Monitor Progress Towards Climate Targets in European Housing Stocks

Main Results of the EPISCOPE Project

- Final Project Report -

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Abstract

The objective of the EPISCOPE project is to make energy saving processes in the European housing sector more transparent and effective with the aim to ensure that the climate protection targets will actually be attained and that corrective or enhancement actions can be taken in due time, if necessary.

Residential building typologies for 10 European countries were further developed and new typologies for 6 more countries were elaborated. In this context, the common typology scheme was extended to additionally include showcases of new buildings exemplifying energy performance levels meeting current national requirements or, as alternatives, more ambitious standards up to nearly zero-energy building (NZEB) level.

As one of the key elements, scenario calculations for residential building stocks on different scaling levels have been conducted in various European countries. Some of these typology-based case studies focused on selected housing portfolios on local level, others on entire regional or national housing stocks. Trend and scenario results for CO_2 emission reductions were compared to national and/or European benchmarks with the aim to identify the necessary path for attaining the targets.

The monitoring procedure and the concerted set of energy performance indicators developed during the project aims to enable key actors and stakeholders on different scales to ensure a high quality of energy refurbishments, the compliance with regulations, to track and steer the refurbishment processes in a cost-efficient way and to evaluate the actually achieved energy savings.

1 Introduction

The European Union is committed to reducing greenhouse gas emissions by 80–95 % below 1990 levels by 2050 [European Council 2011]. Higher buildings energy efficiency and the use of renewable energy sources in existing and new buildings are expected to play a major role in achieving this aim [COM 2011]. This focus is well grounded, as energy consumption in buildings accounts for roughly 40 % of Europe's total final energy consumption, the share of households being 27 % of the total [Eurostat 2015a]. These energy needs are currently predominantly met by non-renewable sources – in 2013 final energy from renewable sources in households in the EU 28 accounted for only 15 % [Eurostat 2015b]. In 2012, greenhouse gas emissions generated by households caused 19 % of Europe's total emissions [Eurostat 2015c].

Improving the energy efficiency of the residential building stock is thus one important field of activity since the housing stock qualities inevitably have a significant impact on operational energy requirements. The European Directive on the Energy Performance of Buildings [EPBD 2010] obliges each member state to implement policies to improve the efficiency of buildings, until new buildings have almost zero energy consumption by end of 2020. However, a comprehensive reduction of emissions in the building sector can be achieved only by acting on the existing stock.

To this effect, setting up targets is not enough – it needs to be taken care of the implementation process. The project EPISCOPE therefore aims to make energy saving processes in the European housing sector more transparent and effective by developing targeted monitoring approaches, combined with scenario analyses and building typologies.

It follows up on the previous EU projects DATAMINE and TABULA: DATAMINE (2006-2008) aimed to improve the knowledge about the energy performance of building stocks' by use of - at that time newly introduced - energy performance certificates [DATAMINE Project Team 2009], whereas during TABULA (2009-2012) a harmonised approach to classify building stocks according to their energy related properties by a commonly used building typology scheme was developed and implemented in 13 European countries [TABULA Project Team 2012a].

The consortium of the EPISCOPE project, co-funded by the Intelligent Energy Europe Programme of the European Union, comprises 17 partners from 16 European countries, and one associated partner from Serbia (see Figure 2 and Figure 9) receiving funding from the Deutsche Gesellschaft für internationale Zusammenarbeit (GIZ) GmbH.

In the following, an overview of the project activities, conclusions, and recommendations is given: In section 2 the inclusion of new buildings in the TABULA concept for residential building typologies is described. As a further step, the scope was extended towards the assessment of building stocks. As can be seen in section 3.1, the elaboration of a concerted set of energy performance indicators shall enable different key actors and stakeholders to track and steer the refurbishment processes and to evaluate the actually achieved energy savings. The indicator scheme also serves as a basis for the elaboration of building stock models and scenario calculations on local, regional or national level to assess refurbishment as well as energy saving processes and project future energy consumption as explained in section 3.2. A long-term objective is to install regular bottom up monitoring procedures for building stocks, see section 3.3. Chapter 4 provides a summary of the EPISCOPE experiences.

2 Inclusion of New Buildings in the TABULA Concept for Residential Building Typologies

Building typologies have proved to be a useful instrument for an in-depth understanding of the energy performance of certain building types and categories. In the framework of the IEE project TABULA, residential building typologies were developed in 13 European countries following a common methodological structure. Each typology consists of a classification scheme grouping buildings according to their size, age and further energy-relevant parameters as well as a set of exemplary buildings representing the respective building types [TABULA Project Team 2012a].

In the course of the EPISCOPE project, 10 of these typologies were further developed[1] and new typologies for 6 more countries[2] were elaborated. In this context, the common typology scheme was extended to additionally include showcases of new buildings exemplifying energy performance levels meeting current national requirements or, as alternatives, more ambitious standards up to nearly zero-energy building (NZEB) level.

Two to four examples for new builds of different sizes (single-family home, terraced house, multi-family house, and apartment block) were investigated for each participating country. Coordinated combinations of typical construction elements and their U-values, heat supply and ventilation systems as well as the calculated energy demands of these examples are presented in typology brochures[3] (Figure 1) [EPISCOPE Project Team 2014 - 2015].

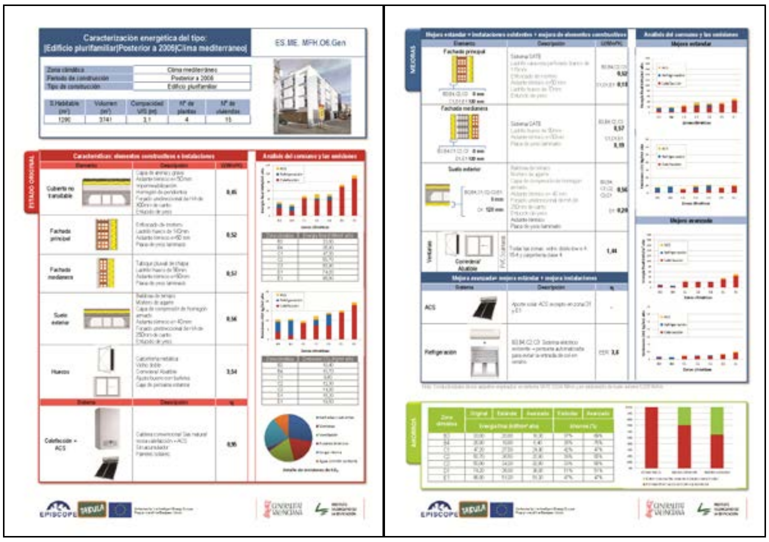


Figure 1: Example of a “Building Display Sheet” in the Spanish typology brochure [IVE 2014]

The data were furthermore included in the TABULA database, publicly available through the TABULA WebTool[4] [EPISCOPE Project Team 2015a]. While the brochures provide information in national languages and refer to national building energy rating methods, the TABULA database and calculation engine are used as a common framework also enabling cross-country comparisons. The TABULA approach is based on a simple, transparent calculation of useful and final energy demand along with an assessment of environmental impacts (primary energy and CO_2 emissions) [TABULA Project Team 2013].

1 For the countries Austria, Belgium, Czech Republic, Denmark, Germany, France, Greece, Ireland, Italy, Slovenia have been developed further. This applies also to the associated EPISCOPE partner country Serbia.

2 For the countries Cyprus, Spain, Great Britain/England, Hungary, The Netherlands, and Norway new residential typologies have been elaborated.

3 In national languages; downloadable from http://episcope.eu/communication/download/

4 In English language; online available at: http://episcope.eu/building-typology/webtool/

Moreover, the first EPISCOPE synthesis report [EPISCOPE Project Team 2014a] documents the status quo for energy efficiency policies for new builds and the implementation of the Energy Performance of Buildings Directive [EPBD 2010] in terms of a building's overall energy efficiency in the investigated countries. It also provides data and calculation results of the above mentioned national examples. Below, a brief overview is provided.

2.1 EPISCOPE Countries by Climate Zone

For the analysis, the countries reviewed were divided into the following climate zones to produce conclusions for comparable climates:

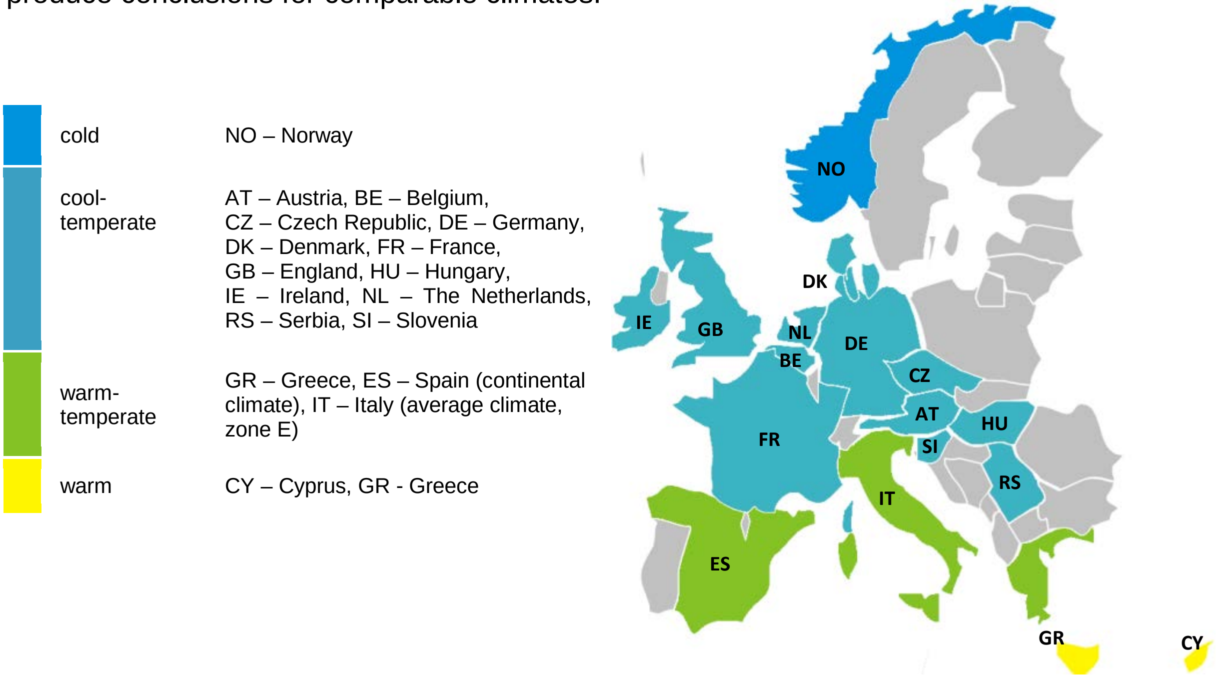


Figure 2: Countries in the EPISCOPE project by climate zone

The parentheticals for Spain and Italy show the national climate zones used for the analysis, putting them in the category of a warm-temperate climate. For Greece, example buildings were calculated considering four different climate zones allocated in warm-temperate and warm climates.

2.2 Investigated Energy Performance Levels for New Buildings

Depending on the classification scheme of the building typologies, each EPISCOPE partner chose two or more exemplary buildings to represent the most recent construction year class. Whereas for existing buildings a widely un-modernised state is compared to two different refurbishment packages [TABULA Project Team 2012a], for new buildings the compliance with current minimum requirements is contrasted with one or two more ambitious energy performance levels (EPLs):

EPL1: "Minimum Requirements": The building complies with the minimum requirements for new build according to the relevant national building code;

EPL2: "Improved": Intermediate energy performance level representing e.g. the requirements of grant programmes or improved EPC rating.

EPL3: "Ambitious/NZEB": As far as possible based on definitions for nearly-zero energy buildings (NZEBs) to be introduced in compliance with the [EPBD 2010]. For several countries NZEB definitions had not been finalised during the time of processing the typologies (see next section). In these cases, the considerations are based on an ambitious energy performance level that is assumed to comply with the NZEB approach. Detailed descriptions of the approaches used for the different member states can be found in [EPISCOPE Project Team 2014a].

2.3 Status of National Nearly-Zero Energy Building Definitions

When the new and upgraded typologies were published in September/October 2014, quite a few countries reviewed had not yet adopted final definitions for nearly-zero energy buildings. Only for Denmark, Ireland, the Netherlands, and (parts of) Belgium, official definitions were formulated. The definition for Cyprus was under revision, and in Italy, Austria, the Czech Republic and Slovenia, draft versions were available. In Hungary, the existing legislative definition was not accurately elaborated, and it was assumed that a more detailed specification will be necessary in the future. Furthermore, the national plan for France was referring to the current requirements for new buildings only. Greece, Spain, Germany, England, Serbia and Norway were still lacking official definitions (whereby Serbia and Norway are not part of the EU and hence not obligated to implement the EPBD). In these cases, the focus of the analysis was on concepts that, based on current knowledge, will probably fulfil future requirements.

2.4 Assessment Approaches for New Buildings

The countries under investigation have quite different ways of determining requirements for new buildings. The EPBD specifies that

"*The energy performance of a building shall be expressed in a transparent manner and shall include an energy performance indicator and a numeric indicator of primary energy use, based on primary energy factors per energy carrier, which may be based on national or regional annual weighted averages or a specific value for on-site production.*"
[EPBD 2010], Annex I, No. 2

As shown in Table 1, almost all countries therefore have requirements for insulation (limits for U-values of building components and/or transmission heat losses) and primary energy. But different countries have different ways of assessing primary energy - some refer to the non-renewable fraction only, some to total primary energy, whereas in other countries, agreed weighting factors are used.

