Scenario Analyses Concerning Energy Efficiency and Climate Protection in Local Residential Building Stocks

Examples from Eight European Countries

- EPISCOPE Synthesis Report No. 2 -

(Deliverable D3.4)

March 2016

Co-funded by the Intelligent Energy Europe Programme of the European Union

Contract N°: IEE/12/695/SI2.644739

Coordinator: IWU Institut Wohnen und Umwelt, Darmstadt / Germany

Project duration: April 2013 - March 2016

Authors:

Britta Stein (editor) Tobias Loga (editor) Nikolaus Diefenbach (editor)	P01 - IWU	Institut Wohnen und Umwelt / Institute for Housing and Environment	Darmstadt / Germany
Aleksandra Arcipowska Filippos Anagnostopoulos	P 02 - BPIE	Buildings Performance Institute Europe	Brussels / Belgium
Marjana Šijanec Zavrl Andraž Rakušček Gašper Stegnar	P 03 - ZRMK	Building and Civil Engineering Institute ZRMK	Ljubljana, Slovenia
Birgit Vandevelde Marlies Van Holm Dieter Cuypers	P 08 – VITO	Flemish Institute for Technological Research	Mol / Belgium
Tomáš Vimmr Otto Villatoro	P 10 – STU-K	STU-K	Prague / Czech Republic
Michael Hanratty Marcin Badurek Bill Sheldrick	P 11 – Energy Action	Energy Action Limited	Dublin / Ireland
Tamás Csoknyai Emma Domahidi Dominika Szoó Sára Hrabovszky-Horvát Gábor Szendrő	P 12 – BME	Budapest University of Technology and Economics	Budapest / Hungary
Despina Serghides Stella Dimitriou Martha Katafygiotou	P 14 – CUT	Cyprus University of Technology	Limassol / Cyprus
Ulrich Rochard Santhiah Shanthirabalan	P 16 – Pouget	Pouget Consultants	Paris / France
Milica Jovanović Popović Dušan Ignjatović Bojana Stanković	Associated partner	University of Belgrade	Belgrade / Serbia

Published by
Institut Wohnen und Umwelt GmbH
Rheinstraße 65, 64295 Darmstadt / Germany
www.iwu.de

March 2016

ISBN 978-3-941140-52-3

EPISCOPE website: www.episcope.eu

The sole responsibility for the content of this deliverable lies with the authors. It does not necessarily reflect the opinion of the European Union. Neither the EASME nor the European Commission are responsible for any use that may be made of the information contained therein.

Contents

Contents I

1 Introduction 1

2 EU Climate and Energy Targets for the Building Sector 3

3 Scenario Results 9

3.1 <BE> Belgium 13

3.2 <CY> Cyprus 23

3.3 <CZ> Czech Republic 33

3.4 <FR> France 41

3.5 <HU> Hungary 51

3.6 <IE> Ireland 59

3.7 <RS> Serbia 67

3.8 <SI> Slovenia 75

4 Summary 85

List of Figures 91

List of Tables 93

1 Introduction

(by EPISCOPE partner IWU)

The European Union has formulated ambitious CO_2 reductions and energy efficiency goals for the next decades. The potential of the housing stock to contribute to these savings is considered to be significant. In 2050 the built environment is expected to be nearly carbon neutral, with greenhouse gas emissions 88-91 % lower than in 1990 [EC 2011].

To track, steer and control the process to attain these targets, knowledge about the characteristics of European housing stocks, their current energy performance and the dynamics in refurbishment is necessary. The EPISCOPE project, co-funded by the Intelligent Energy Europe Programme of the European Union, aims to respond to these requirements by tracking the implementation of energy saving measures in residential building stocks as well as their effects on energy consumption and greenhouse gas emissions. EPISCOPE (2013-2016) is the successor of the DATAMINE (2006-2008) and TABULA (2009-2012) projects, in which the collection and evaluation of EPC data and the implementation of residential building typologies in a series of European countries were realised. Building up on these experiences and findings, the scope was extended towards the elaboration of building stock models and scenario calculations to assess refurbishment as well as energy saving processes and project future energy consumption. A long-term objective is to install regular bottom up monitoring procedures for building stocks.

This report documents methodological aspects and selected results of the scenario analyses. It covers scenario calculations conducted for local residential building stocks in the Sint-Amandsberg district in Ghent / Belgium, the housing stock of the Cyprus land development Corporation (CLDC)/Cyprus, the municipal housing stock in the city of Havířov/Czech Republic, the social housing stock of OPH Montreuillois in the city of Montreuil/France, the residential building stock in the city of Budaörs/Hungary, the municipal housing stock on the Northside of Dublin City/Ireland, in the municipality of Vršac/Serbia, and the municipality of Kočevje/Slovenia.

Thereby, the objective of the scenario analysis is not a prediction of future energy demand in the respective building stock. Rather, the objective is to show the potential future impact of predefined assumptions. This may help respective key actors and policy makers to decide on strategies and policies for transforming building stocks towards carbon dioxide neutrality.

The present report starts with a description of European climate and energy targets for the building sector in chapter 2. Chapter 3 documents the building stocks observed as well as the individual scenario approaches and results. It concludes with a summary of the main findings and conclusions in chapter 4.

In addition, scenario calculations for national and regional building stocks are compiled in the separate EPISCOPE Synthesis Report No. 3 [EPISCOPE Project Team 2016a], whereas Synthesis Report No. 4 highlights the individual procedures to collect the necessary data and information for building stock monitoring and modelling [EPISCOPE Project Team 2016b]. The individual scenario approaches and results for each of the building stocks considered are described in detailed case study reports[1]. Furthermore, data and energy balance calculations referring to the current state of the building stocks considered are included in the TABULA WebTool[2].

---

1 Available at: http://episcope.eu/monitoring/case-studies/ and http://episcope.eu/communication/download/ (case study reports in national languages)

2 TABULA WebTool area “Building Stocks”: www.webtool.building-typology.eu

Table 1: Sources / References Introduction

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[EC 2011]	COM (2011) 112 final, Communication from the Commission to the European Parliament, The Council, the Europeans Economic and social committee and the committee of regions, A Roadmap for moving to a competitive low carbon economy in 2050. European Commission. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52011DC0112 [2015-07-24]	
[EPISCOPE Project Team 2016a]	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 2016b]	Stein, B., Loga, T., Diefenbach, N. (ed.) (2016): Tracking of Energy Performance Indicators in Residential Building Stocks. Different Approaches and Common Results – EPISCOPE Synthesis Report No. 4. Institut Wohnen und Umwelt, Darmstadt. Available at: http://episcope.eu/fileadmin/episcope/public/docs/reports/EPISCOPE_SR4_Monitoring.pdf	EPISCOPE Synthesis Report No. 4 on data collection for building stock monitoring and recommendations for monitoring activities on a regular basis

2 EU Climate and Energy Targets for the Building Sector

(by EPISCOPE partner BPIE)

Energy consumption in buildings accounts for roughly 40 % of Europe's total final energy consumption; energy consumption in households for 27 % [Eurostat 2015a]; these energy needs are currently predominantly met by non-renewable energies[3]. In 2012, greenhouse gas emissions (GHG) generated by households stood in the EU-28 at roughly 871,000 tonnes of CO_2 equivalents and caused 19 % of Europe's total emissions [Eurostat 2015c].

The European Union has a binding legal framework to reduce 20 % greenhouse gas emissions in the year 2020 compared to 1990 levels (Table 2). The EU Climate and Energy Package sets EU wide goals for the EU emission trading system (ETS) and national targets for the non-ETS sectors, including for the building sector[4] [EC 2008a]. These national targets[5] (see Figure 1) shall by 2020 collectively deliver approximately 10 % GHG emission reduction compared with 2005 levels [EC 2009].

Table 2: 2020 and 2030 energy and climate targets for the EU as a whole

	2020	2030
GHG emission reduction target compared to 1990 levels	**20 %**	**40 %***
RES target share in energy consumption	**20 %**	**27 %**
Energy efficiency target** energy savings compared to BAU scenario	**20 %**	**27 %*****

Note: domestic reduction; ** Voluntary target; *** to be revised in 2020 having in mind 30 % target*

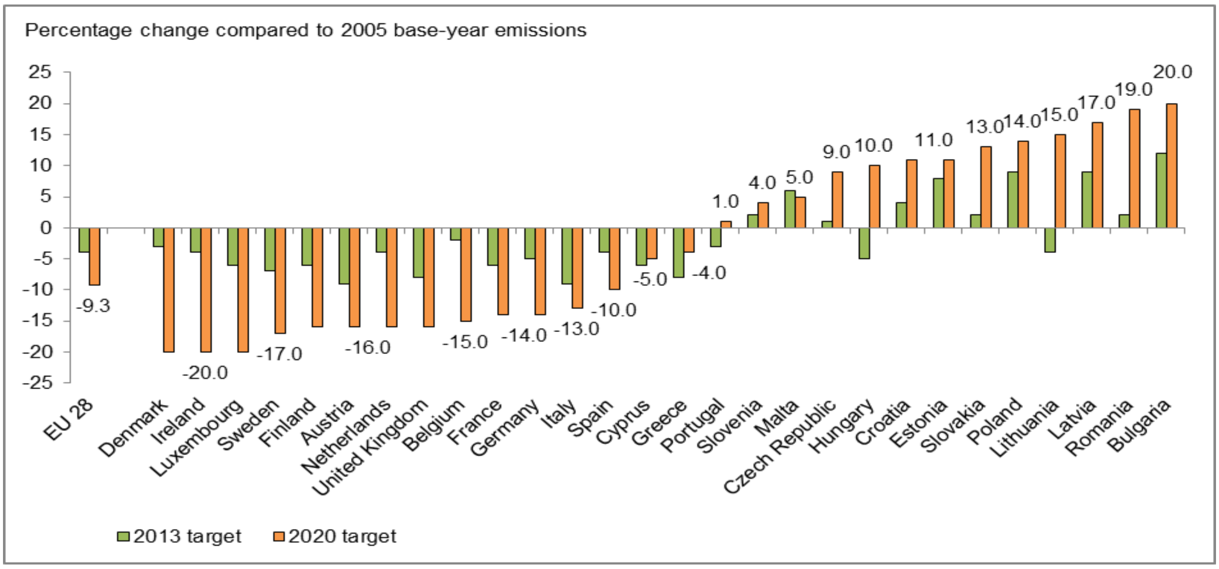


Figure 1: National 2013 and 2020 greenhouse gas emission limits under the Effort Sharing Decision, compared to 2005 emission levels [EEA 2014]

3 In the EU-28 in 2013, the share of final energy from renewable sources in households reached 14.6 % [Eurostat 2015b].

4 The Building sector is responsible for 19 % of the total non-ETS emissions assuming that these emissions include only direct fuel consumption, as electricity consumption is mostly covered by the EU-ETS [Carbon Market Watch 2014].

5 The national targets for the non-ETS sectors (most of the sectors that are not included in the ETS, i.e. buildings, transport (excluding aviation and marine shipping) agriculture and waste), are agreed unanimously in the Effort Sharing Decision (ED) [EC 2009].

In October 2014, the European Council agreed for the 2030 framework regarding the GHG emission reduction [EC 2014a]; the target for the EU as a whole has been set for 43 % in the ETS sectors and 30 % in the non-ETS compared to 2005 levels. The European Commission made an initial proposal in February 2015 to implement the 2030 climate and energy framework [EC 2015]. It has been made clear that exploiting a huge energy efficiency potential in the building sector will be among the key priorities.

The long-term vision of GHG emission reduction has been set by the European Commission in its "Roadmap for moving to a competitive low carbon economy in 2050" [EC 2011a], [EC 2011b]. The potential for cost-effective emission reductions in the non-ETS sectors by 2050 is estimated for 66 % - 71 % (see Table 3) depending on the decarbonisation scenario.

Table 3: Emissions in ETS and Non ETS sectors [EC 2011b]

Reductions compared to 2005	2030	2050
Overall	-35 to -40 %	-77 to -81 %
ETS sectors	-43 to -48 %	-88 to -92 %
Non ETS sectors (incl. building sector)	-24 to -36 %	-66 to -71 %

The 2050 Roadmap shows also the effort of reducing greenhouse gas emissions by sector according to their technological and economic potential (see Table 4). For the EU building sector, the cost effective emission reduction by 2050 only account for 88 % - 91 % decreases of GHG emissions in 2050, compared to 1990 levels. It is mainly due to "*significant reductions in required heating from improved insulation and greater use of electricity and renewables for building heating as well more energy efficient appliances"* [EC 2011b].

Table 4: EU Greenhouse gas emission reductions overall and in different economic sectors in different decarbonisation scenarios [EC 2011b]

GHG reductions compared to 1990	2005	2030	2050
Total	-7 %	-40 to -44 %	-79 to -82 %
Sectors			
Power (CO_2)	-7 %	-54 to -68 %	-93 to -99 %
Industry (CO_2)	-20 %	-34 to -40 %	-83 to -87 %
Transport (incl. CO_2 aviation, excl. maritime)	+30%	+20 to -9 %	-54 to -67 %
Residential and services (CO_2)	*-12 %*	*-37 to -53 %*	*-88 to -91 %*
Agriculture (Non-CO_2)	-20 %	-36 to -37 %	-42 to -49 %
Other Non-CO_2 emissions	-30 %	-72 to -73 %	-70 to -78 %

Although the EU energy and climate framework set the emission reduction targets for non-ETS sectors, **there is no definite sub-sector target for buildings** (both on the EU and MS level). There are however in place a number of supportive polices that target building's energy consumption. Most significant of those are the Energy Performance of Buildings Directive [EPBD 2010] and the Energy Efficiency Directive [EED 2012] which target the energy efficiency of buildings directly, as well as the Ecodesign and Energy Labelling Directives [EDD 2009], [ELD 2010], which target the energy consumption of appliances used in buildings. Furthermore, the Renewables Directive [RED 2009] also sets requirements for buildings (Figure 2).

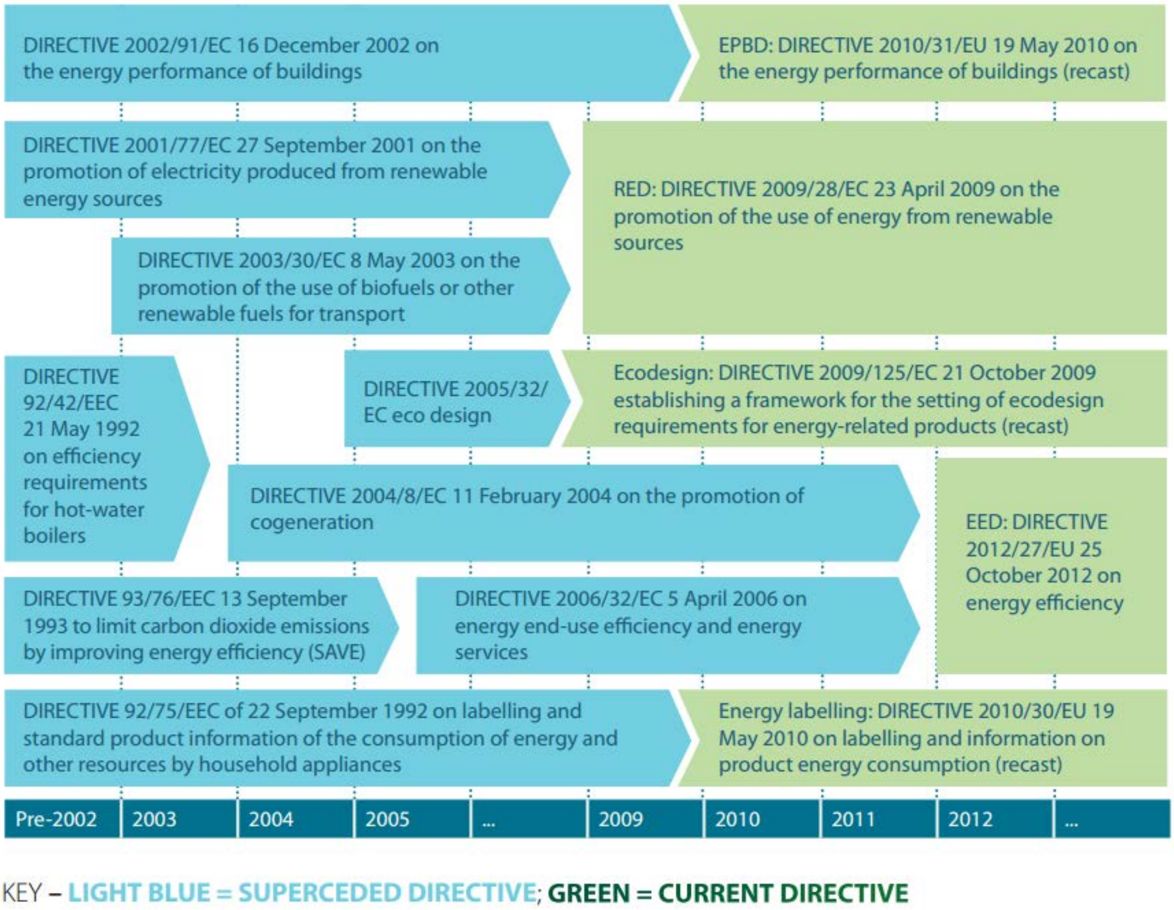


Figure 2: Timeline of key EU legislation affecting energy use in buildings [BPIE 2014]

The Energy Performance of Buildings Directive (hereafter EPBD) increases EU-wide requirements of buildings aiming to improve their energy efficiency and reduce emissions. Among the major provisions under the directive are the following:

- implementation of minimum energy performance requirements for existing buildings; in the case of a major renovation of a building (defined as one affecting 25 % of the building area or where the total cost is 25 % or more of the value of the building) (Article 7)
- development of national plans to increase the number of nearly zero-energy buildings. These national plans may include targets differentiated according to the category of building (Article 9)
- implementation of the requirements for nearly zero energy buildings; All new buildings should from 2021 be built according to nearly zero-energy standards, while owned and occupied buildings of public authorities should reach those standards in 2019 (Article 9)
- implementation of the requirements for inspections of heating and air-conditioning systems (Article 14 - 15)

Without constituting a target per se, the Impact Assessment for the EPBD [EC 2008b] quantified the minimum savings of the most beneficial options as being able to deliver a reduction of 5-6 % of the EU final energy consumption and a subsequent saving of 4-5 % of EU total CO_2 emissions in 2020.

The Energy Efficiency Directive (hereafter EED) introduces the framework to meet the non-binding target of reducing energy consumption. Buildings are important in this effort and therefore certain provisions of the directive aim specifically this sector, such as:

- the requirements for Member States to play an exemplary role in connection with buildings owned and occupied by the central Government; As from 1 January 2014, 3 % of the total floor area of such buildings shall be renovated each year to meet at least the minimum energy performance requirements set out in the EPBD (Article 5)
- preparation of a long term strategy to mobilise investment to renovate the national building stocks. This strategy has to be updated every 3 years and target public and private residential and commercial buildings. (Article 4)

The public sector is considered an important trigger for stimulating market transformation towards more efficient buildings and promoting best practice examples for low carbon measures. However, as the Coalition for Energy Savings [CES 2015] shows, the extent to which Member States are compliant with the requirement for the 3 % renovation rate is unclear and not well monitored.

Similarly, under Article 4, while most MS submitted their renovation strategies, the ambition communicated through these documents does not seem to meet the challenge of renovating the EU building stock by stimulating the market [BPIE 2014].

The Renewable Energy Sources Directive (hereafter RED) is mostly known as the legislative instrument to increase the share of renewable energy to 20 % by 2020, and while this is its main purpose, it is less known for its important requirements for buildings.

Following the ratification of the directive and under Article 13, Member States have to amend their buildings codes and regulations and introduce appropriate measures to increase the share of renewable energy - irrespectively of the kind thereof - in the building sector.

The requirements for renewable energy apply to new buildings and to buildings undergoing major renovation. It is notable that renewable energy does not need to be generated on-site, but could be provided through district heating and cooling produced to a large extent by renewable energy sources.

Specific targets are provided for biomass, where Member States are required to promote technologies that achieve a conversion efficiency of at least 85 % for residential and commercial applications and at least 70 % for industrial applications.

The Ecodesign Directive and the Energy Labelling Directive are among the most effective EU policy tools for the promotion of energy efficiency in buildings, creating a comprehensive framework for performance criteria for a product’s lifetime energy use. The Ecodesign Directive focuses on setting minimum requirements for the products’ performance, thereby reducing the final energy demand of buildings, while the Energy Labelling system aims to increase communication of a range of appliance’s energy efficiency information. Their combination removes products from the market which are wasteful users of energy while directing consumers towards better products. No energy using product can be marketed in the EU area without a guarantee that it complies with the Ecodesign Directive’s standards and an energy label is compulsory for all energy using products, in order to provide consumers with sufficient information so that they can make a choice from the featured marketed products.

Table 5: Sources / References EU Climate and Energy Targets for the Building Sector

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[BPIE 2014]	Buildings Performance Institute Europe (BPIE) (2014): Renovation Strategies Of Selected EU Countries A Status Report On Compliance with Article 4 of the Energy Efficiency Directive. Available at: http://bpie.eu/uploads/lib/document/attachment/86/Renovation_Strategies_EU_BPIE_2014.pdf [2015-07-24]	
[CES 2015]	Coalition for energy savings - Implementing the EU Energy Efficiency Directive: Analysis of Member States plans to implement Article 5 .Available at: http://energycoalition.eu/ [2015-07-24]	
[EC 2008a]	COM (2007) 2 final, Communication staff working documents Impact Assessment Accompanying document to the Communication from the Commission to the European Parliament, The Council, the Europeans Economic and social committee and the committee of regions, Limiting Global Climate Change to 2 degrees Celsius The way ahead for 2020 and beyond. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2007:0002:FIN:EN:PDF [2015-07-24]	
[EC 2008b]	SEC/2008/2865, Commission staff working document - Accompanying document to the proposal for a recast of the energy performance of buildings directive (2002/91/EC) - Summary of the impact assessment. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52008SC2865 [2015-07-24]	
[EC 2009]	Decision No 406/2009/EC of the European Parliaments and of the Council of 23 April 2009 on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2009.140.01.0136.01.ENG [2015-07-24]	
[EC 2011a]	COM (2011) 112 final, Communication from the Commission to the European Parliament, The Council, the Europeans Economic and social committee and the committee of regions, A Roadmap for moving to a competitive low carbon economy in 2050. European Commission. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52011DC0112 [2015-07-24]	
[EC 2011b]	SEC/2011/0288 final; Communication staff working documents Impact Assessment Accompanying document to the Communication from the Commission to the European Parliament, The Council, the Europeans Economic and social committee and the committee of regions, A Roadmap for moving to a competitive low carbon economy in 2050. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52011SC0288 2015-07-24]	
[EC 2014a]	EUCO 169/14m European Council (23/24 October 2014) – Conclusions. Available at: http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/145397.pdf [2015-07-24]	
[EC 2014b]	COM/2014/015 final, Communication from the Commission to the European Parliament, The Council, the Europeans Economic and social committee and the committee of regions, A policy framework for climate and energy in the period from 2020 to 2030. Available at: http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52014DC0015 [2015-07-24]	

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[EC 2015]	COM(2015) 80 final, Communication from the Commission to the European Parliament, The Council, the Europeans Economic and social committee and the committee of regions, A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2015:80:FIN [2015-07-24]	
[EEA 2014]	European Environment Agency (EEA) (2014): Trends and projections in Europe 2014; Tracking progress towards Europe's climate and energy targets for 2020; European Environmental Agency Report No 6/2014. Available at: http://www.eea.europa.eu/publications/trends-and-projections-in-europe-2014 [2015-07-24]	
[EDD 2009]	Directive 2009/125/EC Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of Ecodesign requirements for energy-related products	
[EED 2012]	EED 2012/27/EU Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC	
[ELD 2010]	Directive 2010/30/EU of the European Parliament and of the Council of 19 May 2010 on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products	
[EPBD 2010]	EPBD recast 2010/31/EU Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings, amending Directive 2002/91/EC	
[Eurostat 2015a]	European Commission / Eurostat (2015): Final energy consumption by sector, tsdpc320. Last update: 10.07.2015. Available at: http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=tsdpc320 [2015-07-22]	
[Eurostat 2015b]	European Commission / Eurostat (2015): Final energy consumption in households by fuel, t2020_rk210. Last update: 10.07.2015. Available at: http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=t2020_rk2 [2015-07-22]	
[Eurostat 2015c]	European Commission / Eurostat (2015): Greenhouse gas emissions by industries and households. Data extracted in January 2015. Available at: http://ec.europa.eu/eurostat/statistics-explained/index.php/Greenhouse_gas_emissions_by_industries_and_households [2015-07-23]	
[RED 2009]	Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC	
[ODYSSEE 2015]	Trends and Policies in the Households and Tertiary sectors. An Analysis Based on the ODYSSEE and MURE Databases. Available at: http://www.odyssee-mure.eu/publications/br/energy-efficiency-trends-policies-buildings.pdf [2015-07-24]	

3 Scenario Results

(Introduction by EPISCOPE partner IWU)

In the framework of the EPISCOPE project, scenario calculations were carried out for the local housing stocks listed below:

- BE – Sint-Amandsberg district in Ghent / Belgium
- CY – housing stock of the Cyprus land development Corporation (CLDC) / Cyprus
- CZ – municipal housing stock in the city of Havířov / Czech Republic
- FR – social housing stock of OPH Montreuillois in the city of Montreuil / France
- HU – residential building stock in the city of Budaörs / Hungary
- IE – municipal housing stock on the Northside of Dublin City / Ireland
- RS – residential building stock in the municipality of Vršac / Serbia
- SI – residential building stock in the municipality of Kočevje / Slovenia

Procedure and findings are summarised in the following subchapters: for each case study a description of the current state of the respective building stock, the scenario approach as well as the most relevant data sources is given. Furthermore, results for three different scenarios are discussed, one of them usually being the extrapolation of the current trend. The definition of the two other scenarios as well as the set-up of the building stock model was done individually by the responsible project partner. Finally, conclusions are drawn with regard to the attainment of European and individual climate protection targets.

