Tracking of Energy Performance Indicators in Residential Building Stocks – Different Approaches and Common Results

- EPISCOPE Synthesis Report No. 4 -

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1 Introduction

(by EPISCOPE partner IWU)

The EPISCOPE project, co-funded by the Intelligent Energy Programme of the European Union, is a collaborative effort of 17 partners from 16 European countries, and one associated partner without EU funding. A central task was to carry out energy balance calculations and scenario analysis for national, regional or local residential building stocks against the background of energy saving and climate protection targets. The results of these case studies are documented in the separate EPISCOPE Synthesis Reports No. 2 (local building stocks) [EPISCOPE Project Team 2016a] and No. 3 (national/regional building stocks) [EPISCOPE Project Team 2016b].

This EPISCOPE Synthesis Report No. 4 documents the individual approaches of collecting information for the investigated residential building stocks as a foundation for building stock models and scenario calculations. Issues related to the availability of data and data quality are discussed, and concepts for a continuous monitoring (a regular data collection) are presented as a basis for a future tracking of energy performance in the observed building stocks.

At first glance, the quest for basic data might appear to have secondary importance and more suitable as a topic of expert discussions and footnotes. But during EPISCOPE an emphasis was placed on this issue because the project team considers it to be a key issue of climate protection strategies: Without reliable and up-to-date information the whole discussion remains without a solid basis, and to a considerable extent lack of basic knowledge currently characterises the majority of European building stock databases.

Figure 1 provides a general scheme of climate protection strategies and the central role of monitoring. Up-to-date monitoring data is a first step of model development and scenario analysis delivering basic information of the observed building stocks. Structural data about the existing state (e.g.: How many m² of walls have already been insulated?) are necessary to deliver a starting point of building stock modelling. Information about the current development (e.g.: How many m² of walls are insulated per year?) are necessary inputs for trend analysis.

The development of building stock models (often based on building typologies) and their application for scenario analysis intend to provide sufficient results to show possible future paths, which will lead to complying with the climate protection targets. This is still within the scope of the EPISCOPE case studies, which started from the analysis of available monitoring data, continued with model formation or adaptation, and finally to the assessment of concrete scenarios for the investigated building stocks.

The last and essential step of a climate protection strategy (beyond the scope of EPISCOPE) is the development and establishment of policy instruments for climate protection. At that stage, theory has to come to practice. Nevertheless, the theoretical results, along with the selected paths towards climate protection which were identified by scenario analysis, are a crucial input to the discussion of instruments because they define the targets which have to be achieved (e.g. How many walls have to be insulated per year?).

However, the success of policy instruments can hardly be predicted. Usually the effect can only be measured ex post. Once again, this task has again to be performed by data collection. At this point the information circle shown in Figure 1 is closed: Data of the observed building stock is the starting point of model and scenario formation and at the same time it shows the success of the already established instruments. For defining a successful and sustainable climate protection strategy this circular process has to be repeated several times. Data collection at one point in time is not sufficient, regular monitoring has to be established, which after a couple of years delivers new and up-to-date information on the progress of energy saving and climate protection measures in the building stock.

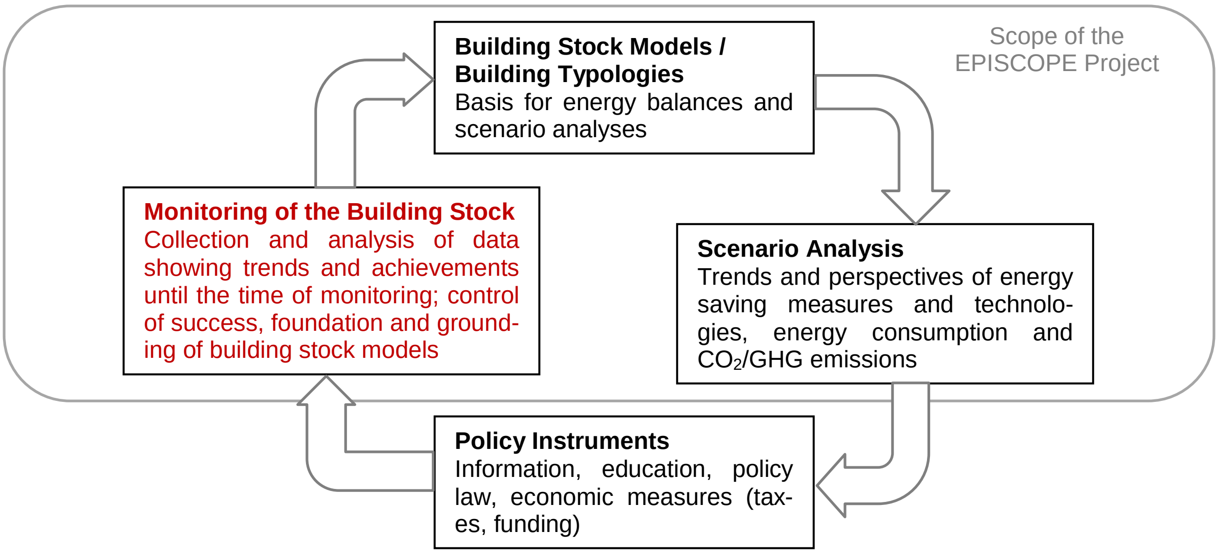


Figure 1: Schematic picture of climate protection strategies for a building stock

Apparently, the described process of climate protection strategies is very complex and deals with a lot of uncertainities. Scenario analysis depends on many assumptions about future development so that different approaches lead to different results and reaching conclusions is difficult. However, these difficulties should not prohibit implementation efforts or lead to the temptation of treating everything (including current building stock data) as more or less arbitrary. On the contrary, data collection and monitoring provides the opportunity to objectify the process. It can fulfil the task of bringing the whole discussion down to earth by providing a linkage between real developments and theoretical models. From the scientific perspective, the analogy is similar to the role that experiments play during the development of theoretical models. But also practical policies need this control of success as a factor of adjustment.

Accordingly the role of monitoring has to be strengthened in the future. It is more than obvious that special attention has to be paid to certain key questions, i.e. how reliable the available data is and how representative it is for the observed building stock.

As described, the monitoring of residential building stocks on the one hand has to deliver structural data showing the development of thermal protection. On the other hand, the energy consumption of the buildings is also important information, which was considered in the EPISCOPE data collection and monitoring concepts. On national level usually a break-down of the total energy balance for the different end-use sectors (including households) is available, which can be used for the calibration of energy balance models. Nevertheless, the energy consumption data alone are not sufficient for monitoring, although it can be used to derive CO_2 and greenhouse gas emissions. One reason is that the observed curves of annual energy consumption are usually not easy to interpret, e.g. because of uncertainties of weather correction, so that short term development can hardly be quantified. But even more relevant is the fact that by only looking at energy consumption does not provide information on the reasons, which cause the observed development. Thus both, structural as well as energy consumption data have to be considered.

During the EPISCOPE project the question of data collection and monitoring played a prominent role in different tasks and subtasks.

- An overview of available statistics of national residential building stocks (showing the data as well as the data sources) was already provided in the TABULA project. It was updated and complemented during EPISCOPE [EPISCOPE Project Team 2016c].
- A set of Energy Performance Indicators for building stocks was developed by the EPISCOPE project team, which makes possible a detailed documentation of input and output data of scenario analysis [EPISCOPE Project Team 2014], [EPISCOPE Project Team 2016d]. Within this concept there is a clear separation between monitoring indicators (which are derived from reliable primary data sources) and scenario indicators (which should be based on the monitoring indicators but may adapt and complete them according to the necessities of model formation). This approach aims at making transparent to which extent the building stock energy balance models are based on empirical data and to which extent additional assumptions were necessary.
- In the EPISCOPE case studies special attention was paid to the question of data availability of the observed building stocks (on national, regional or local level, respectively). An evaluation of the available data sources was provided as well as concepts for improving the situation - to close existing information gaps and approach the aim of a regular monitoring.

Chapter 2 of this report gives a detailed overview of the experiences and concepts of the different EPISCOPE case studies. Chapter 3 introduces the BPIE data hub, an online tool providing information on European building stocks. Enhancements were carried out during EPISCOPE, inter alia by integrating results from the project in the data hub. Chapter 4 provides a summary of the EPISCOPE experiences and results concerning monitoring of residential building stocks.

Table 1: Sources / References Introduction

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[EPISCOPE Project Team 2014]	Diefenbach, N., Loga, T.Stein, b. (ed.) (2014): Energy Performance Indicators for Building Stocks – First version / starting point of the EPISCOPE indicator scheme, EPISCOPE Project Team, March 2014, Available at: http://episcope.eu/fileadmin/episcope/public/docs/reports/EPISCOPE_Indicators_FirstConcept.pdf [2015-10-05]	EPISCOPE report on energy performance indicators for building stocks
[EPISCOPE Project Team 2016a]	Stein, B., Loga, T., Diefenbach, N. (ed.) (2016): Scenario Analyses Concerning Energy Efficiency and Climate Protection in Local Residential Building Stocks. Examples from Eight European Countries – EPISCOPE Synthesis Report No. 2. Institut Wohnen und Umwelt, Darmstadt. Available at: http://episcope.eu/fileadmin/episcope/public/docs/reports/EPISCOPE_SR2_LocalScenarios.pdf	EPISCOPE Synthesis Report No. 2 on scenario analyses in local building stocks (portfolios of housing companies, municipalities, city quarters)
[EPISCOPE Project Team 2016b]	Stein, B., Loga, T., Diefenbach, N. (ed.) (2016): Scenario Analyses Concerning Energy Efficiency and Climate Protection in Regional and National Residential Building Stocks. Examples from Nine European Countries – EPISCOPE Synthesis Report No. 3. Institut Wohnen und Umwelt, Darmstadt. Available at: http://episcope.eu/fileadmin/episcope/public/docs/reports/EPISCOPE_SR3_RegionalNationalScenarios.pdf	EPISCOPE Synthesis Report No. 3 on scenario analyses in regional and national residential building stocks
[EPISCOPE Project Team 2016c]	Institut Wohnen und Umwelt (ed.) (2016): TABULA Building Typologies – Country Pages. Available at: http://episcope.eu/building-typology/country/ [2016-02-03]	Country Pages including statistical data on the combined TABULA/EPISCOPE website

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[EPISCOPE Project Team 2016d]	Diefenbach, N.; Loga, T.; Stein, B. (ed.) (2016): Application of Energy Performance Indicators for Residential Building Stocks Experiences of the EPISCOPE project, March 2016. http://episcope.eu/fileadmin/episcope/public/docs/reports/EPISCOPE_Indicators_ConceptAndExperiences.pdf	EPISCOPE report on the application of energy performance indicators for building stocks

2 Energy Performance Tracking

(Introduction by EPISCOPE partner IWU)

The following sections elaborate the situation of building stock monitoring for the EPISCOPE case studies (also called “pilot actions”), which were carried out on national, regional or local level in the participating countries, some of them dealing with special building stocks (e.g. non-profit rental housing). Each section includes a short introduction to the building stock in question, then the existing data sources are described and evaluated. At the end of each section, concepts for closing information gaps and introducing a regular monitoring scheme are described.

2.1 <AT> Austria

Regional Residential Building Stock of Salzburg

(by EPISCOPE partner AEA)

Observed Building Stock

The optimisation of energy efficiency in existing buildings and the construction of energy-efficient new buildings including energy supply have a central and indispensable role in reaching the climate protection goals. The Austrian EPISCOPE pilot project examines the energy consumption and the development of the energy demand of the residential buildings in the province of Salzburg. This province ("Bundesland") is one of the pioneers in implementing energy efficiency in building regulation, providing consultation in retrofit activities and subsidy programmes in Austria. Since 1993 ecology and energy efficiency has been an important part of housing incentives in Salzburg.

Table 2: Scope of the observed building stock in <AT> Austria
*****[Statistik Austria 2014a]; **[Kurz/Filipp 2014]

Scale	No. of dwellings	No. of buildings	No. of inhabitants	m² national reference area	m² EPISCOPE reference area
Regional	> 282,800*	> 120,400*	534,270**	~20.9 million (living area)[1]	~23 million

In the recent years, the energetical quality of the residential buildings has improved thanks to incentives for better thermal envelope and use of biomass and renewables in the heating system. The evaluation of the EPC database ZEUS[2] [ZEUS 2015] shows that the space heating demand of new buildings in 2013 has decreased significantly as compared to buildings built after 1995.

Over 78,600 of the residential buildings in Salzburg were built before the 1980s, and the majority of these between 1960 and 1980. About half of the buildings are single family houses.

Table 3: Number of residential buildings built till 1990 [Statistik Austria 2004]

Age band	Before 1919	19191-1945	1945-1960	1960-1980	1980-1990
Number of Buildings	13,041	8,319	16,917	40,332	18,466

Evaluation of Data Sources for the Observed Building Stock

In the project for the observed building stock different sources of data have been used:

- ZEUS EPC database (including the data from GECKO-GEQ which is the onsite consulting tool and Energy accounting programme)
- Statistic Austria
- National reports on the energy use in different sectors in Austria

[1] According to [Statistik Austria 2004], the average m² per dwelling in Salzburg is about 88 m².
[2] EPC database ZEUS is used by the Salzburg municipality for storing and evaluating the EPCs.

Energy performance certificate database ZEUS

In Salzburg, the online energy performance certificate (EPC) database ZEUS was introduced in 2004 to collect and statistically analyse data on the building stock, refurbishment measures, and the development of energy efficiency of buildings [ZEUS 2015].

The ZEUS database has a technical interface that allows the upload of EPC data from all EPC calculation programmes available on the Austrian market. Using an open XML format, an average of 400 data fields is registered for each building, depending on its type and characteristics. These data describe the building envelope, the building service (heating and domestic hot water) system, and the energy indicators calculated in the EPC, allowing them to be analysed. Along with different “building types”, it also records the building history to make it possible to measure the improvement of the building stock through refurbishment over given periods of time. The EPC can be classified by so-called filing purposes. EPCs can be filed, e.g., for the purpose of applying for housing promotion subsidies or construction permits, or for selling or renting out property. This makes it possible to relate improvements gained by new construction or refurbishment projects to promotion schemes and the Building Code. The ZEUS database encompasses both residential and non-residential buildings. The main motives for the data collection for residential buildings are housing promotion subsidies for individuals and non-profit housing associations, and the administration of provincial and municipal property for non-residential buildings.

In 2012, the data standard of the ZEUS database was extended to include refurbishment recommendations due to energy consulting activities. This standard is based on the requirements for the EPC to ensure maximum comparability. It includes the status quo of building data as well as calculations of the energy-saving potential of possible refurbishment measures, with the financial investment correlated with the achievable increase in energy efficiency.

The software solution for collecting these energy consulting data is called “GECKO”. The electronic consulting tool is used in Land Salzburg to support on-site energy consulting and supports project management for new construction and refurbishment projects. The programme uses the same calculation methods as the EPC programme (QEQ) but with simpler data input to allow the quick calculation of energy savings that could be achieved with different refurbishment measures during initial energy consultations.

A module for the recording of meter readings (energy accounting) was integrated into the ZEUS database in April 2013 in order to compare the calculated energy demand with the actual energy consumption. Individuals receiving direct subsidies for innovative climate-relevant building service systems (HVAC) receive higher subsidies if they enter the meter readings into the system. All e5 municipalities (the e5 programme supports municipalities to review their energy policy, to develop energy policy objectives and implement concrete energy and climate protection measures) in the province of Salzburg are obliged to record their energy consumption in the system [AEA 2015b]. Many non-profit housing associations, including GSWB – Gemeinnützige Salzburger Wohnbaugesellschaft m.b.H., have also joined the pilot project.

The data in the database ZEUS Salzburg are analysed and recorded by the Salzburg Provincial Administration for the quality assurance of EPCs and the granting of subsidies.

In the EPC database ZEUS the U-value for the whole building (mean U-value) is collected and not the U-value of the individual building elements (e.g. external walls and windows). Therefore the share of insulated walls, ceiling or replaced windows, is not recorded.

There have been over 34,430 datasets collected in the ZEUS EPC database. They include the EPCs of the 3 provinces – Salzburg, Styria and Carinthia – sharing this database. The data is regularly evaluated statistically (e.g. development of the space heating demand of the buildings) and these can be found on the website of the database. For the project the share of the EPCs of the residential buildings for Salzburg has been considered. The EPCs are mainly of the buildings applied for grants (subsidies), newly constructed and recently purchased buildings.

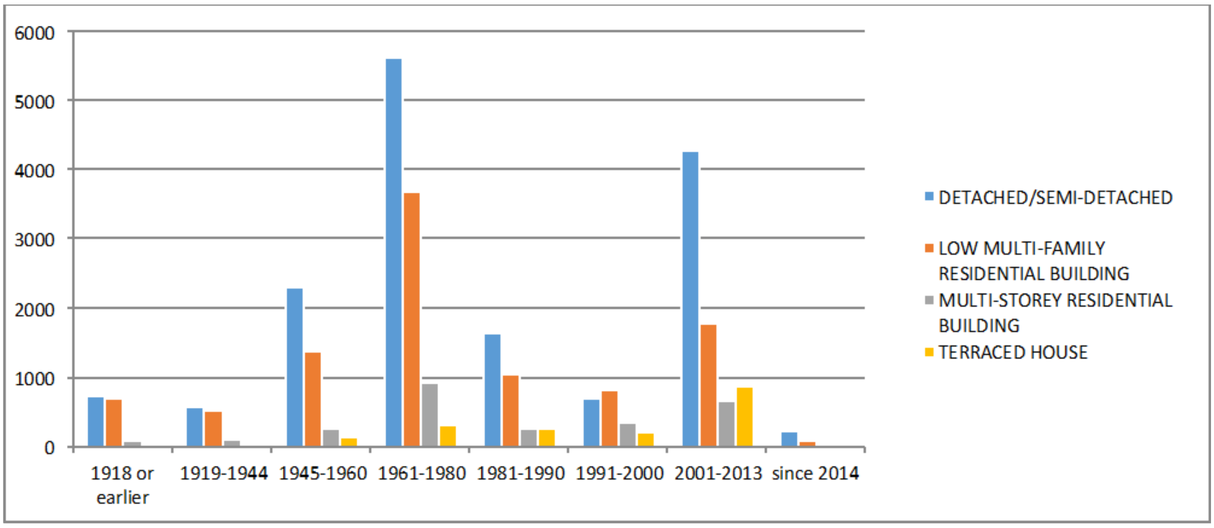


Figure 2: Number of energy performance certificates in the database ZEUS Salzburg [AEA 2015a]

GECKO-GEQ

The electronic consulting tool GECKO is used in Salzburg to help home owners with on-site energy consulting and supports in project management for new construction and refurbishment projects. Between 2012 and the cut-off date 10 July 2014, 4,707 GECKO consultation protocols were uploaded to the ZEUS database.

Energy accounting project

Since April 2013, Salzburg has been supporting online energy accounting via the ZEUS database. The goal is to be able to compare the energy required for space heating and domestic hot water as calculated in the EPC directly with the actual consumption.

The energy accounting module of the ZEUS database makes it possible to create data records for buildings with any number of meters for energy generation (e.g. solar-thermal energy or heat pumps) and energy consumption (e.g. of fossil fuels, district heating or electricity). When adding a meter, the system asks for which purpose the energy is used. Once a meter has been created, the readings must be updated in the database at regular intervals. The data can be entered by individuals or property management companies, or updated automatically via an interface where the daily meter readings are sent by e-mail.

As an incentive for the categories of detached, semi-detached and low multi-family residential buildings, participants receive higher direct subsidies for innovative climate-relevant building technology systems. There are about 277 buildings – mainly apartment buildings – Involved in this programme till the beginning of 2015.

Unfortunately the portion of useable information for the Austrian pilot project was not sufficient for the comparison of the real energy consumption with the energy demand and calculation of service factor. This is due to the lack of regular maintaining of the data and short span of time.

Statistic Austria

For the pilot project the information about the number and area of the dwellings as well as buildings related to the category (single family and multi family houses and apartment buildings) and their age band (building stock and newly constructed) was adducted from Statistic Austria. The amount of energy and type of energy carrier used in the residential building sector among many other data is collected each year in the Statistic Austria database [Statistik Austria 2015]. These have been integrated also in the study.

National reports

The information on the thermal renovation of the buildings in Austria is collected through the annual report of the provinces in context of “15a B-VG” agreement[3]. The passage on the thermal insulation concerns the number of dwellings and not the area (m²) of affected building elements. The development of renovation rate of the buildings used in the study has been specified also in this report [BMLFUW 2015].

Approaches / Concepts for Establishing a Continuous Monitoring

With the current data status, **enormous effort** is required to consolidate the selected **refurbishment measures, achieved reduction of energy demand, and the U-value of the building components in question**. This makes it nearly impossible to identify which refurbishment measures generated which results. As refurbishment measures are generally done cumulatively, future data standards must include a **clear definition of individual building components** and list the energy status before and after refurbishment for each component.

Some functions of the data entry in database could be modified in order to ensure the improved quality of the data and the statistical analyses based on them (currently it is difficult to separate the multi-family houses and apartment buildings, therefore the detailed evaluation cannot be applied easily to these two types). This includes more **plausibility checks** addressing similar issues.

The EPCs are linked to individual addresses in the ZEUS database through geocoding. For each address, one legally binding EPC and any number of planning EPCs can be registered. Planning EPCs can be created for different purposes, such as housing promotion or construction permits. Currently, **extensive** and **error-prone data cleaning** is required to be able to derive a clear building history without redundancies from this data structure. The data structure should be improved to ensure that the creation of an EPC for a completed project (e.g. refurbishment) is automatically considered to be an update of the certificate for existing buildings in the building history. This is currently not the case, as EPCs for existing buildings must be declared manually and can be created for different purposes. This does not reflect reality and should therefore be changed in the structure of the database. Despite the comprehensive definition of existing buildings it is necessary to have **clear delimitations** so that results can be linked to different purposes and measures to ensure that it is possible to evaluate the results of political instruments such as housing subsidies.

The energy accounting function in the ZEUS database where users enter the meter readings should be simplified to avoid confusion between individual elements. A **meter matrix** must be created for each building to allow for assessing the relevance of the entered energy data. The current data structure does not show how many energy meters there are in a building. Therefore, it is not possible to determine whether the values entered refer to total or only partial consumption (e.g. only space heating without hot water or only grid energy excluding energy generated on site with photovoltaics, etc.). Based on the data of the EPC it should be possible to develop a meter matrix that requires the user to enter certain meters for a building to have minimum requirements for data entry. The intervals at which readings are entered must be reduced to make it possible to evaluate data continuously throughout the year. Currently, consumption data can only be evaluated for individual examples due to insufficient incentives or requirements to supply data. A **legal obligation** might improve the situation. In order to **minimise the effort** for property owners, property management companies and developers, the implementation of automatic interfaces for meter reading updates should be promoted further and they should be linked to **smart metering systems**, while respecting data protection and privacy.

[3] Agreement between Federal State and Austrian provinces on measures in building sector to reduce CO_2-emissions

The content and outcomes of the survey on “Current Refurbishment State and Energy Performance of Residential Buildings in Land Salzburg” is conveyed to the stakeholders by holding stakeholder meetings and workshops. To achieve goals by 2020 the cooperation of the federal government, the Salzburg municipalities, energy suppliers and the people of Salzburg is absolutely necessary.

Sources / References <AT> Austria

Table 4: Sources / References <AT> Austria

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[AEA 2014]	Tretter, H./Krutak, R./Zach, F./Krutzler, T/Ibesich, N. (2014): Potenziastudie zum „Masterplan Klimaschutz & Energie 2020“. Österreichische Energieagentur/Austrian Energy Agency (AEA), Wien	A study on the potencials of the master plan for the climate protection and energy 2020
[AEA 2015a]	Altmann-Mavaddad, N./Simander, G./Solacher, E./Tretter, H. (2015): Energetische Qualität und Sanierungstrends des österreichischen Wohngebäudebestands mit Folus auf die Sanierungsentwicklung in Salzburg. Österreichische Energieagentur, Wien. Available at: http://episcope.eu/fileadmin/episcope/public/docs/pilot_actions/AT_EPISCOPE_RegionalCaseStudy_AEA.pdf [2015-11-09]	Analysis oft he renovation activities and strategies in Salzburg 2015 (Austrian case study in EPISCOPE)
[AEA 2015b]	Österreichische Energieagentur – Austrian Energy Agency (ed.) (2015): e5-Programm für energieeffiziente Gemeinden: http://www.e5-gemeinden.at [2015-05-28]	E5 Programme for energy efficient communities
[BMLFUW 2015]	Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (ed.) (2015): Maßnahmen im Gebäudesektor 2013, Bericht des Bundes und der Länder nach Art. 15a B-VG Vereinbarung BGBL. II Nr. 251/2009. Wien. www.bmlfuw.gv.at [2015-05-28]	Measures in building sector, Report of the Federal State and the Provinces according to the 15a B-VG Agreement
[Kurz/Filipp 2014]	Kurz, Peter/Filipp, Gernot (2014): Bevölkerung Land Salzburg Stand & Entwicklung 2014. Available at: http://www.salzburg.gv.at/statistik_daten_bevoelkerung_2014.pdf [2015-06-19]	Status and development oft he population oft he province of Salzburg 2014
[Statistik Austria 2004]	Statistik Austria (ed). (2004): Gebäude- und Wohnungszählung. Hauptergebnisse Steiermark, Wien, Verlag Österreich, Available at: http://www.statistik.at/web_de/services/publikationen/7/index.html?includePage=detailedView&pubId=123&sectionName=Wohnen [2015-05-28]	Statistic Austria building and dwellings ‘register 2001
[Statistik Austria 2014a]	Statistik Austria (ed.) (2014): Wohnen: Zahlen, Daten und Indikatoren der Wohnstatistik 2013. Available at: http://www.statistik.at/wcm/idc/idcplg?IdcService=GET_NATIVE_FILE&RevisionSelectionMethod=LatestReleased&dDocName=102995 [2015-06-24]	Statistical data on residential buildings 2013
[Statistik Austria 2014b]	Statistik Austria (ed.) (2014): Energetischer Endverbrauch 2013 nach Energieträgern und Nutzenergiekategorien für Österreich (NEA), Available at : http://www.statistik.at/web_de/statistiken/energie_umwelt_innovation_mobilitaet/energie_und_umwelt/energie/nutzenergieanalyse/index.html [2015-06-24]	Final energy consumption 2013 according to enery carriers and usage categories for Austria
[Statistik Austria 2015]	Die Institution STATISTIK AUSTRIA - Aufgaben und Grundsätze seit 2000	Statistic Austria, institution for compiling statistics since 2000
[Tretter, et al. 2014]	Tretter, H./Krutak, R./Zach, F./Krutzler, T/Ibesich, N. (2014): Potenziastudie zum „Masterplan Klimaschutz & Energie 2020“. AEA, Wien	A study on the potencials of the master plan for the climate protection and energy 2020
[ZEUS 2015]	ZEUS gizmocraft, design and technology GmbH (ed): Energieausweis Datenbank: http://energieausweise.net/technik [2015-05-28]	Austrian EPC database

2.2 <BE> Belgium

Housings block in the Sint-Amandsberg district of the city of Ghent

(by EPISCOPE partner VITO)

Observed Building Stock

Sint-Amandsberg is a district close to the city centre of Ghent. The project area is defined by the Land van Waaslaan in the North, the Schoolstraat and the Adolf Baeyensstraat in the East and the Dendermondsesteenweg in the South and West. In this project area of about 2000 dwellings, 200 were selected, mainly located in the building block that is marked by Engelstraat, Doornakkerstraat, Verbindingstraat and Wittemolenstraat, complemented with dwellings from the surrounding streets.

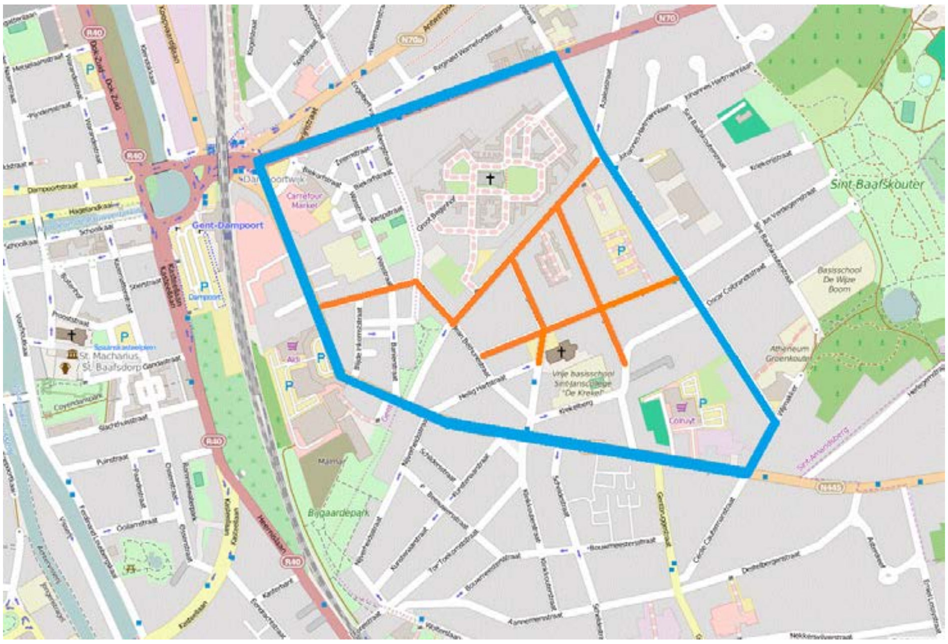


Figure 3: Project area with indication of the building block in the district op Sint-Amandsberg; Map Data [© OpenStreetMap contributors]

The project area is a part of the 19th century belt of the City of Ghent, which consists, like in many other Belgian cities, mainly of single family houses with bad energy performance and low quality. They mainly are terraced houses of approximately 4 m wide with 2.5 stories and an inclined roof. The front masonry façade has a door and one window on the ground floor, 2 windows on the first floor, and 2 windows halve the height on the second floor. This second floor is situated partly under the roof, resulting in 2.5 stories. Some of the houses already had renovation work done, which in some cases resulted in an adjustment of window dimensions.