Table 1: Assessment approaches for new buildings in national buildings regulations; the green fields refer to current national requirements, the grey fields to expected additions with regard to NZEB requirements

	warm & warm-temperate				cool-temperate												cold
	CY	ES	GR	IT	AT	BE (Flanders)	CZ	DE	DK	FR	GB	HU	IE	NL	RS	SI	NO
U-values																	
Heat transfer coefficient by transmission																	
Energy need for heating																	
Final energy																	
Primary energy*	n-r	n-r	t	t + n-r	t	awf	t + n-r	n-r	awf	awf		n-r	t			n-r	
CO_2																	
Share of renewables																	
Other																	

* Assessment of primary energy based on:

t – total primary energy n-r – non-renewable primary energy awf – agreed weighting factors

In some cases (Cyprus, Greece, Belgium, Germany, Ireland, and Norway) minimum requirements for the share of renewable energy need to be met. A few other member states (England and Ireland) have defined minimum requirements for a building's CO_2 emissions. Others (such as Austria, France, and the Netherlands) have special indicators for a building's overall energy efficiency in particular. In addition, a number of countries have requirements for heating energy demand and sometimes for final energy demand. Other indicators to be met refer to cooling/overheating or the efficiency of systems.

Apart from this variety of indicators, also the scopes of national energy balance calculation methods differ. As can be seen from Table 2, lighting is considered in seven of the investigated Member States whereas household appliances are regarded in Austria and Norway only.

Table 2: Scope of energy balance calculation methods referring to national building regulations requirements for residential new buildings

		warm & warm-temperate				cool-temperate												cold
		CY	ES	GR	IT	AT	BE (Flanders)	CZ	DE	DK	FR	GB	HU	IE	NL	RS	SI	NO
Scope according to [EPBD 2010]	Space heating	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Domestic hot water	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Cooling	x	x	x	x	x	x	x	x	x	x	x	x				x	
	Auxiliary energy	x		x	x	x	x	x	x	x	x	x	x	x	x		x	x
	Ventilation	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x
	Lighting	x				x		x			x	x		x				x
	Appliances					x												x

Furthermore, it needs to be considered that a variety of reference areas (living space, gross floor area, net floor area, useful area, …) is used in different countries. As a consequence, indicators and requirements for new buildings and NZEBs are in many cases not directly comparable. This is illustrated by examining the indicators of primary energy use for NZEBs in different member states:

Denmark – Primary energy requirement limited to ≤ 20 kWh/(m²a)

- Related to the gross floor area
- Scope excl. lighting and appliances
- Based on agreed weighted primary energy factors

Ireland – Primary energy requirement limited to ≤ 45 kWh/(m²a)

- Related to the net floor area
- Scope incl. lighting and appliances
- Total primary energy factors (renewable + non-renewable primary energy)

Belgium / Flanders – Primary energy requirement: E-Level ≤ 30

E-Level (e-peil) = primary energy demand of the building divided by a reference value

The Netherlands – Primary energy requirement: epc ~ 0

epc (energieprestatiecoëfficiënt / energy performance coefficient)
= area weighted primary energy demand of the building multiplied with a correction factor

2.5 Cross-country Comparisons

Whereas the nationally defined indicators and benchmarks are difficult to compare, the TABULA database and calculation method allow for cross-country comparisons of the showcase buildings included (see e.g. [IWU 2015b]). Energy balance calculations were performed for all new buildings contained in the database by use of standard boundary conditions and national climate data. Below, results for comparisons of insulation standards and annual heating energy demand are discussed.

2.5.1 Comparison of insulation standards

Table 3, Figure 3, and Figure 4, provide an overview of the component U-values (averages and ranges) for all exemplary new buildings (latest construction year class) included in the TABULA database.

Table 3: Range of building component U-values for national example buildings (minimum and maximum values) for the Energy Performance Levels 1 (current minimum requirements) and 3 (ambitious new building standard/NZEB)

Component U-values [W/(m²a)]		**warm & warm-temperate**	**cool-temperate**	**cold**
EPL1 (current minimum requirements)	Roofs	0.30 – 0.60	0.10 – 0.28	0.12 – 0.14
	Walls	0.34 – 0.65	0.14 – 0.40	0.17 – 0.22
	Floors	0.33 - > 1.00	0.10 – 0.50	0.15
	Windows	2.20 – 3.54	0.70 – 1.85	1.20
EPL3 (ambitious new building standard / NZEB)	Roofs	0.13 – 0.48	0.06 – 0.13	0.08 – 0.09
	Walls	0.13 – 0.48	0.09 – 0.25	0.10 – 0.12
	Floors	0.16 – 1.05	0.06 – 0.32	0.15
	Windows	1.10 – 2.80	0.50 - 1.50	0.80

Even within comparable climate zones, U-values vary to a considerable extend. However, U-values for EPL3 are in general substantially lower compared to EPL1 (up to 60 %).

A closer look at EPL3 reveals that in countries with cold or cold-temperate climates U-values for opaque building elements are in the usual rage for Passive Houses. Also the U-values for windows (not including the installation situation) are generally within the range required for a Passive House, at or below 0.8 W/(m²K) (triple glazing with insulated frame). In countries with a warm or warm-temperate climate, the U-values of windows lie between 1.1 and 2.8 W/(m²K) (double glazing), and therefore in particular exceed the recommendations for Passive Houses (see also [IWU 2015a]).

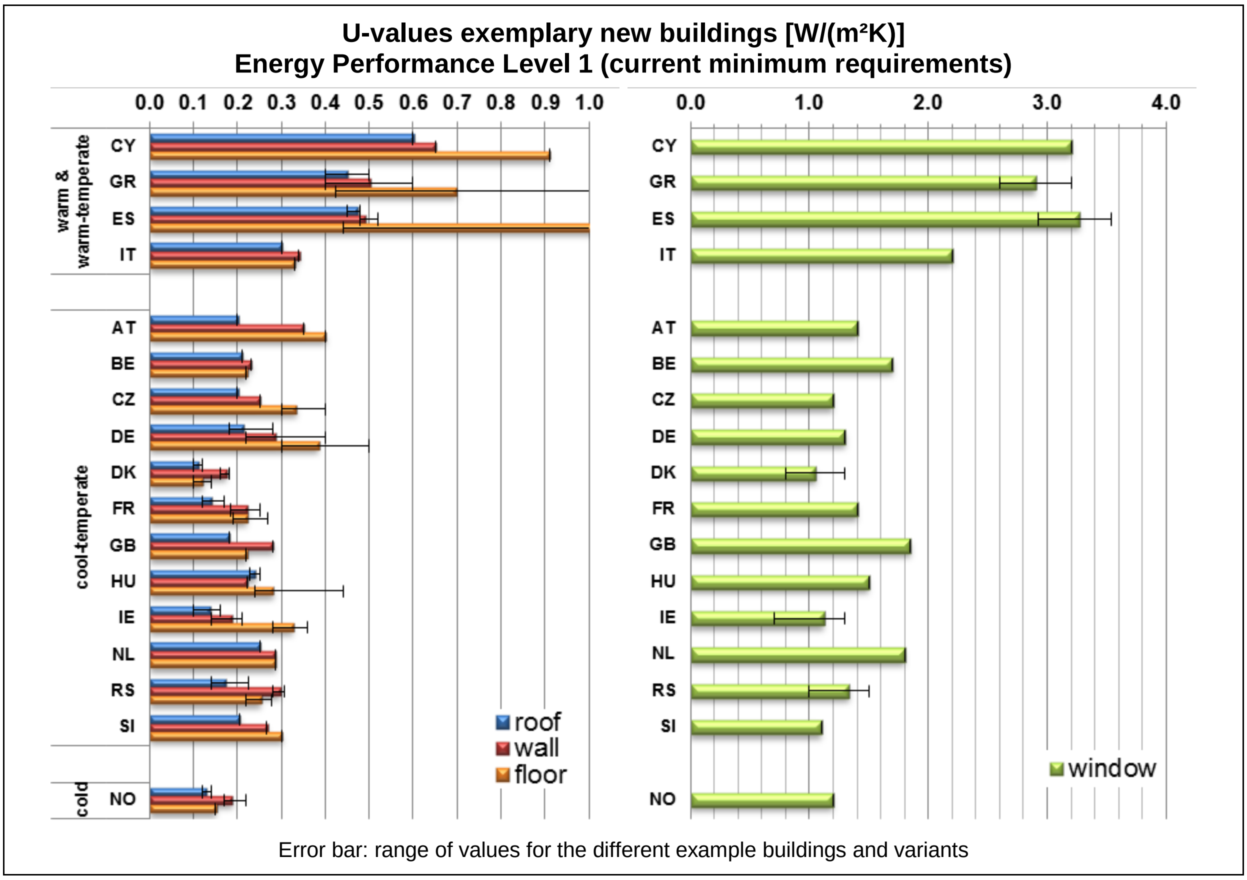


Figure 3: Averages and range of building component U-values for national example buildings EPL1

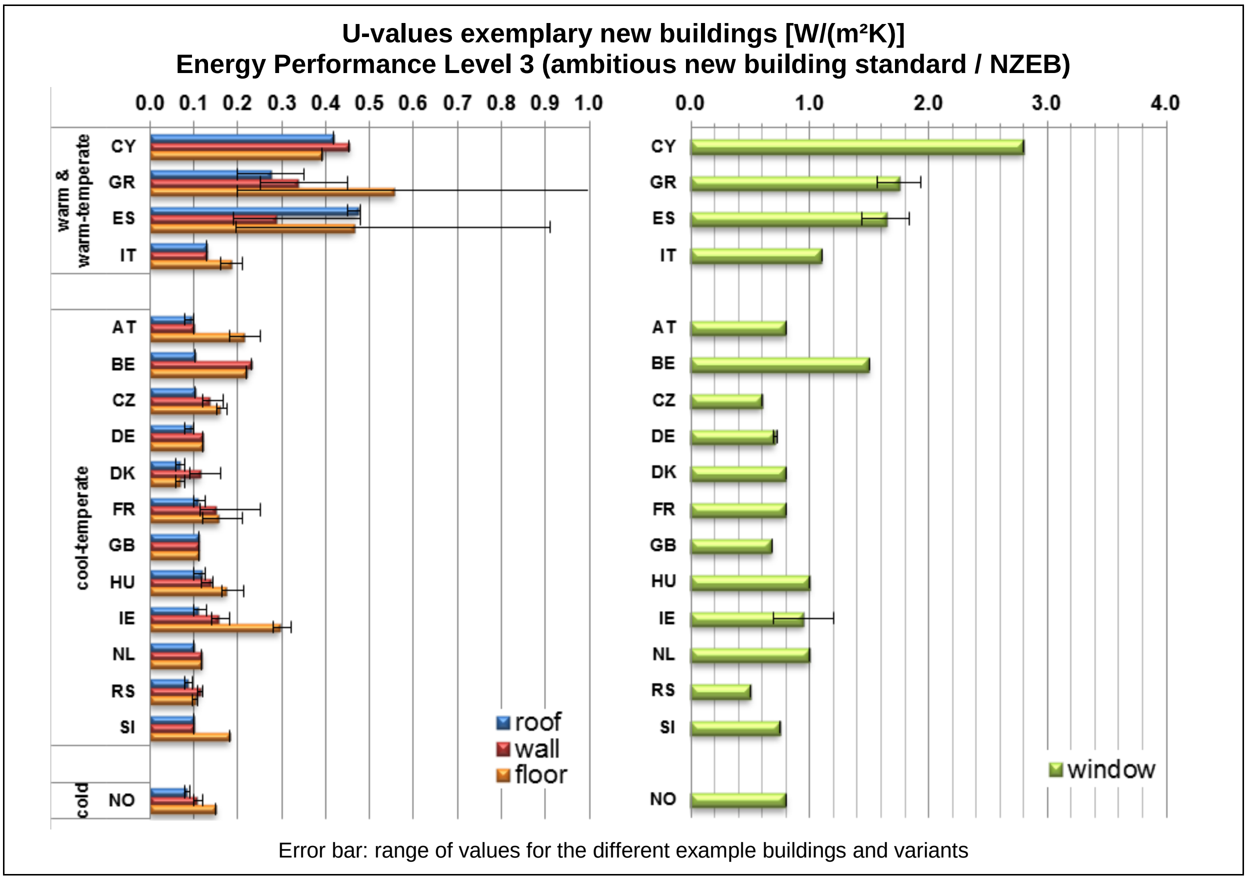


Figure 4: Averages and range of building component U-values for national example buildings EPL3

2.5.2 Comparisons of annual heating demands

Figure 5 and Figure 6 show values for the energy need for heating (average and range) of all national example buildings as calculated with TABULA, and reflecting the TABULA reference area (heated share of net floor space).

In general, differences in the ranges for the various countries are the result of different building sizes. Despite the fact that countries with a warm or warm-temperate climate sometimes have much higher U-values (see section 2.5.1), the resulting levels of heat demand for these examples are within the range (or better) of those in other climate regions.

Average values for the gross energy need for heating referring to the current minimum requirements (EPL 1) vary from 37 to 96 kWh/(m²a). Values for the more ambitious EPL3 lie in average ca. 40 % lower (between 24 and 59 kWh/(m²a)).

Especially with regard to EPL3, there are major differences between the average annual levels of energy need for heating depending on the climate zone.

Ventilation systems with heat recovery were not taken into account for all examples, which clearly increases demand for heating energy in these cases.

In most countries, only the demand levels of individual examples fall below Passive House requirements even in EPL3 (see also [IWU 2015a]). The demand levels are, however, merely rough estimates because the boundary conditions in TABULA (shading, internal heat sources, etc.) are general assumptions.

2.6 Résumé

The inclusion of new buildings in national residential building typologies aims to disseminate information and showcase examples in building typology brochures [EPISCOPE Project Team 2014 - 2015] and online through the TABULA WebTool [EPISCOPE Project Team 2015a]. Referring to the appearance and details of actual existing buildings proves the feasibility of the concepts. Apart from being a source of information for house owners, the showcase examples can also be used in energy advice or energy certificate software as pre-defined datasets in order to show possible combinations of constructions and supply systems. Furthermore, they may be used by key actors to present the impact of policies and measures in an illustrative manner, e.g. for cost optimal studies [Amtmann et al. 2011], [Droutsa et al. 2014], [Corrado et al. 2013], [Corrado et al. 2014].

