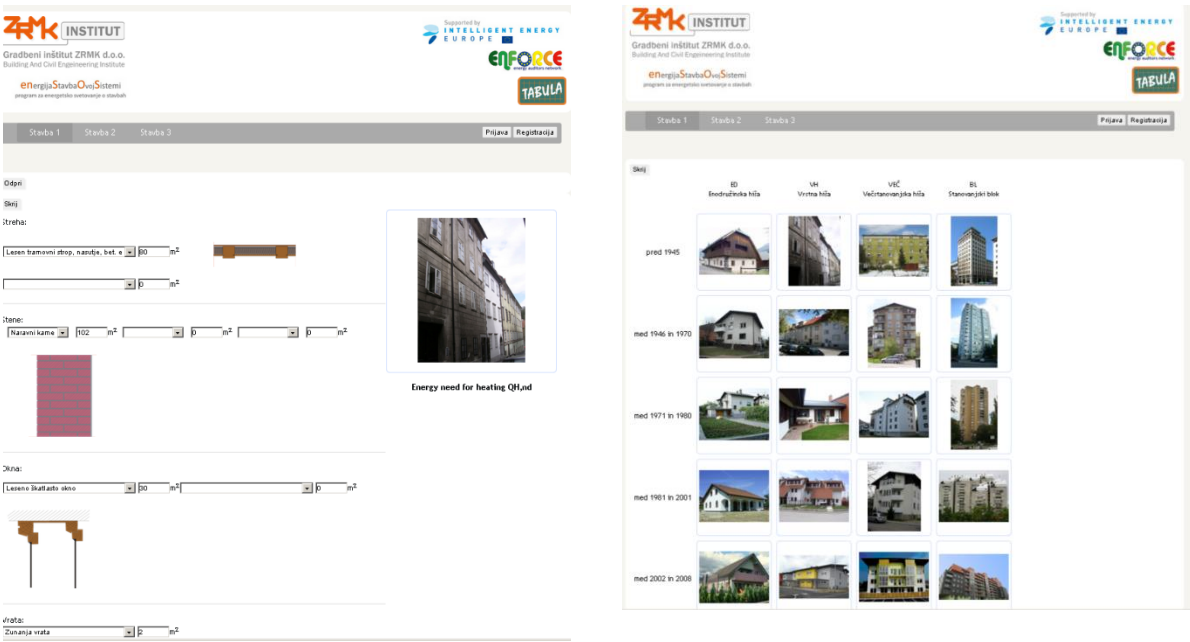


Figure 12: “EnSOS” Web Tool – screenshots

8.2 StavbiX Web Application

There is a large number of existing buildings and new constructions in Slovenia, for which the owners don’t know what energy properties their buildings are showing. In comparison to new constructions, the bigger problem are proving to be with existing buildings, where the problems are in obtaining information and details of the analysis for the calculation of these properties. The goal of this application StavbiX [StavbiX] is to be used by the general public and that it offers information about the energy performance of building, using the building typology.

When designing the application, a key assumption was that the user supplies only information which is not already contained in existing public databases in order to facilitate the process of obtaining results. Precise details of buildings were obtained from the databases of the Geodetic Administration of the Republic of Slovenia. The obtained data were properly structured and a data model of buildings was designed, which the application offers to the user. A further procedure requires from the user only a basic description of the thermal building envelope. For example it is necessary to define the materials in structural elements of roof, wall and floor. Based on the data entered by the user and acquired from the model of buildings, the application seeks for a specific typical building, which is showing similar characteristics to the user one.