Table 5: Scope of the observed building stock in housing blocks in the Sint-Amandsberg district of the city of Ghent [all data derived from the pilot pronect]

Scale	No. of dwellings	No. of buildings	No. of inhabitants	m² national reference area	m² EPISCOPE reference area
local	200	200	±500*	±38400** gross floor area	±32640

* The average family size of the investigated households is 2.5

** The average floor area of the investigated dwellings is 192 m².

Evaluation of Data Sources for the Observed Building Stock

User data on district level of residential consumers of natural gas and electricity were provided under condition of confidentiality from EANDIS. Electricity use and use of natural gas in 2010, 2011 and 2012 was provided with the restriction of houses that withdrown concent.

Primary building characteristics like age band, geometry and building type on individual level are available in the GIS application of the city of Ghent. These data were combined with visual inspection from the public domain and through Goolge maps and Google streetview. Internal zoning was based on the publication 'Smal Bouwen, Ruim Wonen' from the city of Ghent [Stad Gent 2013].

A limited amount of data on the inhabitants like the number of inhabitants, their age and profession were provided by the city of Ghent under condition of confidentiality. These data were a first step towards the definition of different user profiles to consider their impact on the energy use.

Complementary to the above mentioned sources, a survey was conducted to obtain additional specific data on building characteristics, user behaviour and interpretation of the energy consumption. 50 dwellings were surveyed through personal visists by architects, who where thus able to also inspect the current state of the dwelling. Both visits during the day time as in the evening were made, to reach both people that are home during the day as well as people that go out to work.

The survey had 15 basic questions on general items, like the profile of the inhabitants, the building envelope and its technical installations and the energy use. These basic questions also gauge at already implemented renovation measures and, combined with the profound of estimation of the surveyer being an architect, resulted in A to D rates for the different building elements (façades, roofs, floor, windows). The survey also had 15 more detailed questions to better interprete the real energy use and the user behaviour. These detailed questions cover ventilation installations and habits, energy for cooking and possible high volume energy consumers, heat losses to the neighbours, and user behaviour regarding room heating and use of domestic hot water.

Besides the mandatory basic and detailed questions, the survey also had an optional social part, questionning the current family composition, their professional activities and related income, health issues and information on rent or purchase price of the homes.

Approaches / Concepts for Establishing a Continuous Monitoring

In order to set up a proper monitoring strategy, there is need for extra sources that were not available for the pilot project. These include data on the renovation measures already taken on building level. Data for renovation measures for which grants were awarded exist but are not made available for research purposes. Also renovation measures for which no grants are awarded are valuable for research, if listed by the supply side.

Also information on dwellings that have a tax benefit due to executed energy renovation measures were not available at the time of the pilot project, but could contribute to a monitoring platform once they are cleared for research. Other useful existing sources are data on dwellings for which a renovation grant was asked. These data are gathered by the government but not available.

The EPC database containing information of all buildings for which an EPC was made (buildings for sale since November 2008 or for rent since January 2009) is not public but could contribute to a monitoring platform. Also information on building permits for renovation works and their according EPB information is not available at the time, but can be very useful for monitoring purposes.

To set up a monitoring platform, the data sources listed above should be made available by their owners for research purposes. It also should be investigated whether or not these data can be updated on a regular basis. Also, the processing of the data should be discussed with stakeholders, to ensure processing of the defined indicators in a uniform way. Also technical and financial specifications of the monitoring platform need to be taken into account.

Sources / References <BE> Belgium

Table 6: Sources / References <BE> Belgium

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[© OpenStreetMap contributors]	Map Data available under the Open Database License: Copyright and Licence available at: www.openstreetmap.org/copyright [2015-08-12] Open Data Commons Open Database License (ODbL) available at: www.opendatacommons.org/licenses/odbl [2015-08-12]	
[Stad Gent 2013]	Stad Gent (2013): Smal bouwen, Ruim Wonen. 21 inspirerende verbouwmodellen, Gent. Available at: https://stad.gent/sites/default/files/page/documents/Webversie%20sept%202013_0.pdf [2015-08-13]	Brochure of the city of Ghent with possible renovation solution for common types of terraced houses that are available in the city.

2.3 <CY> Cyprus

Housing Stock of the Cyprus Land Development Corporation (CLDC)

(by EPISCOPE partner CUT)

Observed Building Stock

The observed building stock belongs to the Cyprus Land Development Corporation (CLDC), one of the largest housing corporations in Cyprus, which was established in 1980 [CLDC 2015]. The CLDC is a governmental organisation and currently comprises a total of 2484 dwellings, 34 single family houses (SFH), 1120 terrace houses (TH) and 1330 Apartments in 131 multi-family houses (MFH). The average floor area of the SFHs is 120 m^2, of the THs 116 m^2 and of the Apartments 96 m^2. The SFHs and the THs are usually two-storeyed, whereas all the apartments are single-storey. Their construction characteristics are typical of the 1980s and the chronological period onwards, in Cyprus [CUT 2014]. All the dwellings under study have a reinforced concrete frame structure with brick external walls. The finishing of the external walls is usually cement plaster, whereas for the floor the most common practice is the use of ceramic tiles. In Cyprus it is also common practice to raise the Multi-Family Houses in columns, and create a free, open space in the ground floor, which is referred to as Pilotis and is used mainly as a parking space. A 50 % of the CLDC Multi-Family buildings have Pilotis.

The CLDC building stock is divided into two major categories, based on the chronological period of the construction; the old building stock, comprising a percentage of 80.76 % of the total stock, constructed prior to the launch of the minimum energy requirements of 2007 [MCIT 2007] and the new buildings, 19.24 %, constructed from 2007 to 2014. The Cyprus Land Development Corporation used double-glazed windows from 2003 onwards in the construction of the dwellings. Table 7 summarises the main key features of the CLDC housing stock.

For the heating and cooling systems, the CLDC does not provide the equipment, only the possibility to install central heating and cooling systems. The final decision about the type of the system depends on the owners.

The key actors of the CLDC are the Board of Directors, the technical staff (including Architects, Civil Engineers) the Legal Advisers and the Auditor, who is the General Auditor of the Government.

Table 7: Scope of the observed building stock of CLDC [own elaboration from raw data provided by CLDC]

Scale	No. of dwellings	No. of buildings	No. of inhabitants	m² national reference area	m² EPISCOPE reference area
Local	2484	606	9936	261680 net floor area	261680

Evaluation of Data Sources for the Observed Building Stock

The data sources used for extracting information about the construction, the energy consumption and the trends of energy improvement of the building stock under study are divided in two main categories based on the source of information used, which is either direct or adjusted from existing data.

The direct data sources are the architectural drawings, the questionnaire surveys performed for EPICOPE project, the on-site observations and the energy consumption data provided from the Cyprus Electricity Authority (CEA). The adjusted data concern data from sources for the fuel prices [CEA 2015], [Fire Wood retail Price 2015], [MCIT 2014], the RES contribution in the grid electricity production [Cyprus Statistical Service, 2014] and the Directives in force [MCIT 2007].

The data for the share and the levels of the building envelope insulation were collected from the Architectural drawings and details, combined with the compliance with the European and National Directives [MCIT 2007], [MCIT 2009] from the CLDC. Furthermore, the data were compared and verified by a questionnaire survey and an onsite investigation.

For the recording of the systems used for heating and cooling supply, the same sources were used, with the exception of the drawings, since there were no final electromechanical drawings, as the CLDC offers to the owners the option of system instalment. The current refurbishment trends were derived from the questionnaire survey, and the onsite measurements, which showed the alterations made between the present day state and the original structure.

Regarding the energy consumption of the dwellings, the values were based on real consumption data, (electricity consumption in kWh/month) provided by the Cyprus Electricity Authority (CEA), after the consent of the owners. From these data the corresponding energy for heating and cooling was concluded, for the different typologies and the different chronological periods.

Due to the lack of data regarding the energy consumption corresponding to the rest of the heating carriers (such as heating oil), since the owners cannot remember the amounts of the energy consumption or the spent amount on each, the energy balance was estimated based on the percentage of the use of each carrier in the total housing stock and the assumption that the owner would spent the same cost as for electricity. The current prices of the fuels were used for the calculations [CEA 2015], [Fire Wood retail Price 2015], MCIT 2014].

Concerning the availability and the reliability of the data, the ones provided from onsite monitoring are reliable and to a great extend reliable are also the data from the architectural plans. The same doesn’t apply for those provided by the questionnaire survey. Some of the owners due to ignorance or from lack of understanding, provided incorrect or misleading information, which was consequently corrected based on our observations. The only indisputably reliable data is the electric energy consumption given by the CEA.

Generally, the data are not complete. There is lack of information concerning the materials used for the energy refurbishment of the dwellings (type of material, U-value etc.) and the energy consumption of the households. The most difficult to handle is the latter, since all the information must be obtained from the owners and most of them do not have them.

Approaches / Concepts for Establishing a Continuous Monitoring

The current data situation can be greatly improved, since the CLDC doesn’t possess any energy related data; all the necessary information was extracted by means of direct onsite observations, questionnaire surveys contacted by the team and raw electricity data provided by the Cyprus Electricity Authority.

Even when the aforementioned methods of data collection were used, there were still gaps in the information; the most significant concerns the data of the energy consumption per energy carrier, necessary in order to achieve more accurate results. At present, this type of data is provided by the owners, who rarely keep record of the energy related expenses. One effective way is the creation of a monitoring system, in which the fossil fuels energy suppliers, will keep record of detailed information about the served households, in terms of fuel, demand per year, and provide this information, given the consent of the owners. The availability of these data can be improved if the fossil fuel suppliers develop a monitoring system of the buyers and file the information of consumption per household, thus giving the possibility of recurring to it when asked.

The refurbishment practices, documented through onsite investigation and a questionnaire survey, should continue while, at the same time, the current questionnaire survey (based on LARES standards) should be revised, so as to include more straightforward/easy-to-answer questions. The acquisition of refurbishment related data, such as the refurbishment materials used and the heat supply systems placed, by the CLDC and their enlistment in order to make them available, it is also recommended.

At a National level, the Cyprus Statistical Service, could upgrade the current questionnaire used for the housing sector energy profile [Cyprus Statistical Service 2009] by including more relevant and detailed information about the energy refurbishment trends by type of dwelling and relate the values to the date of construction. The same type of information about the upgrading of electromechanical systems, used for heating and cooling, is also essential.

A regular monitoring of the pilot building stock can be performed by the CLDC in collaboration with the Cyprus University of Technology (CUT) based on the format developed in the EPISCOPE program. The time intervals between each monitoring must be short (maximum every 5 years), since the benchmarks of 2020 and 2030 are nearing. As a result, a database with the outcomes of each monitoring will be created and made available to the public. For the data collection, a better option, than carrying out of a questionnaire survey is the creation of an online accessible database, in which the owners can update their data every time they perform an energy refurbishment, recording the most relevant information. This method would provide up-to-date information every month. The database, which will be managed by the CLDC, will include information about the RES contribution for the grid electricity production and show the energy profile of the stock, the corresponding CO_2 emissions, the targets to be reached and redefine, if necessary, the rates of refurbishment to be achieved.

The information and the results from the monitoring will be communicated to the owners and will be published on the CLDC web, as well as the CUT website and sent to the Energy Service of Cyprus.

At a national level the same approach could be followed, with regular monitoring of the building stock, using an updated and complete questionnaire and the creation of an online database.

Sources / References <CY> Cyprus

Table 8: Sources / References <CY> Cyprus

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[CEA 2015]	Αρχή Ηλεκτρισμού Κύπρου (2015): Υπολογισμός κόστους Κιλοβατώρας. Available at: https://www.eac.com.cy/EN/CustomerService/Tariffs/Documents/Domestic%20use%20tariffs%20September%202015.pdf [Accessed 2015-06-20]	Cyprus Electricity Authority, Costumer kWh calculation example.
[CLDC 2015]	Ιστοσελίδα Οργανισμού Ανάπτυξης Γης (2015): http://www.cldc.org.cy/cgibin/hweb?-V=index&_FAA=1&-dindex.html&_VLANGUAGE=gr [Accessed 2015-06-29]	Website of the Cyprus Land Development Corporation.
[CUT 2014]	Serghides, D./Markides, M./Katafygiotou, M. (2014): National Typology Brochures for Cyprus. Cyprus University of Technology, Limassol Available at. http://episcope.eu/fileadmin/tabula/public/docs/brochure/CY_TABULA_TypologyBrochure_CUT.pdf [Accessed 2015-06-26]	Building Typology brochures for Cyprus.
[Cyprus Statistical Service 2009]	Στατιστική Υπηρεσία Κύπρου (2009): Έρευνα για την τελική κατανάλωση ενέργειας στα νοικοκυριά. Available at: http://www.mof.gov.cy/mof/cystat/statistics.nsf/All/4D81522FDBE27569C225779F003B8677/$file/HH_Energy_Consumption-2009-EL-150910.pdf?OpenElement [Accessed 2015-06-21]	Research on the Final Energy Consumption of Households, Questionnaires, published by the Cypriot Statistical Service
[Cyprus Statistical Service 2014]	Στατιστική Υπηρεσία Κύπρου (2014): Στατιστικά στοιχεία παραγωγής και αγοράς ενέργειας. Available at: http://www.cystat.gov.cy/mof/cystat/statistics.nsf/energy_environment_81main_gr/energy_environment_81main_gr?OpenForm&sub=1&sel=2 [Accessed 2015-06-23]	Cyprus Statistical Service 2014, Energy Statistics
[Fire Wood retail Price 2015]	Αντρεας Τορτουρης ΛΤΔ (2015): Τιμές καυσόξυλων. Available at: http://kausoxilacy.com/pricing-tables/ [Accessed 2015-06-23]	Fire-wood prices in Cyprus in 2015.
[MCIT 2007]	Ο περί ρύθμισης Ενεργειακής Απόδοσης κτιρίων Νόμος 2006. Διάταγμα Κ.Δ.Π. 568/2007. Available at: http://www.mcit.gov.cy/mcit/mcit.nsf/0/FBFBEE85D45A6CD5C22575D30034F1A1/$file/KDP568_2007%20%20peri%20Apaithseon%20Elaxistis%20Energeiakis%20Apodosis%20Diatagma.pdf [Accessed 2015-06-23]	Directive 568/2007. First National Minimum energy requirements and terminology explanation.
[MCIT 2009]	Ο περί ρύθμισης Ενεργειακής Απόδοσης κτιρίων Νόμος 2006. Διάταγμα Κ.Δ.Π. 466 /2009. Available at: http://www.mcit.gov.cy/mcit/mcit.nsf/0/FBFBEE85D45A6CD5C22575D30034F1A1/$file/KDP568_2007%20%20peri%20Apaithseon%20Elaxistis%20Energeiakis%20Apodosis%20Diatagma.pdf [Accessed 2015-06-23]	Directive 466/2009. Revised National Minimum energy requirements and terminology explanation.
[MCIT 2014]	Υπουργείο Ενέργειας (2014): Τιμές πετρελαιοειδών στην Κύπρο το 2014. Available at: Gas and oil prices (http://www.mof.gov.cy) [Accessed 2015-06-26]	Ministry of Energy, Oil prices in Cyprus in 2014.

2.4 <CZ> Czech Republic

Municipal Housing Stock in the City of Havirov

(by EPISCOPE partner STU-K)

Observed Building Stock

Havířov is the youngest city in the Czech Republic. It was founded in the early 50s of the 20th century. Vast majority of the municipal dwellings were built in the period 1956–1970. Mainly standardized (repetitive) solutions were used. The housing estates in Havířov consist only of few types of buildings with identical building envelope properties, similar thermal quality rating (cold bridges, infiltration), clearly defined modularity.

Only two size categories are present in this part of the housing stock – multifamily houses and low rise buildings up to 5 storeys and blocks of flats - above 6 storeys. The low rise buildings with pitched roofs were often built with bricks and masonry blocks with no living spaces in the attics. Most of these low-rise buildings were built before 1956.

The housing blocks usually have 3 or more sections and 6 to 9 floors, exceptionally tower blocks 10 to 14 floors were built in the period between 1956 and 1993. These buildings are made of precast concrete elements. The exterior walls are either load bearing or self-supporting sandwich elements with polystyrene insulation. Exclusively flat roofs with bitumen roofing felts were used on this type of buildings.

There is a visible difference between the thermal behaviour of buildings from the period before 1980 and the later constructions. The revised design requirements from the late 70s had favourable impact on the energy performance of the buildings erected after 1980.

In average the mean U value of the building envelopes built after 1980 dropped from 1.5 to 1.1 W/(m^2 K) and the annual heating energy consumption decreased in average by 20 %.

Over 90 % of the municipal housing stock is connected to the district heating network.

Table 9: Scope of the observed building stock in Havířov, Czech Republic, part of the municipal housing stock operated by the facility management company MRA, based on [MRA 3.2015]

Scale	No. of dwellings	No. of buildings	No. of inhabitants	m² national reference area	m² EPISCOPE reference area
local	7,577	225	17,600	378,100 (conditioned area)	415,909

Evaluation of Data Sources for the Observed Building Stock

Main data sources:

The most relevant data source for the observed building stock is the private database and the archives of the local facility management company MRA [MRA 3.2015], [MRA 5.2015], [MRA 7.2015].

Several spreadsheets delivered by MRA contain a lot of useful information, such as the building address, the rough geometric characteristics of the building including the total heated area, the number of floors, number of apartments and the construction date. Heating energy consumption data are available for all buildings connected to the district heating network which is more than 90 % of the municipal stock.

Further, information about the refurbishment date and the refurbishment scope is included (see Figure 4) as well as the information about availability of the energy label or the energy performance certificate including the issuance date. The energy performance certificates are available for 55 % of the housing stock.

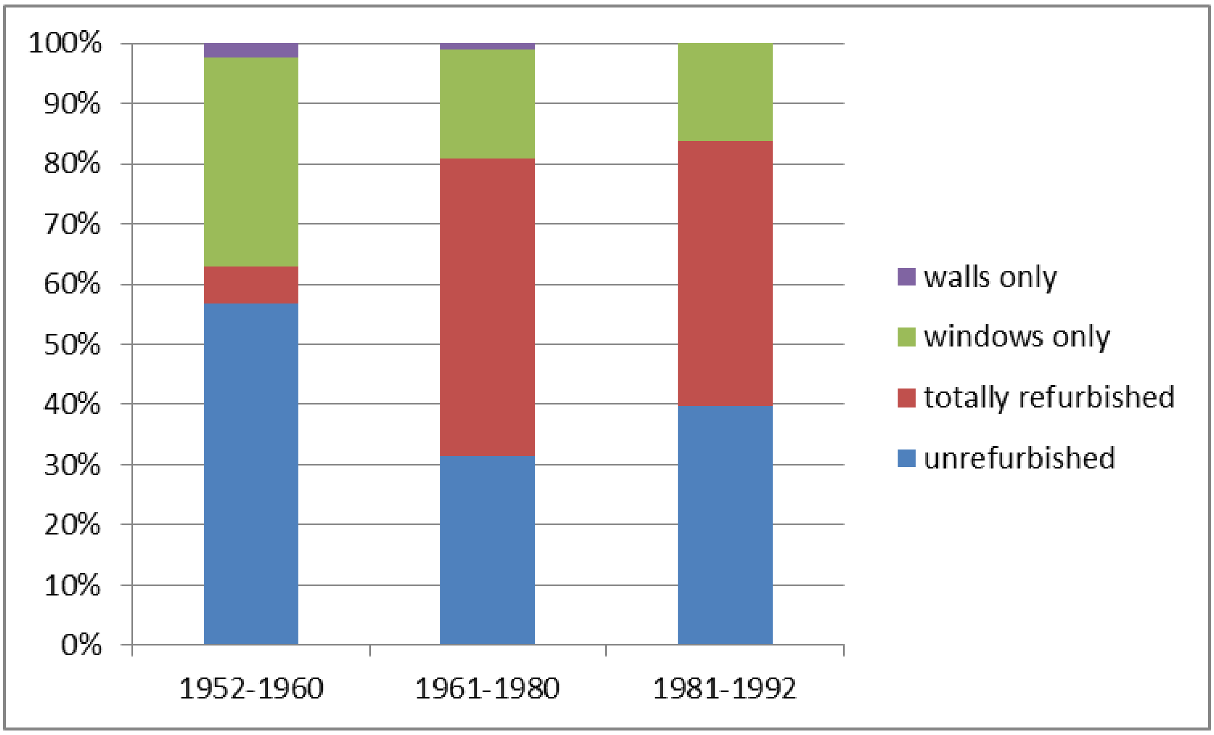


Figure 4: Degree of refurbishment across different age bands

Other data available are:

- National census 2011 data [SLDBVO 2011]
- Data from the power plant (DALKIA) about the type of fuel , the gross calorific value and the CO_2 emissions in kg/MWh of produced energy [DAL 2014]
- Complementary technical information about the used standardized types of buildings and information about the housing renovation strategy according to the implemented recast EPBD [SANCE 2014]

Quality of the data:

Consumption data:

- The quality of heating energy consumption data is generally very high, however in few cases (about 5 % of the stock) common metering is done for a group of several buildings or energy consumption only in part of building is known because the other part has different owner and independent metering.
- DHW data not available in the same extent like the heating data but could be obtained on demand.
- “Heated area” used for energy billing purposes might be slightly different from TABULA definition of conditioned area [IWU 2013], also used as EPISCOPE reference area. These differences cannot be easily found.
- Tenant occupation data not available to correlate it with consumption (e.g. vacant flats).
- Some years of energy consumption are missing for some buildings.

Building data:

- In some cases discrepancies in the data about refurbishments were observed (areas, new U-values, degree of renovation, etc.).
- Some buildings integrate also commercial spaces which are not precisely defined and it is not clear into which extent they influence the energy consumption of the residential part. The buildings with large share of commercial spaces might present distorted values of energy consumption.
- Total number of flats per building available, but no information about the flat size distribution.
- Heat losses due to cold bridges and infiltration through old windows are quantified with errors (more or less estimated).
- The data from energy performance certificates are not aggregated in any database they had to be picked manually from PDF files.

Approaches / Concepts for Establishing a Continuous Monitoring

Following improvements of the current data situation are necessary (N)/recommended as optional (O):

1) Consolidation of data from multiple data sources into one worksheet (N)

Currently several files are available which makes the work with data tiresome and lengthy with some risk of potential errors.

2) Verification of already existing data (N)

During the data consolidation the verification of already existing data is an issue that needs to be done. It is important to define the way to cross check the data collected with the information from [STU-K 2014]. Also geo-referencing is a suitable way to analyse the situation and spot the inaccuracies.

3) Updates of the data (N)

Some existing data need to be updated. This applies especially to the recent massive replacements of the windows mainly in the old part of the housings stock (SORELA). The quality and degree of refurbishments and the date of implementation of the energy saving measures shall be recorded. This is important especially for the tracking of the buildings refurbished in several consecutive steps.

4) Completion of missing data (O, N)

The existing data are sufficient for the monitoring, however further completion of the data would enable to increase the accuracy of the energy performance tracking of the observed building stock.

It is possible to complete the following data:

- Total area of the building envelope/total area of windows – necessary (N)
- Annual DHW consumption for every building (N)
- Number of tenants in the building and vacancy rate (N)
- Conditioned volume of the building (O)
- Specification of energy saving measures on the building envelope (O)
- Specification of energy saving measures on the HVAC systems (hydraulic balance, insulation of pipelines, heating controls) (O)
- Description of non-technical energy saving measures (energy management issues) (O)
- Costs of refurbishment, repair and maintenance costs (O)

5) Regular updates on annual basis (O, N)

- Heating and DHW consumption (N)
- Heating Degree Days (N)
- Evidence of recent energy saving measures (N)
- Qualitative and quantitative description of energy saving measures (O)
- Building occupancy (O)
- Financial data (O)

The facility management company MRA will continue to collect regularly the data of the municipal housing stock. There is no problem with the availability of information. The main problem consists in regular maintenance of the data. For the moment the updates must be done manually. In the future the database could be integrated within company ERP system.

Benchmark values of summary indicators are defined along the timeline for each cluster of municipal residential buildings. Apart from EPISCOPE common indicators (CO_2 emissions, total heat demand and CO_2 emission factor) also national indicator (mean U-value) will be added. The calculation model is based on the idea of average buildings. The calculation model accuracy can be improved during the first years of monitoring through improvements of current data situation.

Regular monitoring of the pilot building stock can be done by MRA in co-operation with STU-K who would comment on the energy refurbishment trends and suggest corrective measures if necessary. For this purpose consolidated and updated database will be used. The information and the results from the monitoring will be periodically reported to the Municipality of Havířov, the housing stock owner, who will formulate its housing portfolio management strategy for the upcoming years.

Sources / References <CZ> Czech Republic

Table 10: Sources / References <CZ> Czech Republic

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[DAL 2014]	DALKIA (2014): Informace poskytnuté zástupcem oddělení nákupu paliv pro region Severní Morava.	Information provided by the local purchase department of the power plant DALKIA.
[IWU 2013]	Loga, T./Diefenbach, N. (ed.) (2013): TABULA Calculation Method – Energy Use for Heating and Domestic Hot Water – Reference Calculation and Adaptation to the Typical Level of Measured Consumption, Institut Wohnen und Umwelt, Darmstadt. Available at: http://episcope.eu/fileadmin/tabula/public/docs/report/TABULA_CommonCalculationMethod.pdf [2015-06-26]	Description of the calculation method developed in the course of the IEE project TABULA
[MRA 3.2015]	Městské realitní agentura, s.r.o. (2015): Seznam bytových domů ve správě MRA. Podrobnější informace o domech.	Database of the Municipal Housing Agency of Havířov, Městské realitní agentura, s.r.o. List of buidlings operated by MRA. Deatiled information about the buildings.
[MRA 5.2015]	Městské realitní agentura, s.r.o. (2015): Údaje o spotřebě tepla na vytápění bytových domů v Havířově spravovaných MRA	Database of the Municipal Housing Agency of Havířov, Městské realitní agentura, s.r.o. Heating energy consumption data of the residential buildings in Havířov operated by MRA.
[MRA 7.2015]	Městské realitní agentura, s.r.o. (2015): Seznam vydaných PENB a auditů. Informace o sanaci domů.	Database of the Municipal Housing Agency of Havířov, Městské realitní agentura, s.r.o. List of EPCs and information about degree of refurbishment and refurbishment date
[SANCE 2014]	Holub, P.; Antonín, J. (2014): Stategie renovace budov. Podle článku 4 Směrnice o energetické účinnosti (2012/27/EU). Šance pro budovy. Available at: http://www.sanceprobudovy.cz/assets/files/strategie%20renovace%20budov%20duben2014a.pdf [2014-04]	Strategie for the refurbishment of buildings according to article 4 of the Energy Efficiency Directive (2012/27/EU)
[SLDBVO 2011]	Český statistický úřad (2011): Sčítání lidu, domů a bytů. Základní výsledky Česká republika. Available at: http://vdb.czso.cz/sldbvo/ [2015-07-29]	National census 2011 final data.
[STU-K 2014]	Bachová, L.; Villatoro, O.; Vimmr, T. (2014): Příručka typologií obytných budov s příklady opatření ke snížení jejich energetické náročnosti. ČESKÁ REPUBLIKA. Aktualizovaná verze, STU-K. Available at: http://episcope.eu/fileadmin/tabula/public/docs/brochure/CZ_TABULA_TypologyBrochure_STU-K.pdf [2014-12-18]	National typology brochure for Czech Republic, developed during the IEE Project EPISCOPE

2.5 <DE> Germany

National Residential Building Stock

(by EPISCOPE partner IWU)

Observed Building Stock

Basic data of the German residential building stock in 2011 are shown in Table 11. The fraction of multifamily houses (with 3 or more dwellings) among the residential buildings is 17 %, but they include 53 % of the dwellings. Among the single / two family houses about one third is detached or semi-detached [SÄBL 2015]. About two third of the residential buildings were built until 1979 (year of introduction of the first German energy saving ordinance).

The total number of inhabitants in Germany was 78.7 million in 2011. Among those 2.9 million (3.6 %) lived in apartments in non-residential buildings which are not considered in the residential building stock.

Table 11: Scope of the observed building stock in <DE> Germany [SÄBL 2015]

Scale	No. of dwellings	No. of buildings	No. of inhabitants	m² national reference area (living space)	m² EPISCOPE reference area
national	38.8 million	18.2 million	75.8 million	3.54 billion	3.89 billion

Evaluation of Data Sources for the Observed Building Stock

General data of the German building stock is delivered by the national census which was carried out in 2011 [SÄBL 2015]. Also data of the centralisation of the heating system (district / central / apartment / room heating) was collected.

More detailed and regular information of the heating system is provided by the “Mikrozensus” [Destatis 2010]. This is an official annual survey of about 1 % of the German households. In the first place socio-economic and demographic data are collected. Every 4 years it is accompanied by an additional questionnaire on the housing situation which also includes questions about the centralisation of the heating system and the type of final energy carriers of heating and of hot water generation (main energy type and additional energy types, respectively). So the general energy supply structure and (by comparison of different surveys) also average 4-year-trends can be observed – for example a decrease of the fraction of oil-heated dwellings. The last additional interrogation on the housing situation was carried out in 2014, but data is not yet available (expected in 2016). Therefore, only data from 2010 can be analysed now.

Even if the “Mikrozensus” delivers some valuable data of heat supply of the German dwellings, there are still very relevant information gaps: For example the type of the main heat generator is not considered (e.g. boiler, heat pump, cogeneration engine). So it is not possible to derive an annual rate of modernisation of heat generators: If for example an old constant temperature gas boiler is replaced by a new gas condensing boiler, this change is not shown in the Mikrozensus data. Moreover, it is unknown if in case of natural gas usage a boiler or a gas driven cogeneration engine is installed in the building.

Concerning the progress of thermal modernisation of buildings there is no official statistical data source in Germany. There is also no suitable regular scientific information base. To be mentioned is only the German Socio-Economic Panel (SOEP) of Deutsches Institut für Wirtschaftsforschung (DIW) which is an annual household panel survey. In the questionnaire there is one single question about thermal insulation during the last year, not distinguishing between the building elements of the buildings (walls, roof, cellar ceiling) [DIW 2014]. But the differentiation of elements is crucial to understand the process in detail and for the calculation of an area-weighted total thermal modernisation rate. So this data source cannot provide the necessary information about energy-related modernisation progress in the German residential building stock.