The first EPISCOPE synthesis report [EPISCOPE Project Team 2014a] presents an overview of the current national minimum requirements, related national calculation methods, the status of the national NZEB definitions as well as information on how these new built concepts were integrated in the residential building typologies for the 17 participating countries.

In many European member states definitions for nearly zero-energy buildings are still under debate. It is clear, however, that national approaches will consider various indicators and assessment methods for overall energy efficiency and environmental impacts.

The assessment of the example buildings for national residential building typologies shows that insulation standards for the most ambitious variant investigated are generally comparable with Passive House requirements. But not all countries take account of Passive House windows and/or ventilation systems with heat recovery.

As a result, with regard to the energy performance levels of the exemplary buildings a large variation can be stated – even for similar climatic zones: In some countries far reaching minimum requirements close to the best available technology can already be found today. Here only small steps to possible NZEB standards are to be expected. In other countries rather weak requirements for NZEBs are discussed at present.

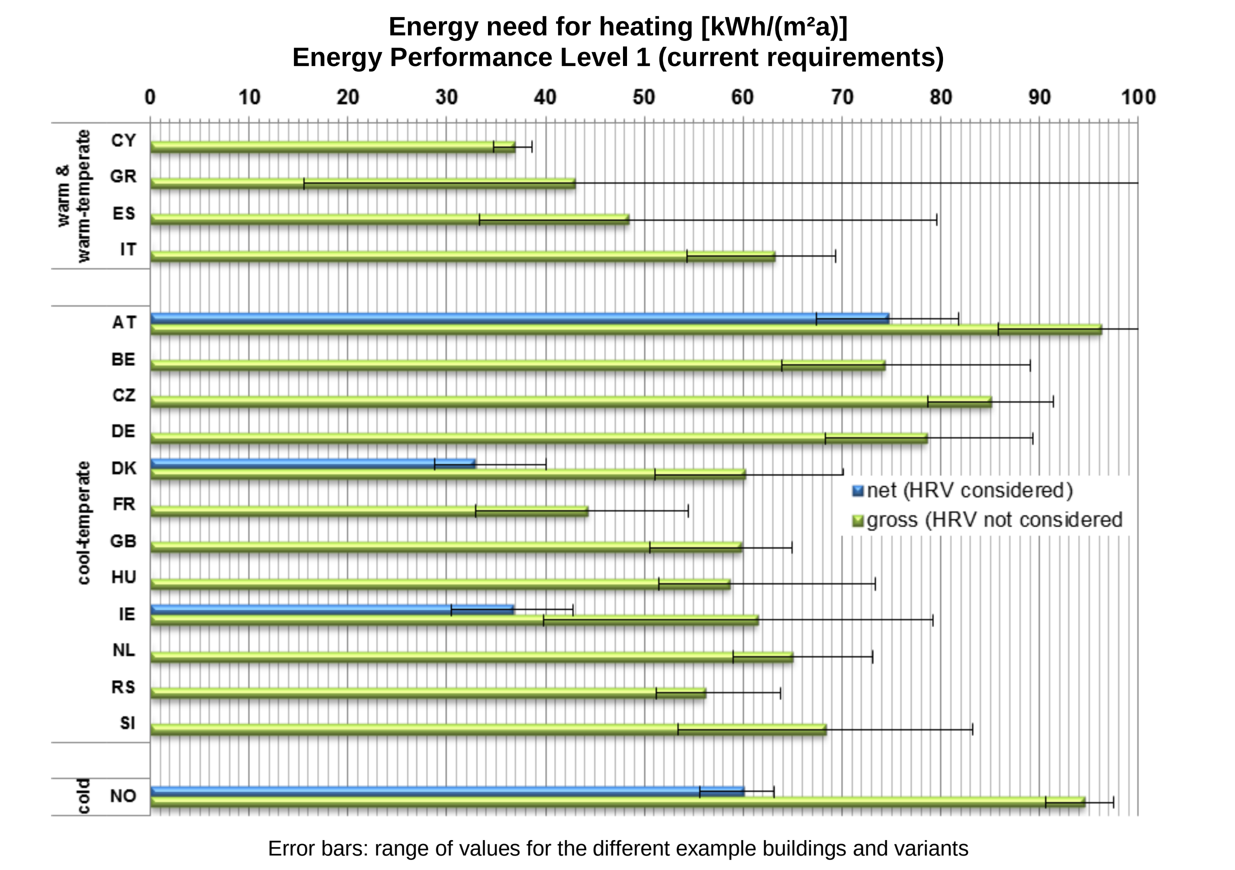


Figure 5: **Averages and range of heating energy demand for national example buildings EPL 1**

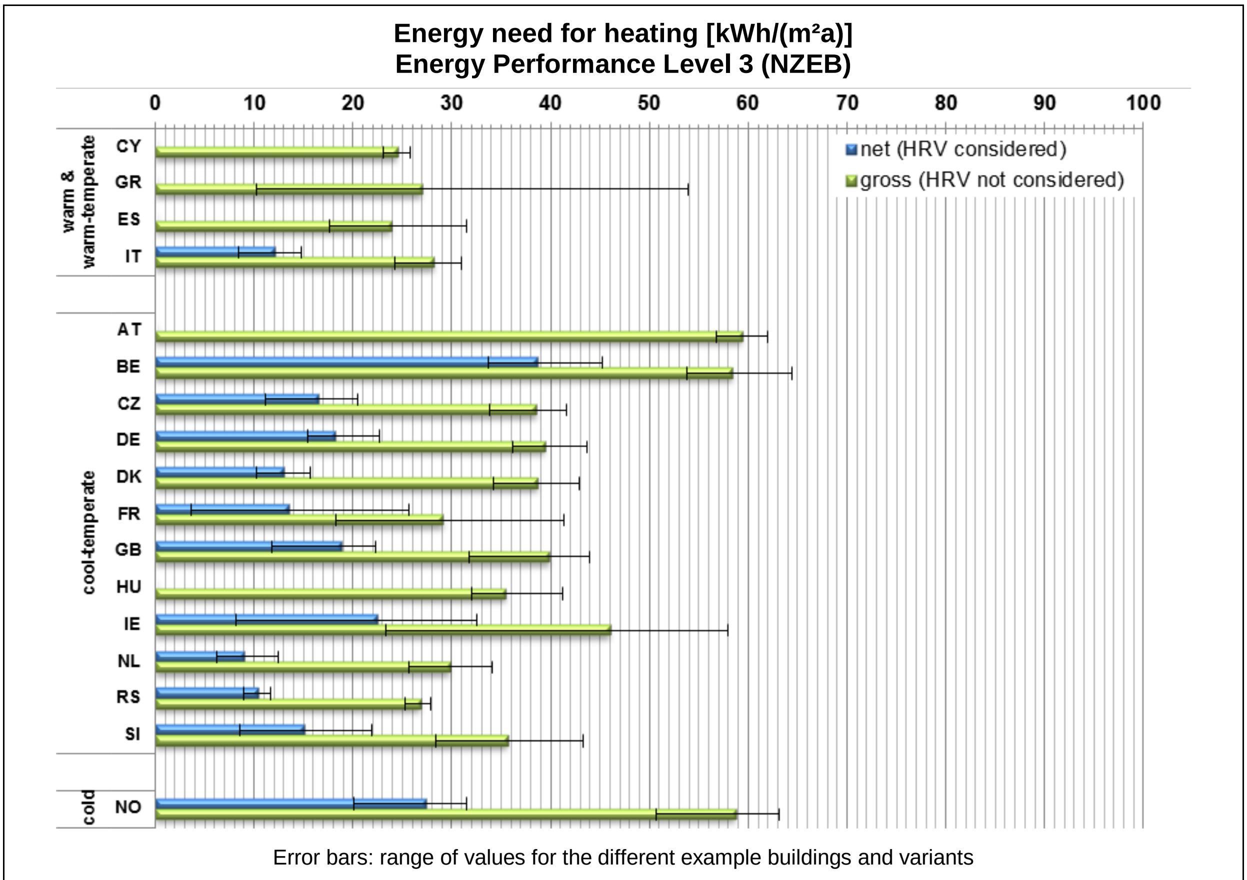


Figure 6: **Averages and range of heating energy demand for national example buildings EPL 3**

3 Case Studies – Scenario Calculations and Monitoring Approaches for Building Stocks

As one of the key elements in the EPISCOPE project, case studies concerning residential building stocks on local, regional or national level were conducted in the participating countries. Data collection and analyses concerning the current situation of the building stocks considered formed the basis to map the existing states by the commonly used average buildings concept as well as for the set-up of individual building stock models and the projection of different future developments. Apart from identifying possible paths or challenges to meet the European or individual (local, regional, national) climate protection targets, quality and availability of required data was discussed, and recommendations to improve the data situation by applying regular monitoring concepts were compiled.

In the following, the elaborated indicator scheme for building stocks (section 3.1), general results of the scenario analyses (section 3.2) and the evaluation of available data and data quality for the EPISCOPE case studies (section 3.3) are summarised. Further details can be found in the documentation of the indicator scheme [EPISCOPE Project Team 2014b and 2016d] as well as the EPISCOPE Synthesis Reports No. 2-4 in English language [EPISCOPE Project Team 2016a-c], and in case study reports in the respective national languages [EPISCOE Project Team 2015b].

3.1 Energy Performance Indicators for Building Stocks

To effectively monitor energy saving processes in building stocks, the identification and definition of appropriate indicators is essential. The indicator scheme needs to be suitable to map the state of the building stock at a particular point in time as well as to understand the dynamics of the development over time. Furthermore, the respective data need to be collected by means of feasible, reliable methods as e.g. representative surveys.

To set up building stock models with regards to energy balance calculations, basic and structural data are needed on the building stock considered:

- Basic data, e.g. number of buildings, number of dwellings; m² reference area, age bands;
- Quantitative information on thermal protection / building insulation, e.g. shares of insulated building components;
- Information on the depth of refurbishment measures, e.g. average thickness of insulation, U-values, classification of insulation levels;
- Information on supply systems, e.g. grade of centralisation, main energy carriers, types of heat generation, solar thermal systems, PV systems, main systems of hot water generation;
- Energy consumption by fuel to enable a calibration of calculated results for the respective years considered.

To be able to distinguish between specific subsets of a building stock, these data are required for the respective clusters, grouped e.g. by building size (single/multi-family home) and/or specific age bands.

Corresponding indicators for national building stocks (building stock characteristics, modernisation trends, policies & regulations) are presented at the EPISCOPE website[5] and in the EPISCOPE area of the BPIE Data Hub (“EPISCOPE Tool”[6]) (see section 3.2.6).

5 Online available at the EPISCOPE country pages: http://episcope.eu/building-typology/country/

6 Online available at: http://www.buildingsdata.eu/data-sources/episcope-data

When analysing past and possible future developments, it is furthermore necessary to distinguish between reliable empirical monitoring indicators and scenario indicators, which may to a more or less extent be based on assumptions. Figure 7 illustrates a complete indicator set, describing the building stock in its actual state at a specific point in time and in its future conditions. Monitoring indicators are supposed to directly reflect the monitoring results, they should not depend on additional (more or less unproved) assumptions. State indicators describe the condition of the building stock in a certain year, and provide information about the current status of energy efficiency. Trend indicators are related to the actual dynamics, and provide information about the current velocity of movement towards better energy efficiency and climate protection. These structural data are basic input data for scenario analyses and thus also form the basis for related scenario indicators. Whereas the indicator scheme in general refers to quite detailed information, results of overriding importance should be shown as summary indicators also understandable for non-experts.

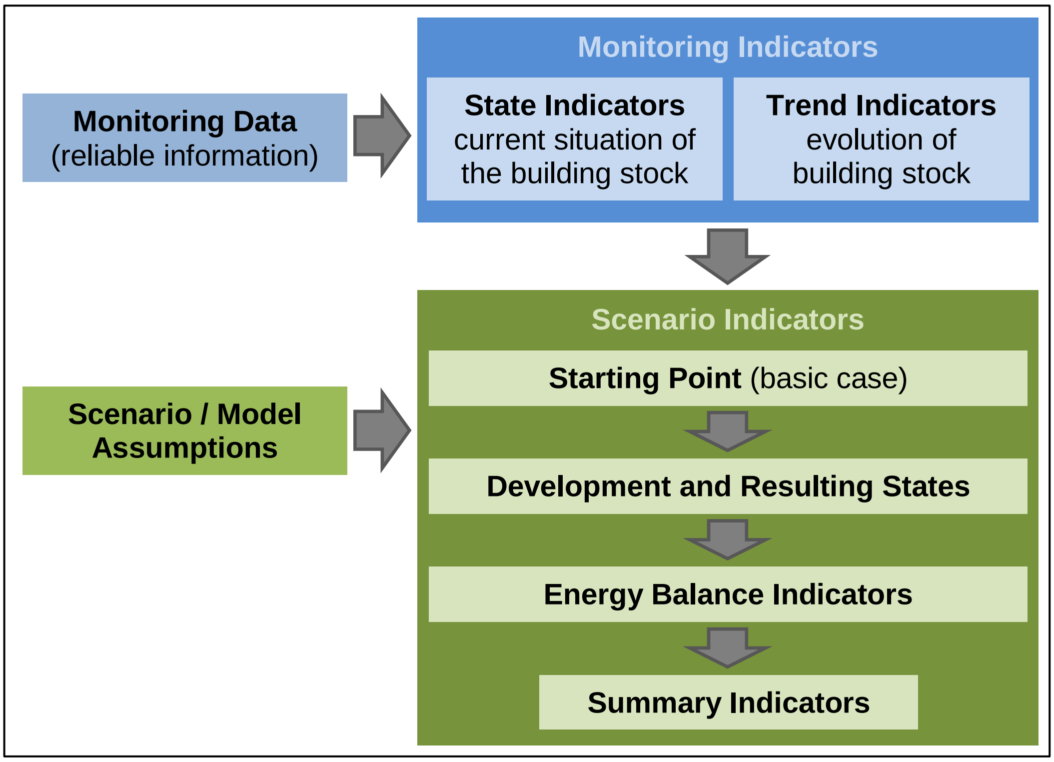


Figure 7: Overview of the EPISCOPE scheme of energy performance indicators for the monitoring of building stocks

During the EPISCOPE project, a general indicator scheme has been discussed [EPISCOPE Project Team 2014b and 2016d], but with regards to the scenarios conducted, no common calculation scheme was applied. It was therefore possible for the project partners to adjust and use the commonly defined scheme according to their needs and individual procedures. Only for the "summary indicators" – CO_2 emissions, total heat demand, and corresponding CO_2 emission factors – common definitions were applied to enable comparisons between different case studies. Figure 8 illustrates the interaction between the typology-based building stock models, the energy performance indicators and the scenario analysis.