Summary Indicators

The main results are illustrated by the use of "summary indicators"[6] as defined in [EPISCOPE Project Team 2014] and [EPISCOPE Project Team 2016], referring to the current states of the building stocks (also called "basic case" in general 2015, in some/single cases 2012), and – depending on the individual periods under review – values for 2020, 2030 and/or 2050.

The main summary indicator is the **annual carbon dioxide emission per m² EPISCOPE reference area**[7]. Included are pure CO_2 emissions caused by heating and hot water supply for the considered building stock including auxiliary energy and energy for ventilation. Not only the on-site CO_2 emissions of heating systems but also the CO_2 emissions for district heating and for electricity production (used for heat supply and auxiliary energy) are considered. CO_2 equivalents of other greenhouse gases are not included. CO_2-emissions for cooling/air conditioning are included in individual cases. But the energy demand for cooling as well as the respective CO_2 emission factor is not considered.

---

6 Documentations of the monitoring and scenario indicators can be found at the case study pages of the EPISCOPE website: http://episcope.eu/monitoring/case-studies/

7 Various types of reference areas are being used in different countries. Therefore, during the TABULA project a common reference area was defined which was also used in the EPISCOPE project for the purpose of comparisons. The common reference area used for displaying the "summary indicators" is the conditioned floor area based on internal dimensions (incl. all areas within the thermal envelope incl. e.g. staircases etc.). The conditioned area includes all zones which are heated directly or indirectly during the heating season (all areas included in the thermal envelope). Conversion factors are given in [TABULA Project Team 2013], p. 27/28.

The second indicator is the **total heat demand**, being defined as the total of:

the energy need for space heating
+ heat losses of distribution and storage systems for space heating*
+ energy need for domestic hot water
+ heat losses of distribution and storage systems for domestic hot water.

* heat recovery by ventilation systems is not subtracted from the energy need for space heating

The third indicator is the **total CO_2 emission factor of heat supply**, being the result for the annual carbon dioxide emissions divided by the total heat demand.

Furthermore, in each subchapter a **break-down of the final energy balance to energy carriers** (gas, oil, electricity, ...) is given.

In the diagrams showing the annual carbon dioxide emissions also benchmarks are included. Those values either refer to individual (national or regional) climate protection targets or to the EPISCOPE benchmarks.

The EPISCOPE benchmarks are derived from a rough and straightforward translation of general EU climate protection targets: compared to 1990 the EU has decided a 20 % emission reduction until 2020 and a 40 % reduction until 2030. A not officially decided but widely agreed minimum climate protection target for industrial countries until 2050 is a reduction of 80 % (again related to 1990) [COM 2011].

According to [UBA 2014] the EU-15 greenhouse gas emissions were reduced by around 12 % (energy-related emissions) or 15 % (all emissions without land use changes) in the period from 1990 to 2012. Carrying out a short extrapolation it can be assumed that until 2015 an emission reduction of 13 % (energy-related) / 17 % (all) – or roughly speaking altogether of 15 % might have been reached (related to 1990). So the gap to be closed until 2020 / 2030 / 2050 would be 5 % / 25 % / 65 % (related to 1990) – or (rounded) 5 % / 30 % / 75 % related to the emission level of the year 2015. This defines the EPISCOPE benchmarks:

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

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

These benchmarks, however, may not be over-interpreted: The straightforward breakdown of EU global emission targets to the CO_2 emissions of concrete local residential building stocks does not consider the individual situation and reduction potentials compared to other countries with other climates, other sectors (like industry or traffic) or other building stocks. So a "really fair" burden sharing of emission targets – if it could ever be found – might lead to different numbers. But the EPISCOPE benchmarks provide the rough common scale, which helps to get a "quantitative understanding" of the situation in the observed building stocks.

Average Buildings

To transfer the results for the current states of the building stocks ("basic case") to a common data format, a concept of so called "average buildings" was developed during the EPISCOPE project. These are theoretical (synthetical) buildings with geometrical and thermo-physical characteristics equal to the average of a building stock subset, which they represent. The annual energy balance for heating and domestic hot water of average buildings is calculated in the same manner as for real buildings. Projections to the building stock can be done by multiplying the single building related figures with the total number of buildings.

For all case studies the basic case (existing state of the building stock) was transformed to the TABULA data structure to be displayed in form of average buildings by the “Building Stocks” area of the TABULA WebTool[8] which also includes a simplified building stock calculation procedure for checking the plausibility.

Furthermore, the concept of synthetical average buildings was used for the building stock models of the Czech EPISCOPE case study.

Case Study Procedure

The general procedure used to conduct the EPISCOPE case studies can be summarised as follows:

1. Definition of the „Basic Case“
   - Setting-up a coherent model of the building stock „today“, e.g. 2015
   - Processing monitoring state indicators as far as possible
   - Determining model assumptions to close information gaps
   - Determining current utilisation conditions by taking into account available information

2. Calculation of the energy balance for the “Basic Case”
   - Calculating the energy balance of the building stock by considering the most important energy flows under usual boundary conditions
   - Processing energy consumption data (monitoring indicators) to validate or calibrate the energy balance model

3. Carrying out scenario analysis
   - Defining a trend and 2 to 4 other scenarios
   - Projecting the development of energy consumption

4. Documentation of scenario indicators and results
   - Recording scenario indicators and results (information for experts) for certain years e.g. 2020, 2030, 2040, 2050 (state indicators and energy balance indicators), see [EPISCOPE Project Team 2016]

5. Determination of summary indicators
   - Reporting summary indicators (information for non-experts) for different scenarios / years to document the compliance with energy saving / climate protection targets and to give an overview of structural development (insulation + heat supply)

6. Deduction of a simplified building stock projection to be displayed in the TABULA WebTool
   - Defining „Average Buildings“ for the most relevant building types of the basic case [EPISCOPE Project Team 2016]

[8] TABULA WebTool / Area “Building Stocks”. http://www.webtool.building-typology.eu/

Table 6 Sources / References Introduction Scenario Results

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[COM 2011]	European Commission (2011): Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: A Roadmap for moving to a competitive low carbon economy in 2050. Available at: http://eur-lex.europa.eu/resource.html?uri=cellar:5db26ecc-ba4e-4de2-ae08-dba649109d18.0002.03/DOC_1&format=PDF [2015-06-08]	With its "Roadmap for moving to a competitive low-carbon economy in 2050" the European Commission is looking beyond the 2020 objectives for climate and energy and sets out a plan to meet the long-term target of reducing domestic emissions by 80 to 95 % by mid-century.
[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, March 2014, Available at http://episcope.eu/fileadmin/episcope/public/docs/reports/EPISCOPE_Indicators_FirstConcept.pdf [2015-11-29]	EPISCOPE report on energy performance indicators for building stocks
[EPISCOPE Project Team 2016]	Diefenbach, N.; Loga, T.; Stein, B. (ed.) (2016): Application of Energy Performance Indicators for Residential Building Stocks Experiences of the EPISCOPE project, March 2016. Available at: http://episcope.eu/fileadmin/episcope/public/docs/reports/EPISCOPE_Indicators_ ConceptAndExperiences.pdf	EPISCOPE report on the application of energy performance indicators for building stocks
[TABULA Project Team 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. Available at: http://episcope.eu/fileadmin/tabula/public/docs/report/TABULA_CommonCalculationMethod.pdf [2015-09-17]	Report on the TABULA calculation method
[UBA 2014]	Umweltbundesamt (2014): "Treibhausgas-Emissionen der EU-15 nach Quellkategorien in Mio. t CO_2-Äquivalenten". Available at: http://www.umweltbundesamt.de/sites/default/files/medien/384/bilder/dateien/2_tab_thgemi-eu15_kategorien_2014-08-14.pdf [2015-06-08] Based on: European Environment Agency (EEA) (2014): Annual European Union greenhouse gas inventory 1990–2012 and inventory report 2014. Submission to the UNFCCC Secretariat, Publications Office of the European union, Luxwmbourg	Table summarising EU-15 greenhouse gas emissions in CO_2-equivalents by source categories; Results in- and excluding Land Use activities and Land-Use Change and Forestry (LULUCF) activities

3.1 <BE> Belgium

Housing blocks in the Sint-Amandsberg district of the city of Ghent

(by EPISCOPE partner VITO)

Observed Building Stock and Aims of the Scenario Analysis

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 of 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. Some of the studied houses already had some energy renovation.

For the selected dwellings a theoretical energy use was calculated and compared to the actual energy consumption. Also a detailed user profile was made. Renovation strategies for the dwellings (including nZEB) were examined.

The analysis leading to renovation strategies will help the city of Ghent reach the goals of its Sustainable Energy Action Plan [Stad Gent 2014]. Ghent wishes to continue to play a pioneering role on environmental issues, and aspires to become a climate neutral city by 2050. To achieve the goals related to a climate neutral Ghent in 2050, the refurbishment rate in Ghent should at least double from 1,500 refurbishments to 3,500 refurbishments per year[9]. In addition, the energy result for each refurbishment must be enhanced.

To this end, the following objectives are put forward:

---

[9] Taking into account the total number of 92930 buildings in the city of Ghent [STATBEL 2014], this would result in a renovation rate of 3.8 %.

- 70 kWh/m² to become the ‘new norm’ (net energy for heating)
- installation of sufficient roof insulation, façade and floor insulation where possible
- the placement of low-emission glass and an energy-efficient heating system are vital steps to be implemented during each residential refurbishment.

At least 80 % of refurbishments should achieve this actual energy consumption level. The remaining 20 % of refurbishments is already held to greater energy ambitions:

- 30 kWh/m² to become the ‘new future norm’ (net energy for heating)
- Many residences have room for profound measures, as well as thicker insulation, or the use of renewable energy.

Table 7: 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 action]

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 192m².

Scenario Approach

The theoretical energy consumption was calculated with a model based on the Flemish EPB calculation methodology [Vlaamse Regering 2013]. However, where EPB only is a single zone model, the model used is a multi-zone model, taking into account different use and physical characteristics of different zones. Also the user behaviour is taken into account by looking at the users’ presence in the building, their temperature preferences and ventilation habits. This bottom-up approach should lead to a more accurate estimation for the energy use for space heating. Primary energy, CO_2-emissions and energy costs for space heating are calculated by the model.

For the buildings, all being from the same type, 6 subtypes were defined based on the geometry of their annexes. For each of these types of annexes a fixed geometry and fixed window partition is considered. Further variation within the subtypes is based on orientation, internal zoning and the characteristics of the building envelope and its technical installations.

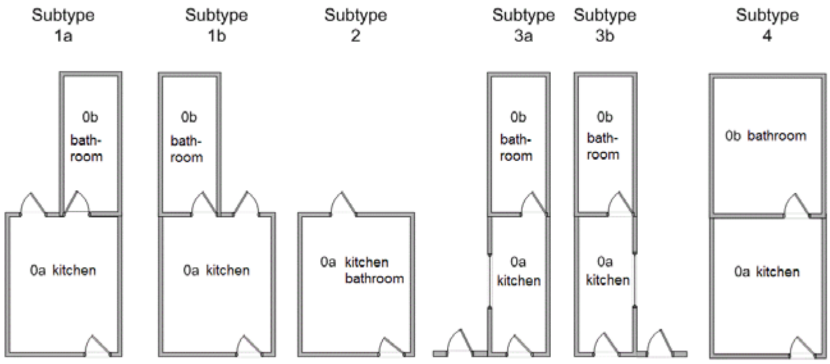


Figure 4: Different subtypes of the annex [own creation]

The information feeding into the model can be obtained from various data sources or also default values are available (see below). For 50 of the selected 200 dwellings, a detailed survey was conducted, to complement the available data sources. Both building characteristics and aspects on user behaviour were surveyed, together with the actual energy consumption of gas and electricity. The survey was conducted by architects, so they were able to check the state of the dwelling during the survey.

Bottom-up calculation of the energy use was compared with the top-down energy consumption based on consumption data of which the use for space heating was isolated.

The energy calculation module was used to investigate the impact of user behaviour into more detail by changing the real user behaviour by a standard more economic user profile. Also 2 renovation measures packages were calculated: a 'no regret' scenario with easy to implement measures and an 'nZEB' scenario with measures to strive for a nearly zero energy building. The model takes into account the rebound effect and envisages modifications in user behaviour after renovation.

Data Sources

To calculate the theoretical energy use of the selected buildings, primary building data like building age band, geometry and building type, are available from the GIS-application of the city of Ghent. Geometrical data is further retrieved from visual inspection from the public domain and through Google maps and Google Streetview. Internal zoning is mainly based on the publication 'Smal Bouwen, Ruim Wonen' (Narrow building, spacious living) of the City of Ghent [Stad Gent 2013].

To take into account user behaviour in the calculation of the energy use, also data on the inhabitants (number of inhabitants, age, profession) were used. These data were provided by the City of Ghent under the condition of confidentiality.

Energy consumption data of residential customers in the studied area were provided by EANDIS under the condition of confidentiality. For each of the supply points for which no complaints were filed, consumption data of natural gas and electricity of 2010, 2011 and 2012 are known.

Besides the above data sources, additional data was retrieved by surveying 50 dwellings and their inhabitants in the project area. These surveys were conducted by architects, so they could also inspect the current state of the dwelling. The survey consists of 15 basic questions on rather general data of the inhabitants, their home, the building envelope and technical installations. Additionally, 15 detailed questions surveyed more specific aspects that might influence energy consumption and user behaviour.

Description of the Basic Case and the Most Relevant Scenarios

As the selected dwellings mainly have the same typology, the variation in energy use will mainly depend on the energy renovation measures already implemented, the technical installations present, the geometrical variation of any annexes, the internal zoning of the main building and annexes, the presence of a cellar and/or a useable loft and whether or not the neighbouring dwellings are heated.

Besides these physical aspects, also user behaviour has an impact on the energy use. The presence of the dwelling occupants in their home therefore is important, alongside set point temperatures for heating and cooling and set back temperatures for heating for each space and the frequency of opening windows and doors for ventilation. Also regulation of the ventilation installation when present is important.

The survey that was conducted in 50 dwellings included questions on already implemented renovation measures and the current state of technical installations and of the building envelope, with rates from A to D, depending on their energy efficiency. If no information on the insulation level was known, default values from the construction or renovation year class could be used. As the survey was conducted by architects, their experience could contribute to a correct estimation of the current state of the building. Also other physical aspects like the presence of a cellar or loft, the condition of the neighbouring dwellings, the subtype of the annex were investigated during the survey. Information on user behaviour, specific for heating, ventilation and the use of domestic hot water, was also surveyed.

90 % of the buildings surveyed originally dated from before 1945, but the survey showed that most of them already had renovation works done, of which the majority is rather recent (> 2006).

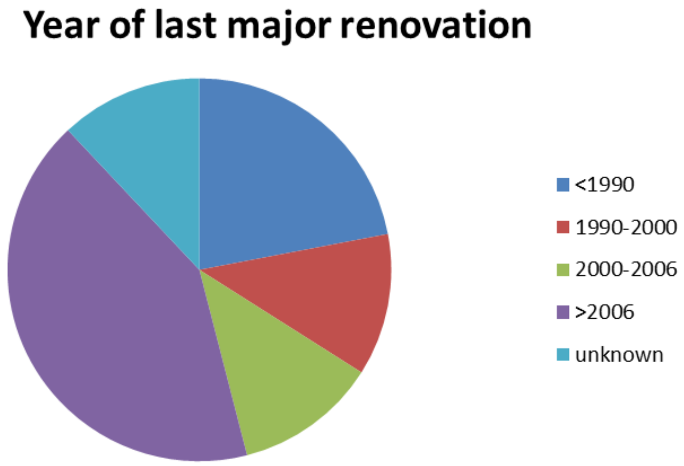


Figure 5: Overview of the year of the last major renovation for the surveyed buildings [own creation]

Windows and roofs were mostly the subject of the renovation works, but most outer walls and ground floor slabs have not yet been renovated. Also the heating systems was often replaced, as survey results show that 66 % of the investigated buildings have a condensing boiler. Most of the buildings do not have a ventilation system.

The survey also revealed differences in user behaviour, mainly on setpoint temperatures and setback temperatures. Set point temperatures between 18°C to 25°C with an average of 21°C were reported for the living area of the surveyed houses. For the sleep zone of the house, setpoint temperatures varied from 0°C to 24°C with an average of 9°C. Setback temperatures where on average 12°C for living areas and 6°C for sleep zones, with respective maxima of 23°C and 20°C (minima in both zones reported to be 0°C).

The calculation model that was used for the bottom-up calculation of the energy use of the current state was also used to calculate several improvement options:

- The real user behaviour is replaced by a standard defined economic user profile, to investigate the influence of behavioural changes;
- The ‘no regret’ renovation package has measures which are low invasive and have a very short payback period;
- The ‘nZEB’ renovation package includes measures to renovate the house to a nearly zero energy state, taking into account the practical constraints of renovation leading to an nZEB level that is slightly different from the one for new dwellings.

The model takes into account the rebound effect and envisages adjusted user behaviour after renovation.

The ‘no regret’ package comprises following measures:

- No more single glazing;
- No more uninsulated roofs;
- Condensing boilers.

These measures correspond to the point of the Energy Renovation program of the Flemish Government [VEA 2015]. An analysis of the EPC database until 2012 showed that only 8 % of the dwellings in the database were OK with all three measures. 28 % already had 2 measures implemented and 34 % had implemented 1 out of 3 measures. These figures indicate that 30 % of the dwellings in the EPC database up to 2012 had none of the suggested measures implemented [Verbeeck 2015].

The 'nZEB' scenario implies thorough insulation of roofs, walls and partition walls. Also a heat pump is implied, together with a mechanical ventilation system with heat recovery. Also optimized user behaviour is assumed.

To calculate the effect of these measures on the studies set of 200 dwelling, following scenarios were studied:

- For the trend scenario, the current yearly renovation rate of 0.7 % referring to the no. of buildings, not including heat supply systems [Energy Saving Pioneers 2015] was used; assuming that only 'no regret' renovations were carried out;
- Scenario B is similar to the renovation strategy of the Ghent SEAP [Stad Gent 2014], with a yearly renovation rate of 3.8 % with 80 % 'no regret' renovations and 20 % 'nZEB' renovations;
- Scenario C represents a deep renovation strategy, with a yearly renovation rate of 2.3 % (target set by Flanders' minister of Energy [Energy Saving Pioneers 2015]) with only 'nZEB' renovations.

The renovation rate of scenario C also corresponds with the one from the deep renovation track investigated in [Ecofys 2012].

For all three scenario's, a demolition rate of 0.1 % per year was assumed [Meynaerts 2013], together with a growth of the total building stock of 4 % until 2020, 0.6 % between 2020 and 2030 and 0.6 % between 2030 and 2050, based on [AG 2014]. For new buildings, nZEB-status was assumed.

Results

Looking at the individual dwellings for which the renovation packages were calculated, they show an average saving potential of 74 % (nZEB) or 26 % (no regret).

However, the first two columns of Table 12 show there still remains a gap between the theoretical consumption of the basic case that is calculated bottom-up (with the model) and the top-down interpretation of the real consumption data, only a fit of ±33 % is reached for these two approaches, indicating the importance of user behaviour and the existing gap between theoretical and actual consumption.

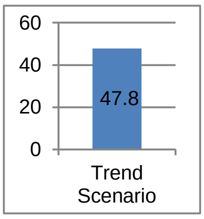
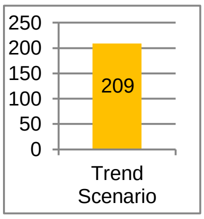
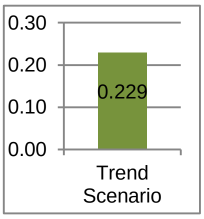
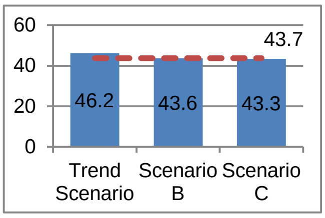
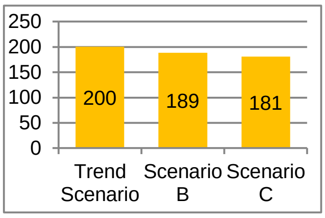
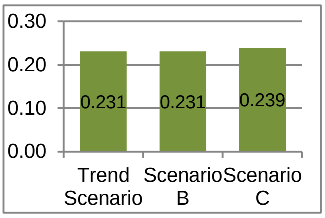
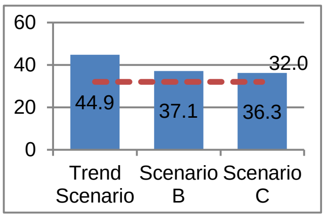
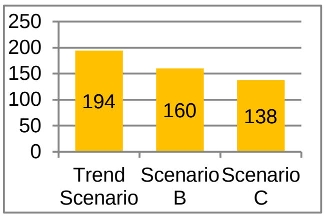
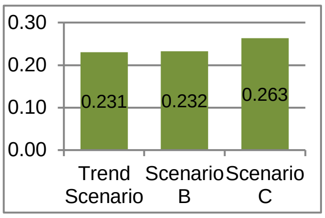
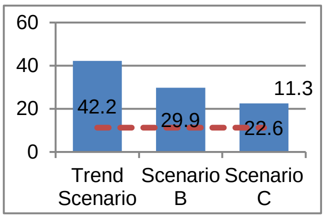
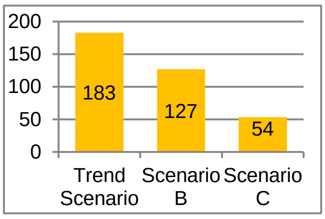
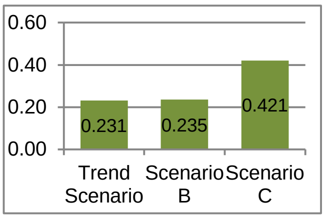
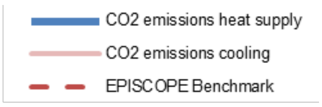
Table 8: Energy consumption and cost and CO_2 emission, average values for 50 investigated dwellings

	Theoretical consumption (bottom-up) average	**Interpretation real consumption (top-down)** average	**fit [%]** average	**'No regret' renovation scenario** Minimum-average (savings)	**'nZEB' renovation scenario** Minimum-average (savings)
Primary energy use [kWh/m²yr]	223	73	33 %	59-166 (-26 %)	33-57 (-74 %)
Final energy use [kWh/m²yr]	210	71	34 %	59-166 (-21 %)	13-23 (-89 %)
CO_2 emission [kg/yr]	9275	2905	31 %	2070-6643 (-28 %)	1713-3378 (-64 %)
Energy cost [€/yr]	2616	858	33 %	597-1916 (-27 %)	448-883 (-66 %)

* Non-renewable primary energy. Primary energy factors for Flanders (agreed weighting factors) are included in [EPISCOPE 2014]

The results of the projection of the renovation measures on the entire building stock considered are summarized in Table 13 and are in accordance with the suggested renovation scenarios. The summary indicators for the housing blocks in Sint-Amandsberg include emissions and energy need for space heating only and are therefore not directly comparable to the values given in the other chapter of this report in which also the domestic hot water supply is considered.

Table 9: Summary Indicators housing blocks in the Sint-Amandsberg district of the city of Ghent

	EPISCOPE Ref. Area	CO_2 emissions	Total heat demad (space heating)	CO_2 emission factor heat supply
	10^3 m²	kg/(m²yr)	kWh/(m²yr)	kg/kWh
2015	32.64			
2020	33.95			
2030	34.15			
2050	34.56			
Explanation				
		$m_{CO2,heat\ supply}$: annual carbon dioxide emissions (related to EPISCOPE reference area) $m_{CO2,heat\ supply} = q_{total} \times f_{CO2,heat\ supply}$ 	$q_{total,h}$: total heat demand for space heating, not including domestic hot water supply (related to EPISCOPE reference area)	$f_{CO2,heat\ supply}$: total CO_2 emission factor of heat supply

Comments

Trend Scenario: observed state and trends in the Flemish building stock

Scenario B: increased renovation rate of 3.8 % with 80 % 'no regret' and 20 % 'nZEB' renovations

Scenario C: increased renovation rate of 2.3 % (target) with 'nZEB' renovation measures

Conclusions

Ghent, like most of the other Belgian cities has a rather old building stock. Ghent, being the first Flemish city to sign the Covenant of Mayors [Stad Gent 2014], has ambitious climate goals. However, the city is not choosing the path of least resistance, but is aiming for a social climate policy [Stad Gent 2014]. Looking at the results from the pilot case, we can conclude that the local authorities should aim for a policy that encourages in-depth energy renovations.