Due to the lack of regular and up-to-date data the scenario model of the German EPISCOPE subproject [IWU 2015] is based on a survey which was carried out 2009/2010 describing the German residential building stock in its state at the end of 2010 and delivering annual trends as mean values of the period 2005-2009 [IWU 2010]. Data of 7364 residential buildings were collected by chimney sweepers. In a 16 page questionnaire detailed information of the buildings was collected. Besides thermal protection, heat supply and ventilation there is also other basic data of the buildings available (e.g. type of wall construction, type of roof, availability of a cellar, monument conservation / facades worth to be preserved).

The survey was carried out according to the principles of sampling theory, so that the statistical errors can be quantified. Annual rates of thermal modernisation which are in general in a magnitude of 1 %/a – even though larger differences did occur with regard to different building elements – could be derived with satisfactory statistical standard errors. For example in case of walls the area-weighted rate is 0.65 %/a as a mean value of 2005-2008 with an absolute statistical standard error of 0.07 %/a.

A special question of interest is the progress of certain energy saving building standards (e.g. nearly-zero-energy buildings NZEBs, for which an official definition does not yet exist in Germany). Different energy saving standards of new and existing buildings are considered by loan programmes of the KfW Bankengruppe. Statistical information of the supported buildings is provided by annual monitoring reports (see [IWU 2013/2014]). But the picture is not complete because in [IWU 2010] it turned out that a relevant fraction of those energy saving building standards is realised without KfW support – presumably because many manufacturers of prefabricated houses or developers keep the standards, but the later buyers of the houses or apartments do not take the KfW support. So also for the fraction of energy saving building standards a regular general survey of the building stock (see next chapter) would be the most suitable data source. Besides, it has to be considered that in the existing building stock energy saving refurbishment measures are carried out step-by-step over a long time in most of the houses. So keeping the long-term energy saving and climate protection targets will be realised by gradual and continuous process in the whole building stock and not in the first place by increasing the number of NZEBs.

Approaches / Concepts for Establishing a Continuous Monitoring

Studies which provide a general overview of existing data sources of the German residential building stock show that the information gaps about the progress of thermal modernisation and heat supply cannot be closed by existing sources [IWU 2007], [IWU 2015]. So a new systematic and regular survey approach will be necessary which can build upon the experiences of [IWU 2010]. Again the house owners (or suitable representatives like building administrators) should be interrogated, because in case of rented homes they are better informed about the building than the tenants. In order to enable detailed analyses, inter alia deriving modernisation rates of building elements with satisfactory statistical errors, a survey volume of about 10,000 houses should be aimed at.

An extended survey scheme is shown in Figure 5. Because of effort and costs the basic survey is carried out every 4-5 years only. Besides the structural data of building thermal protection and heat supply also the energy consumption data are collected in laptop-supported face-to-face interviews by chimney sweepers (or exceptionally, if the house owner is not available, by an internet questionnaire). The building surveys are optionally accompanied by surveys of the house owners and the residents (in rented buildings) so that also socio-economic and demographic data (like income and age) can be collected. The questionnaires are also distributed by the chimney sweepers (e.g. by putting them into the tenants' letter-boxes). A big advantage of collecting all data together in one survey is that now the interrelation between different properties can be observed: For example it can be analysed if also low income households profit sufficiently from energy saving refurbishment measures.

In the period between the basic surveys less expensive short surveys are carried out to deliver up-to-date information of some basic quantities, e.g. the thermal modernisation rates of the different building elements. Short surveys can also be used as a less expensive way to collect sufficiently large regional samples (e.g. in a German Land [IWU 2014]). The distribution of the printed questionnaires to the house owners can be realised via the local real estate tax offices ("Grundsteuerstellen").

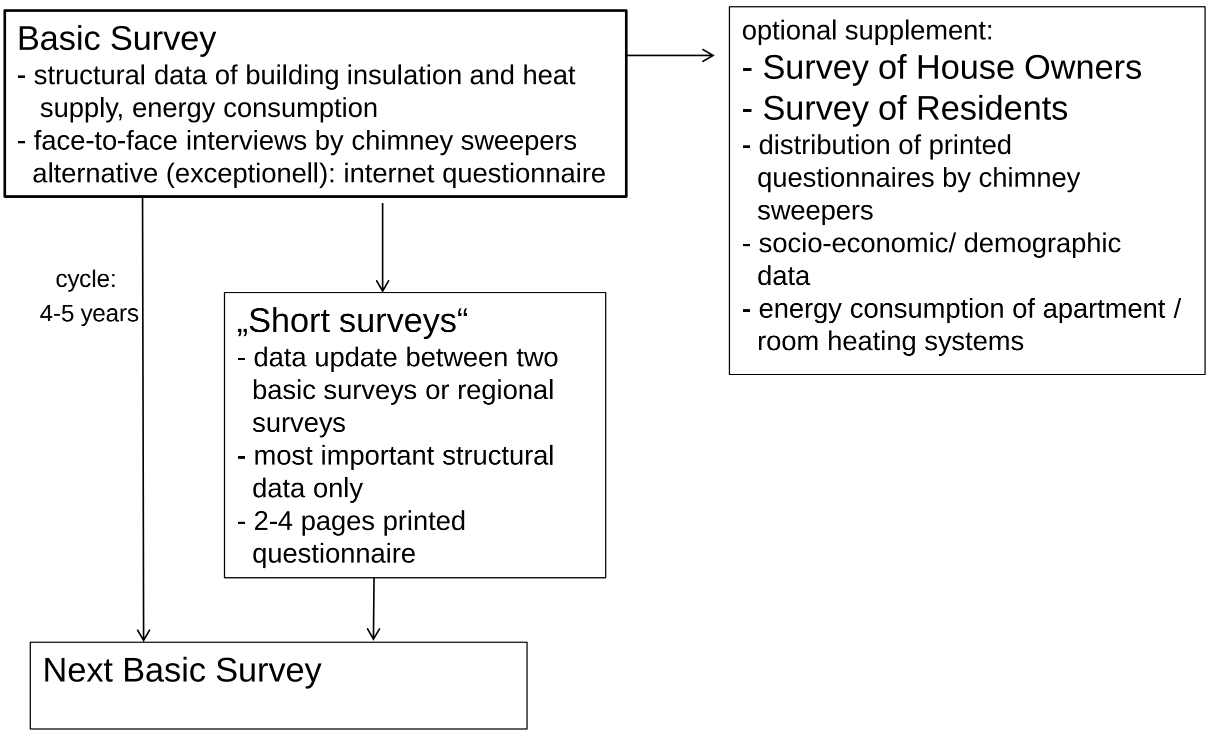


Figure 5: Monitoring scheme for the German residential building stock

Apart from a regular monitoring, currently also the additional problem of adapting energy balance methods to realistical values of energy consumption has to be solved. For that purpose reliable empirical data will be necessary which include at the same time information of the buildings' thermal protection / heat supply system and the energy consumption of recent years. The above mentioned survey could deliver these data, but for a start a better tailored approach might be more appropriate: This is due to the necessity to collect enough datasets also from completely refurbished buildings (which might not be available in the required number in the regular monitoring survey) and to the fact that adoption to realistic values should also be made possible for energy certificates based on the calculated energy demand (which will often not be available in the buildings which enter the regular survey). So a suitable approach to deliver and analyse the necessary empirical data will have to be developed which will than have more the character of a research project than of a regular monitoring because the model development will not necessarily have to be repeated in the same regular scheme – even if a model update from time to time would also make sense, of course.

Sources / References <DE> Germany

Table 12: Sources / References <DE> Germany

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[Destatis 2010]	Auswertung von Daten aus der Mikrozensus-Zusatzerhebung zur Wohnsituation 2010 des Statistischen Bundesamtes (Destatis)	Analysis of data from Mikrozensus 2010, documented in [IWU 2014]
[DIW 2014]	TNS Infratest Sozialforschung (2014): SOEP 2014 – Erhebungsinstrumente 2014 (Welle 31) des Sozio-oekonomischen Panels: Haushaltsfragebogen, Altstichproben. SOEP Survey Papers 236: Series A. Berlin: DIW/SOEP	Questionnaire of the German Socio Economic Panel SOEP http://www.diw.de/en/diw_02.c.221178.en/about_soep.html [2015-07-27]
[IWU 2007]	Diefenbach, N./Loga, T./Cischinsky, H./Clausnitzer, K.-D./Vilz, A. (2007): Grundlagen für die Entwicklung von Klimaschutzmaßnahmen im Gebäudebestand – Grundlagen über die bautechnische Struktur und den Ist-Zustand des Gebäudebestandes in Deutschland, BBR-Online Publikation Nr. 22/2007. Available at: http://www.bbsr.bund.de/BBSR/DE/Veroeffentlichungen/BBSROnline/2007/DL_ON222007.pdf?__blob=publicationFile&v=2 [2015-07-27]	A survey study on existing data sources of the German residential building sector
[IWU 2010]	Diefenbach, N./Cischinsky, H./Rodenfels, M. (2010): Datenbasis Gebäudebestand – Datenerhebung zur energetischen Qualität und zu den Modernisierungstrends im deutschen Wohngebäudebestand, Institut Wohnen und Umwelt, Darmstadt. Available at: http://www.iwu.de/fileadmin/user_upload/dateien/energie/klima_altbau/Endbericht_Datenbasis.pdf [2015-07-27]	Report about a representative survey of German residential buildings
[IWU 2013]	Diefenbach, N./Malottki, C.v. et al. (2013): Maßnahmen zur Umsetzung der Ziele des Energiekonzepts im Gebäudebereich – Zielerreichungsszenario; BMVBS-Online-Publikation Nr. 03/2013. Available at: http://www.bbsr.bund.de/BBSR/DE/Veroeffentlichungen/BMVBS/Online/2013/DL_ON032013.pdf?__blob=publicationFile&v=5 [2015-07-27]	Report on CO_2 reduction scenarios until 2020, a snapshot analysis of 2050 and a discussion of climate protection instruments. Also including information on the applied scenario model which is the basis of the German EPISCOPE approach.
[IWU 2013/14]	Diefenbach, N./Stein, B. et al. (2014): Monitoring der KfW-Programme „Energieeffizient Sanieren“ und „Energieeffizient Bauen“ 2013, im Auftrag der KfW Bankengruppe, Institut Wohnen und Umwelt, Darmstadt und Fraunhofer IFAM, Bremen. Diefenbach, N./Stein, B. et al. (2014): Monitoring der KfW-Programme „Energieeffizient Sanieren“ und „Energieeffizient Bauen“ 2012, im Auftrag der KfW Bankengruppe, Institut Wohnen und Umwelt, Darmstadt und Fraunhofer IFAM, Bremen. Diefenbach, N./Stein, B. et al. (2013): Monitoring der KfW-Programme „Energieeffizient Sanieren“ und „Energieeffizient Bauen“ 2011, im Auftrag der KfW Bankengruppe, Institut Wohnen und Umwelt, Darmstadt und Bremer Energie Institut, Bremen. Diefenbach, N./Loga, T. et al. (2011): Monitoring der KfW-Programme „Energieeffizient Sanieren“ 2010 und „Ökologisch / Energieeffizient Bauen“ 2006 - 2010, im Auftrag der KfW Bankengruppe, Institut Wohnen und Umwelt, Darmstadt und Bremer Energie Institut, Bremen. Available at: http://www.iwu.de/forschung/energie/laufend/monitoring-der-kfw-energiesparprogramme/ [2015-07-27]	Current annual monitoring reports on the KfW support programmes for energy efficiency measures in existing and new residential buildings

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[IWU 2014]	Cischinsky, H./Diefenbach, N. (2014): Konzept für ein Monitoring der Energieeffizienz im hessischen Wohngebäudebestand, im Auftrag des Hessischen Ministeriums für Umwelt, Energie, Landwirtschaft und Verbraucherschutz, Endbericht, Institut Wohnen und Umwelt, Darmstadt. Available at: http://www.iwu.de/fileadmin/user_upload/dateien/energie/sonstiges/Endbericht_Monitoringkonzept_Hessen.pdf [2015-07-27]	Monitoring concept for the residential building stock of the Land Hessen
[IWU 2015]	Diefenbach, N./Loga, T./Stein, B. (2015): Szenarienanalysen und Monitoringkonzepte im Hinblick auf die langfristigen Klimaschutzziele im deutschen Wohngebäudebestand, Institut Wohnen und Umwelt, Darmstadt. Available at: http://episcope.eu/fileadmin/episcope/public/docs/pilot_actions/DE_EPISCOPE_NationalCase_Study_IWU.pdf [2015-11-09]	Detailed Report of the German EPISCOPE case study
[SÄBL 2015]	Statistische Ämter des Bundes und der Länder (2015): Ergebnisse des Zensus 2011 zum Berichtszeitpunkt 9. Mai 2011, Auswertungen 2015 durchgeführt, siehe https://www.zensus2011.de [2015-07-27]	The national census was carried out in 2011. Simple analysis can be carried out on the website, requests of more complex analysis can be sent to the statistical offices of the German federal state and the lands.

2.6 <ES> Spain

Multi-family houses built between 1940 and 1980 in the Regional Residential Building Stock of the Comunitat Valenciana

(by EPISCOPE partner IVE)

Observed Building Stock

The observed building stock consists, mainly, of the following: single family detached house, terraced house, multifamily housing and apartment buildings. These are then divided into different periods of construction time: prior to 1900, 1901-1936, 1937-1959, 1960-1979, 1980-2006 and 2006-onwards.

Both single families detached and terraced houses have 2 or 3 floors, whilst multi family detached homes consist of up to 7 floors, and finally, multifamily terraced homes or apartment block count with up to 13 floors.

Our local pilot actions will then focus on energy reduction in residential homes, with constant occupation throughout the year. These are mainly multi family detached and terraced homes, built during the period 1940-1980.

Table 13: Scope of the observed building stock in <ES> Spain, Multi-family houses built between 1940 and 1980 in the regional residential building stock of the Comunitat Valenciana
[INE 2001], [IVE 2015]

Scale	No. of dwellings	No. of buildings	No. of inhabitants	m² national reference area*	m² EPISCOPE reference area
Regional	692,641	47,984	1,385,282	5.89×10^7	479×10^7

* Note: m^2 national reference data obtained by multiplying 85.02 m^2, which is the average conditioned floor area for this type of dwelling, by the number (692,641) of dwellings (data from [IVE 2015]). m^2 EPISCOPE reference area obtained by the conversion factors described in [IWU 2013].

Evaluation of Data Sources for the Observed Building Stock

Information sources

- RehEnergía Project, carried by Cerdá Institute. Information regarding floor area of the residential dwellings, the characterization of the different type of buildings and their building characteristics, as well as the energy uses in each home, were obtained from this report. We consider it is a top-reliable source, as it was a national scale project, carried in 5 autonomous regions: Catalonia, Galicia, Madrid, Basque Country and the Valencian Community. The project's main aim is to study the rehabilitation potential of the national building stock and to spread know-how regarding this aspect. For its elaboration, 1,740 buildings were analysed, with their real energy consumption data. [Instituto Cerdá 2008].
- INE (National Statistics Institute), provided data for the number of dwellings. [INE 2001]
- AVEN (Valencian Association of Energy) and IVACE (Valencian Institute for business competitiveness) Report on Energy in the Valencian Community (2013). Data regarding energy consumption was taken from this source, which is an official document in which various agents, both public and private, contribute: Spanish Ministry of Industry, Valencian Council on Infrastructures and transport, Repsol, Unión Fenosa, Endesa, BP Oil Refinery Castellón, Valencian Statistics Institute [IVACE-AVEN 2013]
- IDAE (Institute for Energy Diversification, via the project: SPACHOUSEC“Análisis del consumo energético del sector residencial en España” also provided information about

the energy consumption in the residential sector nationally. This project consists on 6,930 telephone surveys, 3,035 real buildings were monitored (1,232 of the in the Mediterranean area), which results in a sampling error of 1.78 % and a confidence interval of 95 %. [IDAE 2011]

- IVE (Valencian Institute of Building) Regarding the different improving measures, we considered (based on the buildings' characteristics stated by RehEnergía project named previously) those measures that guarantee achievement of the minimum insulation requirement established in the official document for energy savings: Documento Básico - Ahorro de Energía (DB-HE) del Código Técnico de la Edificación publicado con fecha 12 de septiembre de 2013 en el Boletín Oficial del Estado la Orden FOM/1635/2013 [FOM 2013]. On the other hand, simulation was carried out through our program 'CERMA_R', with established certain parameters that weren't always as precise as the previous studies. [IVE 2011a]

Further sources:

- Energy certification per building in the Comunitat Valenciana [IVACE 2015].
- Nationally, there is a requirement which implies that all buildings that were 50 years or older as of the 28th of July 2013 should be evaluated in terms of physical state, accesses and energy consumption. This is called the 'Informe de Evaluación del Edificio' (Report on the Building Evaluation), and all the building stock should have it completed on the 28th of July 2018 [MFOM 2013]. Currently, this reports are working at regional level, this means each autonomous community has its own rate and are currently unaware if this data will be available, but the IVE is carrying out works in this direction and has involvement in these actions within the Valencian Community.

Approaches / Concepts for Establishing a Continuous Monitoring

In order to improve the data situation, a good way to start would be to use the data available of recognized and official institutions and by ourselves. For example in the ELIH-Med [ENEA 2014] project IVE monitored 15 dwellings and developed an online audit tool [IVE 2011b] in order to obtain data of the residential consumption. Related to this project information days on the street were held where audits directly to citizens were made. This way the margin of error can be relieved with a more realistic approach regarding consumption levels.

Regarding building' systems, a better approach should include more specific data about the type of systems that can be installed in residential buildings. In Comunitat Valenciana there is a lack of central heat/cold systems and it is very difficult to find relevant data. The National Statistics Institute updates very few times and they do not develop the data from a technical point of view. Another survey is necessary in order to correct the theoretical results from the real consumption and habits.

For a more efficient monitoring in the future, there is a bureaucracy issue: in Spain, the legislation established an Energy Performance Certificate Register that is managed by every different region (autonomous community). So there is crucial information in this Register, but with very difficult access to the data as there are 17 registers autonomously operating, and only the letter of the energy certification scale of the building is a public data. The rest of the data containing energy characteristics is private data and with no possible access by anyone different from the owner or the public administrations. The administration could use the information to elaborate statistics on these aspects, etc. This way we may be able to have a more regular source of update that can contribute to a more regular monitoring.

Sources / References <ES> Spain

Table 20: Sources / References <ES> Spain

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[ENEA 2014]	ENEA (ed.) (2014): ELIH-Med Project. Energy Efficiency in Low Income Housing in the Mediterranean. Project Website: http://www.elih-med.eu/html/ [2015-07-28]	ELIH-Med project (Energy Efficiency in Low Income Housing in the Mediterranean), supported by the European Commission under the framework of the Med Programme (2011-2014)
[FOM 2013]	Ministeri de Foment (2013): Ordre FOM/1635/2013, de 10 de setembre, per la qual s'actualitza el document bàsic DB-HE «Estalvi d'energia», del Codi tècnic de l'edificació, aprovat pel. Reial decret 314/2006, de 17 de març. Available at: http://www.boe.es/diario_boe/txt.php?id=BOE-A-2013-9511 [2015-07-30]	Royal Decree from 10th September 2013, Spanish Ministry of Public Works and Transport. This Royal Decree updates the requirements at the Technical Code for Building.
[IDEA 2011]	IDEA (2011): Proyecto SECH-SPECHOUSEC. Análisis del consumo energético del sector residencial en España. Informe final. Avialable at: http://www.idae.es/uploads/documentos/documentos_Informe_SPAHOUSEC_ACC_f68291a3.pdf [2015-07-28]	Final report ont the analysis Project on the energy consumption by the residential sector in Spain (report in panish).
[INE 2001]	INE, Instituto Nacional de Estadística (2001): Censo de Población y Viviendas de 2001. Avialable at: http://www.ine.es/censo2001/index.html [2015-07-28]	National Statistics Institute data on population and dwellings
[Instituto Cerdá 2008]	Instituto Cerdá (2008): Proyecto RehEnergía Rehabilitación energética de edificios de viviendas. Summary available at: http://www.fomento.gob.es/NR/rdonlyres/E211018F-40C5-411B-B2CB-EE951F97BC3A/98660/EViladomiu1.pdf [2015-07-28]	Study on the potential for energy rehabilitation in the panish building stock
[IVACE-AVEN 2013]	IVACE-AVEN y Generalitat Valenciana (2013): Datos energéticos de la Comunitat Valenciana. Valencia	Report on the energy consumption at the Valencian Community for 2013.
[IVACE 2015]	Instituto Valenciano de Competitividad Empresaria (2015): Consulta Pública del Registro de la certificación de eficiencia energética de Edificios Terminados de la Comunidad Valenciana. Avialable at: http://gcee.aven.es/publico/ [2015-07-28]	Inspection of the Register of certification of energy efficiency of buildings Finished Valencia
[IVE 2011a]	IVE (2011): CERMA (Calificación Energética Residencial Método Abreviado)	Program for the energy consumption qualification at new buildings and simulation of existing ones.
[IVE 2011b]	IVE (2011): REHABilita tu vivienda. Programa: +Calidad en tu vivienda. Available at: http://www.five.es/calidadentuvivienda/inicio [2015-07-28]	
[IVE 2015]	Garcia-Prieto Ruiz, A./ Ortega Madrigal, L./ Serrano Lanzarote, B./ Soto Frances, L. (2015): Estudio del Potencial de ahorro energético y educción de emisiones de CO2 en la Comunitat Valenciana, IVE Instituto Valenciano de la Edificación, Valencia. Available at: http://episcope.eu/fileadmin/episcope/public/docs/pilot_actions/ES_EPISCOPE_RegionalCaseStudy_IVE.pdf [2015-11-09]	Case Study Report on the Spanish EPISCOPE pilot action in Spanish language
[IWU 2013]	Loga, T./Diefenbach, N. (ed.) (2013): TABULA Calculation Method – Energy Use for Heating and Domestic Hot Water – Reference Calculation and Adaptation to the Typical Level of Measured Consumption, Institut Wohnen und Umwelt, Darmstadt. Available at: http://episcope.eu/fileadmin/tabula/public/docs/report/TABULA_CommonCalculationMethod.pdf [2015-06-26]	Description of the calculation method developed in the course of the IEE project TABULA
[MFOM 2013]	Ministerio de Fomento (2013): Informe de Evaluación del Edificio. Available at: https://iee.fomento.gob.es/ [2015-07-28]	General information on the Report of Building Evaluation

2.7 <FR> France

Social Housing Stock of OPH Montreuillois, in the city of Montreuil

(by EPISCOPE partner Pouget)

Observed Building Stock

The French EPISCOPE project's pilot action focuses on the building stock of the social housing company "Office Public de l'Habitat Montreuillois" (OPHM), located in Montreuil, near Paris.

The observed building stock for the scenario analysis presented here is composed of 10 types of buildings. Almost the whole stock of buildings of OPH Montreuillois is included, unless a few buildings, which are very untypical for the building stock: all single family houses and small and medium multi-family houses constructed before 1915. As the floor surface of these buildings represent less than 3 % of the total floor surface, it still makes the analysis' results coherent.

Table 14: Scope of the observed building stock in France [OPH Montreuillois 2015]

Scale	No. of dwellings	No. of buildings	No. of inhabitants	m² national reference area (living area)	m² EPISCOPE reference area
Local	10 648	335	≈ 30 000	≈ 659 750	≈ 725 700

Evaluation of Data Sources for the Observed Building Stock

We had (fortunately but also unfortunately) many sources to establish the state of thermal building insulation and heat supply:

Main data sources

Energy Performance Certificates

The Basic Case Scenario was mainly built with the information given by the Energy Performance Certificates, as the housing company manager had to make them done on all their building stock. The exploitation of the data given by this important source was a bit disappointing as we encountered many difficulties:

On the one hand, there were many incoherencies in the characteristics of the elements entered by the EPC certificator. For example, for buildings built in 2005 there were sometimes double glaze windows with air instead of other gas and despite the fact that it was in 2005.

On the other hand, the information given wasn't complete: for example, sometimes the information was reduced to "insulated roof" without any information about neither the thickness nor the material of insulation.

Anyway, in those two cases, we made hypothesis based upon the requirements of the thermal regulations of the construction time or, if there were any, the refurbishment time. With this method, we could manage to have consistent results on the consumptions calculated with TABULA.

Other ancillary data sources currently available are:

Technical datasheets

Each building (or group of buildings) has its technical datasheet. For now, we can find information about their initial situation such as wall material and insulation, heating and DHW system, windows characteristics, etc.

Current trends

A file they fill with all the building works they do (operation and maintenance), apart from the refurbishments project. The file is filled by themselves year by year (since 2002) and building by building.

They have a certain (few) number of refurbishments each year. The best way to gather information on current trends is to read one by one the technical specifications (if available) and the building companies' estimate (if available too). That work has to be done on each of their refurbishments. Sometimes, those informations are not available.

Energy consumptions

Some building groups newly refurbished have systems equipped with data acquisition of their consumptions but for now we don't have the results yet.

62 % of OPH Montreuillois's building stock is working on gas energy, and it was possible to have consumptions for each concerned group of buildings.

Also, the results of their campaign of Energy Performance Certificate give the split of energy carriers.

Reliability of data

On the whole, the information is reliable as soon as we have access to the technical specifications and companies' estimate for each refurbishment. But for some old refurbished ones there are not available, or missing.

We still miss "real" data, such as measured consumptions. For now, we have access to annual consumptions.

Approaches / Concepts for Establishing a Continuous Monitoring

In our case, as all the information and all the refurbishments are decided at the head quarter, all the information is gathered in one place, which is an advantage (no need to find it anywhere else) but also a disadvantage (there is no one reliable file with the main information gathered), so that, it will be necessary to follow up what types of energy works they do and also what is really done on the ground.

We decided to write technical specifications to guide them for their future refurbishments, in order for them to judge what should be their energy requirements when refurbishing.

Another mission for us is to write guidelines for OPHM to verify if technical specifications correspond to works done on the ground. It will be intended for the buildings companies' in charge of supervision, for the future refurbishments.

We can make the missing data available for the future refurbishments by setting up a file where every energy characteristics of each refurbishment (insulation material, thickness, specifications of new heat supply system set up, etc.) are put together. This file is to be gradually filled up in the course of their refurbishments.

We plan to install a regular monitoring of the relevant data. We are going to write a contract notice with the technical specifications for installing and measuring the real consumptions in the interesting buildings. For now, we don't have decided the concept yet.

The housing company understands the importance of monitoring and is trying to organize themselves in consequence.

They need a support in their efforts and we are currently setting up with them solutions to help them during but also after EPISCOPE.

Sources / References <FR> France

Table 15: Sources / References <FR> France

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[OPH Montreuillois 2015]	Documents fournis par l'OPH Montreuillois	Data from files and sources of OPH Montreuillois

2.8 <GB> England

National Residential Building Stock

(by EPISCOPE partner BRE)

Observed Building Stock

The English Housing Survey showed there were 22.7 million dwellings in England in 2012 [DCLG 2014]. The average (mean) floor area of dwellings in 2012 was calculated to be 92 m^2. Of all dwellings, 20 % were built before 1919, whilst 14 % of the stock was built after 1990. The majority of properties in England were either terraced (28 %) or semi-detached houses (26 %). Some 17 % were detached houses and 9 % were bungalows. The remaining 20 % of homes were flats (mostly purpose built low rise flats).

In 2012 91 % of all homes had central heating; a further 7 % had storage heaters as their main heating system and the remainder having room heaters. In 2012 virtually all homes had a mains electricity supply and 86 % of homes had a mains gas supply.

The majority of English housing is of brick construction. There were 15.5 million cavity walled dwellings in the English stock in 2012, and the remaining 7.1 million are a mixture of solid walls, timber walls and other constructions (concrete etc.).

A summary of some key observations of the English housing stock is shown in Table 16.

Table 16: Scope of the observed building stock in England (English Housing Survey) [DCLG 2014]

Scale	**No. of dwellings**	**No. of buildings**	**No. of inhabitants**	**m² national reference area** (total floor area based on internal dimensions)	**m² EPISCOPE reference area**
National	~22.7 million	~21 million	~54 million	~2.10 x 10^9 m²	~2.10 x10^9 m²

Evaluation of Data Sources for the Observed Building Stock

Main data source:

The main data source which is currently the most relevant for the observed building stock is the English Housing Survey (EHS) data, a continuous national sample survey of the condition and energy efficiency of housing in England. It is commissioned by the Department for Communities and Local Government (DCLG) [DCLG 2015]:

- The survey collects detailed data on all aspects of a dwellings physical characteristics and repair, along with detailed information about the householder. Detailed information about the age and type of fabric (e.g. wall type or window type; insulation) and age, type and fuel of heating system (space and water heating) is collected alongside detailed dimensions and situation of the survey dwellings.
- The EHS runs from April-April each year, and comprises two component surveys
    - A household interview (around 13,300 households per year)
    - A physical inspection of a subsample of the properties by qualified surveyors (around 6,200 properties per year).

  For reporting of physical characteristics two years of data are combined (e.g. for reporting 2012 the two years of either side of a mid point of April 2012 are used) giving a sample size of around 12,400 dwellings.

- This data when weighted is representative of the English housing stock as a whole. This allows the production of annual statistics relating to the fabric and heating systems of domestic buildings.
- The physical survey data is used to analyse rates of installation of measures such as insulation or heating systems and to create a model of energy use based on the SAP methodology and is used to report overall energy efficiency.

Other ancillary data sources currently available are:

– **The Energy Follow Up Survey 2011 [DECC 2014].**

The EFUS is an interview and monitoring programme which revised 2,616 households already sampled as part of the 2010 EHS. This survey was commissioned by the Department for Energy and Climate Change (DECC).

All 2,616 households were interviewed in detail about their energy use and behaviour in their home. The interview was collected by trained interviewers and using Computer-Assisted Personal Interviewing software (CAPI).

Additional data was collected through:

1. Temperature monitors placed around the home (subsample of around 850 homes)
2. Electricity monitors attached to the meter cable (subsample of around 100 homes)
3. Meter readings obtained from the home (subsample of around 1,300 homes).

The EFUS provides important data for policy makers on how people in England use energy in their homes, and is an important link between actual energy use as reported by the householders, and modelled energy use as calculated with the EHS data.

– **National Energy Efficiency Data-Framework (NEED) [DECC 2013].**

The data framework matches actual gas and electricity consumption data, collected for DECC sub-national energy consumption statistics, with information on energy efficiency measures installed in homes, from the Homes Energy Efficiency Database (HEED). It also includes data about property attributes and household characteristics, obtained from a range of sources.