In this context, it has to be noted that the use of reference quantities varies throughout different countries and case studies; e.g. diverse reference floor areas (living space, gross floor area, net floor area) are in use, shares of certain quantities might be related to the number of buildings or the number of dwellings or some reference area, final energy consumption to the gross or the net calorific value. Hence, comparing indicators from different origin needs to be handled with care.

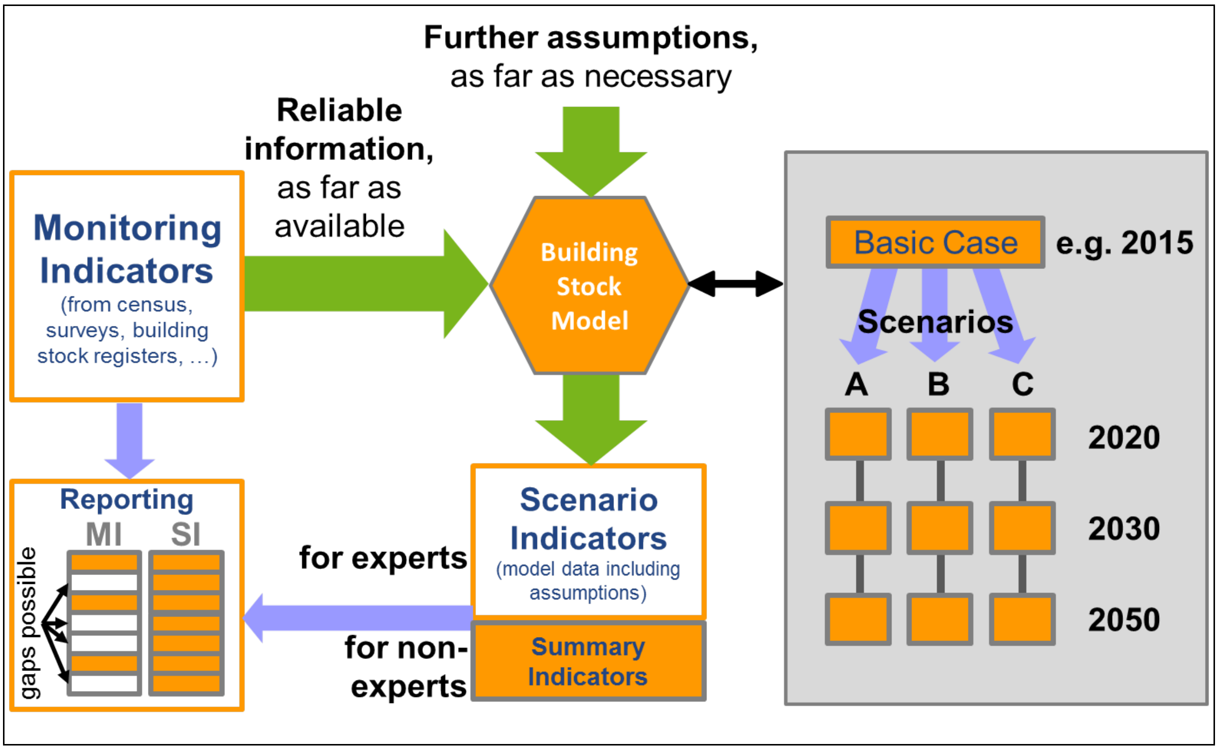
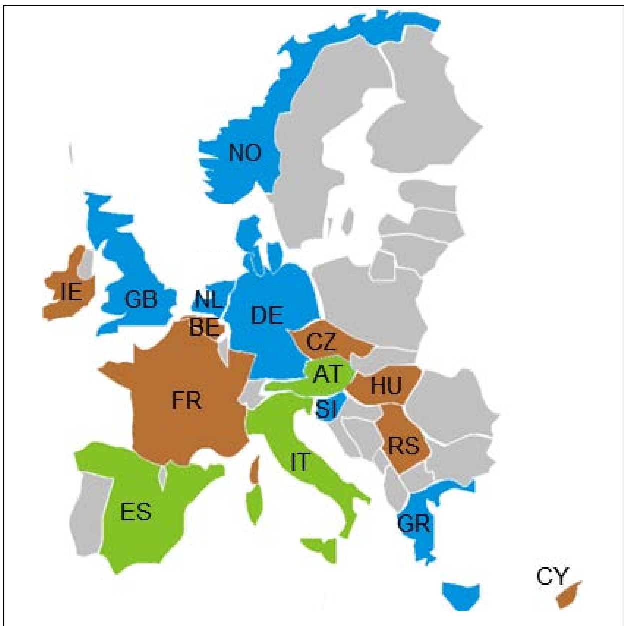


Figure 8: **Interaction between the building stock model, EPISCOPE energy performance indicators and different scenario analyses**

3.2 Scenario Analyses

As illustrated in Figure 9, case studies for residential building stocks on local, regional or national level were conducted in the participating countries.



Local Case Studies

BE – Belgium:
Housing block in the Sint-Amandsberg district in the city of Ghent

CY – Cyprus:
Housing stock of the Cyprus Land Development Corporation CLDC

CZ – Czech Republic:
Municipal housing stock in the city of Havířov

FR – France:
Social housing stock of OPH Montreuillois in the city of Montreuil

HU – Hungary: City of Budaörs

IE – Ireland:
Municipal housing stock on the Northside of Dublin City

RS – Serbia: Municipality of Vršac

SI – Slovenia: Municipality Kočevje

National Case Studies

DE – Germany, DK – Denmark, GB – England, GR – Greece, NL – The Netherlands (national non-profit housing stock), NO – Norway, SI – Slovenia

Regional Case Studies

AT – Austria: Bundesland Salzburg
ES – Spain: Comunidad Valenciana
IT – Italy: Piedmont Region

Figure 9: **Countries and case studies on residential building stocks, covered in the framework of the EPISCOPE project**

As described below, as a first step, building stock models were set-up to map the current situation of the case studies considered. For comparison, these results were transferred to a commonly used scheme called “average buildings” (see section 3.2.1). Actual dynamics or trends, especially concerning refurbishments rates, were identified to apply scenario analyses and project possible future developments (see section 3.2.2). At least three different scenarios were considered for each case study and compared to European (so called EPISCOPE) and individual benchmarks (see section 3.2.5).

3.2.1 Building Stock Models and the “Average Buildings” concept

Whereas some other European projects and studies follow the approach to apply one scenario model to different EU member states [BPIE 2011], [ENTRANZE consortium 2014], individual building stock models were developed and/or applied in the EPISCOPE project for each of the building stocks considered.

Depending on the available data as well as the scope and level of detail of the analyses, there are different possibilities to design bottom-up building stock models, and of course, such models can become rather complex. An important aim of the EPISCOPE project was to contribute to a tracking of the refurbishment process and its effect on the energy consumption involving different key actors and stakeholders. These building stock evaluations and projections need to be understood not only by experts, but also by many other stakeholders involved in the implementation process (e.g. municipality staff, energy consultants, engineers, managers of housing companies, …). In consequence, simplified concepts are necessary, which are easy to handle but still reliable regarding their projections. To meet the above described aims, the concept of “synthetical average buildings” was developed in the framework of the TABULA project [TABULA Project Team 2012b], [Ballarini et al. 2014]. During EPISCOPE, the approach was further developed and used as a common means to map the current state of the building stocks considered.

“Average buildings” (or “archetypal buildings” [Mata/Kalagasidis/Johnsson 2014]) are theoretical (synthetical) buildings with geometrical and thermo-physical characteristics equal to the average of the building stock subset which they represent. Their characteristical values are derived by summing up the total values of all relevant input, interim and output quantities (number of dwelling, floor area, envelope area, energy need for heating, final energy consumption, …) divided by the number of buildings counted in the represented building stock subgroup (see detailed description for an urban district in Germany [IWU 2014]). The annual energy balance for heating and DHW of average buildings is calculated in the same manner as for real buildings. Projections to the building stock can be done by multiplying the single building related figures with the total number of buildings.

The general advantages of subsuming a complex model in an “average buildings model” are:

- The supplemental calculation enables plausibility controls of the complex model.
- The simplified model helps to improve the communication of results: The statements about the total building stock are more seizable, large numbers can be pictured.
- The main input quantities and results can be used as benchmarks to compare features and energy consumptions of distinct real buildings. Projections can easily be done for other subsets of the same building stock.

Furthermore, such simplified building stock projections can be used for basic scenario analyses.[7] If such a simplified building stock model was developed and published this can be useful for other experts:

[7] The concept of synthetical average buildings has been used in for the buildings stock models of the EPISCOPE case studies from Czech Republic, Germany, Italy and the Netherlands.

- If input data are available the energy balance of “average buildings” can be calculated by use of standard energy rating software. Projections to the whole building stock are easily possible as mentioned above.
- A combination of few average buildings with a variety of supply system types is fairly easy to handle – especially when different scenarios are to be calculated.

The common data structure and calculation procedure developed and used within the framework of the TABULA project [TABULA Project Team 2012a], [TABULA Project Team 2013] was extended to process and display average buildings for building stocks. For all case studies the basic case, i.e. the current state of the building stock, was transformed to the TABULA data structure. The included data and calculation are publicly available through the “Building Stocks” area of the TABULA WebTool [EPISCOPE Project Team 2015a], see also section 3.2.6.

3.2.2 Knowledge about the state of refurbishment and refurbishment rates

To map the current state of a building stock, knowledge about the state of refurbishment is necessary. Furthermore, to extrapolate an actual trend into the future, information on current refurbishment rates are needed.

The analyses of the data sources available for the building stocks considered revealed that in this regard in many cases there is a lack of reliable and up-to date data [EPISCOPE Project Team 2016c] (see section 3.3). Most of the data available are not updated regularly, and in many cases, statistical errors are unknown.

Especially for the local case studies, data was therefore collected by in-field research/surveys (Belgium, Cyprus, Hungary, Ireland, Serbia) or/and data analyses of information by housing companies and EPC data (Czech Republic, France, Ireland) [EPISCOPE Project Team 2016a].

For regional and national case studies data from different sources was analysed [EPISCOPE Project Team 2016b]:

- for Greece data by the Hellenic Statistical authority;
- for Italy data by the national energy agency;
- for Austria a report on renovation rates (irregularly published);
- for Norway data from a potential and barrier study for energy savings in residential buildings by energy provider;
- for Slovenia and Germany data from national surveys are available, both of which were so far conducted only once and therefore picture the status for only one point in time (Slovenia 2006, Germany 2009);
- for the Netherlands detailed data are available through the SHAERE monitor;
- for England refurbishment rates and insulation levels are well understood from the English housing survey.

For Spain and Denmark there is basically no information on the share of already implemented refurbishment measures.

Apart from that, it is to be noted, that terms like refurbishment or renovation rates may be used in different ways; they may e.g. be related to the number of buildings, the number or dwellings, the share or building element areas or some kind of reference floor area. Also the definition of when a building is declared to be refurbished may vary.

Figure 10 and Figure 11 show the heat transfer coefficients by transmission for the average buildings of the EPISCOPE case studies. Spain and Greece with a warm and/or warm temperate climate show the highest values > 2 W/(m²K), whereas the values in countries with cool-temperate climates (see Figure 2) lie between 0.5 and 1 W/(m²K).

