EXECUTIVE SUMMARY

1 IEE Project TABULA – in a Nutshell

During the IEE project TABULA residential building typologies have been developed for 13 European countries. Each national typology consists of a classification scheme grouping buildings according to their size, age and further parameters and a set of exemplary buildings representing the building types. They have been published by the project partners in national "Building Typology Brochures", written in their respective languages. As a common element all brochures contain double page “Building Display Sheets” for all example buildings on which energy related features and the effects of refurbishment measures are illustrated graphically.

To exchange information on the European level the "TABULA WebTool" provides an online calculation of the exemplary buildings from all countries, displaying their energy related features and the possible energy savings by implementing refurbishment measures. Basis of the TABULA WebTool is 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). Apart from the reference calculation used for cross-country comparison a calibration of the calculated energy use to the typical levels of actual consumption is foreseen – with the intention to enable a realistic assessment of energyware and heating costs savings.

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.

Figure 1: General idea of TABULA Building Typologies

www.building-typology.eu

TABULA Project Partners

at Austria AEA
be Belgium VITO
bg Bulgaria SOFENA
cz Czech Rep. STU-K
de Germany IWU
dk Denmark SBI
fr France ADEME
gr Greece NOA
ie Ireland Energy Action
it Italy POLITO
pl Poland NAPE
se Sweden MDH
si Slovenia ZRMK

Associated Partners

rs Serbia University Belgrade
es Spain IVE

1 The associated partners elaborated basic typology elements for their country on a voluntary basis without funding by the IEE programme.
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 coun-

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<table>
<thead>
<tr>
<th>Region</th>
<th>Construction Year Class</th>
<th>Additional Classification</th>
<th>SPH</th>
<th>THI</th>
<th>MFI</th>
<th>AB</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>national (Slovenija)</td>
<td>... 1945</td>
<td>genewk (Tipšu)</td>
<td>S124SPH01.Gen</td>
<td>S124SH01.Gen</td>
<td>S124FH01.Gen</td>
</tr>
<tr>
<td>3</td>
<td>national (Slovenija)</td>
<td>1971 ... 1980</td>
<td>genewk (Tipšu)</td>
<td>S124SPH03.Gen</td>
<td>S124TH03.Gen</td>
<td>S124FH03.Gen</td>
</tr>
<tr>
<td>5</td>
<td>national (Slovenija)</td>
<td>2002 ... 2008</td>
<td>genewk (Tipšu)</td>
<td>S124SH05.Gen</td>
<td>S124TH05.Gen</td>
<td>S124FH05.Gen</td>
</tr>
<tr>
<td>6</td>
<td>national (Slovenija)</td>
<td>2009 ...</td>
<td>genewk (Tipšu)</td>
<td>S124SH06.Gen</td>
<td>S124TH06.Gen</td>
<td>S124FH06.Gen</td>
</tr>
</tbody>
</table>

**Figure 2:** "Building Type Matrix" 

*Example from the Slovenian Typology*

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

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page 2 of 16
tries’ 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

Classification of the National Residential Building Stock

An overview of the national building typology is given by the "Building Type Matrix" (Figure 2). 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 "Building Types" of a country.

Exemplary Buildings

To each 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.

4 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.
National Typology Brochures

For each country a brochure has been elaborated which contains the different elements of a residential building typology (Figure 5):

- the classification of the national building stock/display of the building type matrix (see above, section 2);
- frequencies of the building types (see below, section 9);
- typical energy consumption values of exemplary buildings (see below, section 6);
- definition and description of refurbishment measures (see section 4) 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 example in Figure 4);

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 national languages.
6 TABULA Calculation Method

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:

- **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 5), default datasets in energy advice and EPC software, ...

- **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 7) or cross-border building stock models.
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 8).

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.

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 9), 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 7) 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 9: Measured vs. calculated energy consumption for space heating and DHW
Example from Belgium: Analysis for 10 000 dwellings

Energy Advice Procedure databases of Belgian dwellings
Eg. 10 000 Walloon dwellings

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 7);

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>).

7 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 10) and enables a calculation of arbitrary combinations of buildings and systems. A WebToolExpertVersion enables a calculation of arbitrary combinations of buildings and systems. A WebToolExpertVersion enables a calculation of arbitrary combinations of buildings and systems.