Quality of the data

The quality of the EHS data is very high. It is a Government run survey accredited to national statistics standards. The EHS is a sample survey where non response is corrected using weighting factors to correct to national totals. The EHS collects comprehensive data on the physical attributes of the survey dwelling, but does not collect information on actual energy use within the household. The EHS is a long standing survey which can allow analysis of trends over a long time period.

The NEED dataset is relatively new and very large. It combines data from several sources. The quality and coverage of the data are good but any interpretation of results should be considered in the context of the strengths and weaknesses of each of the data sources used e.g. in some cases electricity use is estimated, and may affect analysis on a case by case basis.

Currently the English Housing Survey cannot link to other data sources, thus limiting the linkages between the detailed dwelling data collected on this survey and the information collected on actual energy use as part of the NEED dataset for instance.

Approaches / Concepts for Establishing a Continuous Monitoring

The English Housing Survey currently provides a continuous monitoring method for the state of the English housing stock in terms of physical characteristics and national surveys such as this help to track the national picture over time, however there are gaps in the data collection and improvements which could be made to provide enhanced opportunities to track the energy performance of the housing stock.

Future improvements of data for the future which would improve the observation of the housing stock and monitoring its progress towards targets are outlined below.

- Social housing monitoring at a local level is quite well developed, but private housing monitoring, in particular private rented housing, which tends to be the poorest housing in terms of energy efficiency are not well monitored locally. Future policies could be developed to help this.
- More detailed information on the barriers to installing and improving homes (both regarding the physical practicalities and householder barriers) could be investigated to inform how policy can help to meet future carbon targets.
- Data from Energy Performance Certificate calculations (which are based on the SAP methodology) would add to the existing data sources in this area, and helping to provide a more comprehensive
- Future development of the NEED dataset or similar combining of datasets is likely to provide greater coverage of the housing stock in terms of monitoring actual energy use and efficiency installations in the future.
- Further detailed information to inform modelling assumptions etc. can be collected through studies investigating specific areas of interest (e.g. lights and appliances, wall insulation).

It is also important to establish a clear reporting system to establish progress over time. Currently progress is reported by central government departments on the progress relating to the actual energy use and carbon dioxide emissions of the domestic sector. This is used by central government to inform policy for the future. To further enhance this reporting, better links between the actual and modelled datasets (modelling data with more realistic heating regimes and temperatures using data from the EFUS) could be used to enhance understanding of where policy needs to be aimed in the future to meet targets.

Sources / References <GB> England

Table 17: Sources / References <GB> England

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[DCLG 2014]	Department for Communities and Local Government (ed.) (2014): English Housing Survey: PROFILE OF ENGLISH HOUSING. Annual report on England's housing stock, 2012. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/335753/EHS_Profile_of_English_housing_2012.pdf [2015-05-04]	EHS Profile of the English housing stock 2012
[DCLG 2015]	Department for Communities and Local Government (ed.) (2015): English housing survey. Collection. Available at: https://www.gov.uk/government/collections/english-housing-survey [2015-05-04]	Information and publications on the English housing survey
[DECC 2013]	Department of Energy & Climate Change (ed.) (2013): National Energy Efficiency Data-Framework (NEED) 2013. Available at: https://www.gov.uk/government/collections/national-energy-efficiency-data-need-framework [2015-06-02]	Information and publications on the National Energy Eficiency Data Framework
[DECC 2014]	Department of Energy & Climate Change (ed.) (2014): Energy Follow-Up Survey (EFUS): 2011. Available at: https://www.gov.uk/government/publications/energy-follow-up-survey-efus-2011 [2015-05-04]	Energy Follow-Up Survey data analysed and written up into 11 reports

2.9 <GR> Greece

National Residential Building Stock

(by EPISCOPE partner NOA)

Observed Building Stock

Hellenic residential buildings are reported at 2,990,324 or 79.2 % of the total building stock [ELSTAT 2015a]. The majority (72.8 %) are single family houses (SFH) and 27.2 % are multifamily houses (MFH). The total number of conventional dwellings in residential buildings is estimated 6,371,901 according to the results of the 2011 Population and Housing Census, of which 35.3 % are vacant [ELSTAT 2014a]. The average floor area is estimated for 24.7 % at 60-79 m^2 per dwelling and 23.5 % at 80-99 m^2, while the average useful floor space per person is 34.6 m^2. Over 55 % of the dwellings were built before 1980 (the year that the first Hellenic building thermal insulation regulation (HBTIR) was introduced).

Census data report that 77.5 % of dwellings have central heating [ELSTAT 2014b]. More detailed data are available from the national sampling survey of 3,600 households in the country [ELSTAT 2013]. Accordingly, the annual average thermal energy use is 10,244 kWh per household, of which 85.9 % for space heating, 4.4 % for domestic hot water (DHW) and 9.7 % for cooking. Heating oil (63.8 %) remains the main fuel source for space heating, while 12.4 % uses electricity, 12 % biomass and 8.7 % natural gas. The annual average electrical energy use per household is 10,244 kWh, which is used mainly for cooking (38.4 %), white appliances (28.9 %), DHW (9.4 %), lighting (6.4 %), cooling (4.9 %) and space heating (3.0 %). For DHW, 74.5 % of households use an electrical thermosiphon, 37.6 % have solar collectors and 25.2 % use the central heating system. Although the heating degree-days (HDD) range from 600 in the south to over 2600 HDD in the northern parts of the country, about half of the dwellings have no kind of thermal protection [ELSTAT 2014b], since they were built prior to 1980, the year that the first Hellenic building thermal insulation regulation (HBTIR) was introduced.

Some relevant data of the Hellenic building stock is summarized in Table 18.

Table 18: Scope of the observed building stock in <GR> Greece [ELSTAT 2015a], [ELSTAT 2015b]

Scale	No. of dwellings	No. of buildings	No. of inhabitants	m² national reference area	m² EPISCOPE reference area
National	~6.4 million	~2.9 million	~10.8 million	~480 x 10^6 (gross floor area)	~230 x 10^6

Evaluation of Data Sources for the Observed Building Stock

➢ **Main data sources**

- The Hellenic Statistical Authority ELSTAT is the official source of information relevant to the national building stock. The statistical data come either from the censuses and focused national sampling surveys (e.g. 3,600 households in the country [ELSTAT 2013], with a sampling fraction 0.08 %) carried out by ELSTAT or by other administrative sources of the State Agencies or Organizations of Greece. The Statistical Yearbook includes statistical data covering the years up to 2010. Overall, the data from ELSTAT provided the main knowledge on the number of residential buildings, dwellings, and floor areas for the different 24 Hellenic building stock typologies. Analysis of raw data obtained from ESLTAT was used to derive the breakdown of the building stock for the different characteristics of the typologies (e.g. location, construction periods, thermal envelope construction and technical characteristics of the heating generation systems, DHW and use of energy carriers). Details for the derived number of buildings and floor areas are elaborated in [Dascalaki 2016] and [IWU 2015].

- The national registry for official energy performance certificates [buildingcert 2014]. About 514,000 EPCs had been issued for dwellings, by the end of 2014. Of these, the analysis focused on about 12,000 EPCs for which actual energy use data (for a single energy carrier) was available. Analysis of this data was used to derive empirical adaptation factors to make more realistic estimates of the actual energy use from the calculated values. Two factors were derived. First, considering the raw data that resulted to a factor that reflects an upper bound of energy use (e.g. over-consumption and excessive energy misbehaviour, mainly driven by the role of occupants or even inherent assumption flaws in the calculations). Second, considering filtered data that resulted to a factor that reflects a more average (typical) trend of actual energy use. Details for the derived factors are elaborated in [Dascalaki 2016] and [IWU 2015].
- National energy balance sheets [EUROSTAT 2015]. Analysis of this data provided the necessary background knowledge for the specific total energy uses, energy carriers, emissions etc., in the residential sector. Details for the derived information are elaborated in [Dascalaki 2016] and [IWU 2015].

➢ **EPISCOPE Surveys**

Additional data was collected through two types of field surveys and collaboration with homeowners. The work collected data from

- Over 80 dwellings on the actual energy use “before” and “after” the implementation of popular energy conservation measures. Verification of actual energy savings is necessary in order to overcome potential market barriers and make more realistic estimates of building energy performance. The use of energy bills for one full year or heating season was considered the bare minimum, although averaging data over three years were used if available.

  The quest for data proved to be a great challenge. Initially, the idea was to possibly retrieve data from the national Exoikonomo programme. Unfortunately, a large scale effort stumbled on the reluctance from the supervising ministry (YPEKA) and banks that deal with homeowners and inspectors, to provide access to relevant data. As a result, in order to retrieve actual energy use data from utility and energy bills, the efforts concentrated to direct (personal) communications with homeowners, inspectors, local authorities, organizations, commercial companies etc., that have implemented ECMs. This door-to-door effort proved to be a very time consuming process, but on the other hand increased the level of confidence on the quality of collected data.
- Over 200 dwellings for closing the gap of data on refurbishment rates, identifying common ECMs and trends in the use and operation of heating systems in Hellenic dwellings (e.g. operating hours, heated floor area, indoor temperature settings) and an overall assessment of their indoor comfort conditions. The survey included homeowners at single- and multi-family houses of different construction periods, with a representative coverage of different locations.

Details for the collected information are elaborated in [Dascalaki 2016] and [IWU 2015]. The data were used to derive a third group of empirical adaptation factors to make more realistic estimates of the actual energy use from the calculated values. This addresses the same challenge as before, but from a different angle for adopting the calculation assumptions to the actual role of occupant’s efforts to cut-down heating energy costs. Considering that the information accounts for the recent behavioural changes under the adverse economic conditions and the recession in Greece, these factors are considered as a lower bound, reflecting a very conservative estimate of actual energy use in existing dwellings.

Approaches / Concepts for Establishing a Continuous Monitoring

The main difficulties encountered during this work were mainly related to:

- Data available at different formats, time periods that sometimes may even be conflicting from various sources or given different interpretations. Inconsistencies and issues with data quality and availability.
- Missing data. The most evident lack of information is with accurate data on the rates of refurbishment and demolition of buildings. In addition, detailed data on the types and rates of ECMs that have been implemented for different construction periods and locations.
- Lack of detailed and disaggregated data. For example, the detailed national survey on energy consumption in households [ELSTAT 2013] provides valuable information on a national basis, but due to its limited sample may not be representative on regional level. The national Census [ELSTAT 2015a] performed every ten-years could easily include some relevant questions related to the buildings' energy characteristics and performance. Along these lines, since 2008 there has been an effort to collect data on energy use during the annual household sampling survey [ELSTAT 2010].
- Accessibility to raw data. For example, on-line accessibility is the most direct and efficient process. Some are readily available, e.g. ELSTAT, EUROSTAT and other EU supported data resources (e.g. Entranze). Some of the ELSTAT raw data may not be accessible online, but there are processes in place for requesting and gaining access to this data. Of great potential interest is the exploitation of the national EPC data. The Hellenic Ministry of Reconstruction of Production, Environment and Energy (ex.YPEKA) is responsible for handling the EPC registry [buildingcert 2014]. However, future exploitation of the original raw data from the building audits could provide more valuable insight on the building stock characteristics.
- Delays in publishing data. Some relevant data may take much longer than two years which may be considered typical for most EUROSTAT type publications.

The EPISCOPE field audits and surveys provided some good quality data. However, to keep the derived factors current, it would be necessary to periodically conduct similar surveys in order to capture new trends in energy use and update the knowledge base from the EPC registry that is progressively populated and enriched with new certificates, in order to update the corresponding adaptation factors. Along these lines, the first results for updating the f_1 ratios with data from new EPCs generated over the second half of 2014, resulted to very small variations of the f_1 values, with the exception of typologies with a very small number of data (e.g. new construction periods).

To support future work and further analysis, more good quality data would be valuable. Building monitoring of at least a selected number of typical buildings throughout the country would always provide the best quality data that may be used even during the design phase to adjust the predictions from energy design tools and to improve their accuracy. The data may also be used for fine-tuning equipment to the design conditions, identify possible failures and support the overall commissioning process.

On the front end of EPCs, the national registry is expected to be progressively populated with a growing number of new data that could be exploited to periodically refine the corresponding empirical adaptation factors. Analysing the data at different time periods will facilitate the effort to generate more realistic factors that reflect current actual energy use and populate some missing data for some typologies (i.e. different locations and construction periods).

Policy makers can also benefit by linking the success of existing and new policies on actual data from real buildings. As a first step, a large scale effort may be supported by collecting energy bills in the context of national refurbishment programmes. For example, the ongoing national programme on “Energy Efficiency at Household Buildings” (Exoikonomo) constitutes an excellent opportunity to organize and enforce a mandatory provision to collect actual energy use for at least one year, “before” and “after” the implementation of the ECMs. This would also benefit the impact assessment of the programme’s effectiveness by quantifying the actual energy savings. In addition, this hard to collect data could provide valuable insight for future assessment of success stories and understand limitations of some ECMs in the market under actual operating conditions. Enhancing the knowledge base and expanding the raw data for the effectiveness of more ECMs from different building typologies, at more locations and various combinations thereafter, could enhance the process.

Valuable data is also expected from the implementation of the EPBD recast (2010/31/EU) provisions for the inspections of heating (article 14) and air-conditioning (article 15) systems. These efforts are still pending in Greece since national transposition of the EPBD recast with the national law [N.4122/2013] the work was supposed to have been initiated since 2013 and should be completed by early 2017. The existing technical guidelines outline all the detailed information and document a wealth of new insight and data that will be collected. All inspection reports will once again be collected by the national registry [buildingcert 2014] in a similar fashion as it is currently being done for the EPCs. The challenge for the Hellenic Ministry of Reconstruction of Production, Environment & Energy (ex.YPEKA) that has the oversight of this registry, would be to process, exploit and give access to the data.

Complementary monitoring efforts of major refurbishment works could further support future efforts for more detailed data collection with regard to trends of ECMs. For example, the natural gas companies could easily record the type of new connections to new buildings or existing buildings that switch from other energy carriers and not simply the number of new connections. Similar efforts could easily be implemented by other HVAC equipment suppliers, so that sales of equipment are identified in relation to their installation to existing or new buildings. Apparently, a coordinated plan and commitment by various players could easily reveal valuable detailed information with minimum effort.

Sources / References <GR> Greece

Table 19: Sources / References <GR> Greece

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[buildingcert 2014]	Υπουργείο Παραγωγικής Ανασυγκρότησης, Περιβάλλοντος & Ενέργειας (2014): Μητρώο Ενεργειακών Επιθεωρητών & Αρχείο Ενεργειακών Επιθεωρήσεων. Available at (restricted access): www.buildingcert.gr [2015-07-23]	Official national registry of energy performance certificates (EPCs) and energy inspectors (data analysis up to the end of 2014).
[Dascalaki 2016]	Ε.Γ. Δασκαλάκη, Κ.Α. Μπαλαράς, Κ. Δρούτσα, Σ. Κοντογιαννίδης (2016): Δυνατότητες και προοπτική για την ενεργειακή αναβάθμιση του ελληνικού κτιριακού αποθέματος, EPISCOPE D3.2b/P07 (NOA) Τελική έκδοση, Αθήνα. Available at: http://episcope.eu/fileadmin/episcope/public/docs/pilot_actions/GR_EPISCOPE_NationalCaseStudy_NOA.pdf [2016-03-15]	Overview of the Hellenic pilot action performed within EPISCOPE. Detailed overview of available national data and results of the work, national building stock characteristics, field audit and survey results, empirical adaptation factors, moving towards the national energy saving and CO_2 abatement targets for 2020 and 2030.
[ELSTAT 2010]	Ελληνική Στατιστική Αρχή (2010): Ετήσια Έρευνα Οικογενειακών Προϋπολογισμών 2008-2012, Αθήνα. Available at (in Greek): http://www.statistics.gr/portal/page/portal/ESYE/BUCKET/A0801/PressReleases/A0801_SFA05_DT_AN_00_2008_01_F_GR.pdf [2015-07-23]	Annual Household Budget Sampling Survey published by the Hellenic Statistical Authority (ELSTAT). After 2008 include information on average annual energy use for different energy carriers in permanent dwellings.

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[ELSTAT 2013]	Ελληνική Στατιστική Αρχή (2013): Έρευνα Κατανάλωσης Ενέργειας στα Νοικοκυριά 2011-2012, Αθήνα. Available at (summary): http://www.statistics.gr/portal/page/portal/ESYE/BUCKET/A0805/PressReleases/A0805_SFA40_DT_5Y_00_2012_01_F_EN.pdf [2015-07-23]	National survey (2011-12) published by the Hellenic Statistical Authority (ELSTAT) on energy consumption in households, end uses (space heating – cooling, domestic hot water, lighting, etc), energy carriers, energy consumption habits, type and number of devices and systems used, penetration of energy efficiency technologies, socio-economic characteristics.
[ELSTAT 2014a]	Helenic Statistical Authorrity (2014): 2011 Population and Housing Census, Characteristics and amenities of dwellings. Available at: http://www.statistics.gr/portal/page/portal/ESYE/BUCKET/A1602/PressReleases/A1602_SAM05_DT_DC_00_2011_01_F_EN.pdf [2015-07-23]	Statistical Authority (ELSTAT), press release, September 2014.
[ELSTAT 2014b]	Helenic Statistical Authorrity (2014): 2011 Population and Housing Census, Amenities of Dwellings/Households, press release. Available at: http://www.statistics.gr/portal/page/portal/ESYE/BUCKET/A1602/PressReleases/A1602_SAM05_DT_DC_00_2011_02_F_EN.pdf [2015-07-23]	Statistical Authority (ELSTAT), press release, November 2014
[ELSTAT 2015a]	Ελληνική Στατιστική Αρχή (2015): Απογραφή κτιρίων και οικοδομών 2001 και 2011, Αθήνα. Available at (summary): http://www.statistics.gr/portal/page/portal/ESYE/PAGE-census2011 [2015-07-23]	National Building Census data (2001 and 2011) published by the Hellenic Statistical Authority (ELSTAT) on the number of buildings of Greece and their characteristics (e.g. number of floors and dwellings, use and period of construction, construction material, type of roof and ownership)
[ELSTAT 2015b]	Ελληνική Στατιστική Αρχή (2015): Ετήσια Στατιστική Οικοδομικής Δραστηριότητας, Αθήνα. Available at: http://www.statistics.gr/portal/page/portal/ESYE/PAGE-themes?p_param=A1302 [2015-07-23]	Building Activity Statistics including monthly provisional data published by the Hellenic Statistical Authority (ELSTAT), including private and public building activity calculated on the basis of the number of issued building permits throughout the country.
[EUROSTAT 2015]	Euroepan Commission / Eurostat (2015): Energy Balances. Available at: http://ec.europa.eu/eurostat/web/energy/data/energy-balances [2015-07-23]	National energy balance sheets
[IWU 2015]	Stein, B./Loga, T./ ./Diefenbach, N. (2015): Scenario Analyses Concerning Energy Efficiency and Climate Protection in Regional and National Residential Building Stocks. Examples from Nine European Countries. Institut Wohnen und Umwelt (IWU), Darmstadt	EPISCOPE Synthesis Report No. 3 - (Deliverable D3.5)
[N.4122/2013]	Νόμος 4122, Ενεργειακή Απόδοση Κτιρίων – Εναρμόνιση με την Οδηγία 2010/31/ΕΕ του Ευρωπαϊκού Κοινοβουλίου και του Συμβουλίου και λοιπές διατάξεις, ΦΕΚ 42 Α/19.02.2013. Available online (in Greek): https://www.buildingcert.gr/N4122_2013.pdf [2015-07-23]	National legislation for the transposition of the EPBD recast (2010/31/EU)

2.10 <HU> Hungary

Residential building stock in the City of Budaörs

(by EPISCOPE partner BME)

Observed Building Stock

Budaörs is a city with a very good geographical position. It is located at the western gate of Budapest next to the highways to Vienna which is the most important route for transport. The city therefore has many international companies located in the industrial park and it is also a popular site for commercial centres and is an attractive target for residents to settle. The city has a historic area with densely built village houses, a significant part of detached houses with gardens mostly built after 1980, a small housing estate from the communist era and a small new centre with a couple of multi flat buildings. The total net floor area of the analysed building stock is 1 312 833 m^2 and the number of dwellings is 10 876 [Földhivatal online 2015]. Because of the good economical perspectives a growth in size and population is foreseen for the future [Budaörs Város Önkormányzata 2011]. The majority of the residential housing is of brick construction. Exceptions are the so called commi-block buildings (AB02, AB03) that were built in the seventies and eighties with industrialized technology with prefabricated reinforced concrete sandwich panels.

The local government is aware of the importance of energy efficiency and runs subsidy programmes for the retrofit of residential buildings, which is not typical in most Hungarian cities and settlements. The state of the commi-block buildings (AB02, AB03) is better than the average, because in recent years all of these buildings have been retrofitted with the support of the local government and the state. The majority of the remaining building stock mainly consists of detached houses. Two thirds of the old detached houses (SFH1-3) haven't been retrofitted yet at all, for the other building types the standard (modest) insulation level is the most typical, the "good" (corresponding to the current standard) and "very good" (corresponding to NZEB) levels are very rare.

Table 20: Scope of the observed residential building stock, Budaörs city [Földhivatal online 2015]

Scale	No. of dwellings	No. of buildings	No. of inhabitants	1000 m² national reference area	1000m² EPISCOPE reference area
local	10 876	6 033	27 655	1 311 (net floor area)	1 311

Evaluation of Data Sources for the Observed Building Stock

Benchmark data

In order to define the individual benchmarks the National Building Energy Strategy [EMI 2015a] was taken into account. It defines national level targets, but no local targets have been set up. The objective of the Strategy is to decrease the primary energy consumption of residential buildings by 38.4 PJ/year and public buildings by 1.6 PJ/year. For 2030 the energy saving target is 111 PJ/year. The base year is 2011, when the primary energy consumption of the residential buildings was 242 PJ/year. There are no approved targets for 2050.

Building modelling data

The city level calculations and projections were carried out on the basis of the EPISCOPE/TABULA national typology [BME 2014]. However, we have examined other building typologies as well. A typology has been set in the EnergyCity project supported by the Central Europe programme in order to support a monitoring tool based on remote sensing. It was developed for the building stock of Budapest [EnergyCity 2013].

The second, the most detailed and developed building typology was prepared for the National Building Energy Strategy [EMI 2015a] which was used for national level analysis. The EPISOPE/TABULA methodology has been developed in parallel to the typology of the Strategy and there are important similarities between the two typologies. The main difference is the calculation method: in the Strategy, the national method was used.

Data on the Budaörs residential building stock

In order to achieve the most accurate picture about the residential building stock of Budaörs, the existing data on building stock had to be investigated. Unfortunately, available studies, reports, building cadastres and databases could provide only partial information for our analysis.

Monitored energy consumption data was available for a subset of the buildings (commi-block buildings) in [Budaörs Város Önkormányzata 2012a]. Land areas per typical city patterns were found in [Budaörs Város Önkormányzata 2005].

The most useful data about the building stock was a cadastre of the dwelling stock according to construction period was extracted from the construction database of Budaörs [Budaörs Város Önkormányzata 2012b]. According to this database 35 % of the dwelling units were built after 1990 and 20 % are in commi-block buildings (housing estate in from the 70’s and 80’s). The further distribution of dwellings according to building types was carried out by the second on-site survey. No data about retrofit levels and yearly retrofit rates were available. Although the local government runs subsidy programmes for the retrofit of residential buildings for several years there is no electronic information database about the retrofitted buildings and the actions carried out.

For a better understanding of the building stock the development history of the city was analysed. A study has been found about the architectural values (buildings, areas, industrial objects) of Budaörs [Magyar 2012] providing information about the buildings in the historic centre. A diploma thesis has been developed in cooperation with the EPISCOPE project actions for analysing the historic development of the city in maps. The same thesis covered a preliminary on-site building survey as a preparatory step for the project [Domahidi 2013].

Data surveys within the project

As explained the existing studies and databases were not sufficient to provide information about the distribution of the building types, nor about the retrofit levels and building conditions. Therefore, two on-site data surveys were carried out in order to determine the renovation levels and the distribution of buildings per building types. The first (preliminary) data collection was carried out in selected areas with typical building patterns (e.g. in the historical centre, in the housing estate, etc.). 135 buildings were visited during this phase [Domahidi 2013].

The second data survey was carried out on a random basis. Altogether 340 buildings were visited in 34 randomly selected areas and a more detailed technical questionnaire was filled and the results were exported to Excel. The collected data of this second phase represented the main data source for the scenario analysis.

Quality of the data

As explained, the quality of the data extracted from existing studies and databases was not suitable to monitor the existing state of the buildings. The two surveys carried out within the EPISCOPE project were carried out on-site and covered 475 buildings, almost 8 % of the stock. It is on one hand sufficient to have a representative picture of the building stock, but on the other hand the surveys had some limitations. The buildings could be analysed only from the outside, therefore the overall condition of the buildings, the quality of the windows, the walls, the roof, the existence of the thermal insulation, solar panels could be determined with high accuracy, but the insulations inside the buildings (roofs, cellars) and the applied heating and DHW systems could only be assumed. In a part of the cases the occupants were interviewed, for some building types (larger buildings) the heating mode was given by the Municipality. When the information was not convincing, the national statistics were applied.

To conclude, the quality of the input data for the scenario analysis have limitations, but more precise monitoring of the stock could have been implemented only at efforts that would exceed the possibilities of the project.

Approaches / Concepts for Establishing a Continuous Monitoring

Future improvements on the observation of the housing stock and monitoring its progress towards targets are outlined as follows:

- Private housing monitoring in terms of energy efficiency are not monitored locally at all. Future policies could be developed to help this. It is recommended that Budaörs elaborates an energy and carbon-dioxide saving strategy and action plan. It should cover not only the residential buildings, but the commercial sector as well. The development of a monitoring system for the building retrofits should be a part of the action plan.
- More detailed information on the barriers to installing and improving homes (both regarding the physical practicalities and householder barriers) could be investigated to inform how policy can help to meet future carbon targets.
- The subsidy programs coordinated by the Municipality of Budaörs should include a detailed technical data collection about the supported buildings. The data should be stored in an electronic database.
- Data from Energy Performance Certificate calculations would add to the existing data sources in this area.
- A national building database has recently been developed (the project is still ongoing) by the ÉMI Nonprofit Ltd. [EMI 2015b] that could be a possible information system to store and analyse housing data in terms of energy efficiency. Energy Performance Certificates can be uploaded to the system with most of the calculation details and results. Filtering options are available, therefore filtering for individual cities would be possible. The system currently works on a voluntary basis.
- Further detailed information to inform modelling assumptions etc. can be collected through studies and surveys investigating specific areas of interest (e.g. lights and appliances, heating systems).

Sources / References <HU> Hungary

Table 21: Sources / References <HU> Hungary

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[BME 2014]	Csoknyai, Tamás/Hrabovszky-Horváth, Sára/Seprődi-Egeresi, Márta/Szendrő, Gábor (2014): Lakóépület tipológia. Magyarországon. Budapesti Műszaki és Gazdaságtudományi Egyetem (BME), Budapest, Available at: http://episcope.eu/fileadmin/tabula/public/docs/brochure/HU_TABULA_TypologyBrochure_BME.pdf [2015-07-22]	National typology of residential buildings in Hungary
[Budaörs Város Önkormányzata 2005]	Budaörs Város Önkormányzat. (2005): Településszerkezeti terv	Urban plan of Buaörs city structure
[Budaörs Város Önkormányzata 2011]	Budaörs Város Önkormányzata (2011): Budaörs Város gazdasági programja. Available at: www.budaors.hu/?module=news&action=getfile&aid=36187 [2015-07-22]	Economical Programme of the Budaörs Local Government, 2009-2014
[Budaörs Város Önkormányzata 2012a]	Budaörs Város Önkormányzata (2012): Budaörsi Településgazdálkodási Kft. 2012 éves beszámoló	
[Budaörs Város Önkormányzata 2012b]	Budaörs Város Önkormányzat (2012): Építéshatósági nyilvántartás-KSH	Construction database of Budaörs Local Government
[Domahidi 2013]	Domahidi , E. (2013): Energiamérleg alapú lakóépület tipológia Budaörsön, Diploma thesis	A preliminary phase of the on-site surveys for the EPEIOSCPE pilot project has been carried out in the frame of the diploma thesis
[EMI 2015a]	ÉMI Építésügyi Minőségellenőrző és Innovációs Nonprofit Kft. (2015): Nemzeti Épületenergetikai Stratégia, Budapest, 2015. február. Available at: http://www.kormany.hu/download/d/85/40000/Nemzeti%20E%CC%81pu%CC%88letenergetikai%20Strate%CC%81gia%20150225.pdf [2015-07-22]	National Building Energy Strategy
[EMI 2015b]	ÉMI Építésügyi Minőségellenőrző és Innovációs Nonprofit Kft (2015): Nemzeti Épületenergetikai Rendszer – NéeR. Available at: http://www.emi.hu/emi/web.nsf/Pub/neer.html [2015-07-22]	Voluntary national database for energy performance of buildings
[EnergyCity 2013]	EnergyCity (2013): Preparation of heat loss models – Prepare necessity data, assessment results, and energy loss data. Action report. Output 4.4.2. Available at: http://www.energycity2013.eu/media/Outputs/Outputs_report_3/4.4.2_Preparation_of_heat_loss_models.pdf [2015-07-22]	Report on the preparation of heat loss model
[Földhivatal online 2015]	Földhivatal (2015): Budaörs város adatai. Available at: http://foldhivatalok.geod.hu/telepules.php?page=23278 [2015-07-22]	Online database of land registration
[Magyar 2012]	Magyar Nemzeti Múzeum Örökségvédelmi Központ (2012): Tanulmány az építészeti értékek felméréséről és javaslat a Törzskönyv aktualizálására. Available at: http://www.budaors.hu/?module=news&action=getfile&aid=39940 [2015-07-22]	A study about the architectural values (buildings, areas, industrial objects) of Budaörs.

2.11 <IE> Ireland

Municipal Housing Stock on the Northside of Dublin City

(by EPISCOPE partner ENERGY ACTION)

Observed Building Stock

The pilot action building stock is focussed on the northside of Dublin City. The building stock comprises 133,431 dwellings [CSO n.d.] and a population of 307,000. The stock contains approximately 96,183 houses (72 %) and 37,248 apartments (28 %). 14,060 dwellings are owned by Dublin City Council and a further 2,000 to 3,000 dwellings are owned by Housing Associations. Thus, approximately 12.5 % of the stock is social/ public housing.