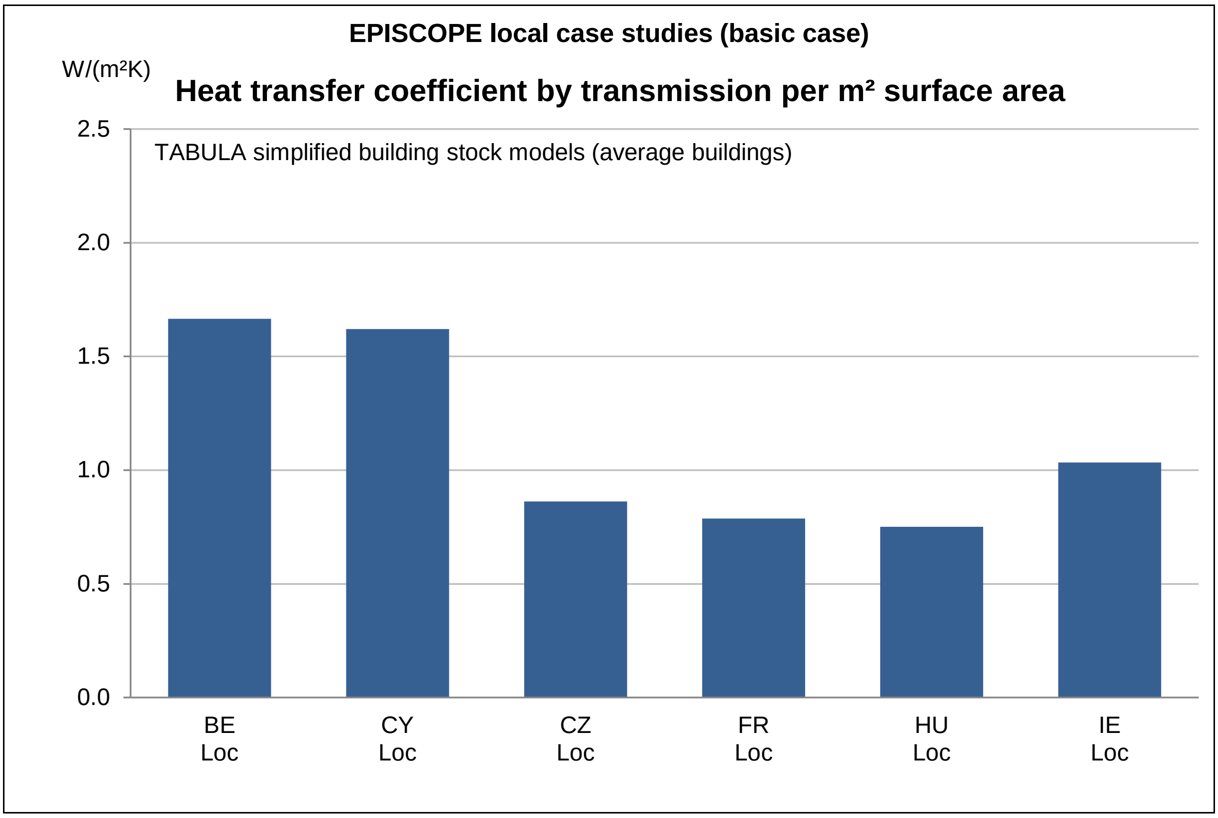


Figure 10: **Heat transfer coefficients by transmission per m² surface area for the average buildings of the local EPISCOPE case studies, basic case (current state of the building stocks)**

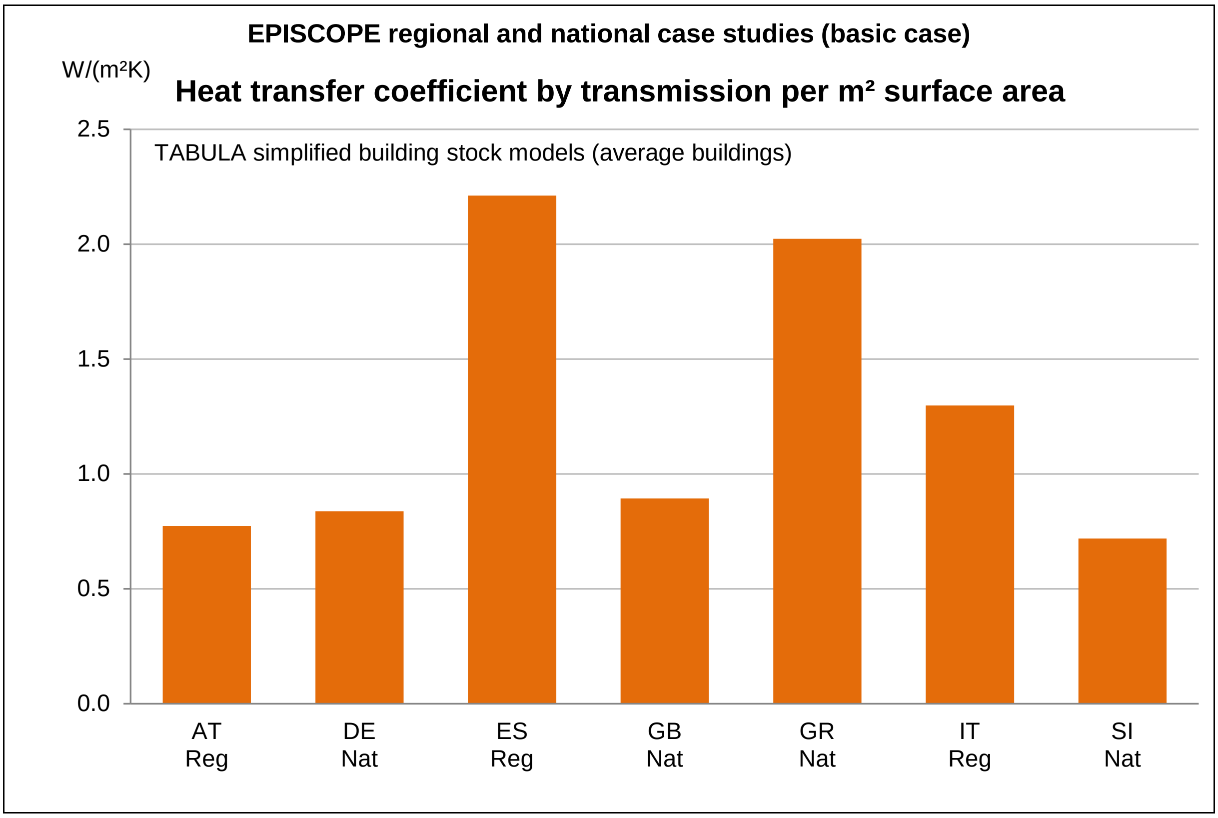


Figure 11: **Heat transfer coefficients by transmission per m² surface area for the average buildings of the local EPISCOPE case studies, basic case (current state of the building stocks)**

3.2.3 Comparison of delivered energy for the starting point of the scenarios

The documented average buildings provide a rough picture of the starting point of the scenario calculations elaborated during EPISCOPE. Figure 12 and Figure 13 show comparisons of the delivered energy for heating and domestic hot water calculated with the individual building stock models used for the scenario analyses and the TABULA calculation procedure, referring to the current states of the building stocks concerned (basic case).

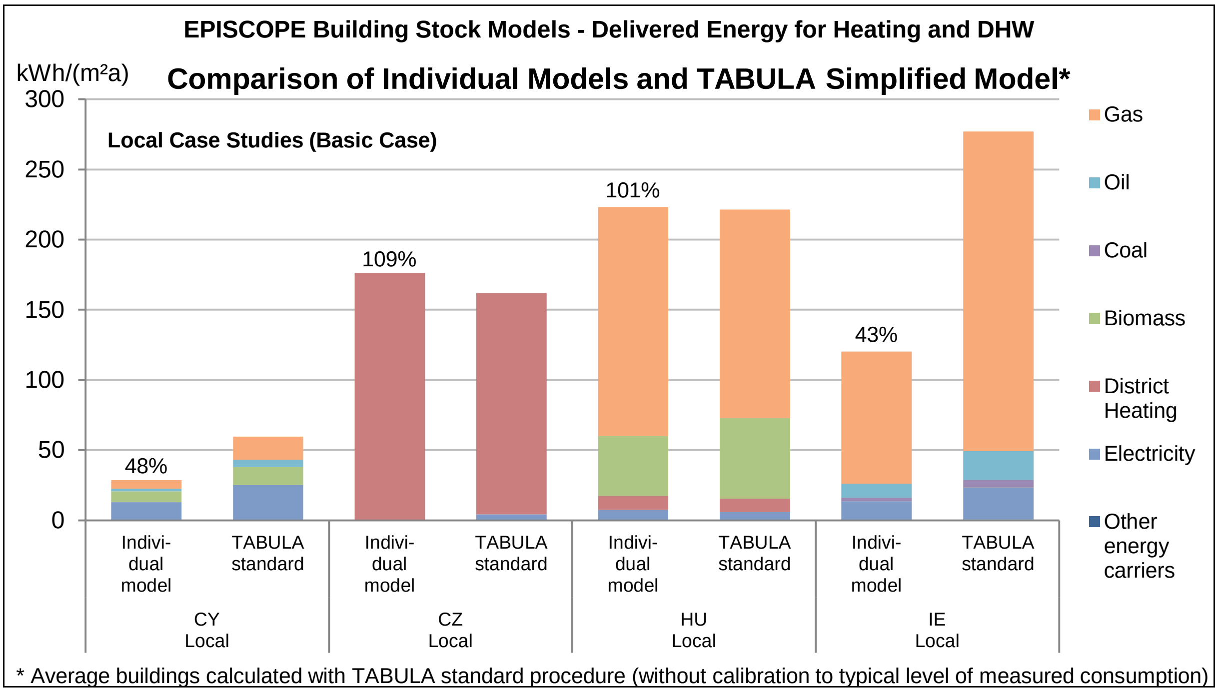


Figure 12: EPISCOPE local case studies – comparison of the delivered energy for heating and DHW per m² EPISCOPE reference area and year for the current state (basic case), calculated with individual building stock models and the TABULA calculation method

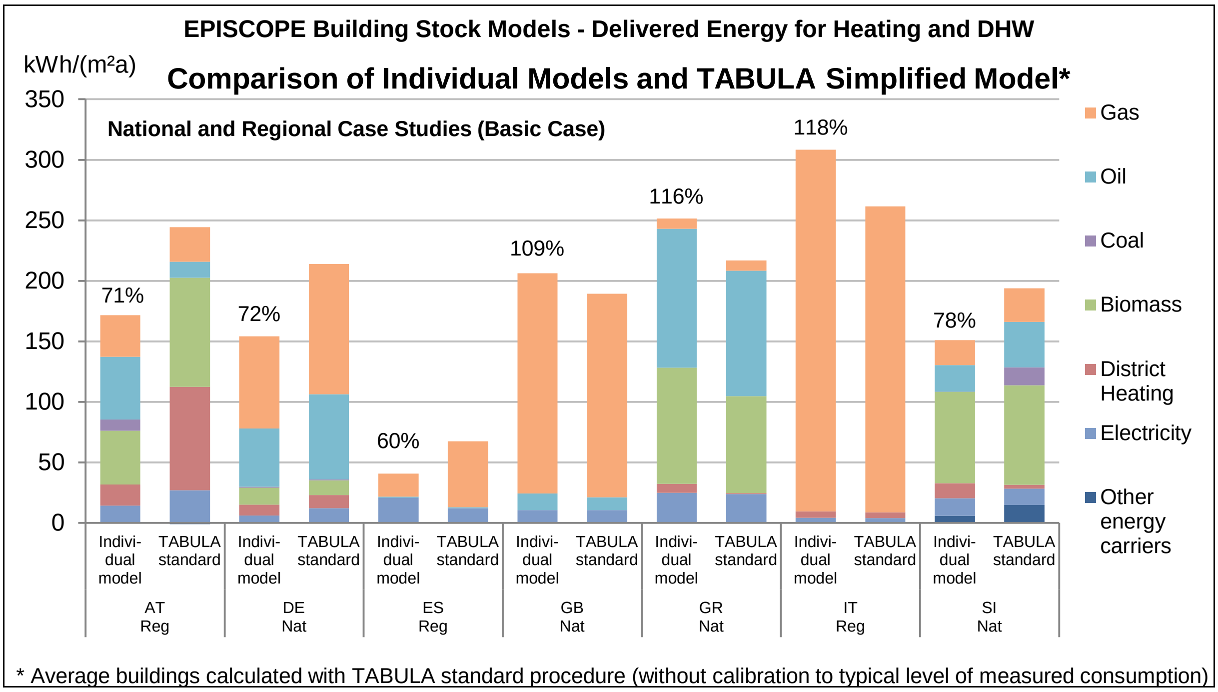


Figure 13: EPISCOPE regional and national case studies – comparison of the delivered energy for heating and DHW per m² EPISCOPE reference area and year for the current state (basic case), calculated with individual building stock models and the TABULA calculation method

The large variation of the total delivered energy per m² TABULA/EPISCOPE reference area (heated share of net floor space) is due to different mixes of building types and refurbishment states, but it is also due to different climatic data and utilisation conditions. Also the distribution of energy carriers is rather different.

Calculation results from the individual models lie between 57 % below and up 18 % above the TABULA calculation. This is partly due to the fact that for reasons of comparison the TABULA calculation is performed using standard boundary conditions, whereas the individual models were, as far as possible, adjusted to specific individual conditions and calibrated with measured consumption.

3.2.4 Calibration to the typical level of measured consumption

Physical models should be verified and calibrated by measurements. Due to lack of information about the real utilisation conditions (indoor temperatures, air exchange rates) and the exact thermal properties of existing buildings (construction elements, supply system elements) it is difficult to calibrate all these input values to realistic levels, even for the average of a building type. In consequence, systematic deviations of the calculated energy use from the typical level of measured consumption are to be expected.

Nevertheless, it is necessary to provide realistic numbers for the possible savings of delivered and primary energy, energy costs, and carbon dioxide emissions – for a single building as well as for a building stock.

As far as possible, the individual models set-up by the EPISCOPE partners were adjusted or calibrated by the use of measured consumption values from different sources: national/regional energy balances, national registries, data from energy suppliers, EPC data, or own field surveys [EPISCOPE Project Team 2016a-c].

By setting these consumption benchmarks in relation to the calculated energy use adaptation factors can be determined, which enable a calibration of the theoretical to empirical values.

3.2.5 Results of the Scenario Analyses

For each case study results for at least three different scenarios were discussed, one of them being the extrapolation of the current trend. The definition of the other scenarios was done individually by the responsible project partner. In the following, selected results for the current states of the building stocks and the trend developments are shown.

In Figure 14 and Figure 15 CO_2 emissions for space heating and domestic hot water per m² EPISCOPE reference area are shown for all trend scenarios calculated for the different building stocks. Furthermore, the EPISCOPE and individual (national, regional or local) benchmarks are displayed.

The EPISCOPE benchmarks were derived from a rough and straightforward translation of general EU climate protection targets [EPISCOPE Project Team 2016a-b]: compared to 1990 the EU has decided a 20 % emission reduction until 2020, a 40 % reduction until 2030 [COM 2014], as well as a reduction of 80-95 % by 2050 [European Council 2011], [COM 2011]. According to [Umweltbundesamt 2014] the EU-15 greenhouse gas emissions were reduced by around 12 % (energy-related emissions) or 15 % (all emissions without land use changes) in the period from 1990 to 2012. Carrying out a short extrapolation it can be assumed that until 2015 an emission reduction of 13 % (energy-related) / 17 % (all) – or roughly speaking of 15 % might have been reached related to 1990. So the gap to be closed until 2020 / 2030 / 2050 will roughly be about 5 % / 30 % / 75 % related to the emission level of the year 2015. This defines the EPISCOPE benchmarks:

benchmark 2020 = 0,95 x m_{2015} x $A_{ref,2015}$ / $A_{ref,2020}$ (“2015 minus 5 %”)
benchmark 2030 = 0,70 x m_{2015} x $A_{ref,2015}$ / $A_{ref,2030}$ (“2015 minus 30 %”)
benchmark 2050 = 0,25 x m_{2015} x $A_{ref,2015}$ / $A_{ref,2050}$ (“2015 minus 75 %”)

m_{2015} = $m_{CO2,heat\ supply,2015}$ (area-related CO_2 emissions 2015)
$A_{ref,year}$ = EPISCOPE reference area of the building stock in the year considered

These benchmarks, however, may not be over-interpreted: The straightforward breakdown of EU global emission targets to the CO_2 emissions of concrete residential building stocks does not consider the individual situation and reduction potentials compared to other countries with other climates, further sectors (like industry or traffic) or other building stocks. A “fair” burden sharing of emission targets – if at all possible – might lead to different numbers. However, the EPISCOPE benchmarks provide a rough common scale, which helps to get a “quantitative understanding” of the situation in the building stocks considered.