A thorough review of typical buildings from project Intelligent Energy Europe Tabula was made, which represents the latest building typology in Slovenia. The results of the project Tabula were used to design a specific procedure to search for a most appropriate typical building based on data specified by the user. This procedure takes into account the construction period of the building as well as building size. With all collected data, the building is first categorized in one of the six periods of construction and then on the basis of surfaces of structure elements and its heat transfer coefficient, seeks for the most similar typical building and assigns its energy indicators as a final result. We adapted the OntoWiki system to the algorithm requirements and made a prototype application. The last part of the application compares the actual data on delivered energy, derived from the E-TOOL project [E-TOOL], with results given by the application, with which we evaluated the nature of such allocation of energy indicators and gave reasons for the deviations.

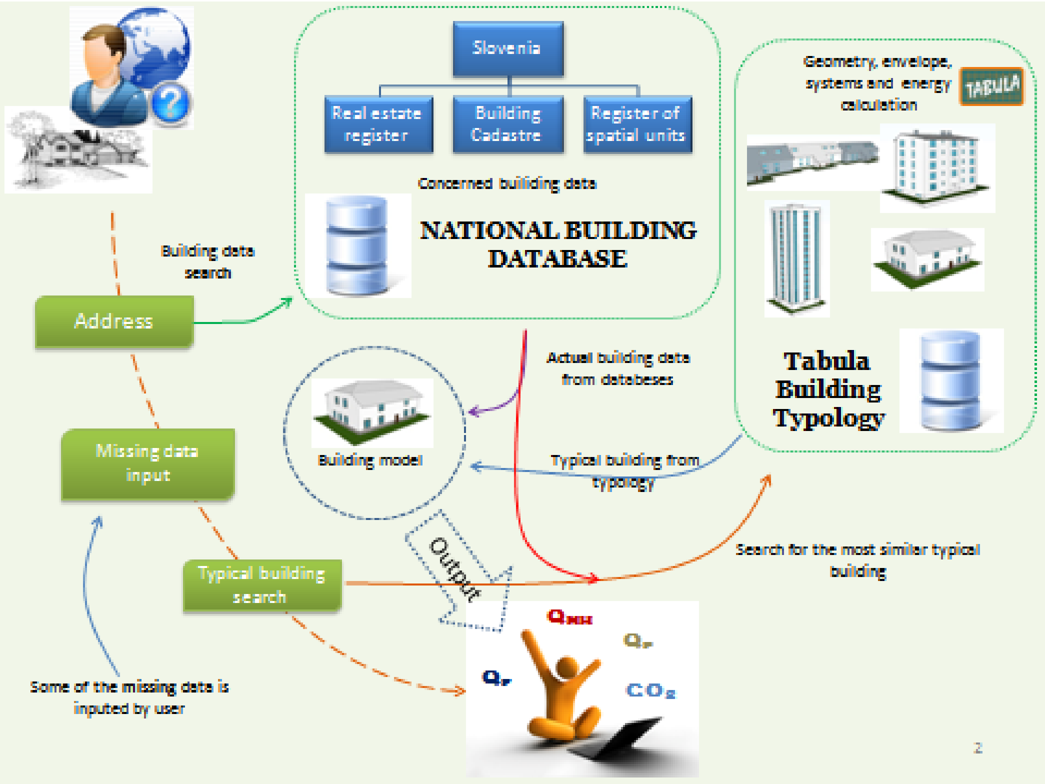


Figure 13: “Stavbix Web Application” – operation process

9 Building Typology Brochure

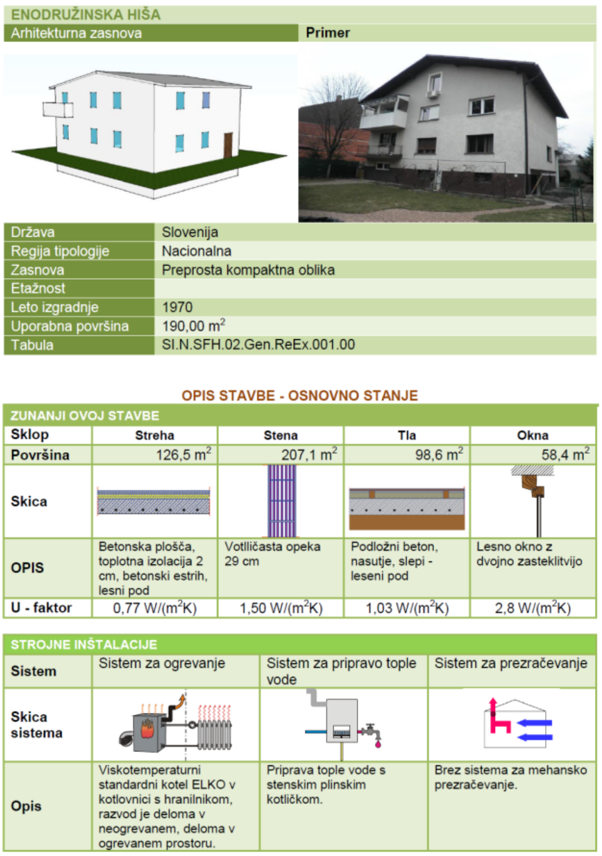
Slovenian Building Typology Brochure is available at:

http://www.building-typology.eu/downloads/public/docs/brochure/SI_TABULA_TypologyBrochure_ZRMK.pdf

Brochure has the following content:

- Introduction
- Typology explanation, past, present and Tabula
- Building data sheets

Building data sheets are on 4 pages. First page shows a typical building at its present stage. On next two pages refurbishment scenarios are shown: moderate and intensive. Last, 4th page is a comparison between existing, moderate and intensive scenarios. Comparison is made on heat transfer, energy class according to Slovenia EPC's and primary energy



ENODRUŽINSKA HIŠA

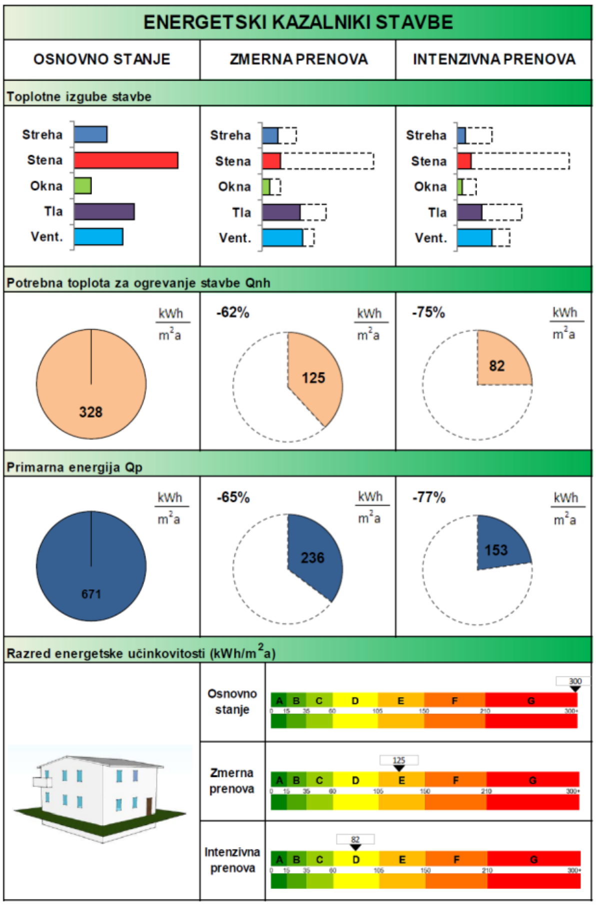
Arhitekturna zasnova	Primer

Država	Slovenija
Regija tipologije	Nacionalna
Zasnova	Preprosta kompaktna oblika
Etažnost	
Leto izgradnje	1970
Uporabna površina	190,00 m²
Tabula	SI.N.SFH.02.Gen.ReEx.001.00