Where it might be easier to convince home owners to perform a 'no regret' renovation, as it has few implications on other building elements, can be easily divided into different renovation phases and payback time is low, this might not be the best option. Danger exists to create a lock-in effect, where home owners will not undergo a deep renovation in the medium term, because they already had renovation works done. Calculation outcome from the pilot project indicates that the 'no regret' renovation as suggested results in an average final energy use of 166 kWh/m²yr for space heating, much higher than the 70 kWh/m²yr aim from the SEAP of the city of Ghent. Scenario B is thus not a strict representation of the strategy suggestion in the Ghent SEAP, but is similar as it uses the same (high) renovation rate and the same ratio for different depths of energy renovations.

Scenario C, with a slower renovation rate than scenario B, but still 3 times faster than the current renovation rate, results in the biggest reduction on CO_2 emissions and primary and final energy use. This scenario takes into account only nZEB-renovations, thus avoiding lock in effects. However, this deep energy renovation is likely to face many barriers. Even though lower energy costs are expected after renovation, the barrier of the initial renovation cost remains. Within city centres, also many dwellings are rented. This might also be a substantial barrier as renovation costs are for the home owner, where renovation benefits (lower energy costs) are for the tenant. A deep renovation strategy, combining a focus on energy efficiency with high use of renewables, was also found to offer the largest job creation potential of the assessed tracks in [Ecofys 2012].

Besides the physical renovation works, where preference is given thorough renovation, also a behavioural change can contribute to energy savings in the built environment. The influence of the user behaviour can be divided into 2 aspects: the behaviour as such, where guidance and optimization is possible and the family composition, considered as a fixed parameter. Importance of user behaviour is shown in Figure 6 where a theoretical exercise was made with different user profiles for houses with different energy standards.

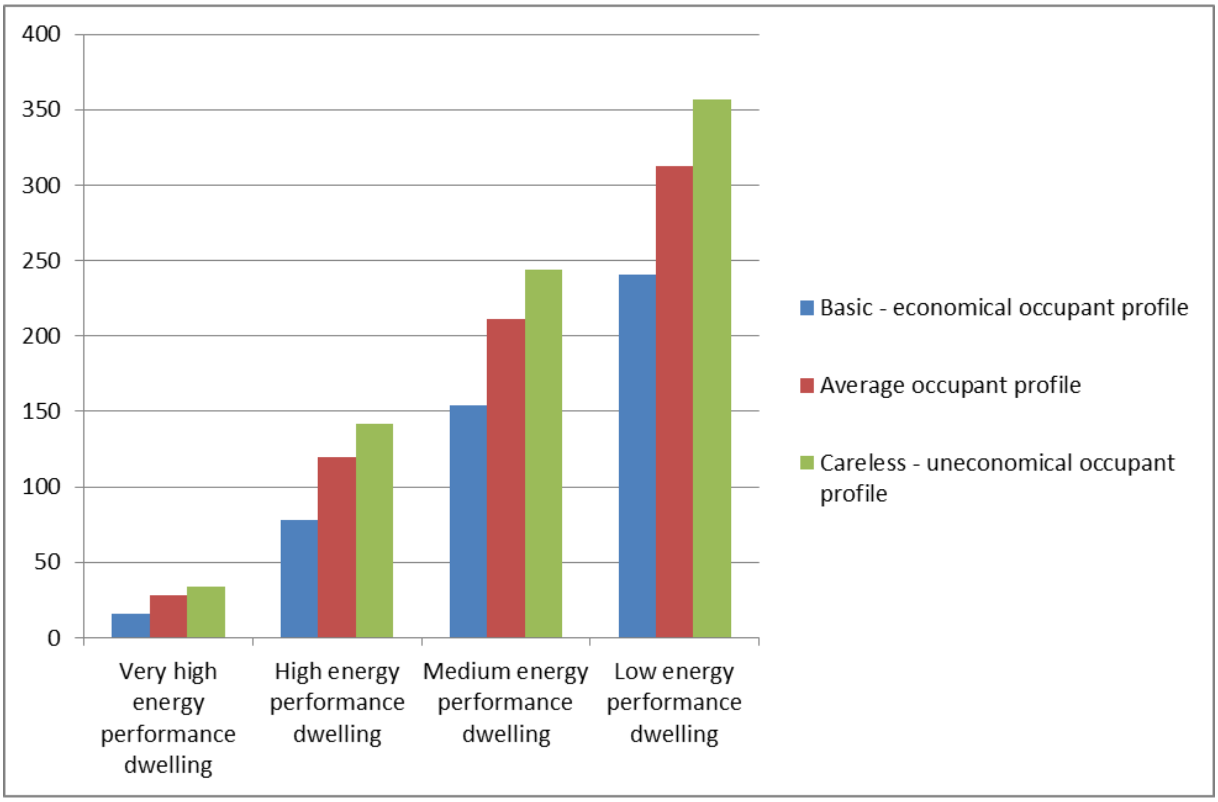


Figure 6: Final energy consumption for space heating excl. RES (kWh/m²yr) - current dwelling compared to dwelling type averages for various energy performance levels and various occupant profiles [own creation]

Figure 6 shows that even in dwellings with very high energy performance, user behaviour can influence the final energy consumption for space heating to a large extent, with the uneconomical profile having more than double the energy consumption of an economical occupant profile. Awareness raising thus remains important.

Sources / References <BE> Belgium

Table 10: Sources / References <BE> Belgium

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[AG 2014]	AG Stadsplanning Antwerpen (2014): Slim Verdichten.	Research report on solution to cope with the need for extra dwellings without extra land use.
[Ecofys 2012]	Ecofys (Boermans, Thomas/Bettgenhäuser, Kjell/Offermann, Markus/Schimschar, Sven) (2012): Renovation Tracks for Europe up to 2050, Köln.	Report by Ecofys, commissioned by Eurima, with an analysis and comparison of possible renovation tracks for the EU building stock.
[Energy Saving Pioneers 2015]	Energy Saving Pioneers (2015): Turtelboom op Batibouw: besparen door energie-efficiënt te renoveren. Available at: http://www.energysavingpioneers.be/turtelboom-op-batibouw-besparen-door-energie-effici%C3%ABnt-te-renoveren [2015-08-17]	Article on the press conference on energy saving renovations of Flemish Minister of Energy Turtelboom on the occasion of the start of Batibouw 2015.

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[EPISCOPE 2014]	EPISCOPE Project Team (2014): Inclusion of New Buildings in Residential Typologies. Steps Towards NZEBs Exemplified for Different European Countries, Darmstadt, Institut Wohnen und Umwelt. Available at: http://episcope.eu/fileadmin/episcope/public/docs/reports/EPISCOPE_SR1_NewBuildingsInTypologies.pdf [2015-08-24]	Synthesis Report No. 1 of the EPISCOPE project.
[Meynaerts 2013]	Meynaerts, Erika/Renders, Nele/Franckx, Laurent/Gorissen, Leen/Lodewijks, Pieter (2013): Ontwikkeling van een afwegingskader voor evaluatie van het CO_2-reductiepotenteel van de stad Gent.	Report on the study of VITO in collaboration with arcadis on an assessment framework for the CO_2-reduction potential of the city of Ghent.
[© 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.
[Stad Gent 2014]	Stad Gent (2014): Ghent Climate Plan 2014-2019. Available at: http://www.stepupsmartcities.eu/Portals/51/Tools%20and%20Resources/Enhanced%20SEAPs/Annex%20A_Ghent%27s%20enhanced%20SEAP_Climate%20Plan%202014-2019.pdf [2015-09-01]	Enhanced SEAP of the City of Ghent for the period 2014-2019, developed through the STEP UP project.
[STATBEL 2014]	FPS Economy, statistics Belgium (2014): Kadastrale statistiek van het bestand van de gebouwen op 1 januari 2014. Available at: http://statbel.fgov.be/nl/binaries/NL_gebouwenpark_statbel_140908_121618_tcm325-255267.xls [2015-08-12]	Spreadsheet with detailed information on numbers of dwellings divided in categories and for different years. Published by the FPS Economy SME's, Self-Employed and Energy.
[VEA 2015]	VEA (2015): Energierenovatieprogramma 2020. Available at: http://www.energiesparen.be/2020 [2015-08-12]	Webpages of the Flemish Energy Agency on the energy renovation program for 2020.
[Vlaamse Regering 2013]	Vlaamse Regering (2013): Bijlage V Bepalingsmethode van het peil van primair energieverbruik van woongebouwen. Available at: http://www.energiesparen.be/bouwen-en-verbouwen/epb-voor-professionelen/epb-regelgeving/bijlagen [2015-08-17]	Official appendix of the energy decree of 19 november 2010 to calculate the primary energy use of residential buildings.
[Verbeeck 2015]	Verbeeck, Griet/Ceulemans, Wesley (2015): Analyse van de EPC databank – Resultaten tot en met 2012, Leuven, Steunpunt Wonen. Available at: http://steunpuntwonen.be/Documenten/Onderzoek_Werkpakketten/zkc4494-wp5-analyse-van-de-epc-databank-eind.pdf [2015-08-13]	Analysis of the EPC data for Flanders from the start of the EPC program until end 2012.

3.2 <CY> Cyprus

Housing Stock of the Cyprus Land Development Corporation (CLDC)

(by EPISCOPE partner CUT)

Observed Building Stock and Aims of the Scenario Analysis

The largest housing corporation in Cyprus, established in 1980, is the Cyprus Land Development Corporation (CLDC) [CLDC 2015]. The CLDC comprises currently of a total of 2484 dwellings, 34 single family houses (SFH), 1120 terrace houses (TH) and 1330 Apartments in 131 multi-family houses (MFH).

The CLDC building stock is divided into two major categories, depending 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 launchment of the minimum energy requirements of 2007 [MCIT 2007] and the new buildings,19.24 %, constructed from 2007 to 2014. Table 11 summarises the main key features of the CLDC housing stock.

Table 11: 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	2,484	606	9,936	261,680 net floor area	261,680

The main energy carrier for heating supply of the observed building stock is the electricity, supplied from the Cyprus Electricity Authority. No Renewable Energy Sources are used for the heat supply. However, all the dwellings are equipped with solar thermal panels for the domestic hot water supply, backed up with electric resistance.

From the survey it was observed that the only energy efficient refurbishments documented refer to the old building stock and concern mainly the roof insulation and the windows replacement with ones of higher energy performance [Serghides et al. 2015].

The scenario analysis aims in finding whether the national climate protection targets will be met if the situation continues with the current trends, and if not, what measures should be taken in order to reach the targets.

Two main renovation categories are examined. Firstly, the thermal and energy upgrading of the building envelope of the existing building stock, is included as a major variable in all the examined Scenarios. Secondly, the significance of the Renewable Energy Sources (RES) for the electric supply is investigated, both for the off-grid and for the local electrical grid supply. The introduction of renewable energy sources on-site refer to the Solar thermal systems and the photovoltaics, which are highly effective in Cyprus [Cyprus Energy Agency 2010a], [Cyprus Energy Agency 2010b]. For the grid supply, the current trend of RES introduction is found [Cyprus Statistical Service, 2014] and, when necessary, enhanced.

The national climate protection targets to be reached in Cyprus include the reduction of CO_2 emissions/m^2 by 5 % until 2020 [Europe 2020], 30 % until 2030 [Europe 2030] and 70 % until 2050 [Europe 2050] with baseline year 2005. The national targets were used in the pilot stock scenarios due to absence of any further specific local targets.

Scenario Approach

The modelling approach sought to find the necessary energy efficient measures to be taken in order to achieve reduction of the CO_2 emission figures to reach the national, or the EPISCOPE targets set for 2020, 2030 and 2050. To this end 3 Scenarios were developed, the Trend, the Basic and the Ambitious. For the modelling the following steps were applied:

1. The existing building stock was divided into categories based on the TABULA developed typology of the dwellings (SFH, TH or MFH) and the chronological period of construction, as developed in earlier stages of this research [CUT 2014]. Chronologically, the building stock is divided in: the old dwellings (constructed up until 2007) and the new dwellings (constructed from 2007 to 2014).
2. The energy consumption for heating and cooling for each dwelling was found, based on the electricity consumption data (kWh/month), provided from the Cyprus Electricity Authority. For the rest of the energy carriers, estimates were made based on the current fuel prices [CEA 2015] [Fire Wood retail Price 2015] [MCIT Prices 2014].
3. The buildings to be constructed in the future were divided in two categories, with construction characteristics based on the energy standards to be followed, specified by the Ministry Directives; a) 2014 – 2020 (improved, compared with the current, minimum requirements) [MCIT 2007] and b) 2020 onwards (NZEB standard) [MCIT 2014].
4. The current prevalence of fuels used for heating energy refurbishment trends were documented from a questionnaire survey and an onsite observation.
5. The three Future Scenarios (Trend, Basic and Ambitious) were developed based on the observed trends and the possible and viable alternatives concerning the energy refurbishment of the building stock and the use of RES in the electricity production both onsite and from the grid.

Data Sources

The data sources are divided in two main categories based on the source of information used, which is either direct or adjusted based on existing data and concern three types of information; the construction, the energy consumption and the trends of energy improvement.

Information about the construction of the dwellings as well as 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 Directives [Europe 2012] by the CLDC. Furthermore, a questionnaire survey was contacted and onsite observation was performed. For the increase in the number of dwellings the construction data from the Statistical Service were used concerning the construction trends in Cyprus [Cyprus Statistical Service 2015].

The energy consumption 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.

Information about the prevalence of the fuels used for heating was found from a questionnaire survey performed by the research team. There is lack of data regarding the energy consumption corresponding to the rest of the heating carriers (such as heating oil suppliers), since the owners cannot remember the amounts of the energy consumption or the spent amount on each. The energy balance presented 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 Prices 2014].

For the current refurbishment trends a questionnaire survey was performed and an onsite observation, which showed the alterations between the existing state of the building and the original structure. The upgrading of the electromechanical systems for heating and cooling were also surveyed and documented.

Description of the Basic Case and the Most Relevant Scenarios

Basis of Scenarios: From the questionnaire and onsite surveys conducted by the research team, in the framework of the EPISCOPE Program, it was shown that currently the only envelope elements for energy upgrading are the roof and the windows, of the old building stock of the CLDC. There was also observed a turn towards electricity as a main energy carrier in the buildings constructed after 2006, compared with those built before. It was also noted that all the dwellings are equipped with solar thermal panels for the domestic hot water supply.

Therefore, it was deducted that there is still significant scope for improvement in the area of the insulation of the buildings and in the implementation of alternative energy sources such as the installation of photovoltaics, in order to reduce effectively the CO_2 emissions and meet the targets.

For the reduction of the CO_2 emissions, both heating and cooling emissions were considered; since the cooling consumption in Cyprus is higher than the heating consumption [Cyprus Statistical Service 2011] and depends almost entirely on electricity supplied from the grid thus having a high contribution to the CO_2 emissions.

The specifications, the variables and the parameters of all three scenarios, were defined to address the issues as outlined above. These, are described below and they are summarised in Table 12.

Basic Case 2015: The Basic Case represents the current situation of the building stock.

National Base Year 2005: For the National targets of reduction in CO_2 emissions, the energy profile of the stock in 2005 was investigated. This corresponds to the energy consumption of the old building stock.

For all the Scenarios it was assumed that from 2014 onwards the dwellings will follow the new minimum energy requirements, as defined in the Directive 366/2014 [MCIT 2014]. Also, for all the new and refurbished dwellings it was assumed that the main energy carrier for heating and cooling would be the electricity.

Trend Scenario: The Trend Scenario is based on the assumption that the current refurbishment trends will continue with the same rate in the future.

Moderate Upgrading Scenario (Scenario B): This Scenario is based on a moderate envelope refurbishment for the old buildings, in order to reach the minimum energy requirements as described in Directive 568/2007 [MCIT 2007], applied together with RES (Solar Thermal) for the heating and cooling supply of all the refurbished buildings and those constructed after 2020.

Ambitious Upgrading Scenario (Scenario C): In this case a more ambitious nZEB level, envelope refurbishment was considered both for the old and the new building stocks, with RES (Solar Thermal + PVs) for both the heating and cooling supply. In this Scenario major contribution of renewable energy in the electricity produced in the public grid was considered [Cyprus Statistical Service 2014].

Table 12: Scenarios description [own elaboration]

	Trend Scenario			Scenario B			Scenario C		
	2020	2030	2050	2020	2030	2050	2020	2030	2050
Percentage of m2 of moderate refurbished stock (%) from the 2015 stock	2 %	7 %	16 %	8 %	33 %	81 %	0 %	0 %	0 %
Percentage of m2 of nZEB refurbished stock (%) from the 2015 stock	0 %	0 %	0 %	0 %	0 %	0 %	9 %	36 %	100 %
Total Percentage of dwellings with roof U-value < 0.75 W/m2K, windows U-value < 3.2 W/m2K and walls U-value < 1.39 W/m2K / total stock	28 %	26 %	20 %	33 %	46 %	55 %	26 %	19 %	5 %
Total Percentage of dwellings with roof U-value < 0.4 W/m2K, windows U-value < 2.25 W/m2K and walls U-value < 0.4W/m2K / total stock	0 %	18 %	45 %	0 %	18 %	45 %	8 %	45 %	95 %
Onsite RES contribution for heating (%) in the complete stock	44 %	49 %	53 %	46 %	56 %	78 %	45 %	58 %	84 %
Onsite RES contribution for cooling (%) in the complete stock	0 %	2 %	7 %	3 %	17 %	50 %	0 %	18 %	70 %
RES contribution in the grid electricity production (%) in the complete stock	13 %	24 %	46 %	13 %	24 %	46 %	17 %	34 %	64 %

Results

The CO_2 emissions, for heating and cooling, for the CLDC stock in 2005 are calculated to be over 12 thousand tonnes per year. If the current trends are to be continued, by 2050 the emissions will increase by 17 % from the 2005 values.

When applying the Moderate Upgrading Scenario (B), this figure was lowered up to 32 % by 2050 compared with 2005 levels. Ambitious Upgrading Scenario (C) utilizes more widely the renewable energy sources for heating and cooling supply through both on-site and off-site solutions. This scenario saves approximately 73 % by 2050, in comparison with the figure of the base year. The Ambitious Upgrading Scenario is the only one to achieve the targets of CO_2 reductions, for all the benchmarks.

From the above, it is derived that the national targets cannot be met, even when extensive and intensive energy refurbishment measures are employed on the existing building stock. The EPISCOPE targets can be met if the adequate measures are taken in time, as described in the Ambitious Scenario C (Table 12).

As far as the energy demand is concerned, only the heating demand is considered. The total energy use for the CLDC stock for heating is modelled to be 11 GWh per year, in 2005. Applying the Trend Scenario, this leads to an increase of 55 %. The energy consumption is also increased after the Moderate and Ambitious Scenarios are applied, with corresponding increase of 36 % and 27 % by 2050. The formula used to find the total energy consumption percentage difference for each benchmark is; (Energy consumption per square meter_ benchmark year)*(Square meters of conditioned space_benchmark year) / (Total energy consumption per square meter_base year) * (Square meters of conditioned space_base year). Therefore, the increase of total energy demand for heating, in all the Scenarios, is consistent with the initial low energy demand for heating per square meter (53 kWh/m2yr), and the impact of the increase of the conditioned square meters, which was doubled from 2015 to 2050.

The CO_2 emission factor for electricity for heating supply is also indicative of the determining impact of the RES in the decarbonisation of the energy system. The progressive turn towards electricity as the main heating energy carrier and the introduction of PVs for its on-site production can be appreciated on the final energy by fuel (Table 14 and Table 15).

Ambitious, nZEB standards, energy refurbishment of the existing buildings envelope and a change towards green electricity for the heating supply are the two measures which constitute a viable pair of refurbishment if the CO_2 reduction emission targets are to be met.

Table 13: Summary Indicators Housing Stock of the Cyprus Land Development Corporation (CLDC)

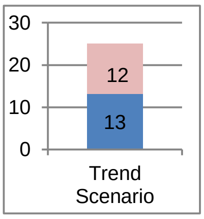
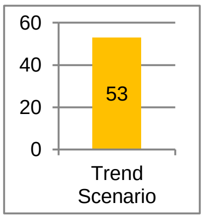
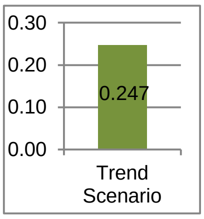
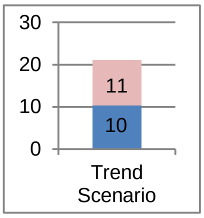
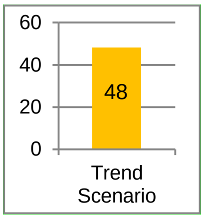
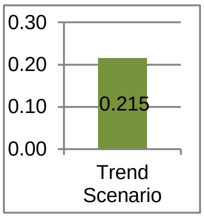
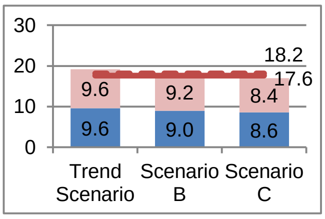
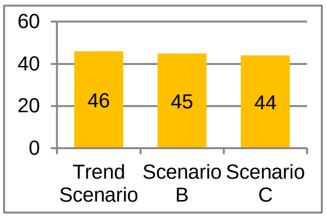
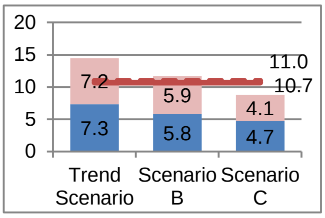
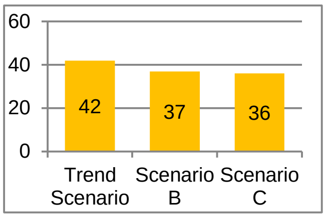
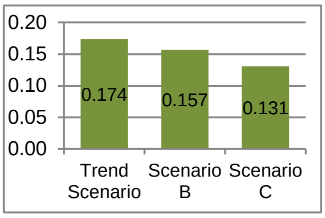
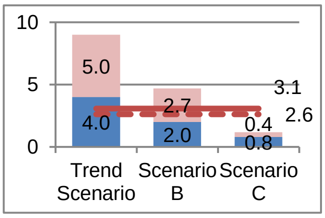
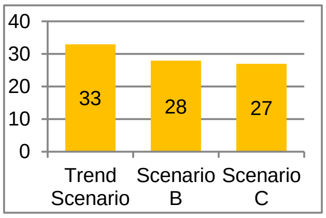
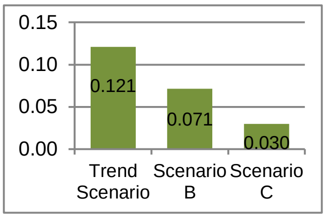
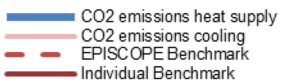
	EPISCOPE Ref. Area	CO_2 emissions	Total heat demand	CO_2 emission factor heat supply
	10^9 m²	kg/(m²yr)	kWh/(m²yr)	kg/kWh
2005	0.21			
2015	0.26			
2020	0.29			
2030	0.35			
2050	0.52			
Explanation				
		$m_{CO2,heat\ supply}$: annual carbon dioxide emissions (related to EPISCOPE reference area) $m_{CO2,heat\ supply} = q_{total} \times f_{CO2,heat\ supply}$ 	q_{total}: total heat demand (heat generation for space heating and DHW, related to EPISCOPE reference area)	$f_{CO2,heat\ supply}$: total CO_2 emission factor of heat supply
Comments				
Trend Scenario: observed state and trends in the CLDC building stock in 2012 Scenario B: not keeping the targets. Scenario C: keeping the EPISOCPE targets for 2020,2030 and 2050.				

Table 14: Final energy by fuel of the CLDC building stock for 2005, 2015 and 2020, gross calorific value [GWh/yr]

	2005	2015	2020		
Absolute figures	Trend Scenario	Trend Scenario	Trend Scenario	Scenario B	Scenario C
natural gas	0.00	0.00	0.00	0.00	0.00
liquid gas	1.59	1.64	1.61	1.49	1.48
oil	0.35	0.37	0.36	0.33	0.33
coal	0.00	0.00	0.00	0.00	0.00
wood / biomass	1.94	2.01	1.97	1.82	1.81
district heating	0.00	0.00	0.00	0.00	0.00
electric energy (used for heat supply)	3.07	3.38	3.56	3.37	3.40
electric energy from the public grid (used for heat supply)	3.07	3.38	3.56	3.37	3.37
Electric energy produced by pv on site (used for heat supply)	0.00	0.00	0.00	0.00	0.03

Table 15: Final energy by fuel of the CLDC building stock for 2030 and 2050, gross calorific value [GWh/yr]

	2030			2050		
Absolute figures	Trend Scenario	Scenario B	Scenario C	Trend Scenario	Scenario B	Scenario C
natural gas	0.00	0.00	0.00	0.00	0.00	0.00
liquid gas	1.54	1.01	1.00	1.39	0.00	0.00
oil	0.34	0.22	0.22	0.31	0.00	0.00
coal	0.00	0.00	0.00	0.00	0.00	0.00
wood / biomass	1.88	1.23	1.22	1.70	0.00	0.00
district heating	0.00	0.00	0.00	0.00	0.00	0.00
electric energy (used for heat supply)	3.94	3.22	3.20	5.01	3.18	2.97
electric energy from the public grid (used for heat supply)	3.83	3.22	2.97	4.60	3.18	2.23
Electric energy produced by pv on site (used for heat supply)	0.11	0.00	0.23	0.41	0.00	0.74

Conclusions

The Carbon Dioxide emissions for conditioning (heating and cooling) and Domestic Hot Water of the building stock under study in 2015, exceed the 46 kg/m^{2}yr. This value can be greatly reduced, since most of the pilot stock has not any insulation or installed any alternative energy sources for energy production, besides for the Domestic Hot Water.