It can be seen that quite a few of the building stocks manage to stay below individual and/or EPISCOPE benchmarks in 2020 and even 2030 when following the trend scenario, but by 2050 they fall far short of keeping the targets.

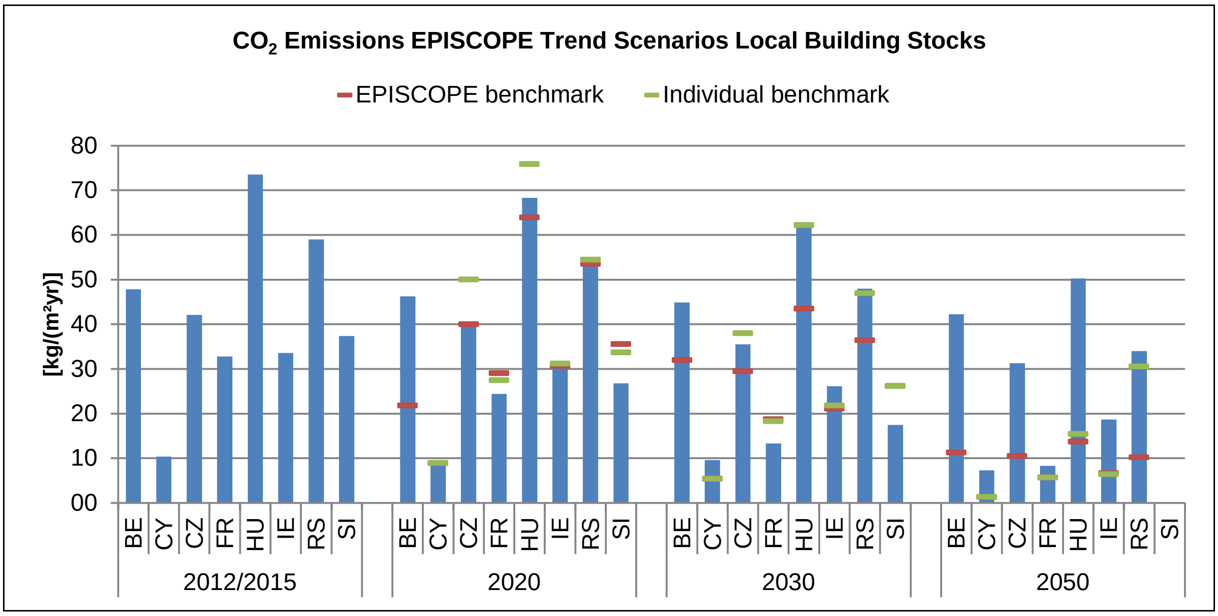


Figure 14: CO_2 emissions for space heating and domestic hot water according to the EPISCOPE trend scenarios for local building stocks, extrapolations of current improvement rates (in many cases partly based on assumptions)
(note: for BE: CO_2 emissions for space heating only)

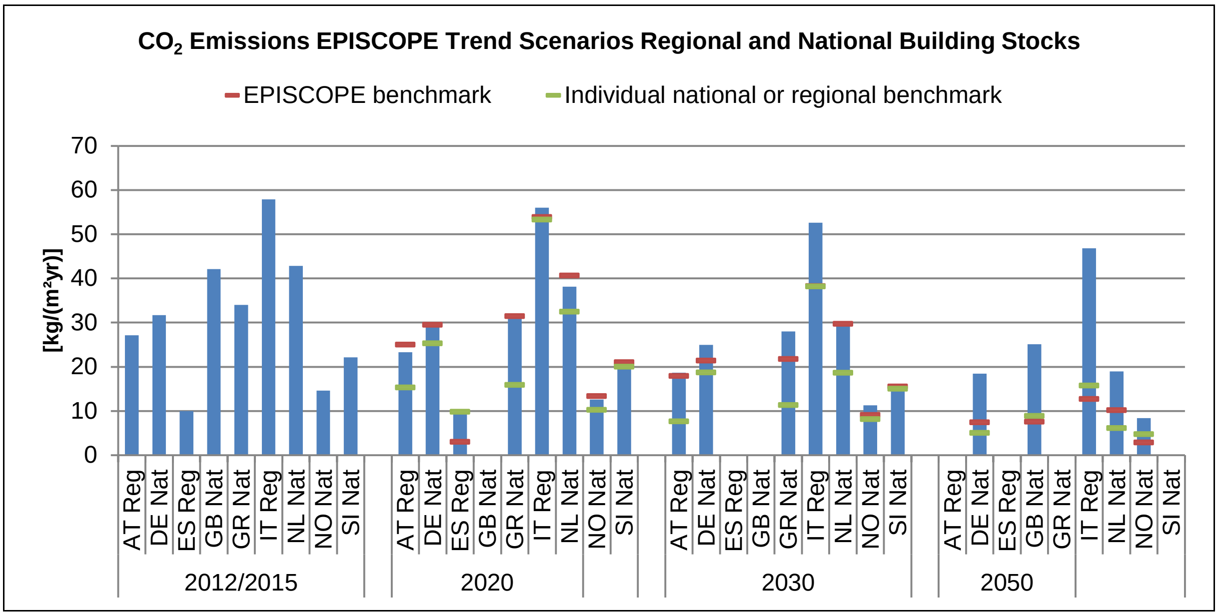


Figure 15: CO_2 emissions for space heating and domestic hot water according to the EPISCOPE trend scenarios for regional and national building stocks, extrapolations of current improvement rates (in many cases partly based on assumptions)

Apart from extrapolating current trends, different scenarios were taken into account for each of the case studies. Mainly, one moderate and one more ambitious scenario were considered; in some cases related to refurbishments of the building envelopes only, but usually also reflecting structural changes in the heat supply system. The cross section over all scenario investigations actually meeting the targets shows that the necessary technological paths to fulfil the requirements of carbon dioxide emission reduction are quite ambitious, and it can be concluded that the targets to 2050 will in general only be met by major changes in the current trends relating to insulation and heating. In many cases, refurbishment rates concerning the buildings' envelopes will at least have to be doubled. Market changes with regard to the introduction of renewables and lower energy distribution and conversion losses, aiming for an overall lower emission factor of the energy mix will be required in the general heat supply structures, and a move to lower carbon electricity generation on national scales will be needed as well as changes in building occupancy behaviour, aiming for lower energy demand and an improved energy use culture.

But without further supporting measures, the more proactive scenarios are considered to be beyond what is likely to be implemented in practice; not because of the technical realism, but due to the likely high investment costs and the low chances that the necessary number of buildings that from a (mathematical) modelling perspective are candidates for energy renovation will be actually lifted to the ambitious levels required. Target-oriented political instruments and considerable incentives therefore need to be implemented already at short term. In this context, the identification of barriers and enablers to implementation of the required technologies need further investigation.

3.2.6 Display of specific results by online tools

Integration of EPISCOPE results at the BPIE Data Hub

It has been an objective of the EPISCOPE project to make the results available publicly and freely via the BPIE Data Hub[8] throughout the life of the project and beyond. The following data and information collated in the project were integrated in the existing structure of the portal:

- **The residential building stock statistics**

  Official statistical information on the building stock characteristics (i.e. number, type of buildings, envelope performance), as well as the type of the heating systems for 20 European countries (AT, BE, BG, CY, CZ, DE, DK, ES, FR, GR, HU, IE, IT, NL, NO, PL, RS, SE, SI, UK/England) provided by the EPISCOPE and TABULA partners.[9]

- **The residential building stock modernisation trends**

  The methodological approach and the list of indicators to track the energy refurbishment progress of housing stocks have been elaborated during the EPISCOPE project [EPISCOPE Project Team 2014b]. The Energy Performance Indicators (EPI) tables that include: building insulation levels, building insulation improvements and modernisation trends for technical systems, were the basis for the new developments at the data hub. The results of 6 national case studies (AT, DE, GR, NO, SI, UK/England) elaborated by the EPISCOPE partners, including the results of the energy performance indicators (EPI) tables (see section 3.1) to monitor the thermal protection and heat supply of the residential building stock.[10]

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8 Online available at: www.buildingsdata.eu

9 See also: http://episcope.eu/building-typology/country/

10 See also: http://episcope.eu/monitoring/case-studies/

- **National building policies and regulations**

  The policy information, including building codes for new and existing buildings, as well as the nearly Zero Energy Building (nZEB) definitions for 20 of the European countries (apart from the countries included in the EPISCOPE project, information for Bulgaria, Poland and Sweden is provided). It's based on the synthesis report "Inclusion of New Buildings in Residential Building Typologies. Steps towards NZEBs exemplified for different European countries "and literature studies [IWU 2014a] and the nZEB factsheet [BPIE 2015].

In order to provide a better recognition of the EPISCOPE project and its results, a dedicated tool has been developed. It has been fully integrated and accessible through the BPIE Data Hub[11].

The EPISCOPE tool is an interactive and user-friendly website that provides a comprehensive overview of all project results for 20 European countries (including: Bulgaria, Poland and Sweden that participated in the TABULA project).

Advanced features of the Data Hub allow generating the country profiles, as well as cross-country comparisons; users can browse the search tool by topic, building type and country (that is either selected from an interactive map or the list), customise the graphs i.e. sort the by value or alphabetic, disable selected information (e.g. type of building), provide a feedback and/or download the raw data (csv, pdf).

Figure 16 presents an exemplary screen shots from the EPISCOPE tool.

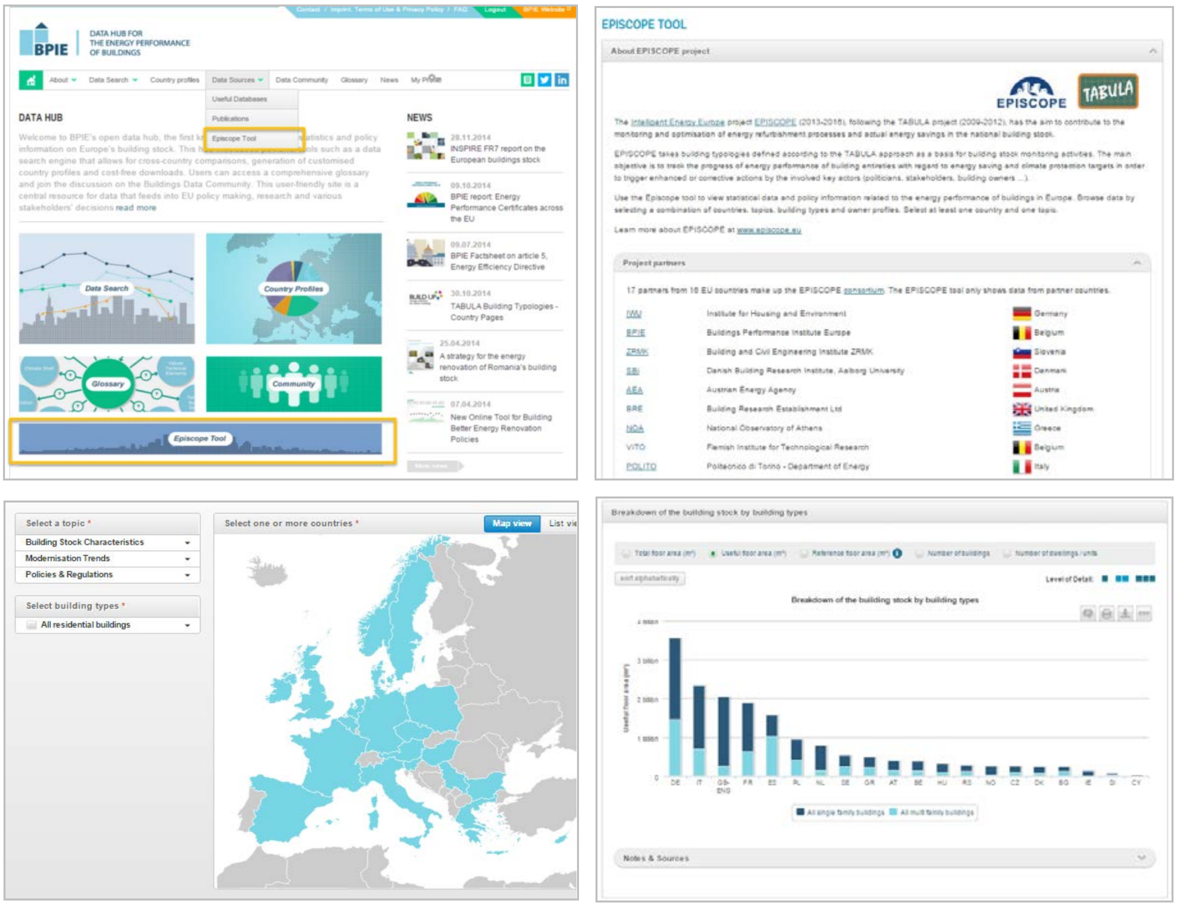

Figure 16: The EPISCOPE tool – a dedicated tool to present the project results

11 Available at: http://www.buildingsdata.eu/data-sources/episcope-data.

The BPIE Data Hub was launched prior to the start of the EPISCOPE project, thus some results had to be integrated in the existing structure of the portal. The new data sets elaborated in the project needed, however, to be harmonised and integrated (Table 4).