8 Cross-Country Comparison of Typical Buildings and Supply Systems

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. Depending on the type of data the evaluations can in the future be useful for different aspects mentioned in the following clauses.

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 12). 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 5), disclosed rather large differences – even between countries in similar climatic zones (Figure 13). Thus, the confrontation and discussion of energy upgrade qualities remains an important task for the future.
Figure 12: Analysis of "TABULA.xls" data – Comparison of features of exemplary buildings
Example: U-values of walls per country and decade

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

Figure 13: Analysis of "TABULA.xls" data – Comparison of insulation measures proposed in the national typology brochures (section 5) <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>.

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 10) in case that more representative information about building stock surface areas is not available.

Figure 14: 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 14). 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.
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 15). 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.

Table 1: Result of the comparative analyses of heating system data – derived default values (simplified common values)

<table>
<thead>
<tr>
<th>TABULA Code</th>
<th>Description</th>
<th>Heat generation expenditure factor (heating systems) divided by produced heat $\varepsilon_{\text{HS}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>B_NC</td>
<td>boiler, non-condensing</td>
<td>1.62</td>
</tr>
<tr>
<td>B_C</td>
<td>boiler, condensing</td>
<td>1.31</td>
</tr>
<tr>
<td>B_WP</td>
<td>wood-pellets boiler</td>
<td>2.12</td>
</tr>
<tr>
<td>G_IWH, NC</td>
<td>gas-fired instantaneous water heater, non-condensing</td>
<td>1.27</td>
</tr>
<tr>
<td>G_IWH, C</td>
<td>gas-fired instantaneous water heater, condensing</td>
<td>1.17</td>
</tr>
<tr>
<td>G_SH</td>
<td>gas-fired space heater</td>
<td>1.50</td>
</tr>
<tr>
<td>E_Immersion</td>
<td>electric immersion heater</td>
<td>1.08</td>
</tr>
<tr>
<td>HP_Air</td>
<td>heat pump, heat source</td>
<td>0.50</td>
</tr>
<tr>
<td>HP_Ground</td>
<td>heat pump, heat source</td>
<td>0.52</td>
</tr>
<tr>
<td>HP_ExhAir</td>
<td>heat pump, heat source</td>
<td>0.36</td>
</tr>
<tr>
<td>Stove</td>
<td>stove</td>
<td>2.96</td>
</tr>
<tr>
<td>OpenFire</td>
<td>open fire</td>
<td>4.44</td>
</tr>
<tr>
<td>TS</td>
<td>district heating transfer station</td>
<td>1.24</td>
</tr>
<tr>
<td>OCH</td>
<td>combined heat and power generation</td>
<td>1.87</td>
</tr>
<tr>
<td>Solar</td>
<td>thermal solar plant</td>
<td>0.00</td>
</tr>
</tbody>
</table>

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.

9 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 refurbish-
ment 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 16: National housing stock statistics at the "Country Pages" of the TABULA website <CountryPages>

Example: housing stock statistics of Denmark

10 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 2: Result of a housing stock energy balance

Example: Belgian housing stock model – comparison of model results with national Energy balance <NatMod>

<table>
<thead>
<tr>
<th>[TJ]</th>
<th>Model</th>
<th>Energy Balance</th>
<th>Deviation related to Single Value</th>
<th>Total Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural gas</td>
<td>1.1120</td>
<td>1.1643</td>
<td>10.2%</td>
<td>4.5%</td>
</tr>
<tr>
<td>Fuel oil</td>
<td>15.193</td>
<td>15.148</td>
<td>-3.0%</td>
<td>-2.3%</td>
</tr>
<tr>
<td>Coal</td>
<td>15.428</td>
<td>15.428</td>
<td>0.0%</td>
<td>0.6%</td>
</tr>
<tr>
<td>LPG</td>
<td>3.521</td>
<td>3.521</td>
<td>0.0%</td>
<td>0.5%</td>
</tr>
<tr>
<td>Electricity</td>
<td>18.130</td>
<td>18.142</td>
<td>-0.6%</td>
<td>-2.3%</td>
</tr>
<tr>
<td>Heating</td>
<td>6.1332</td>
<td>6.1336</td>
<td>0.0%</td>
<td>0.5%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>311.206</td>
<td>253.635</td>
<td>8.5%</td>
<td>4.8%</td>
</tr>
</tbody>
</table>

National Energy balance Belgium 2006 / final energy consumption in TJ

Figure 17: 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)

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 WebTool2. 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>.