The current trend of energy refurbishment (including new NZEB construction after 2020), as depicted in the Trend Scenario, is proven insufficient for reaching the national climate protection targets and the EPISCOPE targets.

The Moderate Upgrading Scenario (B), implementing a moderate building envelope refurbishment, combined with RES (Solar thermal) for heat supply is approaching the 2020 and 2030 targets of EPISCOPE, but is not an effective refurbishment Scenario for reaching them, deviating from the desirable results as we move from 2020 to 2050. Therefore, additional measures were considered.

A combination of ambitious building envelope refurbishment (nZEB standards) and RES for heat supply, included in the Ambitious Upgrading Scenario, with additional contribution of RES in the grid electricity supply, constitute a feasible solution to reach the CO_2emission targets.

The results are indicative of the limits presented in reducing the energy demand for heating in Cyprus, since it is already low, and highlight the importance of the introduction of the RES, in the production of the energy needed, as it is given the situation the most effective means of decarbonisation.

The efforts in Cyprus of minimizing the CO2 emissions must focus in the reduction of energy consumption for both heating and cooling, as cooling is currently depended almost entirely on electricity consumption from the grid and is responsible for the 50 % of the CO2 emissions in 2015 and if any further measures, addressing the cooling consumption in particular will not be taken (Table 12: Trend Scenario CO2 emissions), the impact from the cooling related emissions over the total conditioning emissions will increase from 48 % in 2005 to 53 % in 2050.

One main inhibiting factor in reaching the targets is the high construction rate of 2 % over the existing stock of new buildings in Cyprus, even during the economic crisis. It is therefore important to raise awareness in the construction sector concerning the necessity of investing on improving the energy efficiency of the existing building stock and reduce at the same time the rate of new constructions, which lead to ever increasing square meters of conditioned areas.

Sources / References <CY> Cyprus

Table 16: 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.pdf [Accessed 2015-06-20]	Cyprus Electricity Authority, Costumer kWh calculation example.
[CLDC 2015]	Ιστοσελίδα Οργανισμού Ανάπτυξης Γης 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 Energy Agency 2010a]	Ενεργειακό Γραφείο Κυπρίων Πολιτών (2010): Θερμικά ηλιακά Συστήματα Εφαρμογές στον οικιστικό τομέα. Available at: http://www.agiosathanasios.org.cy/uploadfiles/Solar%20thermal%20systems.pdf [Accessed 2015-06-23]	Cyprus Energy Agency 2010, Solar Thermal Systems, Applications in the residential sector.
[Cyprus Energy Agency 2010b]	Ενεργειακό Γραφείο Κυπρίων Πολιτών (2010): Φωτοβολταικά Συστήματα Εφαρμογές στον οικιστικό τομέα. Available at: http://www.cea.org.cy/TOPICS/Renewable%20Energy/PV%20for%20households.pdf [Accessed 2015-06-23]	Cyprus Energy Agency 2010, Photovoltaic Systems, Applications in the residential sector.
[Cyprus Statistical Service 2011]	Στατιστική Υπηρεσία Κύπρου (2011): Τελική κατανάλωση ενέργειας από τα νοικοκυριά. Available at: http://www.mof.gov.cy/mof/cystat/statistics.nsf/All/D548CFD3B755064CC225792000317B59/$file/ENERGY_CONSUMP_HH-2009-EL-051011.xls?OpenElement [Accessed 2015-06-28]	Cyprus Statistical Service 2011, Final Energy consumption in the households
[Cyprus Statistical Service 2014]	Στατιστική Υπηρεσία Κύπρου (2014): Στατιστικά στοιχεία παραγωγής και αγοράς ενέργειας. Available at: http://www.cystat.gov.cy/mof/cystat/statistics.nsf/energy_environment_81main_gr/energy_environment_81main_gr?OpenForm&sub=1&sel=2 [Accessed 2015-06-23]	Cyprus Statistical Service 2014, Energy Statistics
[Cyprus Statistical Service 2015]	Στατιστική Υπηρεσία Κύπρου (2015): Κατασκευές και Στέγαση. Available at: http://www.mof.gov.cy/mof/cystat/statistics.nsf/All/F173D0C9F27D08F7C225770C0038F90F/$file/CONSTRUCTION-1995_2014-EL-190315.xls?OpenElement [Accessed 2015-06-27]	Cyprus Statistical Service 2015, Construction and Housing
[Europe 2012]	Ευρωπαικό Διάταγμα Ενεργειακής Απόδοσης 2012/27/EU Available at: http://eedguidebook.energycoalition.eu/images/PDF/EED.pdf [Accessed 2015-06-21]	EU Energy Efficiency Directive (2012/27/EU)
[Europe 2020]	Στόχοι της Ευρώπης για το 2020 Available at: http://ec.europa.eu/europe2020/pdf/annexii_en.pdf [Accessed 2015-06-20]	Europe 2020 targets
[Europe 2030]	Στόχοι της Ευρώπης για το 2030 Available at: http://ec.europa.eu/clima/policies/2030/index_en.htm [Accessed 2015-06-20]	Europe 2030 targets
[Europe 2050]	Στόχοι της Ευρώπης για το 2050 Available at: http://ec.europa.eu/clima/policies/roadmap/index_en.htm [Accessed 2015-06-20]	Europe 2050 targets

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[Fire Wood retail Price 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/$file/KDP568_2007%20%20peri%20Apaithseon%20Elaxistis%20Energeiakis%20Apodosis%20Diatagma.pdf [Accessed 2015-06-25]	Directive 568/2007. First National Minimum energy requirements and terminology explanation.
[MCIT 2014]	Ο περί ρύθμισης Ενεργειακής Απόδοσης κτιρίων Νόμος 2006. Διάταγμα Κ.Δ.Π. 366/2014. Available at http://www.mcit.gov.cy/mcit/mcit.nsf/All/DF8E187B6AF21A89C22575AD002C6160/$file/KDP366_2014_peri%20Rytmisis%20Energeiakis%20Apodosis%20Ktirion(Apaitiseis%20kai%20texnika%20xaraktiristika%20pou%20prepei%20na%20pliroi%20to%20KSMKE)Diatagma2014%20.pdf [Accessed 2015-06-23]	Directive 366/2014. Minimum nZEB energy requirements and terminology explanation.
[MCIT Prices 2014]	Υπουργείο Ενέργειας, Τιμές πετρελαιοειδών στην Κύπρο το 2014. Available at: https://www.google.com.cy/gasandoilprices [Accessed 2015-06-26]	Ministry of Energy, Oil prices in Cyprus in 2014.
[Serghides et al. 2015]	Dimitriou, Katafigiotou, Michaelidou (2015): "Monitoring Indicators of the Building Envelope for the Optimisation of the Refurbishment Processes. 2nd International Conference S.ARCH, 19-20 May 2015, Budva, Montenegro.	Monitoring Indicators of the Building Envelope for the Optimisation of the Refurbishment Processes in Cyprus

3.3 <CZ> Czech Republic

Municipal Housing Stock in the City of Havířov

(by EPISCOPE partner STU-K)

Observed Building Stock and Aims of the Scenario Analysis

Havířov is the youngest city in the Czech Republic. It was founded in the early 50s of the 20^{th} century. The vast majority of the city 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 and the same HVAC solutions with typical heat losses in distribution.

About 80 % of the city housing stock is connected to the municipal district heating network. The DH network is currently under renovation. The old 4-pipe system is being continuously replaced with a modern 2-pipe system. The buildings are one by one equipped with pressure-independent heat exchange stations.

Haviřov is heated by district heating. The heat is produced by the company Dalkia using black coal from local mines in Karvina. The gross calorific value of black coal is estimated to be about 24.5 MJ/kg which is 6.81 kWh/kg and with a CO_2 emissions' equivalent of 2.149 kg of CO_2/kg of black coal (which would result in a CO_2 emission factor of 0.3157 t CO_2/MWh) [DAL 2014].

The city of Havířov does not have any particular (different) climate protection targets compared to the national 2020 and 2030 targets. The main target until 2030 is the 40 % reduction of GHG compared to the year 1990 (the target until 2020 is defined as 20 % reduction); the complementary target is at least 27 % share of RES in the total energy consumption until 2030 (the target 2020 is defined on the level 20 %).

The city of Havířov counts in total with 33,400 flats out of which 30,200 are flats in housing blocks. For the purpose of scenario analysis only part of the housing stock was studied. This part corresponds to the municipal housing stock managed by the municipal housing agency MRA. A total of 7,686 dwellings were divided into six clusters according to the age and size of the buildings.

Table 17: 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

Scenario Approach

One of the aims of scenario analysis is to figure out if the current energy performance level and speed of renovation of the housing stock are sufficient to meet the 2020 national targets. Similarly, it is necessary to identify what solutions and optimized refurbishment strategies are needed to achieve climate protection targets for 2030 and 2050.

The national targets set for the milestones 2020, 2030 and 2050, the local social, economic, environmental and demographic trends were taken into consideration for three different scenarios that may be described as: Current trend scenario, Target oriented scenario (Scenario B) and Ambitious scenario (Scenario C).

Methodology

The methodology used to produce our analysis consists of several steps:

Step 1 Clustering of the analysed housing stock into 3 age groups and 2 size groups

The first age group corresponds to the period before 1960, the second one from 1961 to 1980, and the third one from 1981 onwards. The two size groups distinguish between multi-family houses (MFH) and apartment blocks (AB).

Step 2 Setting up the models of “average” (synthetic) buildings for each cluster by adopting average geometrical and physical parameters for these average buildings.

Step 3 Definition of 3 scenarios for each cluster.

The current trend scenario was derived from the history of refurbishments within each cluster. For example in the MFH I and AB I categories complete refurbishments do not exist. The only energy saving measure on the building envelope to date was a massive replacement of windows in 2013. The reason is that this part of the housing stock, known as SORELA buildings, is protected by the Monument´s protection office. Meanwhile, the biggest energy saving potential is in the MFH II and AB II categories. It is assumed in “Scenario C” that 1/3 of these buildings will be upgraded until 2050 and will be replaced at level of passive houses.

Data Sources

The main activities carried out were the calculation of envelope and floor areas (m^2) for the different age and size groups, and the distribution of these areas over refurbished, partly refurbished and unrefurbished dwellings accordingly.

The main local sources of data are coming from the private database and from the archives of the Municipal Real Estate Agency (MRA) [MRA 3.2015], [MRA 5.2015], [MRA 7.2015] and from the [HAV 2005].

a) EPCs are available for limited amount of the buildings (about 40 % of the analysed building stock)

b) Schematic drawings from SIAM database used by MRA (layouts, cross sections, pictures)

c) MRA data and information are structured at the level of building as follows:

- Annual heating energy consumption data collected since 1999 by the MRA Energy management department including local HDD data
- Heated areas in the buildings
- Age of building
- Construction type
- State of refurbishment and last refurbishment date
- Basic dimensions of the buildings,
- Building envelope technical data
- Number of apartments
- Occupancy

d) MRA information about the annual refurbishment rates and investment schemes.

Further, complementary information needed for the modelling of scenarios was taken from the local strategic development studies [HAV 2004] and [HAV 2005]; from the national energy strategic document [MPO 2014]; the national survey of the building stock and the potential for energy savings [MPO EF 2013]; and from the energy refurbishment strategies following the art. 4 of the recast EPBD Directive [SANCE 2014] where 5 different scenarios were considered, calculated and analysed. Stochastic modelling was processed with the matrix of 72 building categories that was developed on the basis of the Czech National Typology brochure [STU-K 2014].

Quality of Data

- Partly lacking data, or data available at different levels of aggregation.
- Inconsistent use of definitions for floor areas in the Czech Republic (e.g. conditioned, living, useful floor area, invoicing area for heating)
- Errors in the information about the refurbishment state or unclear figures in EP certificates.
- Low accuracy of estimations for the future (2030-50); e.g. efficiency of DH production and future types of fuels used (XCO2)

Description of the Basic Case and the Most Relevant Scenarios

- **Trend Scenario** reflects the current situation with conservative projection of the refurbishment trend without introduction of renewable energy sources and without increasing the share of deep refurbishments. Data about the original state of construction elements (roof, wall, windows, floors), the current refurbishment progress, and typical achieved values was extracted from MRA's database. Table 18 shows the data used to calculate the first scenario.
- **Scenario B** shows the current situation with higher share of deep refurbishments compared to the trend scenario and with growing share of renewable energy sources since 2020 onwards. It also takes into account increased amount of refurbishment at passive house levels.
- **Scenario C** displays the progressive improvement of the building envelope with fast growing share of renewable energy sources since 2015. The progressive improvement is achieved through upgrade of 1/3 of the housing stock to the level of passive house standard. Refurbishment and eventually demolition and new construction to level of "passive house" are considered instead of nZEBs because the current nZEB definition is not yet widely accepted. It is expected that this definition will change in the coming years. It is not expected that the number of m2 will substantially change in the future, however.

  The mechanical ventilation with heat recovery is planned only for the passive houses. It is not defined in case of standard refurbishments. The reason is that we try to introduce in our scenarios the real practice solutions with simple controls and low maintenance costs and robust system efficiency that cannot be too much influenced by user´s behavior.

Table 18: Description of Trend Scenario, based on [MRA 3.2015]

		CZ.H.MFHAB. 01-03.Gen.SyAv.001.00	CZ.H.MFHAB. 04-04.Gen.SyAv.001.00	CZ.H.MFHAB. 05-07.Gen.SyAv.001.00	CZ.H.ABAB. 01-03.Gen.SyAv.001.00	CZ.H.ABAB. 04-04.Gen.SyAv.001.00	CZ.H.ABAB. 05-07.Gen.SyAv.001.00
U-values of the original state [W/(m²K)]							
Roof		1.00	0.80	0.50	1.00	0.80	0.50
Wall		1.40	1.20	0.80	1.40	1.20	0.80
Window		2.70	2.80	2.80	2.70	2.80	2.80
Basis		1.10	1.00	0.90	1.10	1.00	0.90
Refurbished fraction of the envelope areas							
Roof		4 %	42 %	29 %	8 %	65 %	36 %
Wall		4 %	42 %	29 %	8 %	65 %	36 %
Window		47 %	57 %	29 %	30 %	74 %	55 %
Basis		4 %	42 %	29 %	8 %	65 %	36 %
U-values of the refurbished fraction (averages) [W/(m²K)]							
Roof		0.30	0.24	0.20	0.30	0.24	0.20
Wall		0.30	0.25	0.23	0.30	0.25	0.23
Window		1.10	1.30	1.30	1.10	1.30	1.30
Basis		0.30	0.28	0.27	0.30	0.28	0.27

Results

The total CO_2 emissions from heating and DHW in the MRA housing stock in 2015 amount to more than 17,500 tonnes per year. If the current building refurbishment trend is followed, the emissions would drop to 13,000 tonnes per year by 2050. The Scenario B would end up with 9,500 tonnes of CO_2 emissions per year by 2050 and the Scenario C would result in 7,200 tonnes by 2050. For this date there is no official national or local target related to the GHG emissions in 2050. It can be concluded, that the calculated result is quite close to the EPISCOPE benchmark for the year 2050 which is 4,400 tonnes of eq. CO_2.

As far as the energy demand is concerned, only the demand for heating and DHW is considered. The calculated energy demand for the MRA stock is 55.5 GWh per year, in 2015. This energy demand shall drop to 41.3 GWh by 2050 if the current trend continues. The energy demand in 2050 would drop to 35.3 GWh in case of the scenario B and to 32.4 GWh if the ambitious Scenario C is adopted.

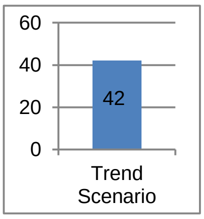
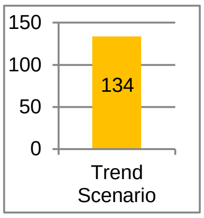
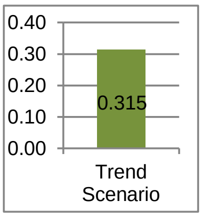
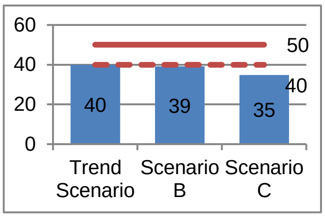
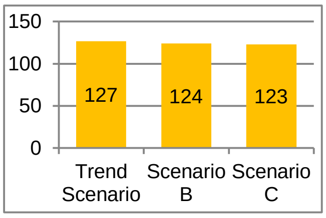
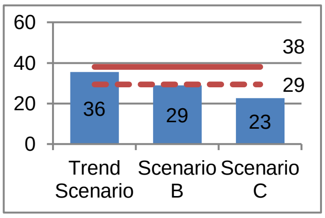
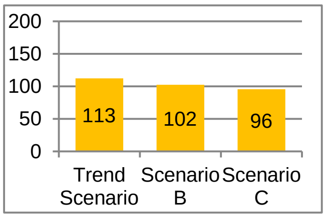
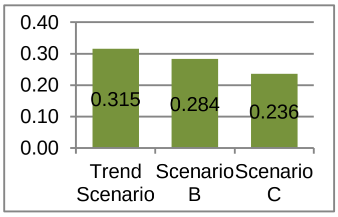
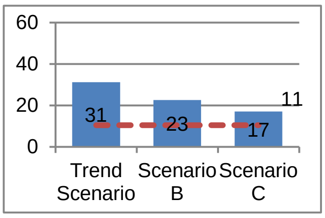
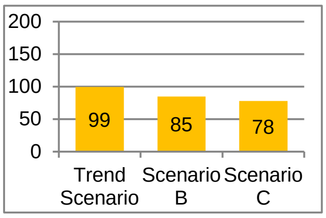
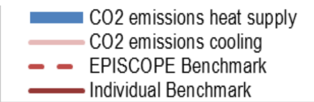
For none of the scenarios changes in the number of flats are projected. The projections are focused only on the improvements of quality of the housing stock. However an assumption of the demolition of the worst part of the housing stock (1/3 of the total area) and its replacement with passive buildings was made in the scenario C.

The CO_2 emission factor for the heat supply is also an important indicator of the environmental impacts. If the municipal district heating network should remain the main source of heat in the city, the reduction of CO_2 emissions to EPISCOPE 2050 benchmark level could be achieved by replacing the black carbon fuel with gas and biomass. Another viable possibility, not explored in these scenarios, would be to increase the share of solar panels for the DHW production on the buildings.

The progressive use of renewable energy sources as well as switching to less polluting fuels than black carbon would substantially decrease the primary energy demand.

Ambitious standards for the newly built (passive and nZEB), deep energy refurbishments of the existing buildings and growing share of renewable energy sources represent viable strategy to meet the environmental protection targets.

Table 19: Summary Indicators of the Municipal Housing Stock in Havířov

	EPISCOPE Ref. Area	CO_2 emissions	Total heat demand	CO_2 emission factor heat supply
	10^9 m²	kg/(m²yr)	kWh/(m²yr)	kg/kWh
2015	416			
2020	416			
2030	416			
2050	416			
Explanation				
		$m_{CO2,heat\ supply}$: annual carbon dioxide emissions (related to EPISCOPE reference area) $m_{CO2,heat\ supply} = q_{total} \times f_{CO2,heat\ supply}$ 	q_{total}: total heat demand (heat generation for space heating and DHW, related to EPISCOPE reference area)	$f_{CO2,heat\ supply}$: total CO_2 emission factor of heat supply
Comments				

Trend Scenario: observed state and trends in the Havířov building stock in 2015
Scenario B: keeping the national targets 2020
Scenario C: keeping the national targets 2030

Table 20: Final energy of the Havířov municipal housing stock, gross calorific value [GWh/yr]

	2015	2020			2030			2050		
Absolute figures	Trend Scenario	Trend Scenario	Scenario B	Scenario C	Trend Scenario	Scenario B	Scenario C	Trend Scenario	Scenario B	Scenario C
natural gas										
liquid gas										
oil										
coal										
wood / biomass										
district heating	65.6	62.7	59.6	53.2	55.7	44.7	34.5	51.1	36.5	27.2
electric energy (used for heat supply)	1.7	1.7	1.7	1.5	1.7	1.4	1.1	1.7	1.2	0.9

Conclusions

The efforts in Havířov of minimizing the CO_2 emissions must focus on the reduction of energy consumption for heating and DHW. The CO_2 emissions resulting from the heating and DHW production of the building stock in 2015 are at the level of 51 kg/m^{2}yr. This value can be substantially reduced by improvements of the building envelope and by increase of the share of renewable energy sources (RES) and at the same time maintaining the high share of district heating. The heat power plant currently using black coal may be later partly replaced by coke gas and biomass.

The most suitable RES in case of Havířov is the solar energy. The priority use of the solar energy is assumed for the production of DHW on SORELA buildings and high-rise buildings where the heat losses in distribution pipes ae rather high.

The current trend of energy refurbishment as figured out in the Trend Scenario is sufficient to comply with EPISCOPE and the national climate protection targets only until 2020. After this year substantial divergence appears which is proving the fact that the current trend is not acceptable as a long term strategy and there is a necessity to apply more efficient and intense energy saving measures.

Scenario B assumes deeper refurbishment combined with RES (solar thermal). This strategy would already meet the 2030 targets; however it is not sure that it would be sufficient for 2050.

Finally, Scenario C is ambitious and financially demanding. It is introducing already substantial share of nZEB and passive (newly built buildings) to replace a demolished part of the housing stock from the 60s and 70s.

Sources / References <CZ> Czech Republic

Table 21: Sources / References <CZ> Czech Republic

Reference shortcut	Concrete reference (in Czech)	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.
[HAV 2004]	Kučera, Vlastimil et al. (2004): Územní energetická koncepce města Havířov. Karbon Invest, a.s. ORTEP. Available at: http://www.havirov-city.cz/dokumenty/rozvojove-dokumenty/uzemni-energeticka-koncepce.html [2015-07-29]	Local Energy Efficiency Plan of the city of Havířov
[HAV 2005]	Ekonomická fakulta VŠB-TU Ostrava (2005): Koncepce bydlení statutárního města Havířova. Available at: http://www.havirov-city.cz/dokumenty/rozvojove-dokumenty/koncepce-bydleni.html [2015-07-29]	Housing policy concept of the city of Havířov
[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
[MPO 2014]	Ministerstvo průmyslu a obchodu (2014): Národní akční plán energetické účinnosti ČR dle čl. 24 odst. 2 směrnice Evropského parlamentu a Rady 2012/27/EU ze dne 25. října 2012 o energetické účinnosti. Odbor elektroenergetiky 30. října 2014, Verze 2. Available at: http://download.mpo.cz/get/50711/59964/631857/priloha003.pdf [2015-04-23]	National Energy Efficiency Action Plan of the Czech Republic, published by the Ministry of Industry and Trade of the Czech Republic
[MPO EF 2013]	Antonín, Jan (2013): Průzkum fondu budov a možností úspor energie. Rešerše stávajících studií a výpočtové ověření pro rezidenční budovy. Šance pro budovy. Available at: http://www.mpo-efekt.cz/cz/ekis/publikace/48574 [2015-07-29]	Survey of the building stock and the potential for energy savings. Inventory of existing studies and computational verification for residential buildings
[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)
[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

3.4 <FR> France

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

(by EPISCOPE partner Pouget)

Observed Building Stock and Aims of the Scenario Analysis

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.

OPH Montreuillois' building stock is typical French social housing's building stock: almost 90 % of the buildings are apartment blocks that are part of "grands ensembles", in other words they are part of bigger housing estates with mainly tower-blocks, that have been constructed in France in the 1970's and 1980's in suburbs or new towns around metropolises.

For the scenario analysis, we excluded all untypical buildings of the building stock such as single family houses and small and medium multi-family houses constructed before 1915. The resting building stock (97 % of the whole building stock) is our Observed Building Stock. It has been distributed into 10 types of buildings, depending on the year of construction and the size of the building (see Table 22).

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 represents less than 3 % of the total floor surface, it still makes the analysis' results coherent.