Energy Performance Certificates (EPCs) / Building Energy Rating (BER) certificates have been published for circa 30 % of the housing stock nationally. EPCs for 40,797 dwellings within the selected pilot action stock were published on the National EPC database as of 11th February 2015 and provide a valuable data source for this study. The pilot action area is shown in the image below taken from the EPC mapping tool images below. This EPC mapping tool [Energy Action 2015] was developed by Energy Action as part of the Irish EPISCOPE pilot action.

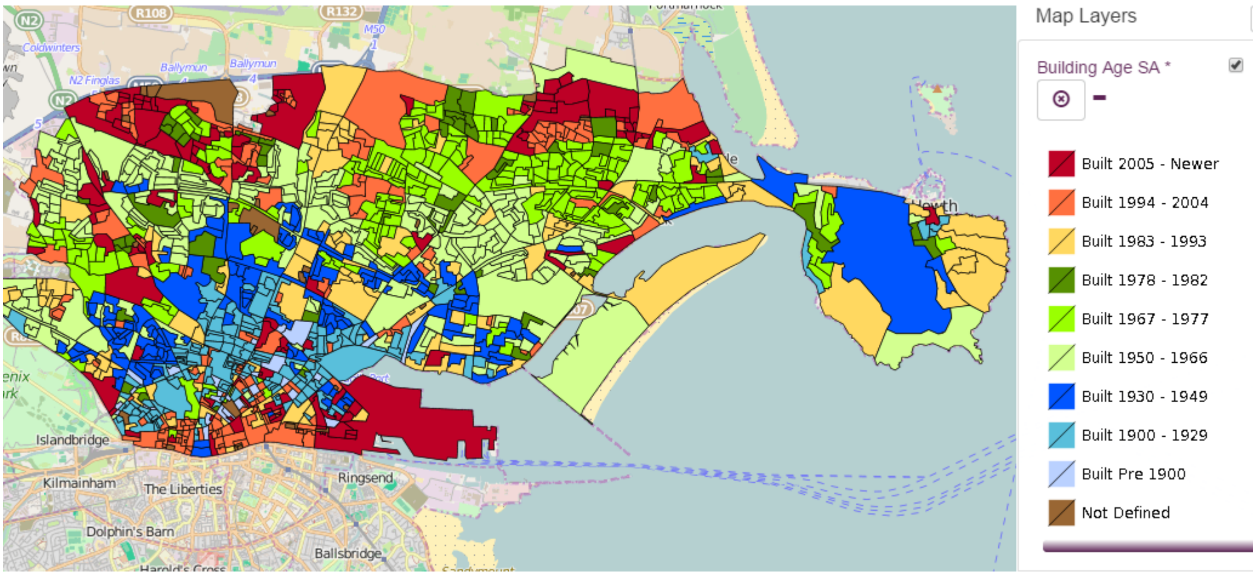


Figure 6: The Building Stock mapped by Building Age Map Data [© OpenStreetMap contributors]

While some refurbishment of the housing stock has taken place, especially in the last 5 years due to Government initiatives for both private owner-occupied housing and for local authority housing, the scale of refurbishment conducted to date and the predicted future rates of refurbishment are not established. The aim of the pilot action is to establish the current energy status of the stock, the refurbishment conducted to date, the current annual refurbishment rates and to assess the current and predicted trends against the national targets set for 2020, 2030 and 2050.

Table 22: Scope of the observed building stock in Dublin City [CSO n.d.]

Scale	No. of dwellings	No. of buildings	No. of inhabitants	m² national reference area	m² EPISCOPE reference area
local	133,431	93,058	307,000	11,142,100 (internal floor area)	11,429,519

Evaluation of Data Sources for the Observed Building Stock

Main Data Sources

As this outset of the pilot action, it was clear that there was no single data source (such as a national house condition survey) available to provide all of the information required to deliver state, trend and summary indicators for the observed stock. Three main data sources were evaluated and analysed to reach conclusions on the energy performance of the selected housing stock and the associated rates of refurbishment.

- **Data from the National EPC Database for the selected stock:**

  Ireland's national EPC database is managed by the Sustainable Energy Authority of Ireland (SEAI). Out of a national housing stock of 1.6 million dwellings, 528,000 dwellings (33 %) had EPCs (based on data at 11.02.2015). Data from the National EPC database is publicly available via the SEAI National BER Research Tool (BRT) [SEAI n.d.a]. EPC data for the Northside of Dublin City was extracted and analysed and provided a rich source of data for the Irish pilot action.

  While the EPC database does not scientifically represent the entire stock, when carefully considered, it can be interpreted to provide key data on the energy performance and refurbishment activity within the selected stock.

- **Data from Existing Energy Upgrade Programmes:**

  There are a significant number of SEAI-managed national energy efficiency schemes (SEAI Better Energy Warmer Homes Scheme, SEAI Better Energy Homes Scheme, SEAI Areas Scheme, SEAI Better Energy Communities Scheme) [SEAI n.d.b] and Local Authority energy upgrade programmes.

  Data for state indicators was provided by Dublin City Council for their dwellings. Data for trend indicators was secured from the two SEAI Better Energy schemes. Data was not available in sufficient detail from the other listed sources.

  Data from the National Census 2011 [CSO n.d.] and National Household Budget Survey [CSO 2012] was not sufficiently detailed to consider when developing the Pilot Action study.

- **Data from Pilot Action Field Survey:**

  In addition to analysing known data sources, a specific field survey of dwellings was conducted as part of the EPISCOPE Pilot Action.

  The survey work commenced in December 2014 and was completed in April 2015. The services of the Economic and Social Research Institute (ESRI) were engaged to assist with designing the survey process and the random selection of addresses to be surveyed.

  Surveyors called to 200 addresses over the 5-month period in order to successfully get 100 survey forms completed through interviews with home occupiers. The survey work presented a considerable challenge due to the random processes associated with a sampled survey. In total, 450 visits to the selected dwellings were made in order to reach the target of 100 completed surveys, i.e. 4.5 visits per successful survey. The most difficult dwellings to access were individual apartments that had keypad bell systems at street level.

  This field survey data was cross-checked with the state and trend indicators developed from analysis of the SEAI BRT data.

Quality of the Data

Of the three data sources used, the EPC database and the field survey where the most valuable.

However, the EPC database is not primarily designed as a stock monitoring tool. If it is to be used for ongoing monitoring of the housing stock, the following needs to be considered:

- In order to establish annual trends via the EPC database, it would be necessary to set up a formal process to save a version of the EPC database each year at a set date. Otherwise, revised EPCs for the same address in a current year will overwrite records in previous years thus skewing the results.
- From the field survey, it is known that many householders carry out energy upgrade work outside of grant schemes and hence these works are not reflected via EPCs. (The dwelling has either no EPC or its existing EPC is not updated to reflect the improvement). Hence, the EPC database will not provide the same quality of data that a comprehensive field survey could achieve in terms of tracking refurbishment rates.

The EPISCOPE field survey was conducted to cross-check the EPC database analysis and to get hands-on experience of a building stock refurbishment survey. The field survey achieved both of these aims.

Approaches / Concepts for Establishing a Continuous Monitoring

Arising from the EPISCOPE Pilot Action, it is recommended that:

- A national housing energy efficiency/house condition survey should be established to comprehensively track the energy efficiency of the residential housing stock and enable scenario forecasting to 2020, 2030 and 2050.
- A detailed study should be conducted to record measured energy use in residential buildings on an ongoing basis. The study needs to take account of the wide variation in building types and BER ratings for both new and existing dwellings. This will enable calibration rates of predicted energy use (via EPC/BER) to actual energy use to be established. This study should take account of gas, oil, electricity use etc. and should separate out EPC/BER energy use (space and water heating, lighting and pumps & fans) from other energy use such as appliances etc. The survey should also consider the use of temperature monitors to compare achieved and assumed room temperatures.
- Where possible, in future revisions of NEEAP [DCENR 2014], specific targets for reduction in energy demand and CO_2 should be set for the residential sector for 2020, 2030 and 2050. The setting of these sector-specific targets will provide a greater focus on the achievement of energy saving measures in the sector.
- The analysis conducted on the EPC database for the EPISCOPE Pilot Action should also be continued, further developed and cross-referenced to the recommended field survey and measured energy consumption data processes. The EPC database will continue to grow and will form a crucial element of future energy and CO_2 trend modelling.
- It will also be important to establish a clear reporting system for the residential building sector to establish progress over time.

Sources / References <IE> Ireland

Table 23: Sources / References <IE> Ireland

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[CSO n.d.]	Central Statistics Office (CSO) (n.d.): 2011 Census Results. Available at: http://www.cso.ie/en/census/index.html [2015-08-07]	National Census 2011
[CSO 2012]	Central Statistics Office (CSO) (2012): Household Budget Survey 2009.2010. First Results. Avialable at: http://www.cso.ie/en/media/csoie/releasespublications/documents/housing/2010/0910first.pdf [2015-08-07]	National Houshold Budget Survey
[DCENR 2014]	Department of Communications, Energy and Natural Resources (DCENR) (2014): National Energy Efficiency Action Plan 2014. Available at: http://www.dcenr.gov.ie/NR/rdonlyres/20F27340-A720-492C-8340-6E3E4B7DE85D/0/DCENRNEEAP2014publishedversion.pdf [2015-07-17]	National Energy Efficiency Action Plan 2014
[Energy Action 2015]	Energy Action (2015): EPC Mapping tool showing Energy Efficiency of Housing on the Northside of Dublin City. Available at http://energyaction-static.s3-website-eu-west-1.amazonaws.com/index.html [2015-09-03]	EPISCOPE EPC mapping tool
[© OpenStreetMap contributors]	Map Data available under the Open Database License: Copyright and Licence available at: www.openstreetmap.org/copyright [2015-08-05] Open Data Commons Open Database License (ODbL) available at: www.opendatacommons.org/licenses/odbl [2015-08-05]	
[SEAI n.d.a]	Sustainable Energy Authority of Ireland (SEAI) (n.d.): National BER Research Tool. Available at: http://www.seai.ie/Your_Building/BER/National_BER_Research_Tool/ [2015-07-17]	National online BER(EPC) Reserach Tool
[SEAI n.d.b]	Sustainable Energy Authority of Ireland (SEAI) (n.d.): Funding. Available at: http://www.seai.ie/Grants/	Link to national SEAI energy efficiency grant schemes

2.12 <IT> Italy

Regional Residential Building Stock of Piedmont Region

(by EPISCOPE partner POLITO)

Observed Building Stock

The Italian pilot action of EPISCOPE focuses on the Piedmont region, in the Northwest of Italy. The main data of the observed building stock are shown in Table 24. The objective of the pilot action is the contribution to monitoring the current state of the regional residential building stock in terms of energy performance, and the scenario analysis is finalised to the optimization of the energy refurbishment processes and energy savings related to the same stock. The results are addressed to local authorities to help them at setting up corrective actions to foster the most effective and efficient refurbishment measures.

On a total amount of about 1.1 millions of buildings in Piedmont region, the 83.5 % is covered by residential buildings. The size of the regional housing stock by number of dwellings is shown in Figure 7, the total number of dwellings is split by construction period and number of apartments in the building.

The following regional key partners have been involved in the pilot action:

- Piedmont Region (Department of Economic Development, Research and Innovation, Department of Environment, Soil Protection, Mining and Civil Protection),
- Finpiemonte Corp., regional agency supporting the development and competitiveness of the Piedmont Region territory,
- CSI Piemonte, consortium for the information system of the Piedmont region.

Table 24: Scope of the observed building stock in <IT> Italy [ISTAT 2011]

Scale	No. of dwellings	No. of buildings	No. of inhabitants	m² national reference area (conditioned floor area)	m² EPISCOPE reference area
Regional	~ 2.44 · 10^6	~ 0.945 · 10^6	~ 4.36 · 10^6	~ 214 · 10^6 m^2	~ 214 · 10^6 m^2

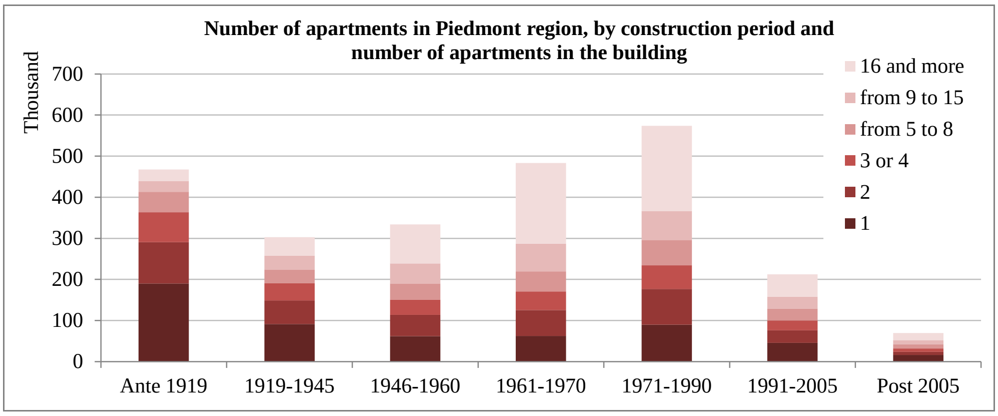


Figure 7: Number of dwellings in Piedmont by construction period and number of apartments in the building [ISTAT 2011]

Evaluation of Data Sources for the Observed Building Stock

The main energy-related data source of monitoring indicators for the Piedmont regional pilot action is the database of the building energy performance certificates (EPCs). In 2009, the Piedmont Region issued an information system for the energy performance certification of buildings (SICEE). The system allows the qualified professionals to compile the certificates and to transmit them to the regional authorities, which in turn analyse and collect the certificates in a database. This database has a limited access and its use is restricted at statistical purposes and research activity. The database includes, for each certified building or dwelling, the following information:

- general data (e.g. building use, year of construction, building typology),
- main geometric data (e.g. heated net floor area, heated gross volume, compactness ratio),
- main data of the building envelope (e.g. thermal transmittance of external walls and windows),
- main data of the thermal systems (e.g. type of thermal system, mean seasonal global efficiency of the space heating system and of the domestic hot water system, mean seasonal efficiency of the heat generator, type of energy carrier for space heating and for domestic hot water, technologies using renewable energy sources, renewable energy ratio),
- the energy performance indicators and the energy class.

A statistical analysis was carried out on the database concerning the available EPCs, i.e. those issued from 2010 to 2013. This data source provided information above all on the state of thermal building insulation and heat supply. The upgrading of the thermal insulation from the original state was derived by comparing the actual U-values with the typical U-values for each construction period. The frequency of the heat generators (for space heating and domestic hot water), the energy carriers and the technologies using renewable energy sources are the main data on heat supply derived from the database.

The current trends concerning building insulation and heat supply were derived from the reports of the “National Energy Agency for New Technologies, Energy and Sustainable Economic Development” (ENEA) concerning the demands of tax deduction for the energy refurbishment of existing buildings. The average building stock floor area annually refurbished was obtained from the number of dwellings refurbished in the period ranging from 2008 to 2012. The following refurbishment measures are concerned: window replacement, thermal insulation of walls and of horizontal enclosures, heat generator replacement, installation of thermal solar system, global refurbishment [Nocera 2011-14].

The annual energy consumption of the regional housing stock, with a split of the different energy carriers, has been provided by the “Regional Energy Balances” (B.E.R.) of the “National Energy Agency for New Technologies, Energy and Sustainable Economic Development” (ENEA). The energy consumption is available for some reference years in the period ranging from 1988 to 2008 [ENEA 2012].

The analysis of the quality of the existing data sources mainly concerns the EPC database of Piedmont Region, as the data are based on surveys done by different professionals, which use different procedures and methodologies to collect data. Therefore, representativeness, reliability and completeness of data should be investigated.

As regards the representativeness, the database does not cover the whole residential building stock (RBS) floor area of Piedmont, but only that area for which an energy certificate was issued. The regional housing stock having an energy certificate is the 19 % of the total and, as regards the motivation issue, 65 % of EPCs was delivered for sale or rent, 16 % for building renovation, 7 % for new building, 12 % for other reason. The information gap between the

EPC database and the whole building stock has been overcome by assigning the monitoring indicators got from statistical analysis of the EPCs issued for sale and rent to the residential building stock not having an EPC. Considering the lack of data, the EPCs for sale and rent have been considered suitably representative of the average existing building stock.

The reliability of the EPC data source is not high. Anyway, an accurate data analysis was performed to depurate the database from inconsistencies (i.e. the outliers). These may occur both in the main parameters object of analysis (e.g. the wall U-value) and in the normalizing parameters (e.g. the conditioned net floor area).

The database does not ensure completeness of information. Some gaps, concerning for instance the state of thermal insulation of the horizontal enclosures, were closed by model assumptions.

Approaches / Concepts for Establishing a Continuous Monitoring

Many improvements of the current data situation are necessary to track the energy performance of the observed building stock, for instance:

- it would be necessary an improvement of the building energy performance certification system, which should include more detailed data and apply more strict controls on the data input, so as to increase both the quantity and the quality of information,
- new possible data sources should be made available from the building energy audits, which will be carried out by means of procedures established by standards (according to Directive 2012/27/EU), and the energy cadastres,
- new methodologies and tools developed in European research projects from Horizon 2020 calls (e.g. EeB-07-2015) should be investigated. The aim is to monitor and assess the actual building energy performance and to accurately predict building energy loads and consumptions, so as to ensure the accuracy required to properly value retrofit technologies.

The information necessary to know the current energy performance and the energy-related properties of the regional building stock, and to develop effective scenario analyses should be made available in the future by the local administrations. This is an important issue that concerns both the quantity (e.g. level of detail) and the quality of data and data sources.

For this reason, a regular monitoring of the relevant data should be undertaken in Piedmont region. A strict collaboration is going on with some regional officers in order to identify procedures and methodologies for setting up a regular monitoring of the residential building stock concerning data on thermal insulation, heat supply systems, energy performance, etc.

In this context, the municipality of Torino (the regional capital of Piedmont) is starting the construction of a system for the real estate management by applying ICT technologies. The data of buildings owned by the municipality will be collected from different data sources and will convey into an integrated platform. In this way the municipality will be able to evaluate and plan interventions in order to maintain and refurbish its real estate effectively.

This innovative approach might be enlarged to the whole building stock of Piedmont region encouraging the application of ICT technologies. Through the Horizon 2020 program, the European Commission is driving the Member States to convert the existing cities into *Smart Cities* in order to reduce the energy consumption and to improve the life quality. This raises the problem of how to collect and handle data from multiple buildings/districts and the local administrations will be made aware of this problem. From this point of view BIM and GIS offer 3D data models that provide information about buildings and environment starting from different data sources: architectural, energy, socio-economic, climate, user behaviour etc. In order to be able to manage all these data, it is essential to set up an infrastructure that allows the interoperability among heterogeneous sources to facilitate analysis of the building energy performance, as well as predictions of the future energy behaviour consequent to refurbishment actions of the building stock.

To this purpose, some related actions should be fostered in the region, such as for instance:

- reliable data on the actual energy consumption should be provided by a regular monitoring of the existing buildings according to the Italian Legislative Decree 102/2014 which transposes the Directive 2012/27/EU,
- an action plan for increasing the number of nearly-zero energy buildings is being developed at a national level. It should address towards the identification of effective energy refurbishment measures to be applied to the existing buildings in order to support a target oriented long-term development of the housing stock towards NZEBs,
- frequent comparisons with the benchmarks (i.e. the climate protection targets) should be carried out to address the local energy policy towards effective strategies for improving the energy performance of the building stock.

Face to face meetings with key actors of the public authorities will be organized to transfer information and research outcomes and to supply suggestions on effective measures.

Sources / References <IT> Italy

Table 25: Sources / References <IT> Italy

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[ENEA 2012]	ENEA (2012): Bilanci energetici regionali (B.E.R.) 2005-2008 e le statistiche energetiche 1988-2008. Available at: http://www.efficienzaenergetica.enea.it/politiche-e-strategie-1/politiche-e-strategie-nelle-regioni/sistemi-informativi-energetici-regionali/bilanci-energetici-regionali/i-ber-2005-2008.aspx [2015-07-23]	This reference from the national energy agency provides the annual energy consumption of the regional housing stock, with a split of the different energy carriers.
[ISTAT 2011]	ISTAT (2011): Censimento della popolazione. Elaborazioni dell'Istituto Nazionale di Statistica (http://www.istat.it/it/).	Statistical data of the census carried out in 2011 by the National Institute of Statistics.
[Nocera 2011-14]	Nocera, M. (2011-2014): Le detrazioni fiscali del 55% per la riqualificazione energetica del patrimonio edilizio esistente – Anni 2008-2012. Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile (ENEA), Roma.	The reports, yearly delivered from 2011 to 2014 by the Italian national energy agency, provide data concerning the demands of tax deduction for the energy refurbishment of the existing buildings at a regional level from 2008 to 2012.

2.13 <NL> The Netherlands

National Non-Profit Rental Housing Stock

(by EPISCOPE partner DUT)

Observed Building Stock

In the Netherlands, the non-profit housing sector counts 2.3 million homes, which is 31 % of the total housing stock [BZK 2013]. This is a unique situation as the Netherlands have the highest percentage of non-profit housing in the European Union. Nearly all homes in this sector are owned and managed by housing associations, which are private organisations that have a legal obligation to provide sufficient affordable housing for low-income households.

64 % of the Dutch non-profit dwellings have a high-efficiency gas boiler (η ≥ 95 %) and 17 % a conventional gas boiler (η = 80 % - 90 %). Heat pumps, PV panels and solar boilers are not very common, but their number is increasing rapidly. Whereas the vast majority of dwellings is in some way insulated (for example, 96 % have double glazing or a better glass insulation), still 52 % of the dwellings have none or very poor wall insulation [SHAERE 2013].

Table 26: Scope of the observed building stock in <NL> The Netherlands (2013)
Sources: [BZK 2013], [Statistics Netherlands 2012], [SHAERE 2013]

Scale	No. of dwellings	No. of buildings	No. of inhabitants	m² national reference area	m² EPISCOPE reference area*
national non-profit rental housing	2,267,199	Not available	~ 4,990,000	191.413 x 10^6 total net floor area	210.555 x 10^6

* This figure, referring to the area within the building envelope, is calculated by adding 10 % to the national reference area, which refers to the living area within the homes only. This 10 % has been found in [Loga & Diefenbach 2013].

Evaluation of Data Sources for the Observed Building Stock

In the Netherlands, gas is by far the most important fuel for domestic heating and hot water. In 2008 *Aedes*, the national umbrella organisation for housing associations (which almost exclusively own the non-profit housing stock in the country), the Ministry of Housing and *Woonbond,* the national tenants' union, signed a covenant in which, among others, a 20 % reduction on the total gas consumption in the non-profit housing sector over the years 2008-2018 was agreed. It was also agreed that Aedes would develop a database to monitor the progress of this form of energy saving. In this monitor, not the actual energy use per home is given, but a model-based estimation of this consumption according to a national calculation method. This method also produces a dimensionless unit for the energy performance of the respective dwelling, called the Energy Index (*Energie-Index*).

Content of the monitor

The monitoring system of the non-profit dwellings is called SHAERE (*Sociale Huursector Audit en Evaluatie van Resultaten Energiebesparing* – in English: Social Rented Sector Audit and Evaluation of Energy Saving Results). It is accepted by the parties in the covenant as the official tool for monitoring the progress in the non-profit housing sector in terms of energy performance and energy saving. SHAERE is a collective database in which the majority of the housing associations participate. The database is filled with the software program *Vabi Assets*, which most of the housing associations (more than three quarters) use for the energy performance management of their stock [Majcen et al. 2014].

Since 2010, when the database became operational, housing associations report their stock to Aedes in the beginning of each calendar year accounting for the situation on December 31st of the previous year (e.g. in the beginning of 2015 for December 31st, 2014).

In 2012 the 2008 covenant was repealed. The covenant that came in place (and that is still in force) states that in 2020 the average Energy Index of all homes of the Dutch housing associations must be 1.25, which is within the bands of energy performance rate B (in the Netherlands categories ranging from A++ (very high energy efficiency) to G (very low energy efficiency) are used). This change did not have consequences for the setup of SHAERE, as the necessary data to monitor the new covenant were already part of the database.

The SHAERE database contains the necessary information per home to calculate an Energy Index. The data imported include physical characteristics and installations of the dwellings in order to be used for their energy labelling. The data includes the U-values (thermal transmittance, $W/m^2{\cdot}K$) and R_c-values (measure of thermal resistance, $m^2{\cdot}K/W$) [ASHRAE 2009] of the envelope elements, estimated energy consumption, expected CO_2 emissions, and the Energy Index itself. For 2013, data for 1,448,266 dwellings were available, representing 64 % of the total non-profit housing stock, which then counted 2,267,199 dwellings [CFV 2014] (see Table 3). The response in terms of number of homes in 2014 was somewhat lower (1,342,139). Because information about the exact size of the sector at that time is not available yet, the relative response for that year is estimated (see again Table 27).

Table 27: Number of dwellings reported in SHAERE per year
[Filippidou & Nieboer 2014] (slightly corrected figure for 2013) and [Aedes 2015a]

Year of reporting	Frequency	Percentage of the total non-profit stock
2010	1,132,946	47%
2011	1,186,067	49%
2012	1,438,700	64%
2013	1,448,266	64%
2014	1,342,139	~ 59%

Some key results from the monitor are presented below.

Table 28: Some key results from SHAERE per year [Aedes 2015b]

	2012	2013	2014
Average surface area per dwelling [m2]	79	80	82
Insulated dwellings [%]	59.5	68.4	68.4
Gas consumption per dwelling [m3/year]	1214	1187	1193
Electricity consumption per dwelling [kWh/year]	994	1008	1035
Heat consumption per dwelling [GJ/year]*	31	32	31
CO2 emission per dwelling [kg/year]	2716	2732	2744
Dwellings with energy performance rate A++ to B [%]**	18	21	24
Dwellings with energy performance rate E to G [%]**	24.5	22.5	20.3
Dwellings with high-efficiency boilers or more efficient heat generators [%]	68.9	70.7	73.2
Number of homes with solar boilers in the sample	18491	19797	24688
Number of homes with PV panels in the sample	4675	8185	16411

* in case of district heating

** The energy performance of a dwelling is expressed in an Energy Index, which can be grouped into a class denoted by a letter ranging from A++ (very energy efficient) to G (not energy efficient).

The table shows a gradual improvement of the energy efficiency of the housing stock, although this is not visible in the amount of CO2 emission per dwelling. A possible explanation for the latter is the increase of the average surface area per dwelling. The rise in the number of homes with PV panels is striking.

Quality of the monitor

A strong point of the monitor is its rich database: per dwelling it contains many, if not all data regarding the energy performance, plus various more general data, such as building form and address. Another strong point is the good coverage of the sector: the annual response is around 60 %.

Although such coverage obviously contributes to the representativeness of the monitor, it does not guarantee that the portfolio of the participating housing associations gives a representative picture of the whole sector. This is aggravated if the quality of the information provided by the housing associations is not or not entirely correct. This problem is not specific for this monitor (it occurs with many surveys and inquiries), but has nevertheless a negative influence of the reliability of the data. From a specific local study with the use of SHAERE we have indications that some housing associations have sent partly outdated information. To date, we do not know how big this problem is, nor do we have solutions for this.

Despite this, the issue of representativeness must not be exaggerated. In [Filippidou & Nieboer 2014] the results from SHAERE for 2013 are compared with results from an annual survey conducted by the Netherlands Enterprise Agency (RVO.nl). These results were highly similar, which can be seen as a confirmation of the quality of the monitor. The number of energy measures calculated on the basis of SHAERE is slightly higher than in the RVO.nl survey, but it cannot be concluded if this is due to an overestimation in SHAERE, an underestimation in the survey or both.

Approaches / Concepts for Establishing a Continuous Monitoring

SHAERE is already operational since 2010 and can be seen as an established monitor. The monitor is ‘owned’ and managed by Aedes, which is willing to continue the monitor in the next years. There are some points for improvement.

- The first point concerns the internal structure of the database: data with regard to a new reference date are ‘simply’ added as new records to the existing dataset, meaning that the database must first be restructured to connect the information about a dwelling with regard to several reference dates. This is a laborious yearly exercise.
- This situation is exacerbated by the fact that, until 2014, individual dwellings did not have an own ID, by which data regarding several reference dates could be coupled. Until then this was done on address (postal codes, street numbers and possible extensions), but although the Dutch postal codes are very refined (on sub-street level), this method is still less reliable than an individual ID.
- The data on building year is not entirely reliable. Since 2014, however, SHAERE contains a dwelling-specific ID variable (see previous point), which allows to connect with data from Statistics Netherlands on building year.
- The monitor could be further improved if it contained data on a possible renovation: is the dwelling renovated and, if so, in which year. Until the 1990s, renovations in the non-profit housing sector were subsidised by the national government. Because of this, and because this type of interventions is relevant for today’s asset management, there is good chance that housing associations still have this data available. A pilot would have to be carried out to check this.