OPIS STAVBE - OSNOVNO STANJE

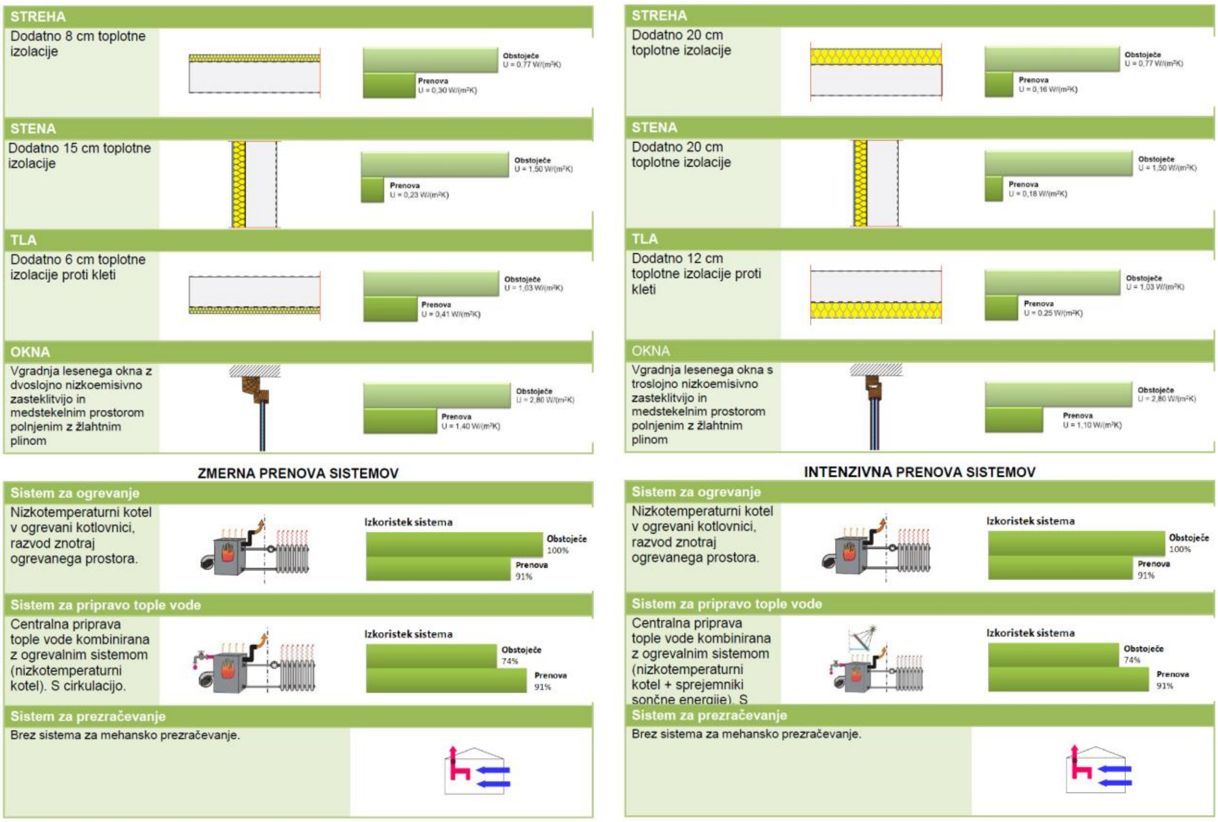
ZUNANJI OVOJ STAVBE				
Sklop	Streha	Stena	Tla	Okna
Površina	126,5 m²	207,1 m²	98,6 m²	58,4 m²
Skica				
OPIS	Betonska plošča, toplotna izolacija 2 cm, betonski estrih, lesni pod	Votličasta opeka 29 cm	Podložni beton, nasutje, slepi - leseni pod	Lesno okno z dvojno zasteklitvijo
U - faktor	0,77 W/(m²K)	1,50 W/(m²K)	1,03 W/(m²K)	2,8 W/(m²K)

STROJNE INŠTALACIJE			
Sistem	Sistem za ogrevanje	Sistem za pripravo tople vode	Sistem za prezračevanje
Skica sistema			
Opis	Viskotemperaturni standardni kotel ELKO v kotlovnici s hranilnikom, razvod je deloma v neogrevanem, deloma v ogrevanem prostoru.	Priprava tople vode s stenskim plinskim kotličkom.	Brez sistema za mehansko prezračevanje.