Table 22: 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	Total stock OHPM (2013)	10 504	333	≈ 33 000	667 350	734 090
	Observed building stock for scenario analysis	10 331	257	unknown	659 289	725 218

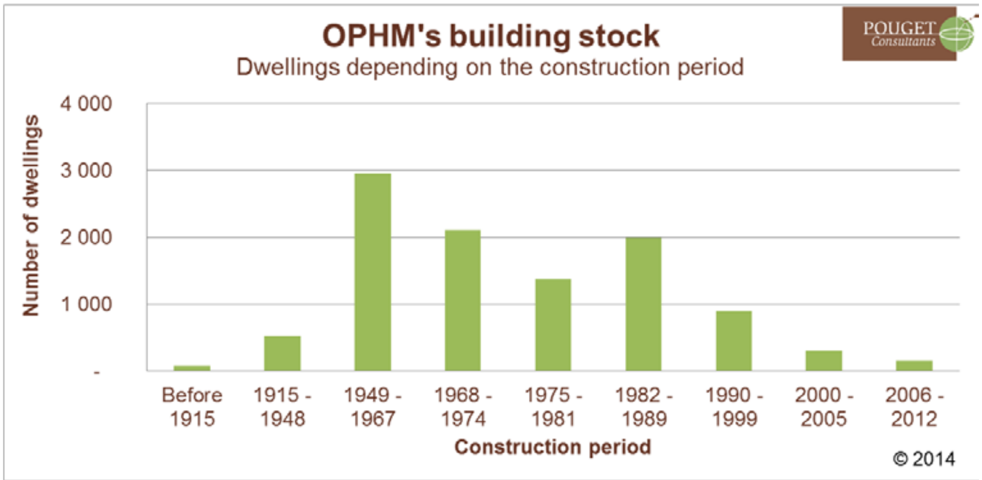


Figure 7: Distribution of the building stock depending on the construction periods [POUGET Consultants 2014]

Table 23: Scope of the observed building stock in France [OPH Montreuillois 2015]

			Living area	EPISCOPE Reference area		Dwellings	Buildings
			m²	m²			
1	LC PE 99	FR.N.LC_PE.99.OPHM	16 518	18 170	2.5 %	232	29
2	LC PE 00	FR.N.LC_PE.00.OPHM	6 054	6 659	0.9 %	82	12
3	LC INT 74	FR.N.LC_INT.74.OPHM	21 441	23 585	3.3 %	349	11
4	LC INT 99	FR.N.LC_INT.99.OPHM	102 936	113 229	15.6 %	1 470	41
5	LC INT 00	FR.N.LC_INT.00.OPHM	23 218	25 540	3.5 %	346	14
6	LC GR 74	FR.N.LC_GR.74.OPHM	13 394	14 733	2.0 %	231	5
7	LC GR 99	FR.N.LC_GR.99.OPHM	64 376	70 814	9.8 %	954	14
8	LC ENS 48	FR.N.LC_ENS.48.OPHM	24 904	27 395	3.8 %	504	15
9	LC ENS 74	FR.N.LC_ENS.74.OPHM	270 279	297 307	41.0 %	4 373	87
10	LC ENS 99	FR.N.LC_ENS.99.OPHM	116 170	127 787	17.6 %	1 790	29
	Total		**659 289**	**725 218**	**100 %**	**10 331**	**257**

Aims of the Scenario Analysis

Our aim is to give OPHM's social housing manager a basis for further thoughts to develop a refurbishment strategy in compliance with the government's targets.

The French government aims to divide by 4 the CO_2 emissions ("Facteur 4") of the whole national building stock by 2050 compared to the emissions of 1990. We considered this aim to the scale of the OPHM's building stock as the division by 4 of CO_2 emissions from 2015 by 2050, considering that their 2015 emissions are approximately equal to those of 2050, as there is no other information available on the situation in 1990, and we are conscious that this is a very consequent hypothesis. The aim of the scenario analysis is to determine what could be the key factors to achieve this target.

Scenario Approach

Refurbishment rate

The average refurbishment rate of the OPHM building stock during the last 25 years is about 2.3 % with a slight upward trend. This rate is much higher as the national refurbishment rate of about 1 %. The French Government aims 500,000 refurbished dwellings every year up from 2017 which corresponds to a refurbishment rate of 1.5 %. We decided to study the impact of the refurbishment rate on the evolution of CO_2-emissions by simulating the stock with a rate of 2 % and 3 %. The refurbishment rate is related to the floor area refurbished per year. As OPH Montreuillois do a lot of global refurbishments, we considered that each of the refurbishments have an energetical impact on the building stock and are not only maintenance.

Chronological order of the refurbished buildings

OPHM mainly operates with complete far-reaching refurbishments of their buildings. At the moment they are renovating buildings which were constructed between 1970 and 1985. All scenarios are based on the principle that the buildings are refurbished in the chronological order of their construction date or the date of their last refurbishment. Every building of the OPHM building stock was attributed to a five-year-plan of refurbishments, regarding this principle and in the way to reach the respective refurbishment rate of 2 % or 3 %.

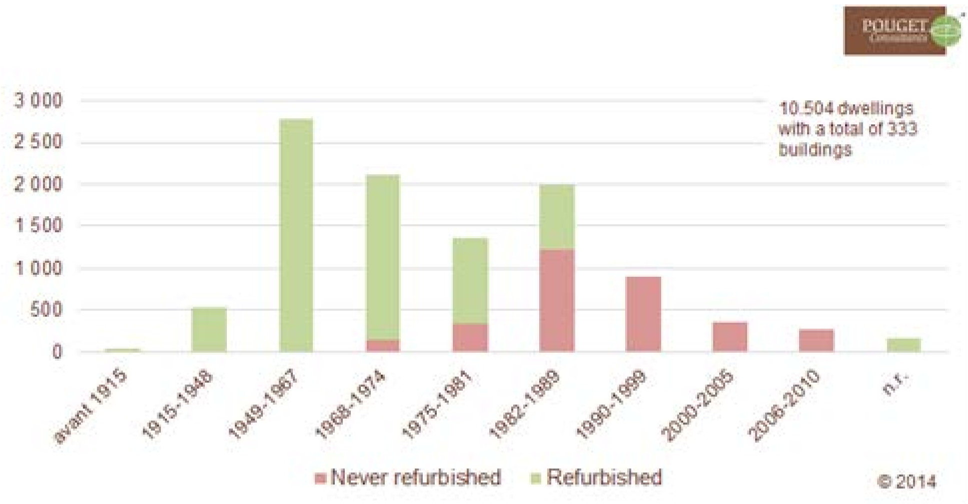


Figure 8: **Share of the number of dwellings by construction periods, with the information of the share of refurbished dwellings and not yet refurbished dwellings [POUGET Consultants]**

Lock-in effect

In some cases, thermal refurbishment is completely uneconomic. For example:

Up from a certain thermal performance of an insulated wall or roof the energy saving by additional insulation will never cover the investment. An improvement of the thermal performance is only rentable when the concerned element reaches the end of his life time.

If the windows of a building were changed ten years ago it doesn't economically make sense to change them in case of refurbishment of the wall, even if they don't have the best thermal performance.

To take into account this economical parameter, we introduce a limit level for each element of the thermal envelope. That limit depends on different factors and varies from one project to the other. In the case of this study, we defined the following U-values as lower limit for refurbishment. Elements of thermal envelope with better thermal performance will not be changed when the building is refurbished if they didn't already reach the end of their supposed life time.

Table 24: **Limit level of refurbishment by construction elements [POUGET Consultants]**

U-value of the element [W/(m².K)]		**Limit level for refurbishment**
Construction element	Ceiling	**≤0,36**
	Roof	**≤0,36**
	Wall	**≤0,44**
	Floor	**≤0,54**
	Window	**≤1,8**
	Door	**≤2,5**

Taking into account new constructions

The current French government aims to build over 500 000 new dwellings per year. This corresponds to a construction rate of 1.5 % per year. We considered the same construction rate for the OPHM building stock until 2035, coming back to a rate of 1 % per year for the period from 2036 to 2050.

For the share of energies carriers among the new buildings, we considered an equal repartition between the energies carriers present in the OPHM building stock: district heating, gas and electricity.

Evolution of CO_2 content of energy carriers

The objectives of the French Energy Transition will have a big impact on the CO_2 content of the different energies. Today the CO_2 content of electricity in France is mainly determinate by the production by nuclear power. The part of nuclear power will decrease the next years and renewable energies will replace it by and by. The production of district heating out of renewable energies and the substitution of natural gas by bio-gas or methane out of methanisation will steeply rise in the next decades. The CO_2 content of those energy carriers will decline in a similar proportion.

This scenario analysis also considered the impact of the evolution of energy carriers: a moderate and an ambitious introduction of renewable energies have been tested on 2 scenarios.

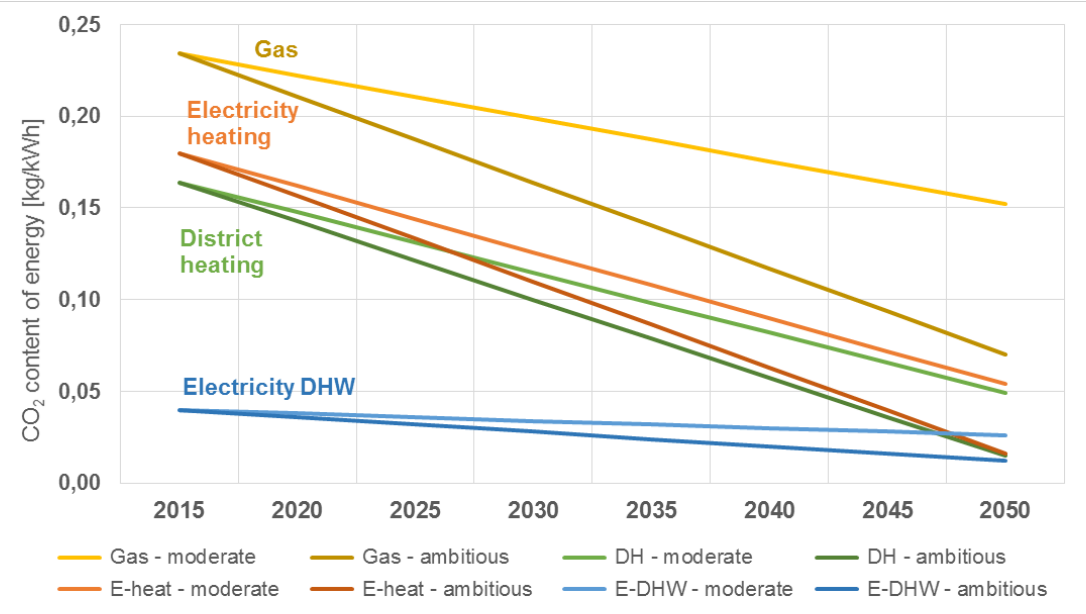


Figure 9: Evolution of energy carriers' CO2 contents considering two approaches: moderate and ambitious introduction of renewables energies [POUGET Consultants]

Data Sources

The model of the present state was built with the information given by the Energy Performance Certificates for all their building stock. The exploitation of the data was somehow flawed by two main difficulties:

- There were many incoherencies in the characteristics of the elements entered by the EPC certifier. 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.
- 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.

In those two cases, hypothesis was made 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.

Average buildings

In the French model, average buildings do not correspond to the definition commonly admitted within EPISCOPE. Thus, we don't have any geometrical information in the Energy Performance Certificates. So, we chose one representative building for each type and calculate its geometrical information. The share of the different materials encountered into the type and the share of performance of the building elements correspond to the distribution of all the buildings of the type (made on the living area).

Description of the Basic Case and the Most Relevant Scenarios

Basic Case Scenario “TREND”

The Basic Case Scenario (TREND) is based on the today’s practice of OPHM.

Refurbishment rate: 2 %;
Performance of refurbishment: Technical specifications of refurbishments OPHM usually applies today;
New buildings: respecting RT 2012’s requirements [RT 2012];
CO_2-content of energy carriers: moderate introduction of renewable energies.

All the hypothesis taken into account are resumed in the Table 25.

Scenario for good refurbishment “GOOD”

This scenario is based on the energy performance level of the French energy label “BBC-Rénovation” for refurbishments and “effinergie+” for new buildings [Effinergie 2014]. It takes into account a refurbishment rate of 3 % and a moderate introduction of renewable energies.

Scenario for excellent refurbishment “EXCELLENT”

This scenario is based on the energy performance level of passive houses for the climate zone of Paris (approximately according to “EnerPHit” label for renovations and “Passive House” for new buildings [PHI 2014]). It takes into account a refurbishment rate of 3 % and an ambitious introduction of renewable energies.

Table 25: Target values of the heat transfer coefficient U for each construction elements and depending on three levels [POUGET Consultants 2015]

Heat transfer coefficient of the construction element		**Level of energy performance**		
		TREND renovation	GOOD renovation	EXCELLENT renovation
Construction elements	Attic	**0,20**	**0,12**	**0,12**
	Roof	**0,20**	**0,12**	**0,12**
	External walls	**0,25**	**0,20**	**0,15**
	Floor	**0,35**	**0,27**	**0,20**
	Window	**1,40**	**1,30**	**0,80**
	Door	**2,00**	**1,50**	**1,00**

The levels of refurbishments differ mostly on the building elements’ requirements. Concerning supply systems, there are few differences between the three levels: for « Good » and « Excellent » refurbishments, more solar DHW systems are installed than for « Trend » scenarios. And “Excellent” level is more ambitious from the other levels by the systematical installation of double-flow mechanical ventilation system with heat recovery in place of humidity sensitive mechanical ventilation for the two other scenarios.

Results

When comparing the 3 refurbishments energy performance's levels and their impact in reducing the energy need for heating, we noticed that there is only little difference between the business as usual of OPHM and "BBC Rénovation" level (the level applied for GOOD scenario). Thus, they used to refurbish the building elements to a close level to "BBC Rénovation" and to approximately the same for systems.

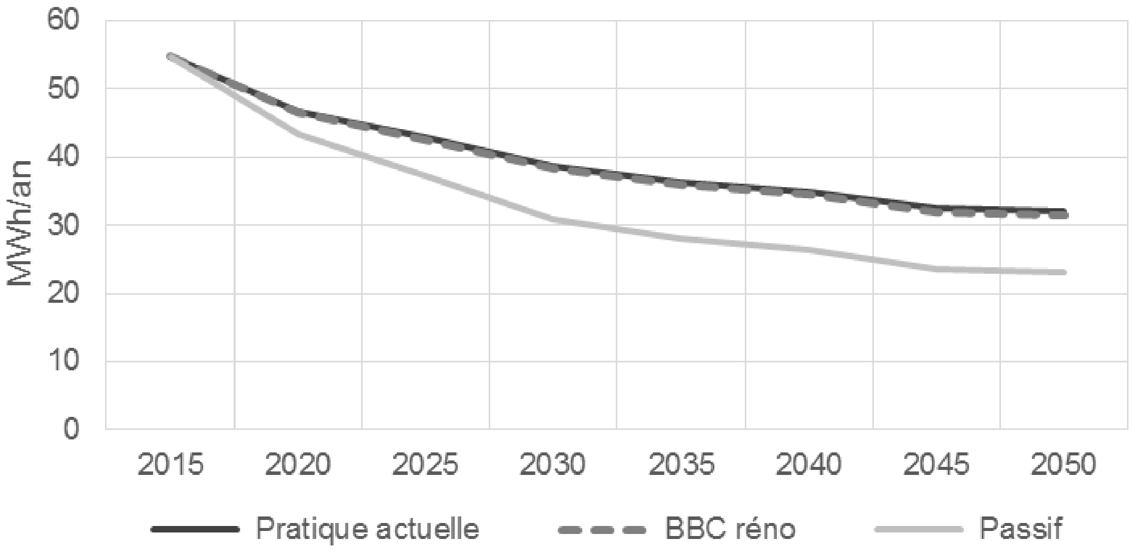


Figure 10: Evolution of the energy need for heating of the Observed Building Stock between 2015 and 2050 taking account the lock-in effect,, with a refurbishment rate of 2 % and three different energy performance levels ("business as usual", "BBC Rénovation", "passive")

Another remarkable result from our scenario analysis is that the quantity of refurbishments can absolutely not be the only parameter to achieve the fixed targets. In fact, we made calculations for a scenario with a refurbishment rate of 2 % taking account of the lock-in effect, and another one with a 3 % refurbishment rate and without taking account the lock-effect. The analysis showed that, by 2050, the result of the second scenario in terms of total heat demand is more or less the same than the result of the first one. The importance of taking account the Lock-in effect was also highlighted with this result.

New constructions bring an evolution of the building stock that goes again the objectives of reducing the final energy and CO_2 emissions of the building stock. The TREND scenario (refurbishments with business as usual, "RT 2012" level for new buildings and refurbishment rate of 2 %) and the GOOD scenario (refurbishments to "BBC Rénovation" level, passive level for new buildings and refurbishment rate of 3 %) go towards a heat demand reduction of 25 % where as it could have been 45 % without new constructions.

Nevertheless, the final energy demand is reduced thanks to the replacements of systems, which is huge during the 15 next years as systems will be widely refurbished during it. New constructions become then the reason why the whole energy demand is slightly increasing since 2035. Improvements in systems' efficiency during the decades are needed to come over this negative evolution.

Reduction of the CO_2 content into the different energy carriers is also a good parameter to accelerate the reduction of CO_2 emissions. Thus, we cannot consider only a moderate evolution of the renewable energies as it cannot allow us to achieve the "Facteur 4" target. There should be an ambitious evolution of renewable energies to achieve this target for the three scenarios.

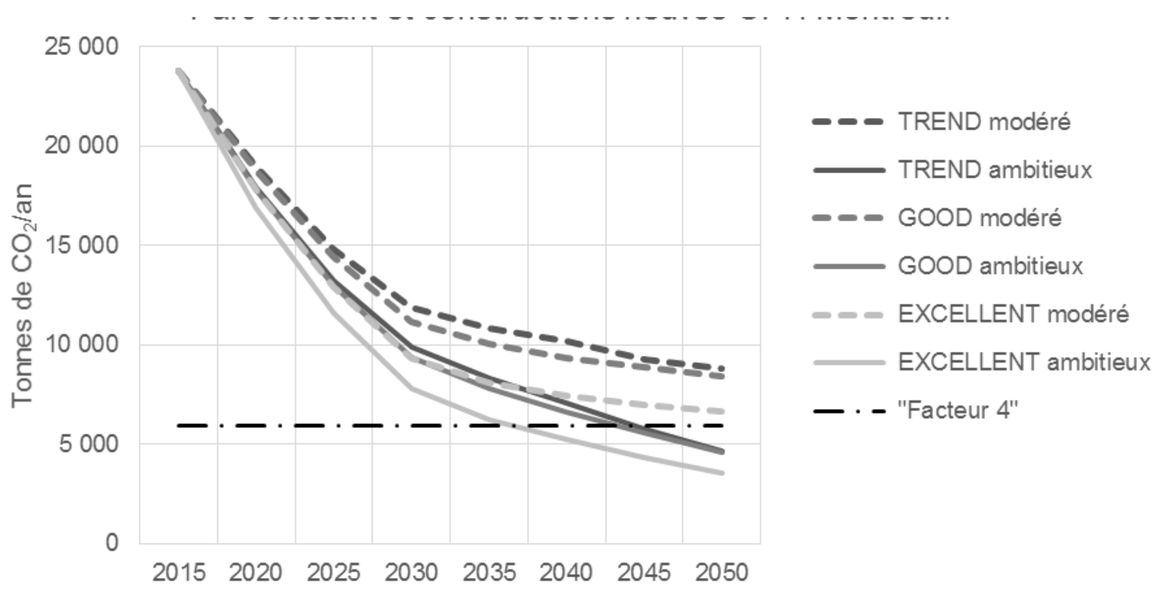


Figure 11: Evolution of CO_2 emissions for the three different scenarios comparing a moderate evolution (“modéré”) of renewable energies to an ambitious evolution (“amibitieux”)

Table 26: Summary Indicators for OPH Montreuillois' building stock

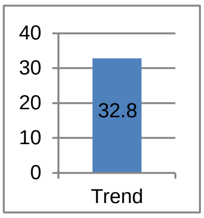
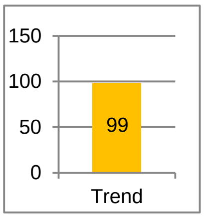
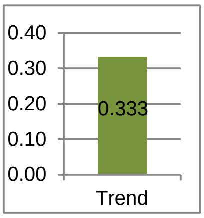
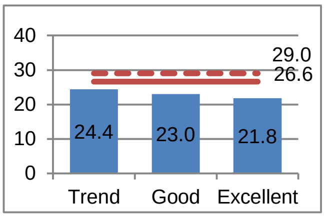
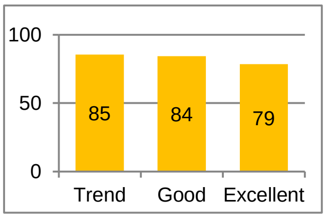
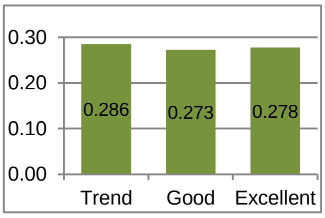
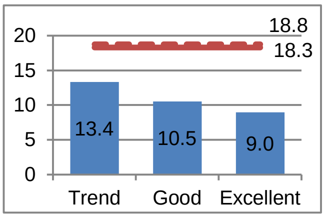
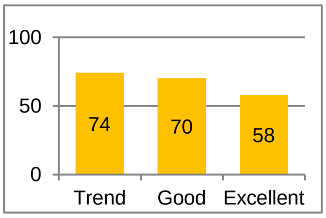
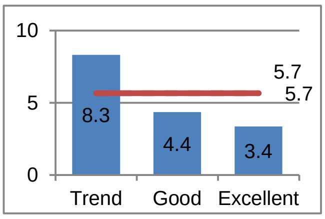
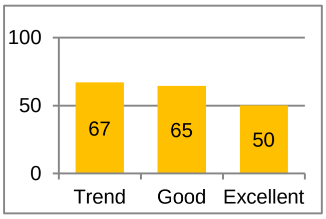
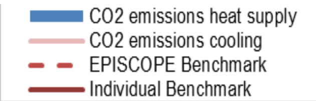
	EPISCOPE Ref. Area	CO_2 emissions	Total heat demand (not including distribution and emission losses) { What about storage losses? }	CO_2 emission factor heat supply
	10^3 m²	kg/(m²yr)	kWh/(m²yr)	kg/kWh
2015	725.7			
2020	725.7			
2030	725.7			
2050	725.7			
Explanation				
		$m_{CO2,heat\ supply}$: annual carbon dioxide emissions (related to EPISCOPE reference area) $m_{CO2,heat\ supply} = q_{total} \times f_{CO2,heat\ supply}$ 	q_{total}: total heat demand (heat generation for space heating and DHW, related to EPISCOPE reference area)	$f_{CO2,heat\ supply}$: total CO_2 emission factor of heat supply
Comments				

Table 27: Final energy by fuel for OPH Montreuillois' building stock, gross calorific value [GWh/yr]

	2015	2020			2030			2050		
Absolute figures	Trend Scenario	Trend Scenario	Good	Excellent	Trend Scenario	Good	Excellent	Trend Scenario	Good	Excellent
natural gas	79.1	69.3	68.7	64.7	56.8	53.3	43.8	61.2	58.6	45.0
district heating	11.4	15.1	14.8	13.4	16.7	15.8	11.7	27.1	25.8	18.2
electric energy (used for heat supply)	25.2	20.5	19.7	18.7	14.3	14.0	13.4	18.0	17.5	16.2

Conclusions

EPISCOPE project with its TABULA calculation tool and the partnership with OPH Montreuillois let us analyze a social housing manager's near Paris and test different energy strategies, for refurbishments as for new constructions. Thus, we could evaluate the necessary measures to achieve the targets. The conclusions of this study are specific to the building stock we analyzed but some of the results can be extrapolate, in a certain limit, to the whole social housing building stock in the North of France.

The struggle to achieve the climate protection targets and to reach the "Facteur 4" target need an energy efficiency transition strategy ("transition énergétique") that is built upon three main characteristics:

- An ambitious refurbishment of the existing building stock, leading to a high energy performance on each refurbishment;
- For new buildings, an energy performance that goes beyond the level of the current French thermal regulation, RT 2012;
- An ambitious program to implement renewable energies in France, in order to achieve at least coverage of 80 % of the energy demand by renewable energies in 2050.

The union of those three pillars is necessary to achieve the climate protection targets.

Ambitious refurbishments mean that we should go towards passive refurbishments, using triple glazing and ventilation systems with heat recovery, for most of refurbishments in the climate zone H1. It's important to achieve this level on all buildings where this is technically and economically possible, to compensate those where were it's not possible to.

"RT 2012" level is absolutely not sufficient for new constructions, and it's almost the same with the "Effinergie+" label as this level seems not to be ambitious enough, for the climate zone H1. New constructions should aim to a passive level the quickest possible.

A rapid transition towards renewable energies is necessary. In the case of our partner's building stock, we need a rate of 65 % to 80 % of renewable energies to achieve the "Facteur 4" target, even in the most ambitious scenario for refurbishments and new constructions.

Sources / References <FR> France

Table 28: Sources / References <FR> France

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[Effinergie 2014]	Collectif Effinergie (2014): TABLEAU DE BORD 2014 de la labellisation BBC-Effinergie	BBC-Effinergie label's dashboard with characteristics and safeguard values
[OPH Montreuillois 2015]	Documents fournis par l'OPH Montreuillois	Data from files and sources of OPH Montreuillois
[PHI 2014]	Passivhaus Institut (2011): Guide écrit par l'insitit pour réaliser un projet respctant les exigences du label pour la rénovation « EnerPhit »	Practical guide by PassivHaus Institut with guidelines and requirements for projects respecting EnerPhit's requirements.
[POUGET Consultants 2015]	Documents réalisés à partir de données fournies par l'OPH Montreuillois	Data made by POUGET Consultants with files and sources given by OPH Montreuillois
[RT 2012]	Arrêté du 26 octobre 2010 de la réglementation thermique des bâtiments neufs en France	Executive order for thermal regulation of new buildings in France

3.5 <HU> Hungary

Residential Building Stock in the City of Budaörs

(by EPISCOPE partner BME)

Observed Building Stock and Aims of the Scenario Analysis

The objective of the work is the analysis of the building stock and the saving potential in the residential building stock of Budaörs city. 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 new small 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]. Budaörs is a popular city at the western gate of Budapest with good economical perspectives, therefore a growth in size and population is foreseen for the analysed period [Budaörs Város Önkormányzata 2011]. We assumed linear growth as a continuation of past trends, thus the predicted growth in size is 9 % until 2020, 18 % until 2030 and 34 % until 2050 (taking into account demolition rates as well). As a consequence, it is hardly possible to apply the national energy and carbon-dioxide saving targets for this city (For the whole country opposite trends are predicted with regards to the population).