Sources / References <NL> The Netherlands

Table 29: Sources / References <NL> The Netherlands

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[Aedes 2015a]	Aedes (2015): Corporatiemonitor: Energie, Available at: http://www.aedes.nl/binaries/downloads/energie-en-duurzaamheid/20150324-aedes-corporatiemonitor_energie-2014.pdf (accessed 30 June 2015)	webpage containing some core facts from the SHAERE monitor for the year 2014
[Aedes 2015b]	Aedes (2015): Expert: Hoe energiezuinig zijn sociale huurwoningen?, Available at: http://www.aedes.nl/content/feiten-en-cijfers/woning/hoe-energiezuinig-zijn-sociale-huurwoningen-/expert--hoe-energiezuinig-zijn-sociale-huurwoninge.xml (accessed 29 June 2015)	webpage containing some core facts from the SHAERE monitor for the years 2012-2014
[ASHRAE 2009]	ASHRAE (2009): 2009 ASHRAE Handbook - Fundamentals (I-P Edition). American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. Available at http://app.knovel.com/hotlink/toc/id:kpASHRAE22/ashrae-handbook-fundamentals/ashrae-handbook-fundamentals (accessed 30 June 2015)	This handbook covers basic principles and data used in the HVAC&R industry. It covers general engineering information, basic materials, climate data, load and energy calculations, duct and pipe design, and sustainability, plus reference tables for abbreviations and symbols, as well as physical properties of materials.
[BZK 2013]	Ministerie van Binnenlandse Zaken en Koninkrijksrelaties (2013): Cijfers over Wonen en Bouwen 2013	Statistical publication on housing in the Netherlands
[CFV 2014]	Centraal Fonds Volkshuisvesting (2014), Sectorbeeld 2014. Available at http://www.cfvpublicaties.nl/FbContent.ashx/pub_1001/Downloads/Sectorbeeld_2014.pdf (accessed 30 June 2015)	This report goes into the financial situation of the Dutch housing associations.
[Filippidou & Nieboer 2014]	Filippidou, F. & Nieboer, N. (2014): Energetische verbeteringsmaatregelen in de sociale-huursector, Delft: Delft University of Technology, OTB - Onderzoek voor de Gebouwde Omgeving	This research, commissioned by the Netherlands Enterprise Agency, deals with the energy measures taken in 2013 in the Dutch social housing sector. The results from SHAERE are compared with those from other studies.
[Loga & Diefenbach 2013]	Loga, T. & Diefenbach, N. (2013): TABULA Calculation Method – Energy Use for Heating and Domestic Hot Water – Reference Calculation and Adaptation to the Typical Level of Measured Consumption, Institut Wohnen und Umwelt, Darmstadt	This report deals with several calculation methods in the TABULA software.
[Majcen et al. 2013]	Majcen, D., Itard, L.C.M. & Visscher, H. (2013): Theoretical vs. actual energy consumption of labelled dwellings in the Netherlands: Discrepancies and policy implications, Energy policy, 54, 125-136.	This article explains the Dutch measure for energy performance and addresses the differences between model-based and real energy consumption of households.
[SHAERE 2013]	monitor SHAERE, figures for December 31st, 2013	own calculations on the SHAERE database
[Statistics Netherlands 2012]	Centraal Bureau voor de Statistiek (2012): Woononderzoek Nederland, Energiemodule	survey among Dutch households about their energy behaviour and the energy performance of their homes

2.14 <NO> Norway

National Residential Building Stock

(by EPISCOPE partner NTNU)

Observed Building Stock

The most recent Norwegian Residential Building and Dwelling Statistics are published 22 April 2015 by Statistics Norway [SSB 2015], and show there were in total 2,466,363 dwellings (occupied and vacant) in Norway as of 1 January 2014. Of these dwellings 52.0 % are detached houses, 22.7 % are flats in multi-dwelling buildings, 11.5 % are dwellings in row houses, linked houses and houses with three or four dwellings, 9.1 % are houses with two dwellings and 1.9 % dwellings in residences for communities. The remaining 2.7 % are dwellings registered in buildings where the main part of the floor space is used for purposes other than dwellings; mainly commercial buildings.

From 2012 to 2014, there was a net growth in the number of dwellings of 44,000, of which almost half were blocks of flats. This corresponds to some 11.8 % increase during two years only, showing that the Norwegian national dwelling stock is growing a lot at the moment, as a result of population growth and welfare, and that the growth is mainly in urban areas.

A summary of some key observations of the Norwegian residential building stock is shown in Table 30. These numbers include occupied dwellings only (not vacant ones). The EPISCOPE reference area value, equivalent to heated floor area, is assumed to be on average 85 % of the national utility reference area (in Norwegian called ‘bruksareal’, BRA).

Table 30: Scope of the observed building stock in Norway per 2013-12-31 [SSB 2014a]

Scale	No. of dwellings	No. of buildings	No. of inhabitants	m² national reference area	m² EPISCOPE reference area
National	~ 2.45 million	~ 1.51 million	~ 5.11 million	~ 0.287 x 10^9 m² (BRA: Bruksareal)	~ 0.244 x 10^9 m²

Figure 8 shows the distribution of utility floor area (national reference area, incl. vacant dwellings) by building type segments (SFH = single family house; TH = terraced house dwellings; AB = apartment block dwellings) and construction year cohorts.

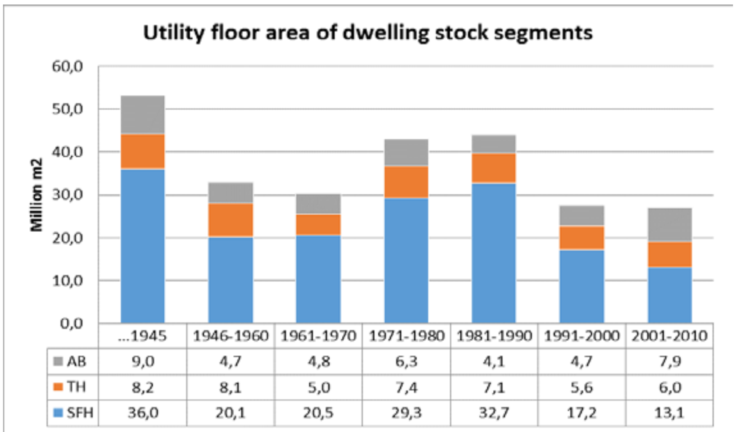


Figure 8: Norwegian dwelling stock by building type and construction year cohort

Evaluation of Data Sources for the Observed Building Stock

The main data source of the observed building stock is Statistics Norway [SSB 2014a] and [SSB 2015], again based on data from different registers and projects. The dwelling statistics is a yearly full accounting of the standing stock, mainly based on each municipality's input to the national 'Matrikkelen' register. Hence there are little systematic or skewed errors in the data, however, there may be other minor errors in the data inputs.

The quality of the dwelling statistics is gradually improving each year. Most of the dwellings in buildings with little information are gradually replaced with new buildings, or new information is available when dwellings are for sale. In addition, the increase in the number of registers used in the production of the statistics also affects the quality.

Availability and quality of data on the status and trends over time regarding thermal building insulation and heat supply is much lower than for the building stock itself, however, some highly relevant information exist:

- The state of thermal building insulation is examined on the background of a representative sample of the national dwelling stock; see Table 31 [Enova 2012]. Here is reported the percentages of buildings still standing that are in their original state, and share of original windows, external walls/facades, and roofs that are not replaced per 2010, per building type (SFH, TH and AB) and construction year cohort (before 1956, 1956-1970, 1971-1980, 1981-1990, 1991-2000 and 2001-2010). Based on this information Prognosesenteret derived weighted average estimates of the thermal characteristics of each building type segment and construction cohort, considered representative for the total national dwelling stock, and further used this for estimating the specific net energy demand (kWh/m^2/year) for each segment and cohort.
- The sources of heat supply are very different in Norway compared to most other countries, as heat is provided mainly by electricity. The most recent data, from 2012, show that 94 % of dwellings have electric space heaters or electric floor heating, 66 % have wood stove or open fireplace (with 60 % closed stove for fuel wood), 4 % district heating and 27 % heat pump (ambient-air, geothermal or ground-source) [SSB 2014b]. The shares of energy carriers delivered to the residential building stock in 2012 are electricity (79.3 %), oil and kerosene (3.5 %) and biofuel (15.8 %), the latter dominated by wood.

Table 31: Share (%) of buildings still standing in original state or with original envelope components in the Norwegian dwelling stock per 2010; Extracted from [Enova 2012]

Share (%)	Segment	Before 1956	1956-1970	1971-1980	1981-1990	1991-2000	2001-2010
Original building	SFH	9	24	61	83	95	100
	TH	14	22	39	91	97	100
	AB	16	25	29	91	97	100
Original windows	SFH	26	36	65	88	96	100
	TH	18	32	44	95	97	100
	AB	27	34	33	93	97	100
Original external walls	SFH	36	68	94	97	99	100
	TH	40	70	88	100	100	100
	AB	57	63	76	95	100	100
Original roof/attic	SFH	45	56	80	86	91	100
	TH	55	63	80	92	100	100
	AB	65	71	94	94	100	100

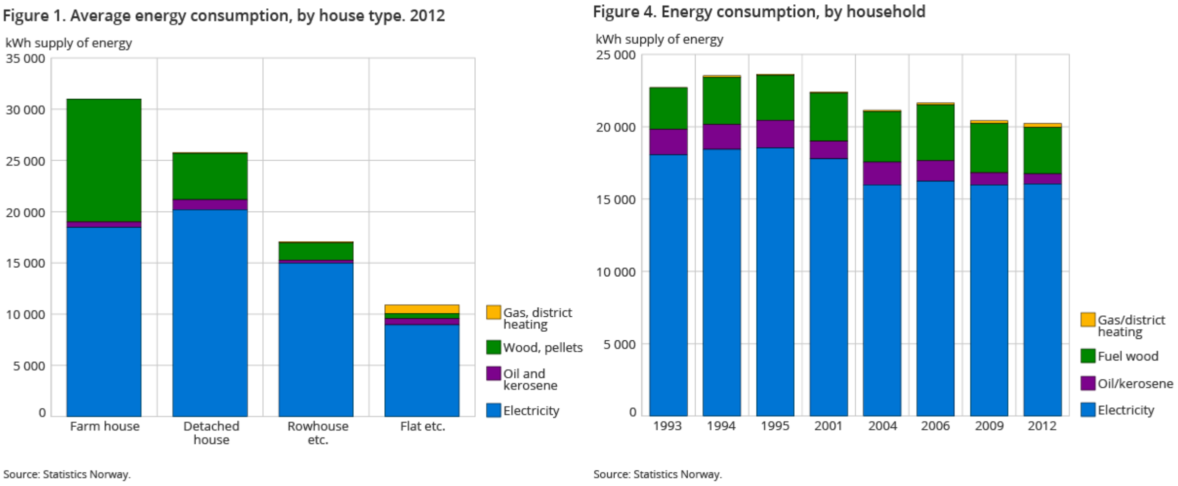


Figure 9: Energy consumption in Norwegian households (all energy purposes) [SSB 2014b]

Approaches / Concepts for Establishing a Continuous Monitoring

As statistical data on the present in-use national residential building stock are easily available, both in aggregated numbers and split for different building types, age cohorts and geographical location, improved data are mainly needed on energy use. This includes average delivered energy intensities (kWh/m^2/year) and energy mix for each type/age segment of the stock, and how these intensity values are improved as a result of energy renovation activity for each segment. In order for this to be used in scenario analysis, better information is needed on the quantities, levels and timing of historical energy renovation (i.e. renovation activities with significant energy saving purposes), and the estimated future implementation of such activities as a consequence of renovation measures taken in the past. There is also lack of good data on how calculated energy demand differs from measured energy demand, today and in the past, for different construction year cohorts and in total.

The national energy efficiency agency reported a potential and barriers study of energy efficiency in buildings, on the basis of a background analysis provided by Prognosesenteret [Enova 2012], which offers an excellent basis for developing scenarios, however, more background data is needed for this to take place at sufficient resolution and quality in a long-term perspective towards 2030 and 2050. Such an improved data basis is partly provided through the Norwegian Pilot Action work in EPISCOPE, as this pilot action provided an improved and consistent selection of average synthetic buildings in each type/age segment of the national building stock as well as energy demand calculations for three variants (energy demand intensity levels according to defined standard and ambitious refurbishment measures). However, in general we believe the following actions should be taken in order to improve the availability and quality of information:

Several improvements of current data are required to track the energy performance of the observed building stock and how necessary information can be made available in future:

1. More detailed monitoring of renovation and demolition activities would make important information available for better analysing the future development of the building stock.
2. Knowledge that is more detailed is needed about the observed and aggregated effects of energy-efficiency measures already implemented through renovation, and about how measured energy demand compares to calculated energy demand in different dwelling types, including the effects of occupancy behaviour in high-efficiency buildings. A representative selection of dwellings from different dwelling types and age cohorts should be used for monitoring measured energy demand for comparison with calculated energy demand.

Given access to such data/findings one may with much better accuracy check if energy reduction targets or national climate protection targets will be reached by scenario calculations, by applying similar modelling principles as used in the Norwegian EPISCOPE action plans, but with improved input quality fed by monitoring facts. These calculation principles would link an energy demand and greenhouse gas emission intensity layer to a long-term dynamic mass-balance consistent building stock model, enabling communication of distance to targets and priority strategies to policy-makers and building portfolio owners. The calculation and scenario methodology could easily be used also on local building stocks or building portfolios of a more limited scope than national level.

Sources / References <NO> Norway

Table 32: Sources / References <NO> Norway

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[Enova 2012]	Enova (ed.) (2012): Potensial- og barrierestudie. Energieffektivisering i norske bygg. Enova rapport 2012:01	A thorough study of energy saving potentials and barreriers for the Norwegian buildings.
[SSB 2014a]	Statistics Norway (ed.) (2014): Norges boligstatistikk 2013. Excel-fil levert fra SSB til NTNU for bruk I EPISCOPE-prosjektet.	Detailed accounting Excel file of the Norwegian dwellings, by numbers and floor area, for each type/age cohort and municipality by 2013-12-31.
[SSB 2014b]	Statistics Norway (ed.) (2014): Energy consumption I households, 2012. Statistics Norway. https://www.ssb.no/en/husenergi/ [2015-06-30]	Recent statistics of the use of energy and heating equipment in Norwegian dwellings.
[SSB 2015]	Statistics Norway (ed.) (2015): Dwellings, 1 January 2014. Available at: http://ssb.no/en/bygg-bolig-og-eiendom/statistikker/boligstat/aar/2015-04-22 [2015-06-30]	Profile of the Norwegian dwelling stock 1 January 2014

2.15 <RS> Serbia

Residential Building Stock in the municipality of Vršac

(by associated EPISCOPE partner University of Belgrade)

Observed Building Stock

Municipality of Vršac is positioned in northern Serbia in Vojvodina region, close to the Romanian border. It covers an area of 801 km^2 and is characterized by good traffic infrastructure. Its landscape is marked with *Vršac Mountains* (*Gudurički vrh* - 641m) and a hilly landscape in contrast with vast Vojvodina's plains. Because it represents the typical municipality of Serbia when number of inhabitants is in question (40000 to 60000) it was chosen for the pilot action. Like other similar size municipalities, Vršac has developed, after the Second World War, unequal distribution of population with 36 040 inhabitants in urban and 15 986 inhabitants in rural settlements. Total number of buildings, dwellings, inhabitants, as well as national and EPISCOPE reference area is shown in Table 33.

Table 33: Scope of the observed building stock in <RS> Serbia (results of the infield survey developed for the purpose of the pilot action)

Scale	No. of dwellings	No. of buildings	No. of inhabitants	m² national reference area	m² EPISCOPE reference area
local	16 835	14 000	52 026	1 489 278 (net living area)	1 638 206

Regarding quality of observed building stock, according to the official census [Census 2013] the average (mean) floor area of the dwellings in Vršac is 84 m^2. When spatial comfort is in question, defined by the area of the dwelling per person, the distribution is not even: the range is between 2.72 % for up to 10 m^2 per person to 24.13 % for 20-30 m^2 per person. Of all dwellings almost 30 % of the stock was built after 1980 when first thermal protection regulations were adopted, out of which less than 1 % after new regulations came into power with the obligation of issuing Energy performance certificates [Rulebook 2011], [Rulebook 2012]. According to the results of the infield survey conducted for the purpose of pilot action, the majority of properties in Vršac are family detached houses (66 %) or semi-detached houses (33 %) while only 1 % represents the part of the residential building stock with other types of multifamily houses without any representative of high rise. According to the Census data [Census 2013a], the occupied residential buildings stock is divided in three groups according to heating system, as illustrated in Figure 10 and Figure 11. The data incorporated in Census were gathered from the gas company and by inquiry of tenants (energy carrier in use). Since this question has multiple choice answers in the census questionnaire, there is no way to determine which of the selected energy carriers is used primarily.

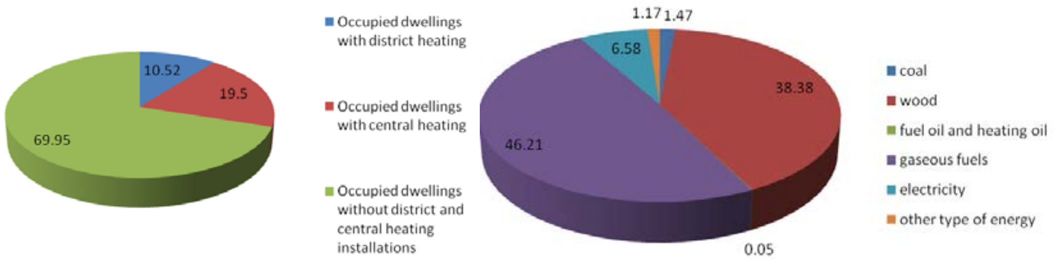
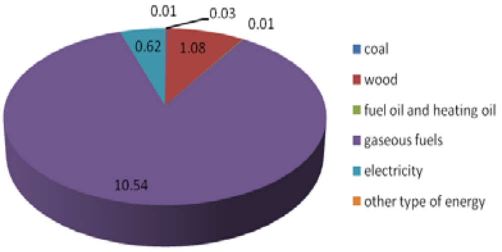


Figure 10: Prevailing heating systems in the observed building stock (left pie chart), and distribution of energy carriers in use in dwellings without district or central heating



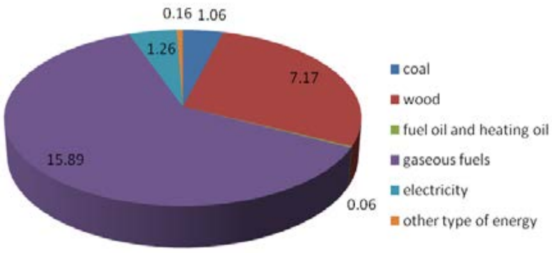


Figure 11: Distribution of energy carriers in use in observed building stock (left pie chart is in dwellings connected to district heating systems, right pie chart for dwellings with central heating systems)

Evaluation of Data Sources for the Observed Building Stock

There are only a few sources available regarding residential building stock of municipality of Vrsac: official sources are Census data and CREP (Central Registry of Energy Passports), as well as unofficial surveys conducted for the purposes of TABULA and EPISCOPE projects by the team from Faculty of Architecture University of Belgrade and IPSOS strategic marketing company, supported by the GIZ organization.

The most reliable and most relevant source is the official state census conducted every 10 years. The last was in 2011, and the results are published in 2013, publicly available on the website of the Statistical Office of Republic of Serbia. The results are structured in 27 books, three of them covering residential buildings and the energy related building characteristics. As the questioners for census are prepared according to international recommendations, the part about building is not too comprehensive, consisting of only of a few questions regarding the quality of buildings and non-concerning their characteristics influencing energy efficiency of building stock. Detailed data about the age, area, structure of dwellings (not buildings), installations, type of fuel and heating systems are available.

CREP (Central Registry of Energy Passports)[4] was established in 2012 after the adoption on Regulations of energy performance of buildings [Rulebook 2011], [Rulebook 2012]. The base and the principles are defined based on the experience of other EU countries with some differences. All the characteristics of buildings should be available including the calculated value for energy needed for heating and energy class. For special purposes (scientific for example), whole calculations should be available only for those with special permit to access data. The obligation to input the Energy certificate related data is mandatory only for new buildings, built according to new regulations, as well as for old buildings undergoing the renovation and reconstruction process for which building permit is needed. Energy certificate is issued in the process of obtaining permit for the use of the building. As the obligation for issuing the energy certificate in the process of real estate turnover is excluded from the Regulations, up to now only a few hundreds of certificates are uploaded. Unfortunately, none of the certificates are for the building in the municipality of Vrsac.

For the purpose of TABULA project, limited survey was conducted as two steps inventory and more than 20000 residential building in Serbia were surveyed. The goal of the survey was to prepare all necessary data for establishing database of residential buildings and definition of National building typology matrix. The questionnaire was based on urban and architectural characteristics of the buildings relevant for energy performance, area of buildings (net and heated), physical characteristics of their thermal envelope, type of fuel and heating systems and systems for domestic hot water preparation. The collected data enabled the calculations of energy performance for selected buildings. All results of the survey were published and are available to the wide public [Jovanović Popović et al. 2013]. Unfortunately, the

4 http://www.crep.gov.rs/ Under jurisdiction of Ministry of Construction, Transport and Infrastructure and Ministry of Minning and Energy

questionnaire did not include questions about the type and scope of conducted energy refurbishment as well as the information about the performed upgrade on electromechanical systems, used for heating and cooling. As, among surveyed buildings only 300 were from Vršac, this database could not be used for a detailed analysis of its building stock, as this sample is not representative, nor it contain sufficient information. Based on the similar principles, new field survey was conducted, again in two steps, for the pilot action in the EPISCOPE project. New methodology, based on bottom up sampling method was developed combining statistical principles with overview of urban and architectural characteristics enabling rather fast and precise way for the development of local residential building typologies. For the first time, the developed methodology was used for the inventory and survey in municipality of Vršac. About 1450 buildings were surveyed (about 10 % of building stock). Up to now, this methodology has not been published.

Approaches / Concepts for Establishing a Continuous Monitoring

According to the Law on rational use of energy [RS MEM 2013] and Action plan [RS II 2013] all the municipalities are obliged to produce and implement Local Energy Action Plans (LEAPs) and establish energy management service (energy managers, energy advisers) with the structure depending on the number of inhabitants in the municipality. The description of their work is defined in 2 rulebooks [RS MME 2015a], [RS MME 2015b]. This service, supported by the municipality government, should and could be the focal point for all the information gathering, data base development and continuous monitoring. Based on the fact that there are only two ways of collecting data on energy characteristics of buildings in municipality of Vršac, official and for research purpose, at least two steps could be planed:

1. Establishing a joint database of all available data by harmonizing existing ones. This data base could cover the whole building stock upgraded with the data from the survey. Further development could be organized by continuous surveys with limited area and questionnaires using developed methodology.
2. Develop and upgrade the joint data base by connecting it to the Cadastre registry since it is the only official data base with the defined unique number connecting the building with its location (lot). Throughout the time, all the data about issued energy certificates, building permits, use permits, bills for gas or electricity converted to final and primer energy and CO_2 emission, could be inserted in this base enabling cross checking on different subjects. Obviously, such a complex data base with necessity of different legal bodies to be included in its functioning, must be established through some legal procedure (law, regulation) in order to be obligatory.

In both cases, the crucial problem is that in municipality of Vršac, as well as in the rest of Serbia, actions concerning family houses, either building new ones or refurbishing, are done without consulting any legal bodies or obtaining any building permits. So it is very difficult to exactly monitor the rate of newly built or refurbished family buildings. The solution for this problem is continuous recognition on the site through surveys, either including 100 % of building for smaller neighbourhood or with limited samples. The same problem and solution could occur with the multifamily building rehabilitation. In this case, actions are organized separately by the flat owners and as a rule, they are almost never synchronized and coordinated. On the other hand, when new buildings are in question, buildings for multifamily housing are almost always built after obtaining the building permit so all the relevant data are available for the input in database.

Sources / References <RS> Serbia

Table 34: Sources / References <RS> Serbia

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[Census 2013]	Republika Srbija Republički zavod za statistiku (2013): Popis stanovništva, domaćinstava i stanova 2011. u Republici Srbiji. Knjiga 22: Broj i površina stambenih jedinica. Beograd. Available at: http://pod2.stat.gov.rs/ObjavljenePublikacije/Popis2011/Knjiga%2022_Broj%20i%20povrsina%20stambenih%20jedinica-Number%20and%20the%20floor%20space%20of%20housing%20units.pdf [2015-06-18]	Census dta - Book 22 - Number and the floor space of housing units.
[Census 2013a]	Republika Srbija Republički zavod za statistiku (2013): Popis stanovništva, domaćinstava i stanova 2011. u Republici Srbiji. Knjiga 27: Stanovi prema vrsti zgrade: Podaci po opštinama/gradovima. Beograd. Available at: http://pod2.stat.gov.rs/ObjavljenePublikacije/Popis2011/Knjiga27.pdf [2015-09-04]	Census data - Book 27 - Dwellings by the type of building: Data by municipalities/cities.
[Census 2013b]	Republika Srbija Republički zavod za statistiku (2013): Popis stanovništva, domaćinstava i stanova 2011. u Republici Srbiji. Knjiga 30: Stanovi prema vrsti energenata za grejanje: Podaci po opštinama/gradovima. Beograd. Available at: http://pod2.stat.gov.rs/ObjavljenePublikacije/Popis2011/Knjiga30.pdf [2015-09-04]	Census data - Book 30 - Dwellings by the type of energy raw material used for heating: Data by municipalities/cities.
[Rulebook 2011]	Pravilnik o energetskoj efikasnosti zgrada, The Official Gazette of Republic of Serbia No. 61/2011	Rulebook on energy efficiency in buildings.
[Rulebook 2012]	Pravilnik o uslovima, sadržini i načinu izdavanja sertifikata o energetskim svojstvima zgrada, The Official Gazette of Republic of Serbia No. 69/2012	Rulebook on conditions, content and method of issuing energy performance certificates.
[Jovanović Popović et al. 2013]	Jovanović Popović, M., Ignjatović, D., Radivojević, A., Rajčić, A., Đukanović, Lj., Ćuković Ignjatović, N., Nedić, M. (2013): Nacionalna tipologija stambenih zgrada Srbije. Beograd: Arhitektonski fakultet Univerziteta u Beogradu, GIZ. Available at: http://www.arh.bg.ac.rs/wp-content/uploads/01415_docs/SAS_EEZA_publikacije/National_Typology_of_residential_buildings_in_Serbia.pdf [2015-09-04]	National typology of residential buildings in Serbia.
[RS MME 2013]	Ministarstvo rudarstva i energetike. Zakon o efikasnom korišćenju energije. Službeni glasnik RS 25/2013. Available at: http://www.mre.gov.rs/doc/efikasnost-izvori/efikasnost/A_01_Zakon_o_efikasnom_koriscenju_energije.pdf [2015-09-04]	Ministry of Mining and Energy - Law on Efficient Use of Energy.
[RS II 2013]	Drugi akcioni plan za energetsku efikasnost Republike Srbije za period od 2013. do 2015. Godine. Službeni glasnik RS 98/2013	“Second action plan for energy efficiency of Republic of Serbia for the period 2013-2015”.
[RS MME 2015a]	Ministarstvo rudarstva i energetike (2015): Pravilnik o uslovima u pogledu kadrova, opreme I prostora organizacije koja sprovodi obuku za energetske menadžere i ovlašćene energetske savetnike. Službeni glasnik RS 12/2015. Available at: http://www.mre.gov.rs/doc/efikasnost-izvori/Pravilnik%20o%20uslovima%20u%20pogledu%20kadrova.pdf?uri=CELEX:32009L0028 [2015-09-04]	Ministry of Mining and Energy – Rulebook on conditions regarding staff, equipment, and spatial requirements for organization that is conducting training for energy managers and official energy advisors.

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[RS MME 2015b]	Ministarstvo rudarstva i energetike (2015): Pravilnik o načinu sprovođenja I sadržini programa obuke za energetskog menadžera, troškovima pohađanja obuke, kao i bližim uslovima, programu i načinu polaganja ispita za energetskog menadžera. Službeni glasnik RS 12/2015. Available at: http://www.mre.gov.rs/doc/efikasnost-izvori/Pravilnik%20o%20nacinu%20sprovodjenja%20obuke.pdf?uri=CELEX:32009L0028 [2015-09-04]	Ministry of Mining and Energy – Rulebook on procedure and content of training programme for energy managers, training fees, as well as detailed conditions, programme and means of taking the exam for energy manager.

2.16 <SI> Slovenia

National Residential Building Stock of Slovenia and Residential Building Stock of the Municipality Kočevje

(by EPISCOPE partner ZRMK)

For the pilot project, ZRMK observed national and local building stock (Municipality of Kočevje). In these report the focus is on the national part of the pilot project. In each sub-chapter we added specific information for the local level.

Observed Building Stock

Slovenia

Residential buildings are in accordance with the classification of types of buildings divided into single-family houses (e.g. separate houses, villas, farmhouses, holiday houses, terraced houses or twins with one dwelling), two- and three-dwelling buildings and multi-dwelling buildings. In 2014 there were more than 844,000 dwellings in Slovenia [SURS 2015a]. The average (mean) floor area of a single-family house in 2012 was calculated to be 160 m^2, apartment 60 m^2. Of all dwellings, 71 % were built before 1985, thus presenting the set of buildings that is responsible for the considerable share of CO_2 emissions [MzI 2015b].

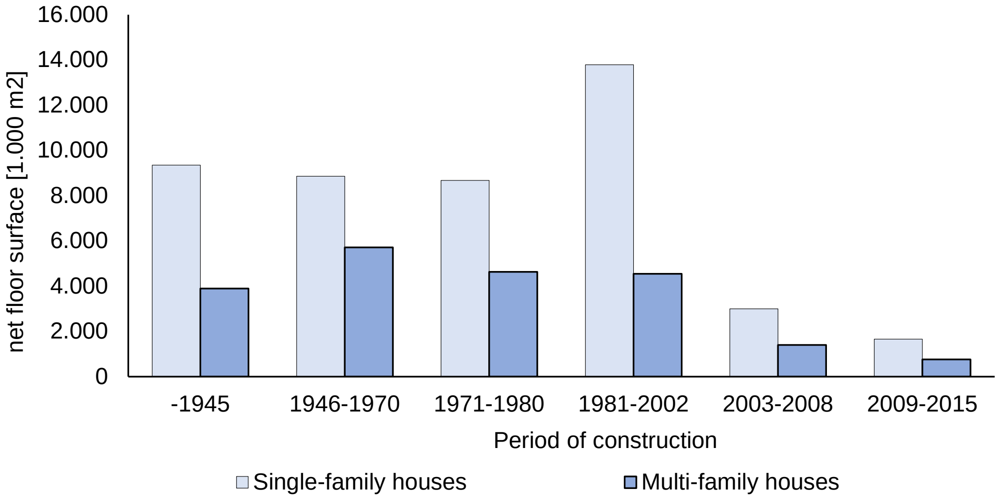


Figure 12: Frequencies of single – family and multi – family houses according to construction year [REN 2014]

When viewed in the usable floor area, the share of single-family houses is 67 %. Viewed in number of dwellings, in 2012 there were 469,911 single-family houses, while there were 305,293 dwellings in multi-family buildings, the usable surface, the proportion of single-family buildings is significantly higher, 73 %.