Table 4: List of indicators integrated in the structure of the BPIE Data Hub.

Indicator		Integration at the BPIE Data Hub
Building stock characteristics	Breakdown of the building stock by building type	Existing structure
	Breakdown of the residential buildings per age band	Existing structure
	Envelope performance: U-value per component	Existing structure
	Level of centralisation for heating and cooling systems	Existing structure
	Technical systems	Existing structure
	Energy consumption per end use per age band and per building type	Existing structure
Modernisation trends	**Building insulation levels**	**New indicator**
	Building insulation improvements	**New indicator**
	Modernisation trends	**New indicator**
Policies and regulations	Buildings codes	Existing structure
	nZEB definitions	**New indicator**

Harmonisation of the residential building typology at the BPIE Data Hub

The results of the EPISCOPE/TABULA project, such as a well-defined typology of the residential building stock, allow for further harmonisation of buildings statistics. With this in mind, BPIE revised the residential typology on the Data Hub and integrated the TABULA typology approach (Figure 17).

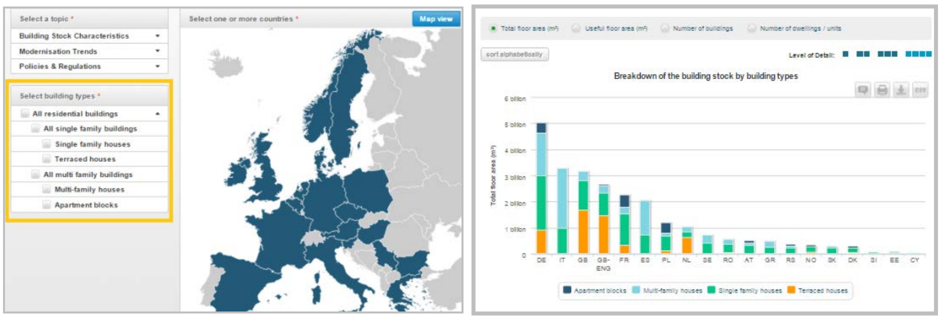

Figure 17: Residential building typology in the EPISCOPE tool and on the BPIE Data Hub

Harmonisation of the EU building stock floor area

The type of the statistical information collected across European countries differs, in particular in regards to the building's floor area. Some of the countries gather official statistics for the useful floor area, others for total, heated or living floor area. On the top of that, the definitions across countries differ. To harmonise the information in the tool, BPIE provided a differentiation by the type of floor area: useful and total/gross floor area (Figure 18). The conversion factors were based on the expert's assumptions and are specific to the country and building type.

Note: The conversion factors between useful and gross floor area are provided in the notes;

Figure 18: Total and useful floor area of building stock

TABULA WebTool

The TABULA WebTool intends to enable an intuitive easy access to the TABULA concept and its possible benefits.[12] It offers energy and building experts to interactively explore, track and understand the data and calculation included in the TABULA database. Basis of the TABULA WebTool is a simple and transparent reference procedure for calculating the energy need, the delivered energy and the energyware assessment (primary energy, carbon dioxide, costs) including a calibration to the typical levels of measured consumption.

Data and calculation results for the average buildings approach for all EPISCOPE case studies were included in the WebTool area “Building Stocks”. Here geometrical data (reference floor area, element areas) as well as U-values and heat supply structures for average buildings are displayed. Furthermore, the TABULA building stock calculation can be viewed – including all input and output data. This calculation is performed using standard TABULA boundary conditions. Furthermore, the relation of the results from the individual building stock model and from the TABULA standard calculation is determined. Under the precondition that the scenario models are validated or calibrated by real consumption values the relation separate model to simplified TABULA provides ratios for the calibration of the TABULA calculation to the typical level of measured consumption (for the given average state of the building stock subgroups).

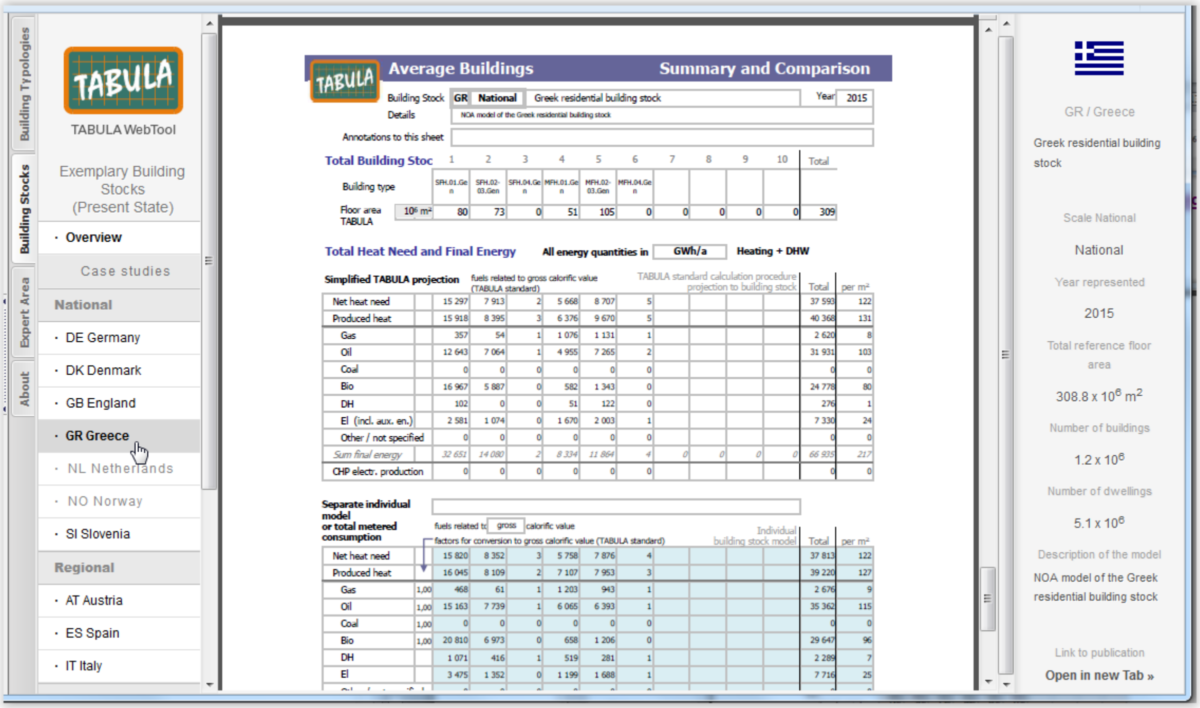

Figure 19: Example of an “Average Buildings” calculation in the “Building Stocks" section of the TABULA WebTool; *Comparison of the simplified building stock calculation with the individual scenario model*

[12] Available at http://webtool.building-typology.eu

Irish Mapping Application

At the outset of the project, the Irish partners identified the significant potential that an EPC mapping tool could add to the objectives of the EPISCOPE project. The Irish case study – monitoring energy refurbishment levels of housing stock on Northside of Dublin city – therefore also explored how mapping EPC data can assist in retrofit strategy development and planning.

The EPC mapping tool[13] uses the latest EPC records from the national EPC database. A major task was to establish a formal process for transferring the EPC records. For reasons of data protection data was aggregated to census defined boundaries, namely small areas and electoral divisions. Small areas typically comprise 50-200 dwellings and electoral divisions include clusters of small areas.

More than 20 mappings views have been created – see Figure 20. 3 sets of layer options can be selected. The first layer tier contains the EPC/BER predominant maps. The second layer tier contains building typologies by wall type. The third layer tier contains census data.

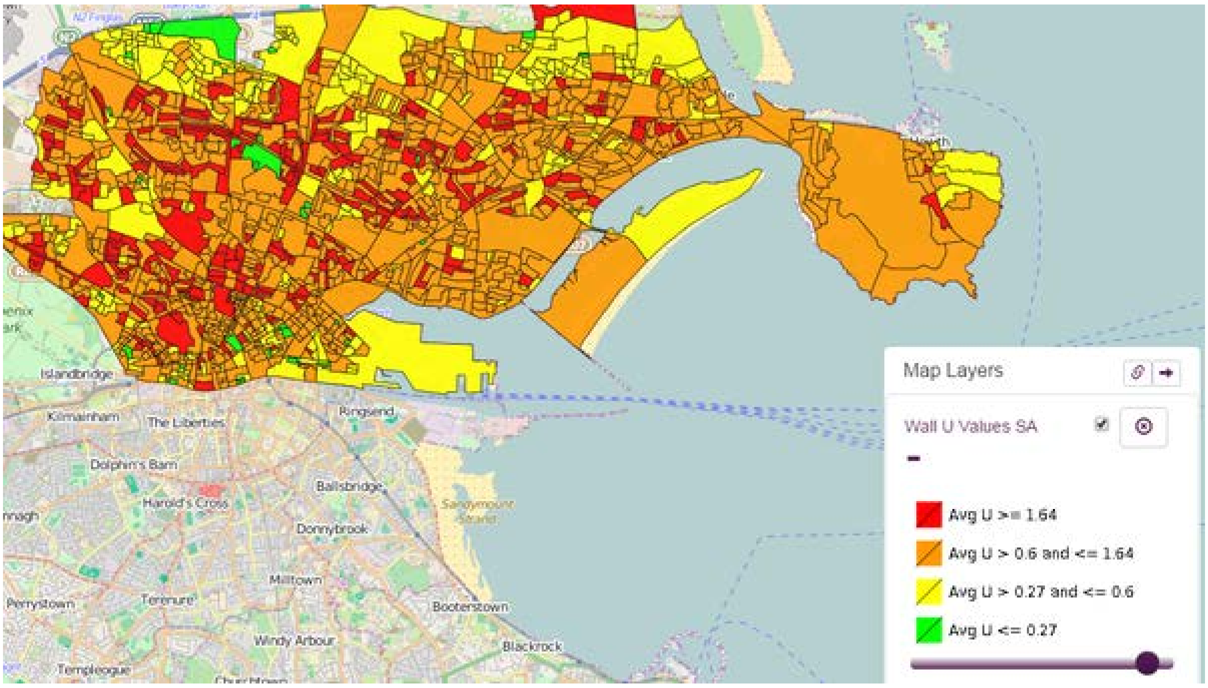

Figure 20: Current Wall U-values for the North Side of Dublin city; Map Data [@ Open StreetMap contributors]

The maps showing U-values ranges (for walls, roofs and windows) are effectively visual status indicators of the stock. As can be seen in Figure 20, the wall U-value map shows indicates which of four U-value bands apply to each small area. The bands range from the best, i.e. less than or equal to U = 0.27 W/(m²K) to the worst, i.e. equal to or greater than U = 1.64 W/(m²K). The EPC colour coding has been adopted for these maps where green is best and red is worst. What the U-value maps shows is that, based on current EPC data, most of the map is brown or red, indicating that the majority of the housing stock has poorly insulated or non-insulated walls. This map format is repeated also for roofs and windows.

[13] The EPC mapping tool is available at http://energyaction-static.s3-website-eu-west-1.amazonaws.com/index.html.
A separate Quick Guide is also available at http://episcope.eu/monitoring/pilot-actions/ieireland/ to assist first time user of the mapping application.

Hellenic tool for energy Building Stock Monitoring (eBSM)

The eBSM software[14] was created in the framework of the Hellenic case study for the EPISCOPE project. It targets the needs of policy makers needing a better insight of the energy-related profile of the Hellenic building stock as well as the means to assess different short and long term energy refurbishment strategies towards achieving the national targets in the near future and beyond. The software consists of two different tools:

1) Scenario analysis: a tool for defining and assessing different scenarios for the energy efficiency upgrade of the Hellenic building stock, incorporating current and future possible trends in demolition, construction and refurbishment of envelope and system components. Starting from year 2012 (base year), the tool makes use of the Hellenic TABULA typology and the national calculation tool to derive the evolution of a set of energy performance indicators (EPIs) for the period 2012-2030. Multiple scenario analysis of results is possible; eBSM permits the simultaneous uptake and overview of a large number of scenarios and facilitates the selection of the most successful ones in fulfilling user-specified ranges of parameters.

2) GMaps: a tool for mapping the energy features of the Hellenic building stock. It exploits the content of an EPC database for a building portfolio or national registry and displays the spatial distribution of their content on the Google Maps.

The “Multi Graphs” section (see Figure 22) is intended to facilitate monitoring and decision making by screening the calculation results with a multi-parametric overview and for selecting scenarios that satisfy userdefined criteria for selected parameters. All the corresponding data is displayed on an annual basis for each scenario, so that one can focus on variations of key parameters aiming to reach a specific target (e.g. final energy use, CO_2 emissions).

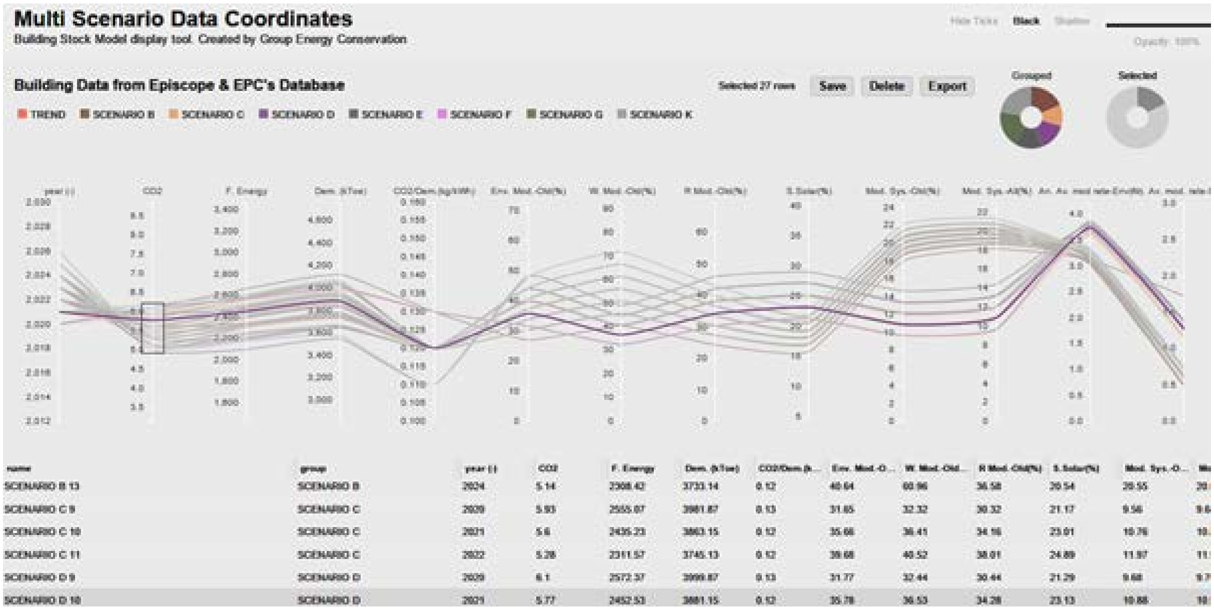

Figure 21: Hellenic tool for energy Building Stock Modelling – “Multi Graphs” section

[14] The software is available at http://www.energycon.org/instructions.htm. A user’s manual can be downloaded from http://www.energycon.org/eBSM_User%20Manual.pdf.