There are no local energy saving targets for this sector of the building stock. The national energy saving targets are laid down in the National Building Energy Strategy [EMI 2015]. The objective is to decrease the primary energy consumption of residential buildings by 38.4 PJ/year and public buildings by 1.6 PJ/year until 2020. 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 by 2050.

Table 29: 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

Scenario Approach

The scenario analysis was based on the TABULA/EPISCOPE residential building typology developed for national building level [BME 2014].

First the available statistics and documents (see “Data Sources”) were investigated on the population and the building stock of Budaörs such as the predicted demographic and economic development trends. It included an analysis of archive city plans in order to estimate the age and type distribution of the buildings. Although the existing data is not sufficient to determine the number of buildings per building type it is known that 35 % of the dwelling units were built after 1990 and 20 % are housing estates from the 70’s and 80’s.

The city level analysis was based on site visits in two phases. Altogether 475 buildings were visited. Based on the site visits it was concluded that from the 15 building types of the national typology only 8 are typical in Budaörs.

During the visits the share of the building types was determined more precisely and questionnaires were filled with the information on building types, size and renovation level. Local site plans were also used for a better determination of size and type. This information was later processed in excel to come to a starting point of the scenario analysis.

Figure 12: Surveyed building examples and a detail of the digital map from the historical centre of Budaörs [Domahidi 2013]

In the study three scenarios have been considered: first, the trend scenario, following current trends of retrofit rates and energy savings as a baseline and two more ambitious scenarios both in retrofit rates and energy efficiency. In all scenarios we considered that a significant part of the building stock is not economical to be retrofitted. These buildings will be partly demolished in the future. On the other hand the city will grow, so new constructions were also assumed. We applied different retrofit rates per different building types taking into account their year of construction and current state. For instance, buildings built after 2000 were considered unchanged until 2030 such as the commi-block buildings that have been retrofitted recently as a joint action coordinated by the local government.

Data Sources

The analysed data sources and the digital cartography were provided by the Municipality of Budaörs. Although the existing data was proved to be not sufficient to determine the number of buildings per building type it has turned out that 35 % of the dwelling units were built after 1990 and 20 % are housing estates 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.

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.

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.

Description of the Basic Case and the Most Relevant Scenarios

The main characteristics of the surveyed buildings and the level of retrofits are summarized by Table 32. It can be concluded that more than two thirds of the old detached houses (SFH1-3) haven't been retrofitted 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 extremely rare. The state of the commi-block buildings (AB02, AB03) is better than the average, because in the recent years all of these buildings have been retrofitted with the support of the local government and the state.

Table 30: Main characteristics of the 340 monitored building including retrofit levels

		SFH.01	SFH.02	SFH.03	SFH.04	SFH.05	MFH.04	MFH.05	AB.02.Ind	AB.03.Ind
average number of floors		1.5	1.2	2.1	2.0	2.0	3.2	2.5	11.0	8.8
net heated floor area		142.9	113.6	218.5	204.4	216.6	925.9	483.4	6872.3	5512.0
average number of dwellings		1.0	1.2	1.4	1.3	1.4	7.0	3.5	100.0	96.0
average dwelling floor area		142.9	91.1	155.5	156.6	154.5	132.3	138.1	68.7	57.4
buildings with cellar		100 %	42 %	35 %	41 %	28 %	0 %	0 %	0 %	0 %
facade insulation	no	83 %	85 %	88 %	63 %	1 %	20 %	0 %	0 %	42 %
	standard	17 %	9 %	4 %	37 %	63 %	80 %	100 %	0 %	0 %
	good	0 %	5 %	8 %	0 %	36 %	0 %	0 %	100 %	58 %
	very good	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
Windows and doors	no	17 %	10 %	0 %	2 %	0 %	0 %	0 %	0 %	0 %
	standard	31 %	56 %	80 %	98 %	100 %	100 %	100 %	0 %	0 %
	good	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	10 %
	very good	51 %	33 %	22 %	0 %	0 %	0 %	0 %	100 %	90 %
Insulation of windows	no	49 %	68 %	61 %	3 %	0 %	0 %	0 %	0 %	0 %
	standard	51 %	29 %	37 %	97 %	65 %	100 %	50 %	100 %	100 %
	good	0 %	3 %	2 %	0 %	35 %	0 %	50 %	0 %	0 %
	very good	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
Attic slab insulation	no	100 %	86 %	93 %	86 %	51 %	80 %	0 %	0 %	42 %
	standard	0 %	14 %	6 %	14 %	28 %	20 %	50 %	100 %	58 %
	good	0 %	0 %	1 %	0 %	21 %	0 %	50 %	0 %	0 %
	very good	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
Roof insulation	no	66 %	81 %	32 %	17 %	45 %	40 %	100 %	100 %	100 %
	standard	34 %	19 %	67 %	83 %	34 %	60 %	0 %	0 %	0 %
	good	0 %	0 %	1 %	0 %	21 %	0 %	0 %	0 %	0 %
	very good	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
Insulation level (overall)	no	67 %	79 %	63 %	31 %	14 %	16 %	20 %	20 %	37 %
	standard	33 %	18 %	33 %	69 %	55 %	84 %	60 %	40 %	40 %
	good	0 %	3 %	4 %	0 %	31 %	0 %	20 %	40 %	23 %
	very good	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %

The objective of the scenario analysis was to determine the energy and CO_2 saving potential until 2020, 2030 and 2050 taking into account different renovation levels and retrofit rates.

The retrofit rates were determined on the basis of past national trends and the survey in Budaörs. According to a representative national survey until 2013 only 11 % of the dwellings were retrofitted [KSH 2013]. Taking into account that the first retrofit subsidy programmes focusing on thermal insulation were launched in 2002 it can be concluded that 1 % of the dwellings were retrofitted annually. Unfortunately the category “retrofitted” was not specified in the survey, therefore we can assume that it includes partial retrofits as well.

On the other hand in Budaörs the retrofit levels are better than the national average although it cannot be supported by data. According to our on-site survey in 42 % of the buildings (floor area) some kind of retrofit measures have been implemented in the city. However, complex renovations were proved to be rare. To conclude, we considered 1 % retrofit rate on complex level for Budaörs in the trend scenario. It means that 1 % of gross floor area of the existing buildings is retrofitted annually.

In all scenarios it was assumed that the city is growing according to a linear trend. Three scenarios were set up as follows:

1. TREND scenario:
   - The non-renovated part of the existing building stock will be partly demolished, partly retrofitted and partly unchanged. Demolition rates are low (2-4 % until 2050), because of the monumental protection and mostly the buildings built before 1990 are to be demolished. Unchanged buildings are mostly new ones.
   - Retrofit rate is **1 %** yearly and **"standard" retrofit** levels are considered in all future cases.
   - The ratio of new buildings was determined from the demolition rates and the city growth. It has been considered that new buildings are built at similar level as **standard** retrofit of SFH.5 and MFH.5 building types. The proportion of newly constructed family houses and multi-family houses are identical to the current ratio between SFH.5 and MFH.5.
2. Scenario "B":
   - The same demolition rates are applied as for the trend scenario.
   - Retrofit rate is **2 %** yearly and **"standard" retrofit** levels are considered in all future cases.
   - The ratio of new buildings was determined from the demolition rates and the city growth. It has been considered that new buildings are built at similar level as **ambitious** retrofit of SFH.5 and MFH.5 building types. The proportion of newly constructed family houses and multi-family houses are identical to the current ratio between SFH.5 and MFH.5.
3. Scenario "C":
   - The same demolition rates are applied as for the trend scenario.
   - Retrofit rate is **3 %** yearly and **"ambitious" retrofit** levels are considered in all future cases.
   - New buildings are built as in scenario "B".

Results

The calculated total primary energy consumption of the residential buildings in Budaörs is 295 GWh/year that can be decreased to 272 GWh/year by the trend scenario, 233 GWh/year by scenario "B" and to 178 GWh/year by scenario "C" (Table 33). The figures relate to non-renewable primary energy components only and do not include energy consumption covered from renewable sources (such as solar and environmental energy).

The average current net heat demand is 239.6 kWh/m^{2}year. The specific primary energy consumption of heating and domestic hot water is currently 363 kWh/m^{2}year" (Table 33). This can be decreased to 69 % in the trend scenario, 59 % in scenario "B" and 45 % by scenario "C". The increase and relative low savings are caused by the growth of the city.

Currently natural gas is the dominant energy source (73.3 %). The energy saving in natural gas until 2030 is -1.6 %-33.8 % depending on the scenario. The reason for the increase and relative low saving is again the growth of the city. For 2050 the picture is better: it is 7.5-74.3 %.

With the most ambitious scenario, the share of natural gas would decrease from 53.3 % to 42.0 % and the share of biomass would increase from 19 % to 46.5 % until 2050. The share of district heating does not change significantly (it is between 2.3 % and 6.7 % depending on the time and the scenario). Electricity has no significance in any of the cases.

In absolute figures, biomass consumption will increase in most cases compared to the current state, but a decrease between 2030 and 2050 is foreseen for scenario “B” and “C”. Until 2050 the biomass based energy consumption will increase by (-7.5 %)-12.8 %.

Table 31: Total and specific primary energy consumption and CO_2 emission results for the original state and per scenario on different time horizons

		test area		entire Budaörs				specific figures	
TREND scenario									
Primary energy (heating+ DHW)	2015	64 903 682		294 982 218		295	10^6 kWh/year	363	kWh/m^2year
	2020	65 979 641	kWh/year	299 872 369	kWh/year	300	10^6 kWh/year	338	kWh/m^2year
	2030	65 806 249	kWh/year	299 084 316	kWh/year	299	10^6 kWh/year	311	kWh/m^2year
	2050	59 882 951	kWh/year	272 163 384	kWh/year	272	10^6 kWh/year	250	kWh/m^2year
CO_2 (heating+ DHW)	2015	13 143 927	kg/year	59 738 132	kg/year	60	10^6 kg/year	74	kg/m^2year
	2020	13 342 744	kg/year	60 641 741	kg/year	61	10^6 kg/year	68	kg/m^2year
	2030	13 285 750	kg/year	60 382 708	kg/year	60	10^6 kg/year	63	kg/m^2year
	2050	12 040 769	kg/year	54 724 365	kg/year	55	10^6 kg/year	50	kg/m^2year
Scenario "B"									
Primary energy (heating+ DHW)	2015	64 903 682	kWh/year	294 982 218	kWh/year	295	10^6 kWh/year	363	kWh/m^2year
	2020	64 531 347	kWh/year	293 289 983	kWh/year	293	10^6 kWh/year	330	kWh/m^2year
	2030	61 919 873	kWh/year	281 421 036	kWh/year	281	10^6 kWh/year	293	kWh/m^2year
	2050	51 310 136	kWh/year	233 200 602	kWh/year	233	10^6 kWh/year	214	kWh/m^2year
CO_2 (heating+ DHW)	2015	13 143 927	kg/year	59 738 132	kg/year	60	10^6 kg/year	74	kg/m^2year
	2020	13 054 195	kg/year	59 330 309	kg/year	59	10^6 kg/year	67	kg/m^2year
	2030	12 506 031	kg/year	56 838 942	kg/year	57	10^6 kg/year	59	kg/m^2year
	2050	10 313 918	kg/year	46 875 960	kg/year	47	10^6 kg/year	43	kg/m^2year
Scenario "C"									
Primary energy (heating+ DHW)	2015	64 903 682	kWh/year	294 982 218	kWh/year	295	10^6 kWh/year	363.0	kWh/m^2year
	2020	62 908 412	kWh/year	285 913 867	kWh/year	286	10^6 kWh/year	322.1	kWh/m^2year
	2030	57 091 734	kWh/year	259 477 517	kWh/year	259	10^6 kWh/year	270.0	kWh/m^2year
	2050	39 261 310	kWh/year	178 439 617	kWh/year	178	10^6 kWh/year	163.9	kWh/m^2year
CO_2 (heating+ DHW)	2015	13 143 927	kg/year	59 738 132	kg/year	60	10^6 kg/year	73.5	kg/m^2year
	2020	12 727 031	kg/year	57 843 370	kg/year	58	10^6 kg/year	65.2	kg/m^2year
	2030	11 532 702	kg/year	52 415 237	kg/year	52	10^6 kg/year	54.5	kg/m^2year
	2050	7 902 596	kg/year	35 916 688	kg/year	36	10^6 kg/year	33.0	kg/m^2year

Table 32: Summary Indicators of the residential building stock, Budaörs city

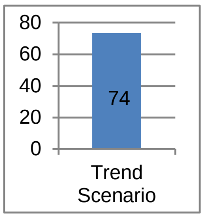
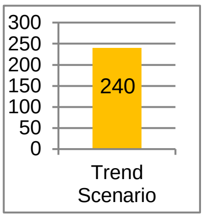
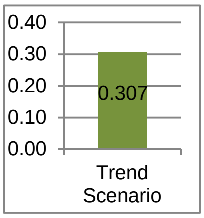
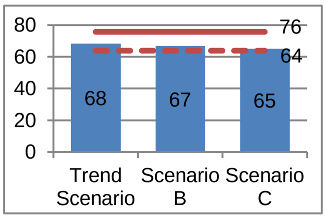
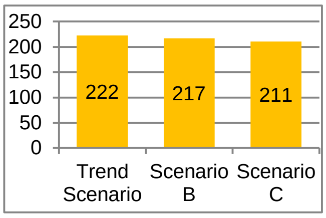
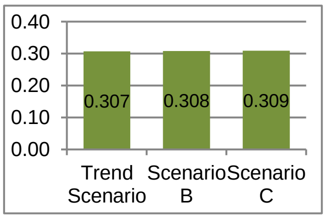
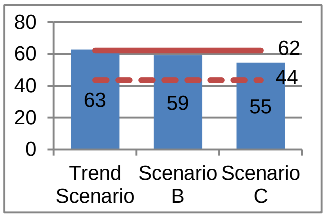
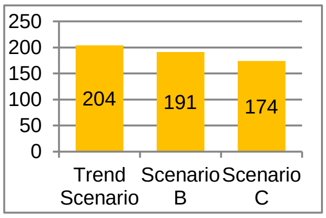
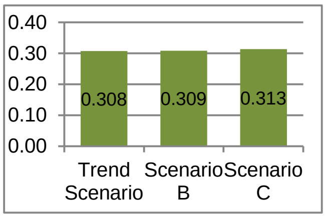
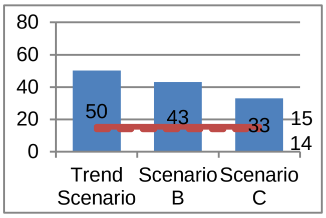
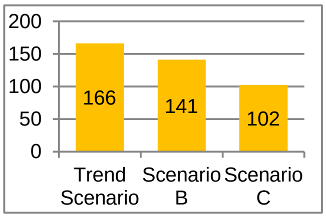
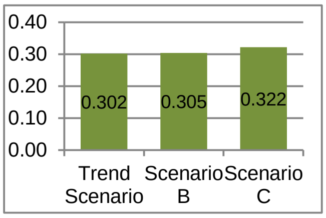
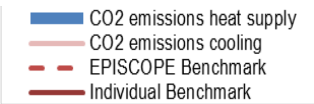
<table>
<tr><th></th><th>EPISCOPE Ref. Area</th><th>CO_2 emissions</th><th>Total heat demand</th><th>CO_2 emission factor heat supply</th></tr>
<tr><td></td><td>10^3 m²</td><td>kg/(m²yr)</td><td>kWh/(m²yr)</td><td>kg/kWh</td></tr>
<tr><td>2015</td><td>1 311</td><td>
</td><td>
</td><td>
</td></tr>
<tr><td>2020</td><td>1 432</td><td>
</td><td>
</td><td>
</td></tr>
<tr><td>2030</td><td>1 550</td><td>
</td><td>
</td><td>
</td></tr>
<tr><td>2050</td><td>1 756</td><td>
</td><td>
</td><td>
</td></tr>
<tr><td colspan="5">Explanation</td></tr>
<tr><td></td><td></td><td>$m_{CO2,heat\ supply}$:
annual carbon dioxide emissions (related to EPISCOPE reference area)
$m_{CO2,heat\ supply} = q_{total} \times f_{CO2,heat\ supply}$

</td><td>q_{total}:
total heat demand
(heat generation for space heating and DHW, related to EPISCOPE reference area)</td><td>$f_{CO2,heat\ supply}$:
total CO_2 emission factor of heat supply</td></tr>
<tr><td colspan="5">Comments</td></tr>
<tr><td colspan="5">Trend Scenario: observed state and trends in the residential building stock of Budaörs in 2012
Scenario B: keeping the national greenhouse gas targets 2020 and 2030
Scenario C: keeping the national targets 2030 only</td></tr>
</table>

Table 33: Final energy by fuel of the residential building stock, Budaörs, gross calorific value [GWh/yr]

	2015	2020			2030			2050		
Absolute figures	Trend Scenario	Trend Scenario	Scenario B	Scenario C	Trend Scenario	Scenario B	Scenario C	Trend Scenario	Scenario B	Scenario C
natural gas	214.0	217.8	202.3	190.3	217.4	177.2	141.5	198.0	118.8	54.8
liquid gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
oil	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
wood / biomass	55.9	56.9	59.6	60.7	56.7	63.5	66.6	51.6	63.1	61.1
district heating	13.0	12.9	12.8	12.6	12.8	12.6	12.0	11.4	10.9	9.2
electric energy (used for heat supply)	9.8	10.0	9.8	9.5	10.0	9.4	8.7	9.1	7.8	5.9

Conclusions

It can be concluded that both the individual and the EPISCOPE benchmarks are too ambitious and unrealistic to achieve even with the most ambitious scenario “C”. The targets could be reached only at higher annual retrofit rates than 3 %. Such an option is not realistic even in a city with relatively good economical background like Budaörs (Table 33) in Hungary. In order to achieve the targets much more significant subsidy actions would be necessary than in the past and present.

To achieve the CO_2 and energy saving goals are particularly challenging for Budaörs because it is foreseen that the city will continuously grow in the future. In case of no actions or suboptimal actions they even have to face an increase of emissions and energy consumption.

It is recommended that Budaörs elaborate an energy and carbon-dioxide saving strategy and action plan. It should cover not only the residential buildings, but also the commercial sector, because Budaörs has an important commercial area and an industrial park.

It is also recommended to build pilot nearly zero energy buildings, particularly in the public sector to provide best practice to the individuals. Communication actions on the significance of energy efficiency would also be necessary particularly because many of the building owners have the financial means to carry out energy efficiency actions without additional financial support.

Sources / References <HU> Hungary

Table 34: 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 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
[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
[KSH 2013]	Központi Statisztikai Hivatal (2013): Háztartási költségvetési és életkörülmények adatfelvétel (HKÉF).	A representative data survey carried out by the Central Statistical Office in 2013 about living conditions in dwellings
[EMI 2015]	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
[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

3.6 <IE> Ireland

Municipal Housing Stock on the Northside of Dublin City

(by EPISCOPE partner ENERGY ACTION)

Observed Building Stock and Aims of the Scenario Analysis

The pilot action building stock is focussed on the northside of Dublin City. The building stock comprises 133,431 dwellings [CSO 2012] 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.

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.

The national target is to reduce CO_2 emissions from 1990 levels by 80 % by 2050. The National Energy Efficiency Action Plan [DCENR 2014] set an energy efficiency saving target of 20 % by 2020 from the average unadjusted final energy consumption 2001-2005, expressed as primary energy equivalent. No local targets are in place for the pilot action stock.

Table 35: Scope of the observed building stock in Dublin City [CSO 2012]

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

Data Sources

Three key data sources were used to analyse the building stock and its refurbishment status and rates.

- **National EPC database**: The national EPC database provided key data and forms the key data source used for the pilot action. Out of a national housing stock of 1.6 million dwellings, 528,000 dwellings (33 %) have EPCs (based on data at 11.02.2015).
- **EPISCOPE Field Survey**: A field survey was conducted to cross-check the refurbishment rates that emerged from the EPC database analysis. 200 dwellings addresses were visited to complete 100 surveys. On average, one completed survey required 4.5 dwelling visits.
- **Energy efficiency upgrade programmes:** Trend data was obtained from the Sustainable Energy Authority of Ireland for two national energy efficiency programmes that have been in operation for more than 5 years. Data for Local Authority upgrade programmes was not available in a usable format.

Scenario Approach

All scenarios are based on the following assumptions:

- The growth in reference areas to 2050 for all three scenarios is based on a prediction that 1,600 new dwellings will be built per annum out to 2050. Given the introduction of the NZEB standard by 2021 [DECLG 2012], the model assumes all new dwellings will have an average primary energy of 45 kWh/m^2/year (including renewable and non-reneable primary energy).
- The CO_2 benchmark is on an estimate of 619.97 ktCO_2 benchmark for the pilot action stock in 1990. A 17 % reduction from this benchmark had been achieved by 2013 [EPA 2015].
- The primary energy demand benchmark is based on the reported achievement of 38 % of the 20 % energy saving targets at the end of 2012, (i.e. 7.6 %) [DCENR 2014].

The three scenarios examined in the Irish Pilot Action are:

Trend Scenario: The trend scenario is based on energy use predicted from the current EPC Database. The EPC energy values are calibrated to reflect measured energy use using calibration factors developed for the pilot action.

The current trend assumes that the existing stock will continue to be refurbished at the aggregate rates (from EPC and field survey) defined in Table 36. The current trend also assumes 1,000 new dwelling to NZEB standard will be added to the stock each year.

Table 36: Aggregate Refurbishment Trends

	Aggregate Trend (annual)		
Element	Field survey	BER Research Tool	Aggregate trend
Walls	2.2 %	2.5 %	2.4 %
Roofs	4.5 %	2.6 %	3.6 %
Windows	3.2 %	2.2 %	2.7 %
Floors	0.0 %	0.0 %	0.0 %
Boilers	4.2 %	2.0 %	3.1 %
Controls	0.8 %	N.A.	0.8 %

Scenario B (Mid Range): This scenario assumes 25 % of the stock will have undergone a deep retrofit by 2050 (spread equally over the 35 year period from 2015) by adopting ambitious fabric upgrades and switching to renewable technologies including heat pumps for space and water heating. It also assumes that the carbon content of the electricity supplied will have been reduced gradually by 30 % by 2050.

Scenario C (Optimum): This scenario assumes 75 % of the stock will have undergone a deep retrofit by 2050 (spread equally over the 35 year period from 2015) by adopting ambitious fabric upgrades and switching to renewable technologies including heat pumps for space and water heating. It also assumes that the carbon content of the electricity supplied will have been reduced gradually by 60 % by 2050.

Results

The energy demand trend scenario results are summarised in Table 37.

Table 37: Energy Demand Reduction Target Predictions

Energy Reduction (base 2005)	Trend Scenario	Scenario B	Scenario C
2015	-8 %	-8 %	-8 %
2020	-11 %	-14 %	-18 %
2030	-17 %	-25 %	-37 %
2050	-26 %	-40 %	-60 %

It is clear that the 20 % energy demand reduction targets for 2020 for the pilot action stock (taking account of space and water heating and lighting) will not be met by the current Trend Scenario, Scenario B or Scenario C which falls just 1 % of the target. However, it is acknowledged that other measures in the residential sector outside of space heating, water heating and lighting (as detailed in the Unlocking the Energy Efficiency Opportunity Report [SEAI 2015] will contribute to reaching the 2020 energy reduction target.

The CO_2 emissions trend scenario results are summarised in Table 38.

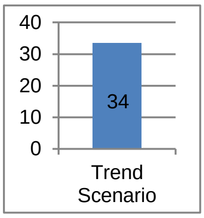
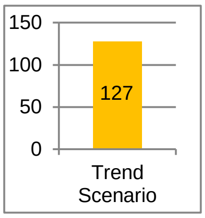
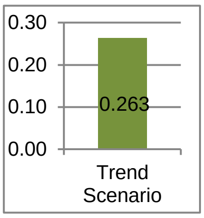
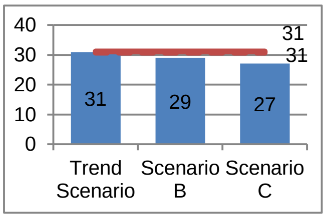
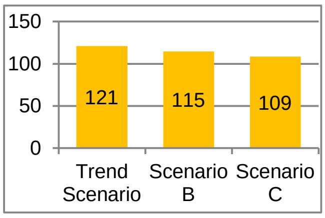
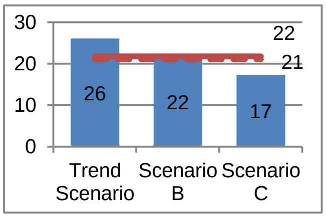
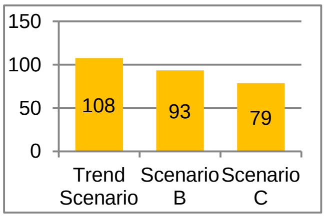
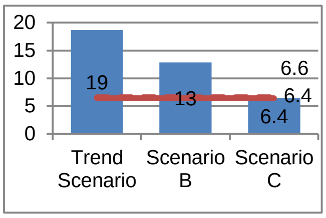
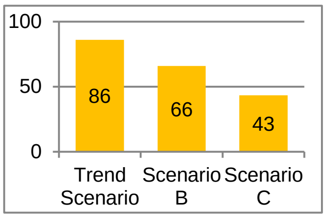
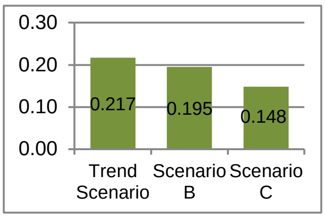
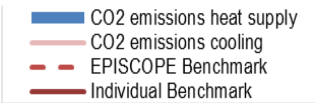
Table 38: CO_2 Emissions Reductions Target Predictions

CO2 Reduction (base 1990)	Trend Scenario	Scenario B	Scenario C	Targets
2015	-17 %	-17 %	-17 %	
2020	-23 %	-26 %	-31 %	-20 %
2030	-33 %	-41 %	-52 %	-40 %
2050	-48 %	-60 %	-80 %	-80 %

The current Trend Scenario will meet the 2020 CO_2 emissions reduction target but falls well short of the 2030 and 2050 targets. The 80 % CO_2 emissions reduction target from 1990 levels by 2050 (taking account of space and water heating and lighting) will only be met by Scenario C.