Municipality of Kočevje

The housing stock of the observed municipality in Slovenia is situated in the average climatic zone that shares the same characteristics as national building stock. By size, the municipality is the biggest in Slovenia.Data sources are the same and come from national statistics [SURS 2015a], [REN 2014]. The stock consists of 1251 single family houses, with an average 104 m² useful floor area 178 m² net floor area. 290 multi-family building consists of 2406 dwellings, where the later has an average size of 54 m² useful floor area.

Table 35: Scope of the observed building stock in <SI> Slovenia and Municipality Kočevje [SURS 2015a], [GURS 2015]

Scale	No. of dwellings	No. of buildings	No. of inhabitants	m² national reference area	m² EPISCOPE reference area
national (Slovenia)	~ 844,000	~ 523,850	~ 2 million	~ 67.2 million (useful area)	~ 73.92 million
local (Kočevje)	~ 3,625	~1,541	~ 9,027	~ 446,714 (net dwelling area)	~ 491,385

Evaluation of Data Sources for the Observed Building Stock

The main data sources of the observed building stock are Statistical office of the Republic of Slovenia [SURS 2015b], Register of Real Estates [REN 2014], and data on subsidies Eko sklad [Eko sklad 2009-2014]. Further data derived from different registers (EPC, E-REN) and projects such as TABULA [ZRMK 2012]. The dwelling statistics is a yearly full accounting of the standing stock, mainly on the number for the building permits and based from the survey in 2007, when REN was set. Hence there are little systematic or skewed errors in the data, which relate to the status up to 2007, furthermore there may be other minor errors in the data inputs. For status after 2007 the Register of Real Estates is very inadequate, due to optional input by building owners into the register. These deficiencies will be solved with fully operating E-REN, which is going to be regularly updated. First steps for the new registry (E-REN) ware undertaken by ZRMK during EPISCOPE project. New building data collection form was developed and proposed to ministry. It was added to EPC registry first.

The quality of the statistics is gradually improving each year. Most of the dwellings in buildings with little information are gradually replaced with new buildings, or new information is available when dwellings are for sale or for rent, since they need an EPC.

Availability and quality of data on the status and trends over time regarding thermal building insulation and heat supply is much lower than for the building stock itself, however, some highly relevant information exist:

The state of thermal building insulation is examined on the background of data in Register of Real Estates, where for each building it is stated the year of renovation of walls, roof and replacement of windows. Though there is no information about the extent of this renovation (e.g. thickness of insulation), national surveys for energy efficiency are being conducted each 2nd year on 1,000 residential buildings [REUS 2013] and it is synchronized with the sources for the TABULA typology, since the start of the surveys REUS.

The reported analysis on residential buildings are structured according to building type (SFH, and AB) and construction year cohort (before 1945, 1946-1970, 1971-1980, 1981-2002, 2003-2008 and 2009-2015). Respective to those two parameters, surveys gives answers on:

- Energy management,
- Segmentation households,
- Condition of buildings,
- Heating and ventilation,

- Energy consumption,
- Heating hot water,
- Cooling,
- Electricity,
- Production of electricity.

These surveys for some types and building's cohorts faces the question of representativeness, since the sample are small for some groups., thus enables to use the result of this survey only for the purpose of further research.

Municipality of Kočevje

Due to the structure of data on the current state of the buildings, on the level of building envelope, in national databases, it is possible to use those databases as well for national, as well for local analysis. It's similar for subsidies databases, from which derive all buildings that were subjected to energy efficient measure(s), so they can be used for regional and national level.

The main difference lies in using data from the national surveys. National surveys represent data from all buildings in the country and if some data is representative, it represents this exact data for all buildings in the country. Regional areas are much more specific and can vary from the national survey.

Considering this, such survey data cannot be exactly used in analysis on local building stock. Main local data source are local key actors that can provide some/much more insight (depending on the municipality) into the local building stock.

Buildings connected to Municipality Kočevnje district heating network were precisely identified. Combining these results with the total local building stock was concluded, that share of total floor area that use district network heating and domestic hot water preparation is much bigger than that derived from the national survey.

Some municipalities or regions (local/region energy agencies) conduct surveys (relating to energy efficiency in buildings) on their own, and if these data are available and accessible, it can be used in the model.

Approaches / Concepts for Establishing a Continuous Monitoring

Data on the existing national residential building stock are available, in both aggregated numbers and split for different building types, age cohorts and geographical location, including the year of renovation of each building construction (for which the extent is not known, e.g. thickness of thermal insulation). Those data are reliable for the status up to approximately 2008. Due to several reasons after this year the tracking and regular update of databases is not reliable, due to decrease of new inputs into databases, despite increased construction activities. An important gap in the past years was mainly related to energy use. This includes average delivered energy intensities (kWh/m^2/year) and energy mix for each type/age segment of the stock, and how these intensity values are improved as a result of energy renovation activity for each segment.

There is also lack of reliable data on how calculated energy demand differs from measured energy demand, today and in the past, for different construction year cohorts and in total.

Several improvements of current data are required to track the energy performance of the observed building stock and how necessary information can be made available in future:

- **Monitoring**: Detailed monitoring of renovation and demolition activities would make important information available for better analysing the future development of the building stock.
- **Renovations**: Data on effects of energy-efficiency measures already implemented through renovation, and about how measured energy demand compares to calculated energy demand in different dwelling types, including the effects of occupancy behaviour in high-efficiency buildings

Based on EPISCOPE experiences ZRMK (with NAG) started building a comprehensive database on the energy performance of buildings where all the data from the actions associated with the EPBD is collected. Existing databases (building cadastre, registry of buildings) were linked with new EPBD database that include: data from energy performance certificates, regular inspection of boilers and air conditioning systems, energy management and also with the data from the inspection of central-heating boilers by chimney sweepers and with data on real-estate market. This is called energy registry of buildings (en-registry, E-REN).

The general idea is to collect the date about the state of the building each time somebody does regulatory assessment/inspection. This is achieved by electronically collection of the data and with a specially prepared questioner that collects info about state of the building.

This new databases are filled through different online/offline applications. Each of the users (e.g. EPCs assessor, chimney sweeper) has her unique access. Energy Performance Certificates are calculated and issued through online application. Chimneysweepers are using offline tablet app on the site and they deploy the data later when they prepare the report. Data about energy management of building is collected through standard-web-service-protocol that connects public database with different offline apps developed for building monitoring.

All of the above collection protocols are open type. Standard XML files are defined that have to be imported to the central database. This enables assessors/inspectors to develop commercial software tools for supporting the assessment process.

Regardless of origin of the data, it is stored in a central place – linked to the assessed building. Data can be divided into two groups. In the first group is the data derived from assessment process. For energy performance certificate this data is for example: conditioned area of the building, primary energy indicator, envelope area, location of the building, etc. In the second data group one can find data that is not directly connected to the assessment process. For EPC this would be the information about the year of the past refurbishment measures, shape of the building, use of rain water, number of storeys, etc. The first data group changes according to the assessment process; the second data group is the same for all assessments processes.

During the uploading of new data an assessor/inspector has the opportunity to check the existing en-registry data. In the occurrence of data mismatch, e.g. number of storeys, assessor can correct the value. This correction does not erase the old value, but serves as a mark, a pinpoint. During data quality check this marks are evaluated, cross data checked and corrected.

The first predictions show that it will take 2-3 years, in order to have the entire building stock in one single database, which is going to consist the data on thermal envelope and used technologies for heating, cooling, DHW etc. But already now the database is filled with more than 6.000 buildings, which already represents a representative sample in residential sector.

For renovations and new construction projections to 2030 have been set up and based on the energy registry of buildings, the projections are going to be regularly updated respectively. The last gap of data is related to lack of information of energy consumption of buildings. The gap will be filed in the future with the upgrade of the registry to serve as an energy-performance-contracting platform. With energy performance-measuring IoT (internet of things) devices installed in the building during energy performance contract en-registry will collect data on user behaviour and energy use of the buildings.

In the past 2 years, EPC databases was set up and gradually the later gap will soon be smaller, but for the buildings without EPC the energy use will still be unknown. In order for this to be used in scenario analysis accordingly, better information is needed on the quantities, levels and timing of historical energy renovation (i.e. renovation activities with significant energy savings), and the estimated future implementation of such activities as a consequence of renovation measures taken in the past.

Given access to such data/findings one may make better accuracy check if energy reduction targets or national climate protection targets will be reached by scenario calculations, by applying to the bottom-up building stock model, that was created during EPISCOPE project. Regular monitoring and application to the model would link an energy demand and greenhouse gas emission intensity layer to a long-term dynamic consistent building stock model, enabling communication of distance to targets and priority strategies to policy-makers and building portfolio owners. The model methodology can easily be used also on local/regional building stocks (e.g. Municipality of Kočevje) or on a national level.

Municipality of Kočevje

The model methodology can be used also on local level (e.g. Municipality of Kočevje).

Considering the fact that for the moment there are more data available on the local level actual scenarios and plans for the future are easier to apply. With new data collection model on national level, these gaps will be smaller.

Sources / References <SI> Slovenia

Table 36: Sources / References <SI> Slovenia

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[Eko sklad 2009-2014]	Eko sklad (2009): Letno poročilo o dejavnosti in poslovanju Eko sklada, Slovenskega okoljskega javnega sklada v letu 2008, Ljubljana, marec 2009. Available at: http://www2.ekosklad.si/pdf/LetnaPorocila/LP_08_slo.pdf [2015-07-21] Eko sklad (2010): Letno poročilo o dejavnosti in poslovanju Eko sklada, Slovenskega okoljskega javnega sklada v letu 2009, Ljubljana, marec 2010. Available at: http://www2.ekosklad.si/pdf/LetnaPorocila/LP_09_slo.pdf [2015-07-21] Eko sklad (2011): Letno poročilo o dejavnosti in poslovanju Eko sklada, Slovenskega okoljskega javnega sklada v letu 2010, Ljubljana, marec 2011. Available at: http://www2.ekosklad.si/pdf/LetnaPorocila/LP_10_slo.pdf [2015-07-21] Eko sklad (2012): Letno poročilo o dejavnosti in poslovanju Eko sklada, Slovenskega okoljskega javnega sklada v letu 2011, Ljubljana, marec 2012. Available at: http://www2.ekosklad.si/pdf/LetnaPorocila/LP_11_slo.pdf [2015-07-21] Eko sklad (2013): Letno poročilo o dejavnosti in poslovanju Eko sklada, Slovenskega okoljskega javnega sklada v letu 2012, Ljubljana, marec 2013. Available at: http://www2.ekosklad.si/pdf/LetnaPorocila/LP_12_slo.pdf [2015-07-21] Eko sklad (2014): Letno poročilo o dejavnosti in poslovanju Eko sklada, Slovenskega okoljskega javnega sklada v letu 2013, Ljubljana, marec 2014. Available at: https://www.ekosklad.si/dokumenti/media/LetnaPorocila/LP_13_slo.pdf [2015-07-21]	Eko Fund - The Environmental Fund of the Republic of Slovenia. A review of subsidies in the housing sector for the period 2008-2014 – annual reports.
[EPC 2015]	Ministrstvo za infrastrukturo (2015): Register energetskih izkaznic [Status: May 2015]	Registry of Energy Performance Certificates.
[GURS 2015]	Geodetska uprava Republike Slovenije (2015): Register nepremičnin in Kataster stavb. [Status: May 2015]	Geodetic Administration of the Republic of Slovenia. Anaylsed databases: Register of Real Estates, Building cadastre.
[MzI 2015b]	Republika Slovenija Ministrstvo za infrastrukturo (2015): Dolgoročna strategija za spodbujanje naložb energetske prenove stavb. Available at: http://www.energetika-portal.si/dokumenti/strateski-razvojni-dokumenti/dolgorocna-strategija-za-spodbujanje-nalozb-energetske-prenove-stavb/ [2015-07-21]	Long-term strategy for mobilising investment in the renovation of the national stock
[REN 2014]	Geodetska uprava Republike Slovenije (2014): Register nepremičnin Slovenije	Registry of Buildings
[REUS 2013]	Dolinšek, Rajko (2013): Raziskava energetske učinkovitosti Slovenije za stanovanjski sector.	The survey of energy efficiency Slovenia for the housing sector.
[SURS 2015a]	Statistični urad Republike Slovenije (2015): Podatki o izbranem naselju. Available at: http://www.stat.si/krajevnaimena/default.asp?txtIme=KO%C8EVJE&selNacin=celo&selTip=naselja&ID=1615 [2015-07-21]	Statistical Office of the Republic of Slovenia. Data on population

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[SURS 2015b]	Statistični urad Republike Slovenije (2015): Ocena gradnje stavb. Available at: http://pxweb.stat.si/pxweb/Database/Ekonomsko/19_gradbenistvo/05_19238_graditev_stavb/05_19238_graditev_stavb.asp [2015-07-21]	Statistical Office of the Republic of Slovenia. Data on buildings
[ZRMK 2012]	Rakušček, Andraž; Šijanec Zavrl, Marjana; Stegnar, Gašper (2012): National Scientific Report – Slovenia. IEE TABULA – Typology Approach for Building Stock Energy Assessment. Gradbeni inštitut ZRMK; Ljubljana / Slovenija; May 2012. Available at: http://episcope.eu/fileadmin/tabula/public/docs/scientific/SI_TABULA_ScientificReport_ZRMK.pdf [2015-07-21]	Pregled pristopa k tipologiji za oceno energijske bilance stavbnega fonda

3 Information on the BPIE Data Hub

(by EPISCOPE partner BPIE)

3.1 Introduction to the BPIE Data Hub

In November 2012, BPIE launched a comprehensive repository for statistics and policy information on the European building stock (www.buildingsdata.eu). The objective of the BPIE Data Hub was to support the EU policy making process and to provide the statistics for a fact-based discussion on how to leverage the energy saving potential of EU buildings while maximizing environmental, economic, and social benefits.

The BPIE Data Hub includes a wide variety of technical data collected in EU-28, Norway and Switzerland either through statistical offices or from informal databases from research or other bodies. The primary source of information is the BPIE Survey on energy use in buildings undertaken in 2011 [BPIE 2011].

To better monitor, compare and look for more comprehensive and robust data, BPIE has integrated other sources of information on the European building stock. This includes, in particular, findings of the EU funded projects such as: the TABULA (2009-2012) [EC IEE 2015a], the ENTRAZNE (2012-2014) [EC IEE 2015b], as well as the EPISCOPE project (2013-2016) [EC IEE 2015c].

To date, there are over 17 600 unique users of the portal, including different group of stakeholders around the globe (Figure 13). The BPIE Data Hub proved to be a useful source of information for the European Commission, industry associations, researchers and many others. The BPIE Data Hub methodology will now also contribute to the development of the EU Building Stock Observatory currently developed for the European Commission (under the service contract no 2014/S 146-261501).

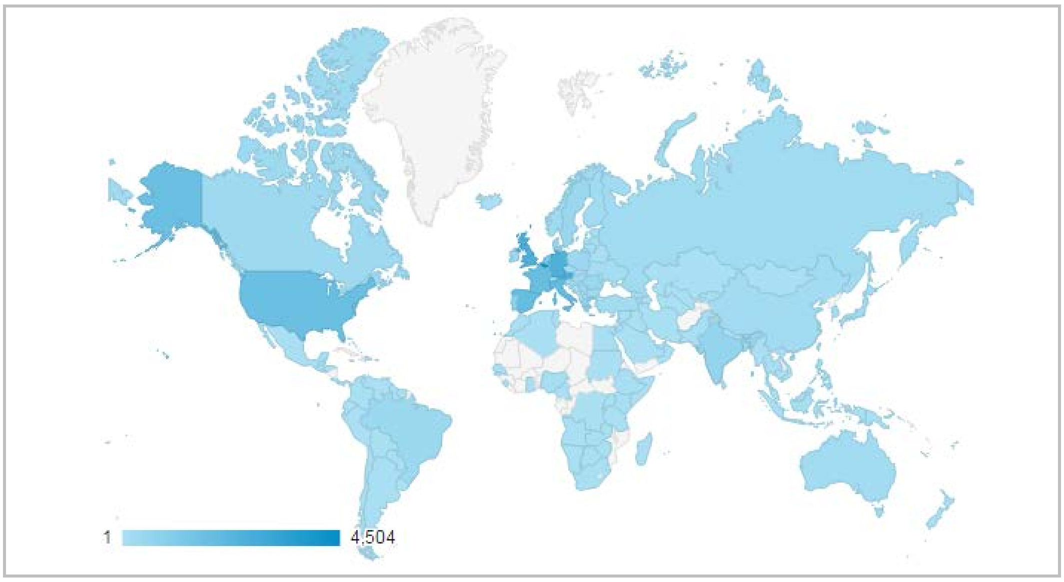


Figure 13: The BPIE Data Hub users by geographic location; Google Analytics, 08/2015. © 2015 Google

3.2 An integration of the 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 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 (Figure 14):

- ✓ **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.

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

- ✓ **The residential building stock modernisation trends**

  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 to monitor the thermal protection and heat supply of the residential building stock.

  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 2014b] and the nZEB factsheet [BPIE 2015].

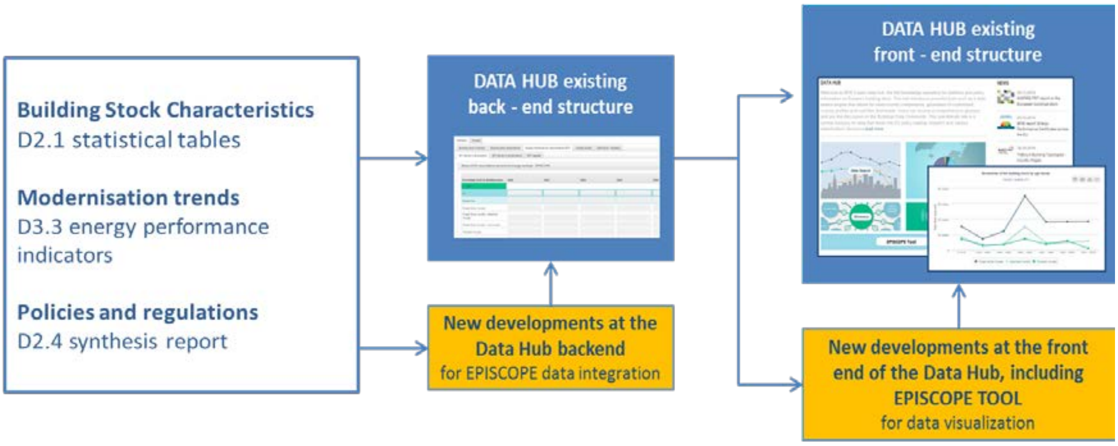


Figure 14: Schematic overview of integration of the new data sets in the existing BPIE Data Hub structure

The EPISCOPE tool

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 at: www.buildingsdata.eu.

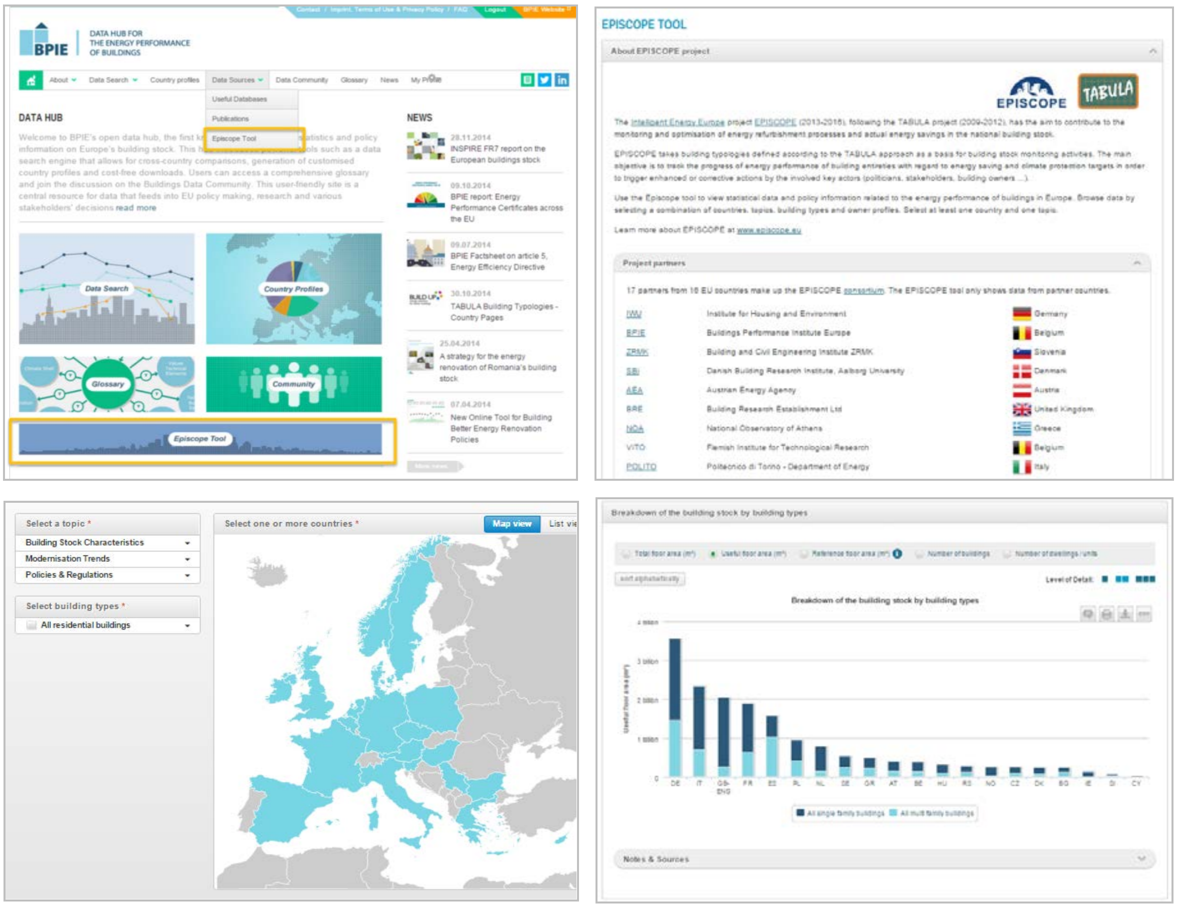


Figure 15: The EPISCOPE tool – a dedicated tool to present the project results.

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 15 presents an exemplary screen shots from the EPISCOPE tool.

3.3 Exemplary results

New indicators at the BPIE Data Hub

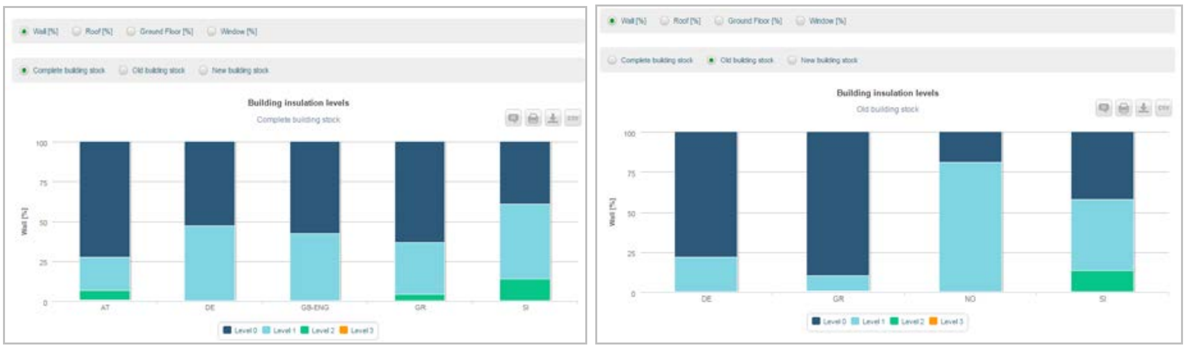
The BPIE Data Hub was launched prior to the start of the EPISCOPE project, thus some results had to be integrated the existing structure of the portal. There were, however, the new data sets elaborated in the project that needed to e harmonised and integrated (Table 37).

Table 37: 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**

Modernisation trends

The methodological approach and the list of indicators to track the energy refurbishment progress of the housing stock have been elaborated during the EPISCOPE project [IWU 2014a]. 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 (2013 status) for six countries have been integrated in the EPISCOPE tool; see exemplary results in Figure 16.



Note: The insulation levels have been set by the national experts; detailed explanation is provided in the notes; for example: AT/DE/: Level 0: U> 0,7 W/m^{2}K; Level 1: 0,7 W/m^{2}K >= U > 0,3 W/m^{2}K; Level 2: 0,3 W/m^{2}K >= U > 0,20 W/m^{2}K; Level 3: U <= 0,20 W/m^{2}K and UK/ENG: Level 0: U > 1,7 W/m^{2}K; Level 1: 1,7> U> 0.5 W/m^{2}K ; Level 2: 0,5 W/m^{2}K >= U > 0,2 W/m^{2}K; Level 3: U< 0,20 W/m^2

Figure 16: The EPISCOPE tool – exemplary results of the building insulation levels for walls for complete and old residential building stock;

nZEB definition

A new indicator on the nearly Zero Energy Buildings (nZEB) definition for new and existing building has been integrated in the structure of the Data Hub. It was based on the methodology developed for the BPIE factsheet [BPIE 2015] in cooperation with the EPISCOPE project. An exemplary result for Slovenia is shown in Figure 17.

Slovenia (SI)

New/existing buildings	New Buildings	Existing Buildings
Status	Yet to be approved	Yet to be approved
Numerical indicator	Yet to be approved	Yet to be approved
Share of renewable energy	Under Dvelopment	Under Dvelopment
nZEB definition	The nZEB definition was defined in the National plan for nZEBs (in public consultation since October 2014). It is based on strengthened minimum requirements valid for all new buildings, major renovation and maintenance measures imposed in the technical regulation PURES 2010, which is valid from 31 December 2014 onwards. In addition, the nZEB definition prescribes: - Maximum primary energy consumption: o 85 kWh/m²/y for single-family houses o 80 kWh/m²/y for multi-family houses o 55 kWh/m²/y for non-residential buildings - A maximum specific heat demand of 25 kWh/m²/year - The primary energy needs can only be met through a significantly higher actual share of renewable energy (expected to increase from 25% to 50%) in the total final energy consumption	The nZEB definition was defined in the National plan for nZEBs (in public consultation since October 2014). It is based on strengthened minimum requirements valid for all new buildings, major renovation and maintenance measures imposed in the technical regulation PURES 2010, which is valid from 31 December 2014 onwards. In addition, the nZEB definition prescribes: - Maximum primary energy consumption: o 90 kWh/m²/y for single-family houses o 105 kWh/m²/y for multi-family houses o 80 kWh/m²/y for non-residential buildings - A maximum specific heat demand of 25 kWh/m²/year - The primary energy needs can only be met through a significantly higher actual share of renewable energy (expected to increase from 25% to 50%) in the total final energy consumption
Sources	Official Journal 17/14, National nZEB Plan	Official Journal 17/14, National nZEB Plan

Figure 17: The EPISCOPE tool – exemplary results of the nZEB definition in Slovenia for new and existing buildings.

Further harmonisation of the Europe's buildings stock statistics

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 has revised the residential typology at the BPIE Data Hub and integrated the TABULA typology approach (Figure 18).

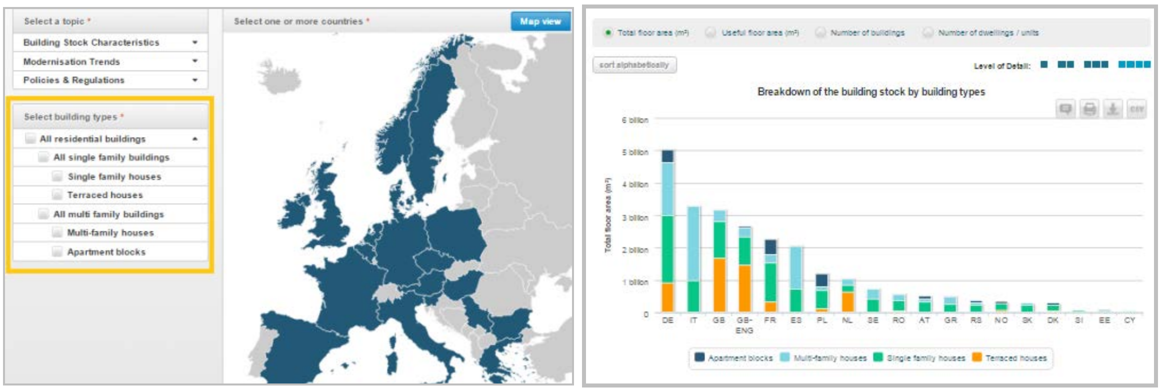
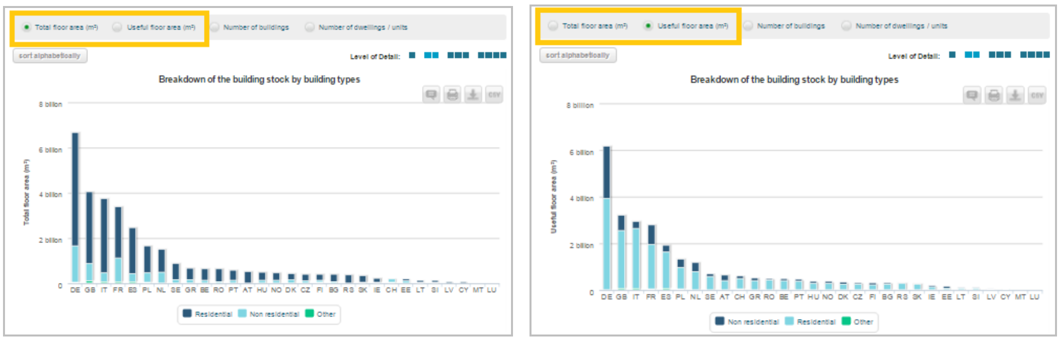


Figure 18: Residential building typology in the EPISCOPE tool and at the BPIE data hub

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 at the hub, BPIE provided a differentiation by the type of floor area: useful and total/gross floor area (Figure 19). The conversion factors were based on the expert's assumptions and are specific for the country and the building type.