1 page 4th page

Figure 14: First and last display sheet page



Moderate Intensive

Figure 15: Moderete and intensive refurbishement measures

10 Conclusions

Tabula approach brought new concept to building typology and national balance calculations. By defining subtypes we were able to describe building not only at their original state but also in present modernized state. This was taken as a starting point for calculating different refurbishment scenarios on a national residential building fund.

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 web tool applications addressing home owners and energy advisors were developed – one based on the TABULA web tool concept, the other with a separate approach using typology data.

At the end of Tabula project a national EPC database in Slovenia is starting to form its shape (ZRMK being its developers). 12.000 asset rating EPC for residential buildings and measured EPC for non-residential buildings will be collected each year. This data will allow us future definition of average buildings for residential buildings and with it we will get better insight into our national residential fund. Based on Tabula project experiences we proposed that extra necessary data about the building is collected with the EPC (e.g. refurbishment measures, actual energy consumption).

11 Sources and References

Reference shortcut	Short description	Reference
[TABULA SI Bro]	Slovenian Building Typology Brochure	Rakuscek, Andraz; Sijanec Zavrl, Marjana; Stegnar, Gasper: Tipologija stavb: energetska učinkovitost in tipične stavbe v Sloveniji, ZRMK, 2012, Ljubljana
[TABULA NatBal]	National Balance report	Rakuscek, Andraz; Sijanec Zavrl, Marjana: chapter “Slovenia” in: Diefenbach, Nikolaus / Loga, Tobias (ed.): Application of Building Typologies for Modelling the Energy Balance of the Residential Building Stock (TABULA Thematic Report N° 2). Models for the national housing stock of 8 countries: Belgium, Czech Republic, Denmark, Germany, Greece, oord, Slovenia; IWU, Darmstadt / Germany 2012 http://www.building-typology.eu/downloads/public/docs/report/TABULA_TR2_D8_NationalEnergyBalances.pdf
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[ZRMK 1996]	Manual for Energy Advisors	Malovrh, M. et al.: Priročnik za energetske svetovalce ; 1996
[EN ISO 13790:2008]	European Standard. Energy performance of buildings – Calculation of	Energijske lastnosti stavb – Račun rabe energije za ogrevanje in hlajenje prostorov

	energy use for space heating and cooling	
[STAT]	Statistical Journal of Slovenia	Statistični letopis 2010, (SI-STAT), Statistični urad Republike Slovenije.
[NEP]	National Energy Program	NEP 2004, Resolucija o nacionalnem energetskem programu
[AN]	National Action Plan	AN URE, Nacionalni akcijski načrt za energetsko učinkovitost za obdobje 2008–2016, RS, 2008
[REN]	Registry of Buildings	Register nepremičnin Slovenije, 2009
[Stegnar]	Article on use of Tabula results	Stegnar, G., Šijanec-Zavrl, M., Stankovski, V., The use of information sources for typification of buildings in Slovenia. Gradbeni vestnil, št. 11, letn. 61, str. 256-262, 2012
[SURS]	Statistical Office	The Statistical Office of the Republic of Slovenia
[REUS]	Survey	Energy performance of buildings and user behaviour survey, performed annually on 1.000 buildings.

NATIONAL SCIENTIFIC REPORT - SLOVENIA

IEE TABULA - Typology Approach for Building Stock Energy Assessment

Gradbeni inštitut ZRMK, d.o.o.
Dimičeva 12
1000 Ljubljana

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