The Summary Indicators for the Northside of Dublin City residential building stock are shown in Table 39.

Table 39: Summary Indicators for Northside of Dublin City residential building stock

	EPISCOPE Ref. Area	**CO_2 emissions**	**Total heat demand (final energy, including heat generation losses)**	**CO_2 emission factor heat supply**
	10^6 m²	kg/(m²yr)	kWh/(m²yr)	kg/kWh
2015	11.43			
2020	11.87			
2030	12.74			
2050	14.49			
Explanation				
		$m_{CO2,heat\ supply}$: annual carbon dioxide emissions (related to EPISCOPE reference area) $m_{CO2,heat\ supply} = q_{total} \times f_{CO2,heat\ supply}$ 	q_{total}: total heat demand (heat generation for space heating and DHW, related to EPISCOPE reference area)	$f_{CO2,heat\ supply}$: total CO_2 emission factor of heat supply

Comments

Trend Scenario: observed state and trends in the North Dublin building stock in 2014.

Scenario B: Field survey based retrofit rate, 25 % deep retroft and 30 % decarbonisation of grid

Scenario C: Field NEEAP/NREAP predictions based on 75 % deep retrofit and 60 % decarbonisation of the grid

CO_2 emissions: national targets: -20 % (2020), -40 % (2030), -80 % (2050) based on 1990: global national targets were here transferred to the observed building stock and divided by the EPISCOPE reference area

The energy balance indicators by fuel type are provided in Table 40.

Table 40: Final energy by fuel Dublin City Northside, gross calorific value [GWh/yr]

	2015	2020			2030			2050		
Absolute figures	Trend Scenario	Trend Scenario	Scenario B	Scenario C	Trend Scenario	Scenario B	Scenario C	Trend Scenario	Scenario B	Scenario C
natural gas & LPG	1,110	1,054	1,008	941	940	819	638	750	525	187
liquid gas										
oil	119	113	108	101	101	88	69	80	56	20
coal	29	28	27	25	25	22	17	20	14	5
wood / biomass	0.40	0.30	0.30	0.30	0.30	0.30	0.20	0.20	0.20	0.10
district heating										
electric energy (used for heat supply)	161	153	155	158	136	145	158	109	137	179

Conclusions

When coming to conclusions, it is important to refer to the current situation in Ireland regarding energy and CO_2 emissions targets. The latest National Energy Efficiency Action Plan [DCENR 2014] states a 20 % energy saving target by 2020 spread across all sectors. It reports on saving made to date and outlines a basket of measures and actions across all sectors that will collectively enable the 2020 target to be reached. Thus, it does not explicitly lay out specific targets for the residential sector. Also, NEEAP 2014 does not focus on CO_2 emissions targets for 202 or beyond. At this time, national energy savings targets are not yet agreed for 2030 (and 2050 is not under immediate consideration).

The recent Unlocking the Energy Efficiency Opportunity Report (June 2015) published by SEAI also outlines the energy saving potential across all sectors up to 2020 and 2030 [SEAI 2015]. This report includes very comprehensive analysis but it stops short of specific energy demand and CO_2 emissions targets for the residential building stock.

From the pilot action analysis, it is clear that targets will be missed if business as usual continues. In order to give a greater focus on the residential building stock, it is recommended that specific targets for the residential sector be set out in future revisions to the National Energy Efficiency Action Plan.

If the residential sector has to achieve a pro rata 80 % reduction in 1990 CO_2 emissions levels by 2050, this will require 75 % of the stock be deeply retrofitted and the carbon content of the electricity supply to be reduced by 60 % from current levels as indicated by Trend C. While many variations to the inputs to Trend C can be examined, the scale of the task is very considerable. It will require a huge move away from fossil fuel-based heating systems, a dramatic improvement in the thermal insulation of the stock and significant investment in renewable technologies.

The current situation is starkly shown in the EPC mapping tool images below. This EPC mapping tool was developed by Energy Action as part of the Irish EPISCOPE pilot action [Energy Action 2015]. Figure 13 showing that current wall U values indicate that the vast majority of walls are either uninsulated or poorly insulated.

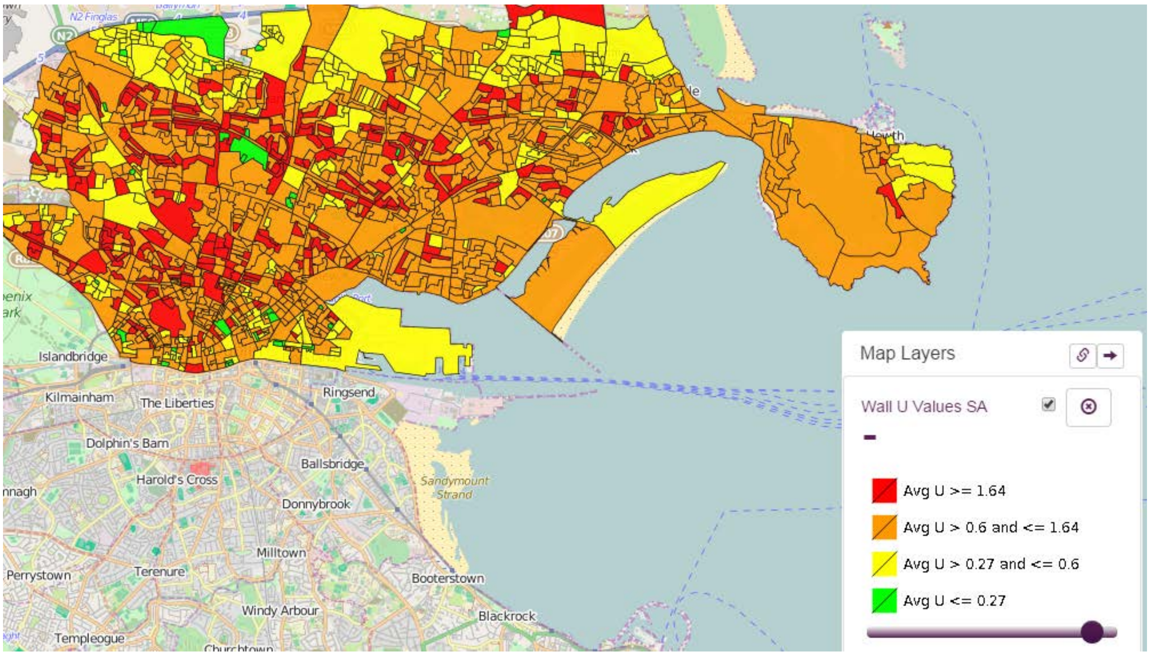


Figure 13: Current Wall U values; Map Data [© OpenStreetMap contributors]

The challenge is to turn the U value map, the EPC map in Figure 14 and all other building energy maps to yellow and green in a very significant way.

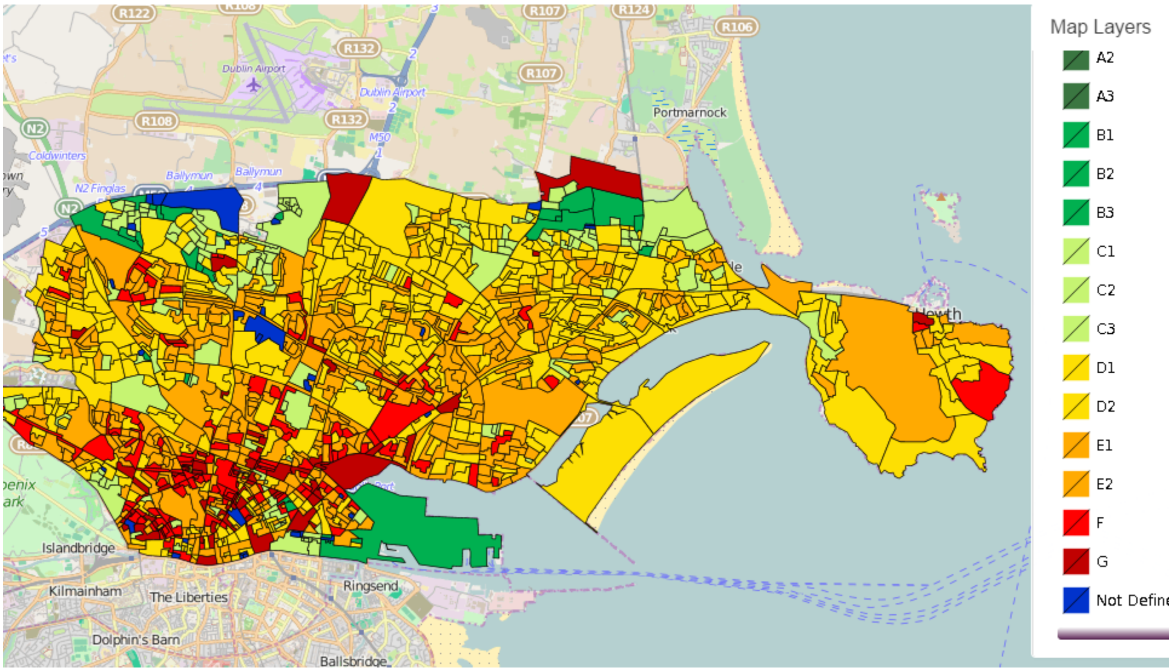


Figure 14: EPC Map; Map Data [© OpenStreetMap contributors]

Sources / References <IE> Ireland

Table 41: 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
[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
[DECLG 2012]	Department of the Environment, Community an Local Government (DECLG) (2012): Towards Nearly Zero Energy Buildings in Ireland – Planning for 2020 and Beyond	Towards NZEB in Ireland – Planning for 2020 and beyond
[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
[EPA 2015]	Environmental Protection Agency (2015): Greenhouse Gas Emissions by Sector. Available at http://www.epa.ie/irelandsenvironment/environmentalindicators/#.Ve2wWMuFOM8 [2015-09-08]	Irish Greenhouse Gas Emissions by Sector
[© 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]	OpenStreetMap
[SEAI 2015]	Sustainable Energy Authority of Ireland (SEAI) (2015): Unlocking the Energy Efficiency Opportunity, June 2015. Available at http://www.seai.ie/Publications/Statistics_Publications/Energy_Modelling_Group_Publications/Unlocking-the-Energy-Efficiency-Opportunity-Main-Report-.pdf [2015-07-17]	Unlocking the Energy Efficiency Opportunity

3.7 <RS> Serbia

Adjusting the national building typology to the local conditions – case study for the municipality of Vršac

(by associated EPISCOPE partner University of Belgrade)

Observed Building Stock and Aims of the Scenario Analysis

National building typology of Serbia has been formulated through the cooperation between the Faculty of Architecture University of Belgrade and GIZ (Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ) GmbH) and is primarily based on the methodology developed within TABULA project [Jovanović Popović 2013]. It provides valuable information and serves as the knowledge base for planning activities regarding the energy performance of building stock on national level, prescribing the use of TABULA as one of the applicable methodologies for strategic planning [RS II 98/2013]. At the same time it is not easily applicable on local – municipal level. For this reason a further development, primarily in the methodological and operational part is needed in order to facilitate the possible local implementation and forms ground for creation of Local energy efficiency local plans, obligatory by law.

Serbian municipal structure is, due to the various historical, economical and political circumstances, quite diverse both in physical structure and population characteristics. Majority of them are not characterized by as many building types, as being represented in national typology, limiting direct use of such methodology locally. It can be said that spatial development has not been uniform and has resulted in overpopulation of some cities rapidly expanding their urban fabric but also leaving some 70 (out of 169) local municipalities with less than 20000 inhabitants, commonly characterized with almost abandoned residential areas. This phenomenon is best illustrated by the results from last national census where some 113,956 flats out of total 3,231,931 [Census 2013], are declared as abandoned and 475,759 being temporary used, with majority of non-inhabited units located in small communities.

Pilot project has focused on municipality of Vršac being the typical representative of “middle size” city in Serbia with population between 40-60,000 inhabitants (it stands for 12 % of total municipalities), having at the same time distinct urban and rural areas with locally characteristic building types.

The goal of applied methodology, which has enabled formulation of local building typology, is illustrated through the energy performance and CO_2 estimation as well as local building fund and its performance projections through different scenario models. On national level “Second action plan for energy efficiency of Republic of Serbia” [RS II 98/2013] is the only adopted strategic document that is addressing the benchmarks for consumption aiming at the goal of 9 % reduction CO_2 emission for the year 2018 based on the level of consumption for the period 2001-05. At the same time there are no projections on building stock development trends neither on national nor local level.

Like other similar size municipalities Vršac has unequal distribution of population with 36,040 inhabitants in urban and 15,986 inhabitants in rural settlements. Other relevant data is presented in Table 42**.**

Table 42: Scope of the observed building stock in municipality of Vršac (results of bottom up methodology for development of municipal typology)

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

Scenario Approach

Starting point for any strategic planning or scenario development is represented in base case local building stock model out of which further trends and projections were derived. Statistical data were used from annual publications [SORS 2010-2014] and census results [Census 2013], based on which annual increase in number of buildings and demolition rate were determined. Following the current trend that annual demolition rate is almost negligible (0.1 %), modelling of building stock was executed based on three major portions: **new stock, refurbished stock and unrefurbished stock**.

Refurbishment rate needed for the scenario modelling does not exist in available statistical data and for the purpose of the pilot project it has been derived according to the results from the in field research executed in 2015. Refurbishment rate for each building type was determined, as combination of identified refurbishment actions (window replacement, facade insulation, attic slab insulation etc.); influencing the initial projections of the energy performance for the entire stock, by inducing 10 % of savings (influence of each measure on overall savings is presented in Table 43).

Table 43: Refurbishment actions influence on savings in total stock [%] (results of in field research)

	total	SFH (TYPE 1)	TH (TYPE 2)	MFH (TYPE 3)	AB (TYPE 4)
Window replacement	**36**	27.5	8.3	0.15	0.05
Façade insulation (5 cm)	**37**	24.8	12.2	0	0
Façade insulation (8 cm)	**20**	14.7	5.3	0	0
Insulation of slab towards attic (5 cm)	**7**	3.2	3.80	0	0

Besides refurbishment rates, estimation of values for energy needed for heating for the new buildings was concluded for each defined scenario, influencing respectively the energy performance of the new part of the stock. Current values defined in Serbian regulations [Rulebook 2011, 2012] were used as base values for scenario 2020, while for 2030 and 2050 new, lower values, are expertly defined and presented in Table 44**.**

Table 44: Energy needed for heating for new buildings in defined scenarios [kWh/m²yr]

	2020	2030	2050
TREND scenario	**65**	50	30
SCENARIO B	**60**	45	25
SCENARIO C	**55**	40	20

Scenario calculations for the refurbished part of the building stock are based on values obtained from two improvement levels: standard and ambitious, similar to those defined in National typology [Jovanović Popović 2013]. In pilot project, improvement measures on thermal envelope were simplified and reduced to more typical ones as described in Table 45. Impact of refurbishment has been calculated for each building type and then recalculated for the entire building stock for the municipality.

Projections of energy needed for heating after improvement 1 were used for estimation of refurbished stock performance in 2020, and after improvement 2 scenario for 2030.

Further estimations for 2050 scenario were defined on different method. Since there are no measures that can be defined as improvement level 3 projection is made according to the indicator that illustrates the average consumption per m^2. This indicator can be determined for the period up to 2020 following the impact of improvement 1 with value of 88 kWh/m^2, and for the period up to 2030 following the impact of improvement 2 with value of 63 kWh/m^2. Estimated value for the period up to 2050 following further improvements is 40 kWh/m^2.

Table 45: Description of improvement measures on thermal envelope

	Improvement 1 (Scenario 2020)	Improvement 1 (Scenario 2030)
Façade wall	addition of 10 cm of thermal insulation	addition of 20 cm of thermal insulation
Walls to unheated area	addition of 10 cm of thermal insulation (if applicable, if not then addition of 5 cm)	addition of 20 cm of thermal insulation (if applicable, if not then addition of 10 cm)
Slabs to unheated area above (attic)	addition of 10 cm of thermal insulation	addition of 20 cm of thermal insulation
Slabs to unheated area below (basement)	addition of 10 cm of thermal insulation	addition of 20 cm of thermal insulation
Slabs to outside area below	addition of 10 cm of thermal insulation	addition of 20 cm of thermal insulation (if applicable, if not then addition of 10 cm)
Flat roof	addition of 15 cm of thermal insulation	addition of 25 cm of thermal insulation (if applicable)
Pitched roof	addition of 10 cm of thermal insulation	addition of 20 cm of thermal insulation
Floor to ground	addition of 5 cm of thermal insulation (if applicable, if not then addition of 3 cm)	addition of 10 cm of thermal insulation (if applicable, if not then addition of 5 cm)
Windows	1.5 W/m^2K	1.1 W/m^2K
Doors	1.5 W/m^2K	1.5 W/m^2K

Unlike projections of total heat demand derived from different scenarios, projections and necessary calculations for CO_2 emissions and CO_2 emission factor of heat supply is more complex. It basically rely on relevant data on structure of energy carriers and heating systems efficiency currently in use in municipality Vršac, and further estimations of their improvements and replacements. For the present state these data was also obtained from the results from the inquiry of local buildings (Table 46, unrefurbished stock) and used for calculations of the unrefurbished part of the stock. For the refurbished part of the stock estimation was done taking into account relevant building types, their present heating system, and possibilities for their upgrade and change of energy carrier.

Table 46: Distribution of energy carriers in municipality of Vršac – current state and projections [%] (results of in fled research)

	gas	Wood/biomass	electricity	coal
Unrefurbished stock	**42**	55.4	1.8	0.9
Refurbished stock	**46**	54	/	/
New stock	**11**	89	/	/

Rather optimistic assumptions were adopted, that part of the family housing stock will mostly transit to biomass as energy carrier, except the part already using gas, which uses the more complex heating system installation. As for the multifamily housing stock, it was estimated that, since district heating in Vršac municipality is using gas as energy carrier, this will remain the same, which gives the distribution presented in Table 46 (refurbished stock). Similarly, for the new stock, which remains the same in structure in all scenarios (11 % multifamily and 89 % family housing) it is estimated that multifamily part of the stock will use district heating on gas, and part of family housing will use biomass as energy carrier. Efficiency of heating systems is addressed through variation of efficiency factors, as given in Table 47.

Table 47: Variation of heating system efficiency factor throughout different scenarios [%]

	2015	2020	2030	2050
gas	0.68	0.82	0.9	1.03
Wood/biomass	0.5	0.61	0.85	3.5
electricity	0.75	/	/	/
coal	0.9	/	/	/

Data Sources

One of the main goals of pilot project was development of adequate methodology for data acquisition and local matrix formulation. Methodologically, two different approaches have been developed in order to derive local typological matrix: top-down and bottom up.

In **top-down** method, data from national typology [Jovanović Popović 2013] is being used and expert projections are done for the local level. Applicability of the typology is directly influenced by the extent of the existing data bases and other data sources available locally: cadastre, district heating companies, energy utility companies etc. as well as expertise of the team conducting the work.

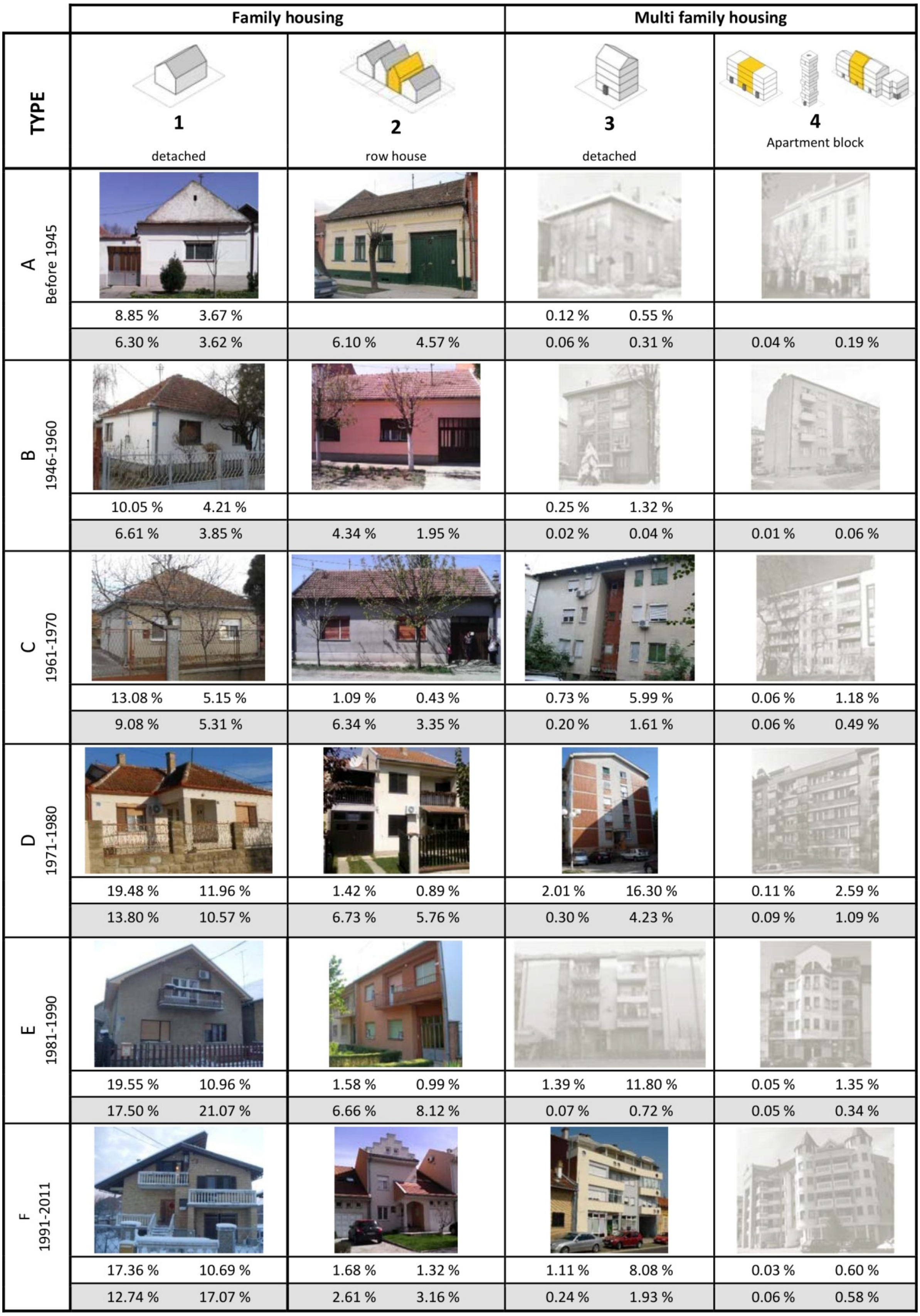
Bottom-up method, on the other hand represents direct, in field, approach where new approach has been developed enabling adequate data acquisition serving as the reliable basis for future work. Methodology bottom-up enables different size municipalities to define, execute and evaluate locally programmed censuses covering for the diversity and individuality of their building fund. Bottom-up combines statistically relevant and, at the same time, urbanistically and architecturally representative approach in formulation of census which has to be executed in field. For this reason method is largely dependent on local experts and knowledge and team in charge should, apart from experts, also needed for top-down: statistics, building typologies, energy efficiency, calculation procedures etc., always have a strong local support.

It can be said that top down method is more theoretical, with lower level of adjustability to individual characteristics, less dependent on local support but faster in implementation while bottom up is much more precise with high local significance by provision of local building stock database but also more expensive and time consuming.

Residential building typology matrix for the Vršac municipality has been developed based on both methods with finally adopted matrix (bottom up) presented in Figure 15. At first, several changes compared to the National building matrix [Jovanović Popović 2013] can be observed: the age classes have been condensed by merging the periods before the 1945 and building types narrowed by excluding the high rise building, also some of the building types are not represented at all.

The matrix represents a synthesis data from both approaches with locally representative buildings marked in colour, while ones statistically not significant taken from National typology and marked as grey.

By analysing all the available data, especially one gathered in the previous research of formulation of national building typology, and using them for the chosen top-down method it was obvious that non-uniformity between individual and multifamily building representation is notable. Actually whole top-down matrix is influenced by the very small data set derived from the sample of less than 300 buildings in Vršac that were surveyed for national typology development. The noted discrepancy shows the uncertainty of top-down method when confronted with the relatively small sample. For this reason another research based on bottom up principle was applied. This method imposes the topic of spatial zoning by definition of representative macro zones, containing between 1,000-2,000 buildings, formulated as parts of settlement with similar building types according to the national typology definition principles. Within macro a lower level of micro zones as geometrically defined areas that can be observed and analysed by one enumerator usually containing 70-120 buildings are defined. Data gathering covers a survey of representative number of micro zones through two step investigation. First step is done through a process of expert identification of building characteristics and second step through direct interview with tenant representatives. Number of macro-zones needed for the adequate representation is in correlation to the size of the municipality and its complexity but they should not contain more than 2,000 buildings.