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 presumably a rather complex task. 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 general, the analysis shows that the current states of the non-residential building stocks and on-going retrofit processes are not very well known. For this reason, further knowledge is currently generated through national and European projects, energy audits and studies, e.g. in the framework of consulting activities. In Austria and Poland databases to collect benchmarks or data from energy certificates have been set up in the more recent past. In Germany studies analysing the possible structure of a non-residential building typology, benchmarks, and end energy uses in the tertiary sector have been carried out. Apart from these running activities in the different countries, the need for setting up representative surveys to continuously monitor the refurbishment rates was emphasized.

On the basis of the existing national information draft classification schemes were proposed by the concerned partners referring 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 working with a limited number of building categories to begin with.

Table 3: National statistics of the non-residential building stock

Example: number of non-residential buildings and gross floor areas in Austria, differentiated by building category and construction year class <NonRes>

<table>
<thead>
<tr>
<th>Number of buildings</th>
<th>Trade/office</th>
<th>Factory/operational</th>
<th>Tourism</th>
<th>Public</th>
</tr>
</thead>
<tbody>
<tr>
<td>- 1880</td>
<td>8.404</td>
<td>4.967</td>
<td>3.500</td>
<td>5.025</td>
</tr>
<tr>
<td>1880-1918</td>
<td>7.937</td>
<td>6.291</td>
<td>2.141</td>
<td>3.446</td>
</tr>
<tr>
<td>1919-1944</td>
<td>4.454</td>
<td>6.751</td>
<td>1.464</td>
<td>1.764</td>
</tr>
<tr>
<td>1945-1960</td>
<td>7.005</td>
<td>9.396</td>
<td>2.373</td>
<td>3.096</td>
</tr>
<tr>
<td>total</td>
<td>56.531</td>
<td>63.390</td>
<td>21.974</td>
<td>26.061</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gross floor area (m²)</th>
<th>Trade/office</th>
<th>Factory/operational</th>
<th>Tourism</th>
<th>Public</th>
</tr>
</thead>
<tbody>
<tr>
<td>- 1880</td>
<td>13.930.724</td>
<td>7.144.596</td>
<td>4.259.481</td>
<td>5.678.504</td>
</tr>
<tr>
<td>1880-1918</td>
<td>18.942.421</td>
<td>11.110.819</td>
<td>2.156.258</td>
<td>7.096.492</td>
</tr>
<tr>
<td>1981</td>
<td>22.146.521</td>
<td>22.681.378</td>
<td>5.368.772</td>
<td>8.926.927</td>
</tr>
<tr>
<td>total</td>
<td>104.896.999</td>
<td>101.212.175</td>
<td>24.499.175</td>
<td>46.108.784</td>
</tr>
</tbody>
</table>

% of the total building stock

|                  | 13,5% | 13,0% | 3,2% | 5,9% |

12 Recommendations and Outlook

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 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 project3. They understand the TABULA approach as a public concept open for attaching additional themes and research items –

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2 <WebToolExpertVersion>: The identification code contains “SyAv” for “Synthetical Average” in contrast to “ReEx” for real existing building).

3 building type matrix, exemplary buildings, building stock statistics; if applicable: average buildings and building stock model
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).

- **"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 8). 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)

<table>
<thead>
<tr>
<th>Reference Shortcut</th>
<th>Short Title and Link</th>
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</thead>
<tbody>
<tr>
<td>&lt;EPCdatabases&gt;</td>
<td>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 <a href="http://www.building-typology.eu/tabulapublications.html">http://www.building-typology.eu/tabulapublications.html</a></td>
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<tr>
<td>&lt;TABULA.xls&gt;</td>
<td>Excel workbook “TABULA.xls”, master file containing all building, construction and system data and used as a template for programming the TABULA WebTool <a href="http://www.building-typology.eu/tabulapublications.html#Download_Data_Tool">http://www.building-typology.eu/tabulapublications.html#Download_Data_Tool</a></td>
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Executive Summary

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