3.3 Development of Approaches for Continuous Monitoring

Apart from a discussion on applicable indicators [EPISCOPE Project Team 2014b], special attention was paid to the identification and discussion of available data sources including information about the considered building stocks as well as data quality, data gaps and possibilities to improve data collection [EPISCOPE Project Team 2016c]. At first glance, the question of basic data might appear secondary and more a matter of expert discussions and footnotes. But the project team considers it to be a key question, because reliable and up-to-date information is needed as a basis to control the success of already implemented measures on the one hand and the further development of appropriate strategies on the other hand.

Figure 22 shows the procedure of implementing and monitoring climate protection strategies in building stocks in schematic form: Reliable monitoring data on the building stock is needed to form a foundation for building stock models, often based on building typologies, and scenario analysis. Structural data about the existing state – e. g. the current share of wall areas already insulated – deliver the starting point of building stock modelling, while information about recent dynamics – e. g. the share of wall areas insulated per year – are necessary inputs for trend analysis. Observation of changes over time therefore not only shows if specific milestones have been reached in the past and corrective actions are needed, they also deliver important information for the further development of strategies and policy instruments. The effect of measures undertaken can in turn only be determined by means of renewed data collection and analysis. To effectively monitor a climate protection strategy this process needs to be run through several times. As a consequence, a continuous monitoring procedure to provide and analyse up-to-date information on a regular basis needs to be established.

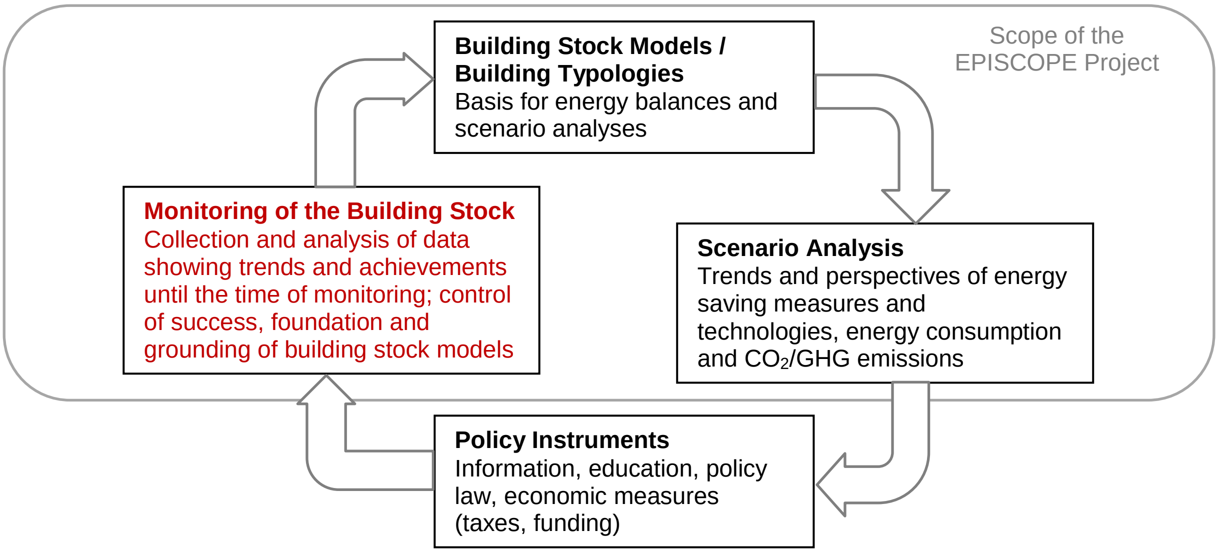

Figure 22: Scheme of the procedure of implementing and monitoring climate protection strategies in building stocks

Special emphasis was laid on the evaluation of available data sources and information on the observed building stocks. The different approaches taken by the EPISCOPE partners revealed common issues in the study of the housing stocks [EPISCOPE Project Team 2016a]. First, and foremost, the lack of reliable primary data is widespread. Data collected by census and small surveys, with some exceptions, generally is not tailored to track the refurbishment progress of building stocks in regard to achieving climate protection and energy saving targets, and can provide only a partial view of the stocks characteristics.

Empirical data resulting from observing the evolution of housing stocks can be collected from several applicable sources depending on the scale of the stock. For example, energy performance certificate (EPC) databases, which are available in some countries, might be used – to some extent – as complementary sources of information. However, data available might not be representative of the overall building stock.

The use of sample surveys was explored by some partners. Here, high-quality primary data can be obtained. Inspired in part by the English Housing Survey (EHS), which is a permanent yearly sample survey of the condition and energy efficiency of housing in England [DCLG 2014], the EPISCOPE team provided some outline of a basic survey concept for monitoring other housing stocks, illustrating also a cost saving minimal variant [EPISCOPE Project Team 2016a].

In general, such a kind of broadly based survey approach can be strongly recommended to close existing information gaps, especially on national level. According to the basic meaning of building stock monitoring for climate protection at least basic data on building insulation and heat supply should be collected. Of course one large survey cannot alone collect all interesting data and cover the complete requirements of empirical information about housing or energy efficiency in buildings, so supplementary empirical research will still be necessary.

A further identified step to increase the reliability of the energy balance methods is to obtain more realistic energy consumption estimates based on empirical data. Calibration of these energy balance models can be improved with better and more representative data acquisition.

3.4 Résumé

As one of the key elements in the EPISCOPE project, case studies concerning residential building stocks on local, regional or national level were conducted in the participating countries. A set of commonly used energy performance indicators was developed distinguishing empirically justified “monitoring indicators” and “scenario indicators” which include additional assumptions and the results of scenario analyses. The indicator scheme is supposed to enable comparisons of different building stocks, but due to the large variety of individual characteristics and scenario models it was not intended to predefine the exact data format of the concerned quantities and the way of partitioning the respective building stocks. Thus, the harmonised concept is open for individual adaptations. This approach has proved to be feasible for the EPISCOPE partners [EPISCOPE Project Team 2014b and 2016d]. Data with regards to the current state of the building stocks considered are publicly available by the BPIE data hub and the TABULA WebTool (see section 3.2.6).

The data collection and analyses concerning the current situation of the building stocks considered formed the basis to map the existing states by the commonly used “average buildings” concept as well as for the set-up of individual building stock models and the projection of different future developments. Quality and availability of the data required was discussed, and recommendations to improve the databases by applying regular monitoring concepts were compiled. It was found that currently available data sources often are not representative, incomplete, outdated, and/or inconsistent. As a consequence, there are wide information gaps concerning the actual state as well as the trends of refurbishment. Therefore, recommendations to improve the data situation by applying regular monitoring concepts were compiled [EPISCOPE Project Team 2016c].

Individual building stock models and scenario approaches were developed and compliance with EU climate and energy targets was checked for different strategies. The result is fairly straightforward: Almost all identified current trends of energy refurbishments for the building stocks considered are far from being sufficient to meet the respective climate protection goals. Therefore, major changes in the current trends relating to insulation and heating are required in order to meet the targets [EPISCOPE Project Team 2015b], [EPISCOPE Project Team 2016a-b]. In the context of the case studies, two more online tools were developed: one to map EPC data on the Northside of Dublin city, and the Hellenic tool for energy Building Stock Monitoring (see section 3.2.6).

4 Conclusions

Within the framework of the EPISCOPE project a far-reaching approach has been carried out, comprising data collection and data evaluation, the setup of building typologies and building stock models as well as the implementation of scenario analyses for building stocks of different scaling levels. Common conclusions are summarised as follows:

Enhance the data basis and implement regular monitoring procedures for European building stocks

To track and steer the progress towards climate targets in buildings stocks, a reliable and regularly updated data basis is required. Inadequate information would likely lead to failures in the implementation of requested measures and to a serious risk of falling short in reaching the anticipated impacts.

Experiences gained during the data analyses for the EPISCOPE case studies, however, showed that regular monitoring schemes were mostly not in place and the information bases for the residential building stocks considered were in many cases not sufficient to keep track of energy relevant changes and the respective energy consumption over time. Available data sources often were not representative, incomplete, outdated, and/or inconsistent. As a consequence, there are wide information gaps concerning the actual state as well as the trends concerning building thermal insulation and energy supply systems.

These information gaps cannot be closed by bringing together existing data: Suitable primary data collections will be necessary for most of the building stocks, especially when aiming to derive refurbishment rates. Regularly updated and representative sample surveys were identified to be a transferable approach for closing the information gap.

To generate acceptable bottom-up statistics at European level, national surveys need to be carried out following a common EU-wide framework. Due to various boundary conditions in different countries sample and/or survey design and the respective implementation is required on Member State level. However, to facilitate comparisons of key figures between countries a concerted data structure is required. The indicator scheme developed during EPISCOPE provides a foundation for such a collection of relevant monitoring data. Furthermore, the concept of “average buildings” provides a consistent approach to implement simple and descriptive building stock models on the basis of the collected monitoring data.

In addition to national sample surveys, supplementary data collection will be necessary. Therefore, it is also important to enhance, quality assure, and harmonise further databases (like e.g. EPC registers or databases of housing companies) - even if they only represent specific subsets of building stocks. The inclusion and verification of consumption data for example would give indication for the calibration of building stock models. Furthermore, data imports and quality checks could be simplified by defining harmonised data interfaces and the implementation of respective software solutions.

Improve support to meet EU climate and energy targets

Although the EU energy and climate framework set the emission reduction targets for non-ETS sectors, there is no definite sub-sector target for buildings (both on the EU and Member State level). Hence, for the EPISCOPE case studies, commonly used benchmarks were derived from a rough and straightforward translation of general EU climate protection targets.

The results of the EPISCOPE scenario analyses show that almost all identified current trends of energy refurbishments for the building stocks considered are far from being sufficient to meet these respective goals. Major changes in the current trends relating to insulation and heating are required. The annual rates of thermal building refurbishment will have to be significantly raised and at the same time a far-reaching change of the structure of heat supply systems will have to be achieved. In this framework electric energy will likely be of growing importance for the heat supply sector (being used in electric heat pumps and produced by CHP and/or systems using renewable energy like photovoltaics and wind energy).

On the whole, the scenario analyses towards 2030/2050 indicate that European as well as national CO_2 emission reduction targets (as far as defined) are likely to be very hard to reach in practice. Target-oriented political instruments as well as far-reaching incentives need to be implemented on national and European level. Long term strategies for mobilising investment in the renovation of national building stocks, as required in article 4 [EED 2012], clearly need to provide additional impulses to motivate stakeholders to realise the necessary changes and measures.

Implement harmonised approaches for cross-country comparisons

The variety of country specific climate conditions, ambition levels, calculation methodologies and building traditions in EU Member States obstructs quick and easy comparisons of energy performance levels as well as current or future building requirements (e.g. NZEB) and codes between European Member States. To carry out cross-country comparisons, e.g. with the intention to track the status and development of different building stocks or the transition to NZEBs, harmonised approaches for data collection, benchmarks and energy balance calculations are needed.

Several results and tools developed during EPISCOPE are well-tailored for such a purpose. The common framework for energy performance indicators, for example, has proved to be manageable to document relevant indicators of the EPISCOPE case studies following a structure that could furthermore be transferred into the BPIE Data Hub.

Moreover, the TABULA data structure and calculation method aims to harmonise and display different energy related values e.g. energy need for heating, final energy, primary energy, CO_2) for single buildings as well as for building stocks. Comparable to the inclusion of the requirement to establish reference buildings in the regulations supplementing the EPBD 2010 [EC 2012a], [EC 2012b], the average buildings concept could be established for encompassing overviews of national building stocks as e.g. requested in article 4 [EED 2012].

Specify benchmarks and top runner concepts for NZEBs

The assessment of the example buildings for residential building typologies shows that insulation levels for the most ambitious variant investigated - including NZEB requirements as far as already defined - are generally comparable with the Passive House standard. But not in all countries Passive House windows and/or ventilation systems with heat recovery are considered. These findings are in line with those of the IEE project ENTRANZE [ENTRANZE consortium 2014], which concluded that because cost-optimal and NZEB levels are equated in many European countries the impact of the NZEB requirement is reduced and does not present a breakthrough for more ambitious standards for new buildings.

Guiding benchmarks for the “nearly zero or very low amount of energy required” according to [EPBD 2010] might help to clarify the initial intention of the directive and adjust these figures with the requirements to meet climate and energy targets. To ensure satisfactory results in practice, the actual energy consumption of NZEBs should be monitored to verify if the performance is in line with the calculated expectations. These new build benchmarks would also offer the opportunity to regularly reconsider and optimise the legal requirements by using building concepts with the best actual performance as a reference for the new level – similar to the top runner approach for improving the energy efficiency of end-use products.

All publications produced during EPISCOPE are downloadable from: http://episcope.eu/communication/download/

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