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

Figure 19: Total and useful floor area of building stock

3.4 Sources / References

Table 38: Sources / References Information on the BPIE Data Hub

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[BPIE 2011]	BPIE (2011): Europe's Buildings under the Microscope; A country-by-country review of the energy performance of Europe's buildings, Brussels. Available at: http://www.bpie.eu/eu_buildings_under_microscope.html [2015-08-03]	The report presents the results of the BPIE Survey 2011 in 27 EU Member States as well as Norway and Switzerland. The goal was to provide a vital and up-to-date picture of the European building stock and its energy and CO2 savings potential.
[BPIE 2015]	BPIE (2015): Nearly Zero Energy Buildings Definitions across Europe. Factsheet, Brussels 2015. Available at: http://bpie.eu/uploads/lib/document/attachment/132/BPIE_factsheet_nZEB_definitions_across_Europe.pdf [2015-08-03]	The factsheet summarises the current status of different approaches and indicators used by EU Member States (and Norway) for the nZEB definition of new and existing buildings.
[EC IEE 2015a]	European Commission / Intelligent Energy Europe (2015): Typology Approach for Building Stock Energy Assessment (TABULA). Available at: https://ec.europa.eu/energy/intelligent/projects/en/projects/tabula [2015-08-05]	Information on the IEE project TABULA in the Intelligent Energy Europe projects database
[EC IEE 2015b]	European Commission / Intelligent Energy Europe (2015): Policies to enforce the transition to nearly zero energy buildings in the EU-27 (ENTRANZE) Available at: https://ec.europa.eu/energy/intelligent/projects/en/projects/entranze [2015-08-05]	Information on the IEE project ENTRANZE in the Intelligent Energy Europe projects database
[EC IEE 2015c]	European Commission / Intelligent Energy Europe (2015): "Energy Performance Indicator Tracking Schemes for the Continuous Optimisation of Refurbishment Processes in European Housing Stocks" (EPISCOPE). . Available at: https://ec.europa.eu/energy/intelligent/projects/en/projects/episcope [2015-08-05]	Information on the IEE project EPISCOPE in the Intelligent Energy Europe projects database
[IWU 2014a]	Diefenbach, N.; Loga, T.; Stein, B. (ed.) (2014): Energy Performance Indicators for Building Stocks First version / starting point of the EPISCOPE indicator scheme (to be developed during the project), Institut Wohnen und Umwelt (IWU), Darmstadt. Available at: http://episcope.eu/fileadmin/episcope/public/docs/reports/EPISCOPE_Indicators_FirstConcept.pdf [2015-08-03]	The report presents the methodology approach to track of the energy refurbishment progress of housing stock entities in the field of thermal protection and heat supply (heating and hot water). It presents an initial list of the Energy Performance Indicators (EPI) to be used in the national, regional and local pilot actions.
[IWU 2014b]	Stein, B.; Loga, T.; Diefenbach, N. (ed.) (2014): Inclusion of New Buildings in Residential Building Typologies. Steps Towards NZEBs Exemplified for Different European Countries. EPISCOPE Synthesis Report No. 1, Institut Wohnen und Umwelt (IWU), Darmstadt. Available at: http://episcope.eu/fileadmin/episcope/public/docs/reports/EPISCOPE_SR1_NewBuildingsInTypologies.pdf [2015-08-03]	The report 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 national residential building typologies for the 17 participating countries.

4 Summary and Conclusions

(by EPISCOPE partner IWU)

In the framework of the EPISCOPE case studies a large variety of residential building stocks on different spatial levels (national, regional and local) was analysed. Accordingly - and also due to the varying availability of information sources – the concepts of data collection and monitoring, which are presented in chapter 2, differ substancially. But nevertheless, there are some common conclusions which can be drawn.

4.1 The general problem: Lack of empirical primary data

The data situation of European residential building stocks is in general unsatisfactory. Available information sources are not sufficient to fulfil the prominent role they should play for climate protection strategies (see chapter 1). There are wide information gaps concerning the actual state as well as the trends of building thermal insulation and efficient / renewable heating systems.[5] Altogether the problem appears to be fundamental.

A reason for that might be on the one hand a lack of awareness of the importance of a reliable information basis: Since it takes a lot of time to solve the climate and energy problem and the future is uncertain anyway: Why should we care so much about the present? But this perspective does ignore the chances of giving a complex discussion a necessary fundament (see chapter 1) and from a scientific point of view it is simply not acceptable.

On the other hand there might be the impression that if there is so much effort and research about buildings and energy efficiency as in the recent years, sufficient data should have been generated somehow by those activities and projects. So the only task would be to collect and merge all that information in order to draw a complete picture. Indeed there are many studies using building stock energy balance models describing the current state of the building stock. But information gaps are often closed by estimations, which are not based on objective knowledge. Closing gaps by assumptions is a necessary approach and acceptable as long as assumptions are denoted as such. However, estimations – even if they make a career of further quotations – cannot replace the necessary objective observations. The basic problem is not a lack of secondary studies which describe the status quo of existing building stocks; it is the lack of reliable and comprehensive primary data. Although some primary data is available in almost all cases: Only occasionally (like in England, see Chapter 2.8) the available primary data appears to be sufficient to deliver meaningful and almost complete information - especially if regular monitoring is considered and not only singular activities (e.g. in Germany only the status quo for the residential building stock in 2009, see chapter 2.5).

In the framework of the EPSCOPE case studies, the availability of primary data necessary to setup building stock models and scenarios was investigated, and subsequently complemented by further assumptions [EPISCOPE Project Team 2016a], [EPISCOPE Project Team 2016b]. Carrying out own primary data collections during EPISCOPE was in most cases not within the project scope, but there were exceptions: Some partners who analysed local building stocks carried out small surveys (BE, CY, HU, IE, RS) to get at least a rough picture of some basic properties of the observed building stocks.

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5 This concluision can also be drawn by looking at the available data sources of national building stocks on the TABULA ”Country Pages” [EPISCOPE Project Team 2016c]. All partners, even those who were dealing with local building stocks in their EPISCOPE case studies, provided available data of energy efficiency for their national residential building stocks. They followed the rule to feed in only reliable information based on meaningful primary data. The outcome shows that in fact a lot of information exists. But on the other hand many gaps remain, which could not be filled with data, or due to the lack of regular monitoring approaches the information available is out-of-date.

During the project also effort was made to compile the available information on national building stocks of all countries involved and make it usable online. This was done by presenting the numbers (and the underlying data sources) at the "Country Pages" of the TABULA/EPISCOPE website ([EPISCOPE Project Team 2016c], see also footnote 5) as well as by integrating detailed data of some of the countries in the BPIE data hub (as described in Chapter 3), a broadly based internet information platform of energy efficiency and climate protection issues for European building stocks. In this way different data sources are brought together in order to provide a comprehensive overview of available information. But of course it cannot solve the fundamental problem of existing gaps in primary data.

To proceed with this task a single standard solution cannot be presented because of the large variety of building stocks and data sources. Accordingly, concepts for improving the situation and establishing regular monitoring referring to the individual situation of the observed building stocks were in the first place elaborated by the single partners and documented in the subsections of chapter 2.

Nevertheless, recommendations can be given for the design of data collection methods which have the potential of a harmonised approach in European countries. After providing a more detailed look on different data sources in section 4.2, the outline of such a concept is given in section 4.3 – focused on the application on large (preferably national) building stocks. Afterwards empirical data of buildings' energy consumption as a basis for improving energy balance methods is discussed as a special question in section 4.4.

4.2 Applicable data sources

Complete Inventory Counts and Building Portfolios

In two case studies (CZ, FR) the partners could make use of data comprising almost all buildings of the observed stock. This situation seems to be rather convenient, but in practice it turned out that there still were relevant data gaps, fractions of the data were flawed, and the maintenance of the data was not sufficiently organised. Usually, complete inventory counts are restricted to special building stocks, e.g. building portfolios of housing companies. But there are exceptions: Data of the national register played a considerable role among the Slovenian data sources (chapter 2.16)[6]. But the database was to a large extent not up-to-date, so that other and less convenient data sources had to be used in addition. These examples result problematic as: The (almost) complete covering of the building stock alone is not sufficient. The data also need to be maintained: they must be up-to-date and complete (provide information of all relevant building characteristics[7] for all buildings). Depending on the building stock the EPISCOPE partners made specific suggestions to organise the data update in case of changes (especially refurbishments) and to introduce supplementary building characteristics to complete the picture.

Also the use of a census will mostly not be a realistic option. In fact, national censuses may often include a complete inventory count of buildings or dwellings. But in practice the number of collected variables is usually small: Energy efficiency and climate protection is not the main focus of a census. Introducing new properties in the census or even establishing a new and special inventory count would be very difficult because of complexity, involvement of all kinds of key actors and costs.

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[6] Besides, in the Dutch case (chapter 2.13) building portfolios of housing companies were used for a national data base of the non-profit building stock. But the data base itself is not complete because only a sample (although in fact the majority) of housing companies participate.

[7] This was for example to a large extent not given by the information pool which was available in the Cypriot case study.

EPC Databases

The question may be asked if Energy Performance Certificate (EPC) Databases can fill the gap: In some countries they exist or are being established – sometimes on national level. Even if they do not include all buildings: They include information of all buildings which already have an energy performance certificate. So this might be an interesting option and in fact some of the EPISCOPE case studies made use of EPC databases as main or major data sources (AT, IT, FR, IE, GR).

In the previous European project DATAMINE [DATAMINE Project Team 2009a] the role of EPC data to monitor building stocks had already been analysed - on the basis of bottom-up actions but also in general. The project showed that EPCs can serve as a valuable information basis for specific questions and specific subsets of the building stock (e.g. the new building sector, if all certificates of new buildings are collected in a data base). But concerning the general task of monitoring the complete building stock some obstacles were identified:

- EPC data might be not comprehensive since they are designed to serve different purposes than building stock monitoring: Depending on the type of certificates and the level of detail of documented data some of the necessary basic information is often not included in the certificates and in the central data base: For example, the data base might only consider results of energy balance calculations and not the basic input data itself (U-values of building elements, information of heat supply systems).
- The EPC data base might be not representative for the building stock. Usually such a data base does not include data of all buildings and in addition the available EPC data might be out of date in some cases (not describing the current state of the buildings). So even if there is a large number of buildings available and a high percentage of the building stock is covered by the database, it might be biased since EPC issuing is by law linked to specific occasions (selling, renting, renovation) which may have different probabilities of refurbishment than the average building stock. Thus, analyses of the EPC data base might provide incorrect statistical information on the building stock.

The EPISCOPE project partners who applied EPC data for building stock monitoring were aware of this problem and, as far as possible, took corrective action: For example in the Italian case study (chapter 2.12) information of the different occasions of issuing the energy certificate (sale and rent / new building / building renovation) were used for a stratification of the available sample – placing the EPCs into different subsets and assigning different expansion factors to the subsets for projection to the whole building stock.

But still it had to be verified if corrective action is sufficient to ensure representative results of EPC database analysis. At least this is a question of the individual case and it becomes clear that EPC databases cannot provide a general solution for building stock monitoring, which is suitable for harmonisation. In [DATAMINE Project Team 2009b] it was recommended to follow holistic monitoring concepts making use of representative surveys as an additional (or alternative) data source, if necessary.

Sample Surveys

In many cases sample survey data was used by the EPISCOPE project partners as the main or as a further data source (BE, CY, HU, IE, RS, DE, GB, NO, SI). Carrying out sample surveys is a standard method for the acquisition of reliable data if a full survey (like a portfolio or EPC data base of the complete building stock) is not available because effort and costs would be too high. This is typically the case in large building stocks so that sample surveys play a very relevant role.

If principles of sampling theory are recognised [Särndal et al. 1992], representative data of a building stock can be attained by a sample survey of buildings (or dwellings) under the following preconditions: It should be assured that (in principle) every building (or dwelling) of the observed stock has a chance to enter the survey, that selection of buildings is done by random sampling only[8] and that for all selected buildings the probability of selection is known. Under these circumstances unbiased results can be expected and statistical standard errors as a measure of significance of the derived expectation values can be estimated.

In the EPISCOPE case studies the type and quality of available survey data was very different. In most of the cases available data of the surveys was incomplete (covering only a part of the necessary information), not statistically robust (e.g. due to a small survey size) or out of date. An exceptional case with a very high data quality is the English Housing Survey[9] documented in chapter 2.8: It can build upon interviews of around 13,000 households per year and a physical inspection of around 6,200 properties per year by qualified surveyors.

In general, such a kind of comprehensive and 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 strategies (see chapter 1) a highly reliable data basis should be aimed at. Of course also a large survey alone cannot collect all interesting data and cover the complete requirements of empirical information about housing or building energy efficiency. Supplementary empirical research will still be necessary. But for collecting the basic structural data of the building stock in the framework of a regular monitoring scheme a comprehensive approach has many advantages: It is very recommendable to include an as large as possible number of the interesting properties in the same survey so that also correlations can be analysed. Merging the data from different sources is always a difficulty, usually not making possible the observation of interrelations of the different variables.

Even if housing surveys can cover only a small percentage of the complete building stock, i.e. the sampling fraction is usually very small, this hardly affects the robustness and representativity of the results. But the survey size (the absolute number of data sets or returned questionnaires) plays a relevant role: To analyse rare characteristics with a satisfactory small statistical error a large number of data sets is necessary. As a rough rule of thumb a survey size of about 10,000 can be recommended to attain robust results also for annual thermal insulation rates of the building elements which are usually in a magnitude of about 1 % per year. But also smaller survey sizes might be sufficient if mean values of annual rates over some years are considered or analysis is restricted to other quantities (with higher frequencies than the magnitude of 1 %)[10].

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[8] This applies to all stages of the survey: If, for example, at the first stage survey districts (e.g. municipalities) are selected and at the second stage buildings within the selected districts, random sampling must be applied at both stages.

[9] In a comparable way such surveys are also carried out in the other parts of the UK, see for example [The Scottish Government 2015].

[10] For example, if in case of a simple random sample 100 out of a total sample size of 10,000 show a certain characteristic, the expectation value of the frequency of that characteristic in the building stock will be 100 / 10,000 = 1 % with (as can be shown by sampling theory) an absolute standard error of 0.1 %. This means that with a probability of about 68 % the actual frequency of that characteristic will be between 1 % - 0.1 % and 1 % + 0.1 %, that means between 0.9 % and 1.1 %. This may still appear tolerable but for smaller survey sizes or the analyis of subsets of the building stock the error does grow. So for the calculation of annual insulation rates it will often be necessary not to analyse them at a certain year but to look at mean values of a couple of years to reduce the statistical error. With such an approach it might be possible to acheive also robust results for the annual insulation rates with a survey size below 10,000.

4.3 Outline of a basic survey concept: A manageable monitoring approach

In principle, a comprehensive sample survey approach as described above can be seen as first choice for the monitoring of national building stocks: Effort of a broad based sample survey is much smaller than of a full survey and it appears adequate considering the relevance of reliable data. Nevertheless, the expenses are still quite high. In practice, the chances of finding financiers or the time needed for convincing them might be so difficult as to be considered pessimistic against the background of the short-term need of reliable data.

Therefore, in the following the outline of a reduced sample survey concept is given, which aims at providing the minimum acceptable solution for the collection of basic structural data of residential building stocks. It can be applied at short term and manageable expenses in all types of building stocks if no other suitable data sources are available:

- Questionnaires are submitted to the interviewees by letter post. To save costs there are no on-site interviews. If applicable, the survey may also be carried out via internet.
- A survey size of around 10,000 returned questionnaires should be aimed at. A minimum target value of circa 5,000 (or in case of a small building entirety a full inventory count) can be recommended. A further reduction would make it much more difficult to derive robust results for annual insulation rates of building elements, for example. But even this might be adequate if analysis is restricted to building stock characteristics with higher frequencies than circa 1 %.
- The observed statistical units can be buildings or dwellings: Both approaches are possible. In case of a dwelling survey also some data of the respective building as a whole will have to be collected (e.g. in case of a central heating system) and vice versa. In the following text a building sample is assumed.
- The interviewees should usually have the necessary basic knowledge to answer the questions about building insulation and heat supply of the buildings observed, ideally without doing extra inquiry (e.g. searching for documents or interrogating other contact persons). So usually building owners (or their representatives like housing managers or the staff of housing companies) should be interrogated rather than the tenants of rented buildings.
- To attain representative (unbiased) results and make possible the quantification of statistical errors the survey should follow the principles of sampling theory. Inter alia this means that random sampling is carried out and that access to the (almost) complete population of buildings must be available. In practice it will not be easy to fully solve this task, because national building registers (which should include also house owners as contact persons) are often not available, not usable (e.g. due to data protection) or not up-to-date[11].
- It should be possible to analyse not only the residential building stock as a whole, but also major subsets like multi-family houses or new buildings. Survey design should ensure that there is a sufficient return of questionnaires for these subsets. As, for example the number of multi-family houses is usually small compared to the number of all residential buildings, a higher than mean fraction of multi-family houses must be selected. This

[11] It may for example be the case that all houses of a building stock are in the register but the owner has changed and the contact data of the new houser owner are not available. For a represenative survey this is a very serious problem, because it can be expected that the changing of ownership is often an occasion for carrying out energy saving modernisation measures, preferably by the new owner. So if, as can be expected, the return rate of questionnaires of this certain subset is lower than average, the survey results will be biased. For the same reason it is a major difficulty to establish a panel survey, that means to carry out regular surveys with the same building sample: There is always a “panel mortality” with buildings leaving the panel, and new ownership might be a major occasion.

can be done by disproportional stratification (defining multi-family houses as a separate subset with an individual expansion factor for the projection to the whole building stock).

- A major cost factor of the survey will be the return rate of questionnaires. It will be highly recommendable to use a small questionnaire only (e.g. not more than about 4 pages or two leaves of paper) and to concentrate on the most relevant information. Before starting the main survey a pilot phase should be carried out, inter alia to give an estimation of the expected return rate.

Even with restricted to minimum effort the sample survey should aim at collecting the most relevant basic data of thermal building insulation and heat supply systems which are needed to control the success of existing policies in the past and deliver the necessary input data for building stock energy balance and scenario models. The following properties should be considered in the questionnaire:

- Building utilisation (e.g. to clarify if it is really a residential building), vacancies;
- Basic data of the building: construction year, number of dwellings, reference floor area, number of floors. Is the building detached or semi-detached? Are cellar and/or attic heated?
- Additional basic information on building construction, for example type of wall construction, type of roof (pitched or flat).
- Type of ownership (private owner, housing company, association of dwelling owners);
- Insulation of the building elements (walls, roof/upper floor ceiling, basement /cellar ceiling, windows): existing insulation layers, type of windows, if possible: area fraction of element insulation, quality (thickness) of insulation and windows;
- Information on the heating system: centralisation (e.g. central dwelling / single room), energy carrier and type of the main heat generator (e.g. gas condensing boiler, electric air heat pump), accompanying solar thermal systems, other additional systems (e.g. wood stoves), if possible also the insulation level of distribution pipes of central heating and hot water supply;
- Year or time period of the installation of heating systems and building insulation. For example: Were the walls already insulated at the time of building construction or in the framework of refurbishment measures? If so: When was it carried out? This information will make it possible to calculate the general modernisation progress and annual modernisation rates of the recent years.

As mentioned the described concept is only a minimal solution and second best compared to a broad-based survey with a more extensive questionnaire and if possible on-site interviews. But it offers the perspective of a straightforward short-term realisation and may have the advantage of providing the option of a harmonised international approach – due to the simplicity of the questionnaire concept which might more or less be applicable in different countries without major adaptation. Nevertheless, the problem of how to create a sample of buildings which is representative for the residential building stock will have to be solved in each country in an individual way.

Even if it is a concept with reduced demanded effort, expenses might be too high for an application in small building stocks (e.g. municipalities), not least because of the recommended number of 10,000 returned questionnaires which is motivated by the aim of measuring annual insulation rates. Of course, the survey could be further reduced (setting aside some pieces of information in such a case) and distribution of questionnaires might be easier in small units than in the whole country or a large region. So if no other data sources exist, the question if a sample survey is applicable in a small building stock must be answered according to the individual situation and the expected benefits: If for example a municipality is carrying out an individual and far-reaching climate protection strategy, which is different from the national approach, it will probably be worth to spend the money and have a deeper look at the factual results of the strategy, so that others can learn.

4.4 Realistic energy balances: A special empirical problem

In order to come up with meaningful monitoring assessments it is necessary to realistically calculate energy consumption and other related indicators like CO_2 or greenhouse gas emissions. Like all physical equations also the methods for calculating the energy consumption of buildings need thorough validation.

It is well known – also discussed during the TABULA and EPISCOPE projects – that calculation methods used for EPCs or to proof compliance with national requirements mostly do not provide realistic pictures of actual energy consumptions [TABULA Project Team 2012a], [TABULA Project Team 2012b], [Majcen et al. 2012], [Majcen et al. 2015], [BRE 2015].[12] Of course it is clear that a fit of both cannot be expected in the single case, mainly due to different behaviour of building users. But experiences show that furthermore in general there are also a large systematic deviations between the mean values of calculated and measured energy consumption.

In many of the EPISCOPE case studies (e.g. BE, DE, ES, FR, GB, GR, CY), calculation results were calibrated with or compared to measured energy consumption. Thereby, different sources providing energy consumption data were used: for the local case study in Belgium data derived from an own survey, for the national case study in Germay national statistical consumption data for the residential sector were used, for the national case study in England statistical data for energy consumption in households were availabe, in Greece calibration factors were derived from EPC data, and in France consumption data for a considerable part of the building portfolio considered were available. In other cases, it was difficult (e.g. AT) or not possible to come up with reliable consumption data for the purpose of model validation.

In addition, calibration of energy balance methods should not only be carried out for the building stock as a whole: Even if model calculations fit with the building stocks' total consumption, broken down they might be wrong (e.g. overestimating the consumption of unrefurbished buildings or certain heat supply systems and underestimating the consumption of refurbished buildings or other heat supply technologies). This would affect the robustness of scenario calculations in which building refurbishment and weights of heat supply technologies change.

An approach to improve the situation would be to collect reliable empirical data from a sufficient large sample of buildings, which contains the relevant input data for energy balance calculations as well as measured energy consumption over the last years. This task has many parallels to the task of regular building stock monitoring as described above, and indeed data acquisition might be combined in the framework of a preferential comprehensive sample survey monitoring approach.

The necessary development or calibration of energy balance methods has more the character of a unique scientific model development, which does not have the need of a short-term regular update as building stock monitoring has: A model that is once proofed can be expected to have a longer lifetime than monitoring data which serves as a continuous success control and adjustment basis for the dynamic climate protection process. Of course also the model should be checked and updated from time to time, but rather in a ten year period than every two or four years which could be seen as a desirable interval of building stock monitoring. Moreover, the way of drawing the building sample must consider different needs: For the development of energy balance procedures it will be necessary to cover as far as possible

[12] The calculation method used for the TABULA WebTool therefore foresees the introduction of calibration factors to adjust calculated and measured energy consumption [TABULA Project Team 2013].

the complete spectrum of building insulation standards and heat supply systems, which are supposed to play a major role at present but also in the future (on the path towards energy saving and climate protection). This means that a sufficient number of data sets must be collected also for modernised buildings with very high insulation standards or forward-looking but still rare heat supply system types which may not yet play a significant role in the present building stock (and thus will not appear at large numbers in a monitoring survey).

To solve this task individual approaches in the different countries appear necessary. In general at least the recommendation can be given to pay special attention to the data entries of measured energy consumption which are provided: Available studies comparing calculated and measured energy consumption [IWU 2012] do not only show the mentioned systematic deviation of mean values, but also a surprisingly high level of variance. This high variation and especially some extreme deviations of calculated and real energy consumption can probably not be attributed to the user behaviour. Rather it can be supposed that a relevant fraction of data entries might be not correct. For that reason on site-interviews by skilled surveyors checking available energy bills and the application of computer-based questionnaires with integrated plausibility checks can be recommended.

4.5 Conclusion

It can be summarised that the data situation of European residential building stocks is in general unsatisfactory. In many cases, the information sources available are not sufficient to fulfil the prominent role they should play for climate protection strategies. 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 building thermal insulation and efficient / renewable heating systems.

The effort and research on buildings and energy efficiency in the recent years as well as the variety of data sources available might raise the impression that a sufficient database should have been generated somehow by these activities and projects, and the only task is to compile and merge all this information to draw a complete picture. But what needs to be considered is the fact that for establishing building stock energy balance models data gaps are filled with assumptions because in many cases this is the only possible way to proceed.

The high relevance of providing a better data base for energy saving and climate protection concepts by improving the acquisition of reliable empirical data can be underlined as a general outcome of the EPISCOPE project.

Individual solution approaches may be applicable for the individual building stocks, but sample surveys can be seen as a generalisable approach at least for the monitoring of large (e.g. national) building stocks.

Providing a better empirical information basis for the calibration of energy balance methods is a further task of high relevance which has parallels with building stock monitoring and might need well-tailored special approaches.

4.6 Sources / References

Table 39: Sources / References Summary and Conclusions

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[BRE 2015]	Summers, C.; Hulme, J. (2015) BRE Client Report. EPISCOPE Pilot Project: England, BRE, Watford. Available at: http://episcope.eu/fileadmin/episcope/public/docs/pi-lot_actions/GB_EPISCOPE_NationalCaseStudy_BRE.pdf [2015-11-10]	EPISCOPE report on the English case study, including information on the modelled-to-actual ratiofor energy consumption
[DATAMINE Project Team 2009a]	Loga, T.; Diefenbach, N. (2009): DATAMINE Collecting Data from Energy Certification to Monitor Performance Indicators for New and Existing Buildings – Final Report. Available at: http://www.iwu.de/fileadmin/user_upload/dateien/energie/DATAMINE_Public_Final_Report.pdf [2015-11-09]	Final Report of the IEE project DATAMINE (2006-2008)
[DATAMINE Project Team 2009b]	Loga, T.; Diefenbach, N. (2009): Collecting Data from Energy Certification to Monitor Performance Indicators for New and Existing Buildings – Executive Summary. Institut Wohnen und Umwelt, Darmstadt. Avaialble at: http://www.iwu.de/fileadmin/user_upload/dateien/energie/DATAMINE_Executive_Summary.pdf [2015-11-09]	Executive Summary of the IEE project DATAMINE (2006-2008)
[EPISCOPE Project Team 2016a]	Stein, B., Loga, T., Diefenbach, N. (ed.) (2016): Scenario Analyses Concerning Energy Efficiency and Climate Protection in Local Residential Building Stocks. Examples from Eight European Countries – EPISCOPE Synthesis Report No. 2. Institut Wohnen und Umwelt, Darmstadt. Available at: http://episcope.eu/fileadmin/episcope/public/docs/reports/EPISCOPE_SR2_LocalScenarios.pdf	EPISCOPE Synthesis Report No. 2 on scenario analyses in local building stocks (portfolios of housing companies, municipalities, city quarters)
[EPISCOPE Project Team 2016b]	Stein, B.; Loga, T.; Diefenbach, N. (ed.) (2016): Scenario Analyses Concerning Energy Efficiency and Climate Protection in Regional and National Residential Building Stocks. Examples from Nine European Countries – EPISCOPE Synthesis Report No. 3. Institut Wohnen und Umwelt, Darmstadt. Available at: http://episcope.eu/fileadmin/episcope/public/docs/reports/EPISCOPE_SR3_RegionalNationalScenarios.pdf	EPISCOPE Synthesis Report No. 3 on scenario analyses in regional and national residential building stocks
[EPISCOPE Project Team 2016c]	EPISCOPE Project Team (2016): TABULA Building Typologies – Country Pages. Available at: http://episcope.eu/building-typology/country/ [2015-11-09]	Country Pages including statistical data on the combined TABULA/EPISCOPE website
[IWU 2012]	Loga, T.; Diefenbach, N.; Stein, B.; Born, R. (2012): Typology Approach for Building Stock Energy Assessment TABULA – Scientific Report Germany – Further Development of the German Residential Building Typology, Institut Wohnen und Umwelt, Darmstadt. Available at: http://episcope.eu/fileadmin/tabula/public/docs/scientific/DE_TABULA_ScientificReport_IWU.pdf [2015-11-09]	TABULA Scientific Report Germany
[Majcen et al. 2012]	Majcen, D.; Itard, L.; Visscher, H. (2012): Theoretical vs. actual energy consumption of labelled dwellings in the Netherlands: Discrepancies and policy implications. Energy Policy 54 (2013) PP. 125-136	Article on the discepancies between calculated heating demands and actual consumption in Dutch dwellings including an anylsis of relevant influences

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[Majcen et al. 2015]	Majcen, D.; Itard, L.; Visscher, H. (2015): Statistical model of the heating prediction gap in Dutch dwellings: Relative importance of building, household and behavioural characteristics. Energy and Buildings 105 (2015), pp. 43-59	Article on the discepancies between calculated heating demands and actual consumption in Dutch dwellings
[Särndal et al. 1992]	Särndal, C-E.; Swensson, B.; Wretman, J. (1992): Model Assisted Survey Sampling, Springer series in statistics, Springer-Verlag New York, Inc.	Comprehensive account of survey sampling theory and methodology
[TABULA Project Team 2012a]	Loga, T.; Diefenbach, N.; Stein, B. (2012): Typology Approach for Building Stock Energy Assessment. Main Results of the TABULA project – Final Project Report, Institut Wohnen und Umwelt, Darmstadt. Available at: http://episcope.eu/fileadmin/tabula/public/docs/report/TABULA_FinalReport.pdf [2015-11-10]	Final report of the IEE project TABULA including information on the calibaration to the typical level of measured consumption
[TABULA Project Team 2012b]	Loga, T.; Diefenbach, N.; Stein, B. (2012): Typology Approach for Building Stock Energy Assessment. Main Results of the TABULA project – Final Project Report: Appendix Volume, Institut Wohnen und Umwelt, Darmstadt. Available at: http://episcope.eu/fileadmin/tabula/public/docs/report/TABULA_FinalReport_AppendixVolume.pdf [2015-11-10]	Appendix volume to the final report of the IEE project TABULA, including adaptation factors used for the Belgian and German building typologies
[TABULA Project Team 2013]	Loga, T.; Diefenbach, N. (ed.) (2013): TABULA Calculation Method – Energy Use for Heating and Domestic Hot Water – Reference Calculation and Adaptation to the Typical Level of Measured Consumption. . Institut Wohnen und Umwelt, Darmstadt, Avaialbel at: http://episcope.eu/fileadmin/tabula/public/docs/report/TABULA_CommonCalculationMethod.pdf [2015-11-09]	Documentation of the TABULA calculation method
[The Scottish Government 2015]	The Scottish Government (2015): Scottish Household Survey. Institut Wohnen und Umwelt, Darmstadt. Avaiable at: http://www.gov.scot/Topics/Statistics/16002 [2015-11-09]	Information on the Scottish Housing Survey on the website of the Scottish Government

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