TYPE	Family housing				Multi family housing			
	1 detached		2 row house		3 detached		4 Apartment block	
A Before 1945	8.85 %	3.67 %			0.12 %	0.55 %		
	6.30 %	3.62 %	6.10 %	4.57 %	0.06 %	0.31 %	0.04 %	0.19 %
B 1946-1960	10.05 %	4.21 %			0.25 %	1.32 %		
	6.61 %	3.85 %	4.34 %	1.95 %	0.02 %	0.04 %	0.01 %	0.06 %
C 1961-1970	13.08 %	5.15 %	1.09 %	0.43 %	0.73 %	5.99 %	0.06 %	1.18 %
	9.08 %	5.31 %	6.34 %	3.35 %	0.20 %	1.61 %	0.06 %	0.49 %
D 1971-1980	19.48 %	11.96 %	1.42 %	0.89 %	2.01 %	16.30 %	0.11 %	2.59 %
	13.80 %	10.57 %	6.73 %	5.76 %	0.30 %	4.23 %	0.09 %	1.09 %
E 1981-1990	19.55 %	10.96 %	1.58 %	0.99 %	1.39 %	11.80 %	0.05 %	1.35 %
	17.50 %	21.07 %	6.66 %	8.12 %	0.07 %	0.72 %	0.05 %	0.34 %
F 1991-2011	17.36 %	10.69 %	1.68 %	1.32 %	1.11 %	8.08 %	0.03 %	0.60 %
	12.74 %	17.07 %	2.61 %	3.16 %	0.24 %	1.93 %	0.06 %	0.58 %

Figure 15: Building typology matrix for the municipality of Vršac. (top-down - white cell: left -percentage by number of buildings, right - percentage by area / bottom-up - grey cell: left-percentage by number, right –percentage by area)

When the method was applied on Vršac it was divided on 17 macro and 123 micro zones with total number of around 1,300 listed buildings which formed the base for further statistical investigation. By expanding the characteristics of analysed micro zone to the whole area of macro zone we were imposing the principle of representation and statistical relevance.

When choosing the representative building types for all portions of the stock that do not represent significant number (either by the number or by the surface) national building types were chosen while for those being the numerically significant local buildings were identified and further analysed. In this way matrix of building types represents the combination of national and local model buildings calculated according to the same methodology both in the existing state and in improvement levels enabling cross-referencing of data and estimation of energy performance as well as CO_2 characteristics on municipal level. By implementing such a method we have achieved uniformity of data and local recognition of representative buildings.

By comparing the gained results we proved the assumed uncertainty of top down method for locally representative types. Some of the buildings types (for example A2, B2) were not part of the top-down matrix but after, in field bottom-up defined, survey they proved to be of high significance accounting for more than 10 % of total building fund. This phenomenon appears as the consequence of uneven distribution of initial sample. On the other hand for the types that are most common both methodological approaches are giving similar results (E1).

Description of the Basic Case and the Most Relevant Scenarios

For purpose of calculation of the Basic Case and Future scenarios data relevance proves to be of an utmost importance and developed bottom-up method serves as the only applicable methodology. Precision, data structure and openness for local specific questions in the process of surveying as well as adaptability to diverse municipal structures recommends this method for wider application, especially in the situation where no other data sources are available.

By using local surveying we were able to determine refurbishment rate, energy carrier structure, levels of interventions and to statistically support the building matrix by providing relevant data.

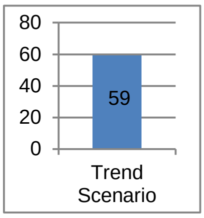
Basic case (Trend Scenario) is following the identified trends in the sense of refurbishment and valid regulations for the new buildings with projections of strengthening these regulations in the future. Annual refurbishment rate was estimated at 0.6 % since it was assumed that refurbishment actions have taken place in previous 15 years. SCENARIO B and SCENARIO C annual refurbishment rates of 1 % and 1.5 % were estimated, respectively and also benchmark values of energy needed for heating have been set more stringent, as shown previously in Table 44.

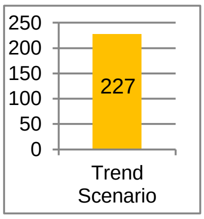
Results

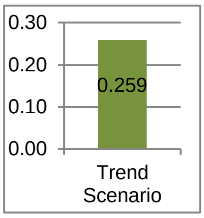
Individual benchmarks for CO_2 emissions were derived based on the draft plan for reduction of CO_2 emissions, currently in legislative procedure [Plan 2015] which prescribes reduction of 9.8 % until 2030 based on the values from 1990. Since there are no relevant data for 1990 we assumed, in a similar manner when estimating refurbishment rates, that no significant reductions occurred so far, and derived an annual trend of reduction of 0.65 % until 2030. For projections of savings until 2050 this trend was slightly increased, to 25 % compared to 2015.

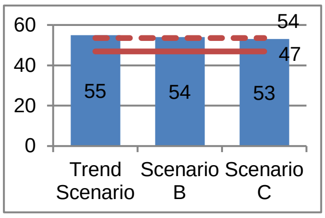
As presented in Table 48 this individual goal is achievable only by implementation of scenario B and C in 2030, and only by implementation of scenario C in 2050. Also, EPISCOPE benchmark values have been proven unachievable for 2030 and 2050, and potentially achievable for 2020.

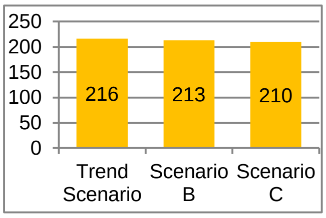
Table 48: Summary Indicators for municipality of Vršac building stock

<table>
<tr><th></th><th>EPISCOPE Ref. Area</th><th>CO_2 emissions</th><th>Total heat demand</th><th>CO_2 emission factor heat supply</th></tr>
<tr><td></td><td>10^9 m²</td><td>kg/(m²yr)</td><td>kWh/(m²yr)</td><td>kg/kWh</td></tr>
<tr><td>2015</td><td>1.64</td><td>


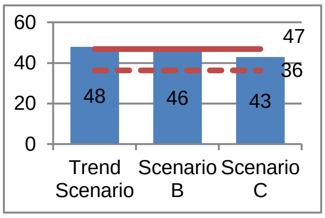
</td><td>


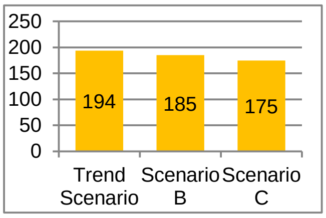
</td><td>


</td></tr>
<tr><td>2020</td><td>1.72</td><td>


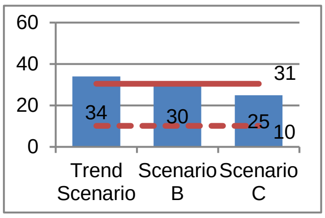
</td><td>


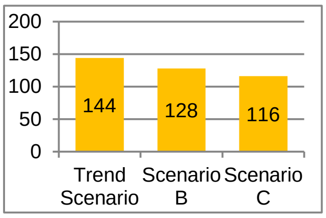
</td><td>


</td></tr>
<tr><td>2030</td><td>1.86</td><td>


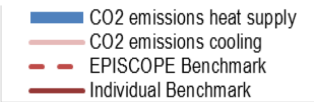
</td><td>


</td><td>


</td></tr>
<tr><td>2050</td><td>2.38</td><td>


</td><td>


</td><td>


</td></tr>
<tr><td colspan="5">Explanation</td></tr>
<tr><td></td><td></td><td>$m_{CO2,heat\ supply}$:
annual carbon dioxide emissions (related to EPISCOPE reference area)
$m_{CO2,heat\ supply} = q_{total} \times f_{CO2,heat\ supply}$


</td><td>q_{total}:
total heat demand
(heat generation for space heating and DHW, related to EPISCOPE reference area)</td><td>$f_{CO2,heat\ supply}$:
total CO_2 emission factor of heat supply</td></tr>
<tr><td colspan="5">Comments</td></tr>
<tr><td colspan="5"></td></tr>
</table>

Table 49: Final energy by fuel for municipality of Vršac building stock, gross calorific value [GWh/yr]

	2015	2020			2030			2050		
Absolute figures	Trend Scenario	Trend Scenario	Scenario B	Scenario C	Trend Scenario	Scenario B	Scenario C	Trend Scenario	Scenario B	Scenario C
natural gas	242	206	203	199	199	190	180	184	163	139
coal	5	6	6	6	6	5	5	5	5	4
wood / biomass	320	374	368	361	362	344	323	326	284	237
electric energy (used for heat supply)	10	8	8	8	8	7	7	7	6	5

Conclusions

Pilot project for the municipality of Vršac has enabled us development of specific methodology that proves to be a solid base for an energy related planning in residential sector on local level. Deriving of typical buildings and definition of improvement levels proves to be a sufficient method for improvement of the building fund. On the other hand, specific conditions valid for one municipality are influencing the results, limiting its universality especially when estimating the heating systems and energy carriers used. Overall CO2 emission indicators are dominantly influenced by energy carrier, and any projections are quite uncertain both in the terms of improvement of the systems and selection of fuels.

Local survey conducted in bottom up method has given us very precise data on current energy carrier structure but future projections are, due to the lack of strategic planning documents, mere expert based. These trends are illustrated in Table 49, where rather optimistic future projections are given, relying on current trends prevailing on local energy market, where some energy carriers (commonly used in other municipalities – electricity, coal) are not represented. For example district heating system in Vršac is using natural gas, determining this energy source as the dominant for the multifamily portion of the stock.

In future projections research respected current situation and improvement were envisioned as ones that have greater environmental impact (use of biomass) and are locally applicable.

Sources / References <RS> Serbia

Table 50: 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]	Statistical Office of Republic of Serbia (2013) Census of Population, Households and Dwellings in the Republic of Serbia, Book 22: "Number and the floor space of housing units", Belgrade
[Jovanović Popović 2013]	Jovanović Popović, M., Ignjatović, D., Radivojević, A., Rajčić, A., Đukanović, Lj., Ćuković Ignjatović, N., Nedić, M. (2013): Nacionalna tipologija stambenih zgrada Srbije. Belgrade: Faculty of Architecture University of Belgrade, GIZ.	National typology of residential buildings in Serbia
[Plan 2015]	Министарство пољопривреде и заштите животне средине (2015): Србија прва у региону усвојила план о смањењу емисије штетних гасова. Available at: http://www.eko.minpolj.gov.rs/srbija-prva-u-regionu-usvojila-plan-o-smanjenju-emisije-stetnih-gasova/ [2015-06-18]	Serbia adopted a National Plan for reduction of greenhouse gas emissions, Ministry of agriculture and environmental protection
[RS II 2013]	Drugi akcioni plan za energetsku efikasnost Republike Srbije za period od 2013. do 2015. Godine. „Službeni glasnik RS", broj 98/2013	"Second action plan for energy efficiency of Republic of Serbia for the period 2013-2015".
[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
[SORS 2004]	„Popis stanovništva, domaćinstava i stanova u 2002 – Stanovništvo - Uporedni pregled – podaci po naseljima- knjiga 10", Republički zavod za statistiku	Statistical Office of Republic of Serbia – parallel data on population and households, Book 10
[SORS 2010-2014]	„Opštine i regioni u Republici Srbiji – Stambena izgradnja ", Republički zavod za statistiku , godišnja izdanja	Statistical Office of Republic of Serbia - Annual publication with data on municipalities and regions in Republic of Serbia, section on residential builidns

3.8 <SI> Slovenia

Residential Building Stock of the Municipality Kočevje

(by EPISCOPE partner ZRMK)

The Kočevje region is one of the most naturally preserved areas of Slovenia and Central Europe. The forests cover more than 90 % of the total area. A real pearl are primeval forests with a total area of 217 ha. Municipality started to work on sustainable energy policies systematically in the year 2008, when there was adopted the local energy concept. It includes analysis of existent condition in the field of energy use and supply (which emphasizes the public buildings), possibilities of use of local renewable sources. In the local energy concept there are defined the goals in the energy field in community and the action plan [LEK 2008].

From the local energy concept from year 2008 follows, that the annual emissions in the territory of municipality were estimated to be 24,000 tons of CO_2, not taking into account emission from the electricity. In the past years, extended energy audits were prepared for the most public buildings with detailed energy efficiency analysis, inventory of systems and elements, with emphasize on heating (also with thermovision) and lighting systems. With regard to condition of examined building, audits suggested the measures for reduction of energy use for all used energy sources.

In the urban area of city of Kočevje the prevailed way of building heating is district heating system, powered by wooden biomass and fuel oil. Most of the individual houses in sub-urban area use wood and fuel oil as a heating source for heating. Municipality plans to replace oil fuel sources powering the district heating system with innovative cogeneration system with wooden biomass gasification process to considerably lower the carbon footprint from building heating, to increase local energy self-supply and to increase level of renewable energy sources in national power grid.

From 2014, among other activities for sustainable development support, there are energy renovations of 6 public buildings (schools and kindergartens) in progress, co-financed by EU funds by more than 3 m EUR. In February 2014, City council of Kočevje adopted decision to join to the Covenant of Mayor initiative [Covenant of Mayors 2014]. The ceremonial signing of the CoM adhesion form was held in the end of March 2014.

Observed Building Stock and Aims of the Scenario Analysis

The Slovenian pilot project on local scale of EPISCOPE concerns the housing stock of the Municipality Kočevje, which has set ambitious goals in its local energy concept [LEK 2008]; [Covenant of Mayors 2014]. Its short-term goals for 2020 are a reduction of greenhouse gas emissions by at least 30 % compared to the emissions in 2005 and an increase of the share of the renewables up to 50 %. The main advantage of the city for exploitation of renewables is its local biomass district network. The municipal plan is continuous expansion of the network in order to increase the share of renewables with exploitations of local wood.

Table 51: Scope of the observed building stock in Municipality of Kočevje <SI> Slovenia [GURS 2015], [SURS 2015a]

Scale	No. of dwellings	No. of buildings	No. of inhabitants	m² national reference area	m² EPISCOPE reference area
local	3,625	1,541	9,027	410,200 (net dwelling area)	451,220

The energy balance of a city/municipality is interesting to key actors and stakeholders from several points of view. One of the main being able to see the energy use on a local level – in order to see the biggest potentials for energy savings. Such model and analysis can be used for updates of local energy concepts. The main aim of scenarios analysis is to see how scenarios on national levels reflects on a local level, are the renovation rates possible to implement and how does local energy plan reflect on energy balance of the observed building stock. The municipality Kočevje has an ambitious plan, since they are planning to spread the local biomass district network and with this analysis it is clear how does this reflect on e.g. carbon footprint on the regional level.

Scenario Approach

The scenario approach uses a dynamic calculation model (developed in MS Excel) with "three layers". The first layer is a long-term dynamic consistent model of the building stock. It quantifies the expected future annual in-use stock of dwellings and reference floor area (m^2) on the basis of the assumed past and future demand, i.e. the assumed development in persons, persons per dwelling and reference floor area per dwelling, potential for (partial/full/deep) renovation, based on the assumption for renovation and new build rates. This layer of the model also follows the ageing development of each type/age segment of the stock, with predicted lifetime of building component and it is technologies for heating and DHW, after which the building becomes the potential for renovation. Based on the renovation rates for each age band, buildings in each year, the model identifies the buildings for renovation, respective to their age of construction, potential (based on a time from the last renovation) and type. The second layer of the model is an energy and emission layer. Here are provided as model input data energy intensity values (kWh/m^2/year; deriving from typology [ZRMK 2012a], [ZRMK 2014] and EPCs [EPC 2015]), for different energy carriers, for each type/age segment of the stock and for each scenario. The last layer takes into account local or national plans, which can be implemented into a model on several different ways, e.g. more intensive renovation rates in specific year due to increased subsidies fund, increased share of grid connections due to network expansion in a city district.

To be able to carry out a comprehensive analysis, all EPCs from the database [EPC 2015] were studied. In the municipality Kočevje, the EPC database collects data on the building stock, refurbishment measures, and the development of energy efficiency of buildings. For this pilot action, 150 EPCs from this database were considered.

Data Sources

Several data sources were used in the model and analysis in order to ensure thorough, comprehensive and as realistic as possible. The model and analysis derive from next data sources:

- **Databases from Geodetic Administration of the Republic of Slovenia** [GURS 2015]
- **The National Action Plan for Energy Efficiency for 2014-2020** [MzI 2015a]
- **The Institute of Macroeconomic Analysis and Development of the Republic of Slovenia**: population projections are used for the observed period and the revised scenarios of economic development of Slovenia until 2030th [UMAR 2013]
- **Statistical Office of the Republic of Slovenia**: contains information on the number and area of completed dwellings (new construction, extensions, conversion according to the CC-SI classification), the number of demolished dwellings and others. [SURS 2015b]
- **Intelligent Energy Europe TABULA** [ZRMK 2012a], and [ZRMK 2014]
- **Register of Energy Performance Certificates** [EPC 2015]
- **Research of the energy efficiency in Slovenia** (2010, 2011, 2012 and 2013): survey results on efficient energy management presents 12 indicators in the key areas of energy consumption in households. Indicators show the status of the buildings and technical equipment of households with the intention of modernizing buildings and facilities, conduct and attitude to energy use, estimates of savings and CO_2 emissions [REUS 2013].

Description of the Basic Case and the Most Relevant Scenarios

The starting point, which determines the current state of the energy balance is the basis from which arise all the following scenarios. The first step is gathering the data and determining the potential for energy renovation. The current state of the building depends on its potential for renovation, where four possible levels of the current state are considered [ZRMK 2012b]:

- **Unrefurbished:** Based on the existing data, the building was not subjected to any renovation in the past, therefore it has potential for renovation on all components of the thermal envelope (walls, roof, and windows). Unrefurbished buildings can be subjected to partial, full and LE renovation.
- **Part_Renovation:** Based on the existing data, the building was subjected to renovation of one building construction (walls, roof or windows) in the past, therefore the building has potential on two components of the thermal envelope (walls, roof or windows). Buildings with partial renovation can be subjected to partial or full renovation.
- **Full_Renovation**: Based on the existing data, the building was subjected to renovation of two building constructions (walls, roof or windows) in the past, therefore the building has potential on one component of the thermal envelope (walls, roof, and windows). Buildings with full renovation can be subjected to partial renovation only.
- **LE_Renovation**: the building was subjected to major renovation works in the past, all building constructions had been renovated and is thus considered as a building with low energy (LE) demand for space heating. Buildings with LE renovation are not considered as a potential for renovation.

One of these states was determined for each representative of building typoplogy of the building stock. Renovation rates in the model do not apply for rates of one building component only, e.g. 3 % of walls renovation, but apply to the extent of possible renovation (partial, full, low energy). Partial renovation in the model covers renovation works on building's envelope only, while full and LE renovation can include the replacement of a heat, DHW supply system, as well as installation of a mechanical ventilation system. All buildings cannot be renovated in one year only so the model is taking into account several limitations when renovating the building stock.

The model adopts Slovenian national strategies, where reference and intensive scenario are considered as a maximum renovation rate in the building category, as shown on Figure 16 for single-family houses and for multi-family houses. The scenarios present a share of renovated buildings with respect to the total sum of usable floor area, where the usable floor area of building subjected to partial renovations are taken into account with 0.5 factor, full and LE renovations are taken into account with factor 1.

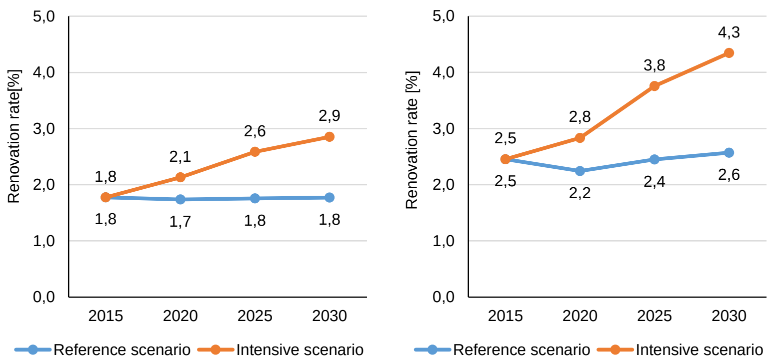


Figure 16: Renovation rate for single – family houses (left) and multi – family houses (right) from 2015 – 2030 to the Slovenian national strategy [MzI 2015b]

Actual renovation rates can be deducted from two main sources – Register of Real Estates [REN 2014] (Table 52) and Eko sklad's subsides [Eko sklad 2009-2014] (Table 53). Fraction of renovation rates in case study Kočevje can be extracted from Eko sklad's subsidies in the 2008 – 2014 period. Fraction because not all building owners applied for subsidies, thus disabling to exactly determine the renovation rates. In national strategic documents [MzI 2015a], [MzI 2015b] it is predicted that this subsidised rates account for approximately 1/3 of all renovation rates, meaning that renovations where building owners do not apply for subsidies, on average account for 2/3 of all renovation works. The reference scenario is based on the past renovation works and predicts slight improvement of the rates. Intensive, as the name suggest, predicts more intensive and bigger renovation rates.

The renovation rates in all scenarios take into account renovation of thermal envelope's components and replacement of generation systems. Taking into account lowering the share of fossil fuels heat generators (especially oil) and increasing share of RES technologies e.g. heat pumps and biomass boilers, due to large potential for exploitation of local forests.

Taking into account reference and intensive scenario in the future, we can deduct that renovation rates in single-family houses will be achieved, if the rates in the future will be similar as they were in the past years. It cannot be said exactly with the same amount of confidence for multi-family houses, since the rates from subsidies are below 1 %, while reference scenario predicts the rates over 2 % and the share of spontaneous rates it not accurate, since it's an assumption on a national level.

For case study Kočevje, the results show the biggest potential for energy savings in the residential sector for buildings built in the period 1946 – 1980. It also shows that a majority of buildings built after 1980 have not been subjected to any renovation yet and it is expected the considerable share will be subjected to renovation in the near future, since the life-time period of construction element is 30 years.

Table 52: Share of recorded renovation rates on thermal envelope in the municipality Kočevje (percentages relate to usable floor area) [REN 2014]

	Walls	Roof	Windows
2000	0.59 %	1.59 %	1.10 %
2001	0.54 %	1.19 %	0.64 %
2002	0.71 %	1.06 %	0.95 %
2003	0.96 %	1.56 %	0.78 %
2004	1.30 %	0.94 %	1.30 %
2005	1.52 %	1.14 %	1.37 %
2006	1.71 %	1.70 %	1.72 %
2007	0.53 %	0.39 %	0.34 %
2008	0.63 %	0.20 %	0.42 %
2009	0.15 %	0.11 %	0.00 %
2010	0.64 %	0.22 %	0.24 %
2011	0.54 %	0.15 %	0.00 %
2012	0.91 %	0.10 %	0.11 %
2013	0.02 %	0.00 %	0.02 %
2014	0.00 %	0.00 %	0.00 %

REN national survey was conducted in 2007/2008. After that, owner can report to the REN if they renovated the building envelope. The table above shows that owners do not report these events.

Table 53: Share of subsidied recorded measures on thermal envelope in the municipality Kočevje (percentages relate to usable floor area) [Eko sklad 2009-2014]

	Walls	Roof	Windows
2009	0.07 %	0.00 %	0.61 %
2010	0.39 %	0.05 %	0.93 %
2011	0.26 %	0.02 %	0.94 %
2012	0.35 %	0.00 %	0.34 %
2013	0.27 %	0.07 %	0.15 %
2014	0.13 %	0.33 %	0.13 %

Reference and intensive scenario are taking into account as with the share of used technologies, which follows the national strategies and local state and limitations. Share of heat pumps and biomass boilers is slowly increasing, while share of energy carriers' oil and liquid gas is decreasing. Reference scenario strictly follows real local policy. From municipal plans for expanding biomass district network it was deducted which exact buildings in the future are going to use the DH for heating and DHW. This scenario presents a realistic applicability of the model on-site and demonstrates its potentials, e.g. measuring the effects of local policy on carbon footprint.

Results

Key results are shown in Table 54 and Table 55 below. In the base case of 2015 the estimated total final energy of the residential building stock in Municipality Kočevje is 116.406 GWh/year, with an emission factor of 0.192 kg CO_2/kWh. This gives a specific total average heat demand of 161 kWh/m^2/year and a specific emission level of 37.4 kg CO_2/m^2/year.

Trend scenario, intensive and reference scenario (local policy scenario) give substantial reductions in annual total heat demand and CO_2 emissions compared to 2015, as shown in Table 54. The total average heat demand decreases from 195 kWh/m^2/year to a level of 133 - 136 kWh/m^2/year in 2020, and 78 - 81 kWh/m^2/year in 2030. With the given changes in the energy mix, and an overall CO_2 emission factor increases from 0.192 to 0.216 kg CO_2/kWh in trend scenario, although considerable improvements are recorded in annual CO_2 emissions. The later are reduced from 37.4 kg CO_2/m^2/year in 2015 to 26.3 – 26.8 kg CO_2/m^2/year in 2020, 15.8 – 17.5 kg CO_2/m^2/year in 2030.

Despite the significant growth in building stock reference area by 17.5 % from 2015 to 2030, these emission intensity improvements yield significant overall emission reductions (tons CO_2/year) of around 29 % in 2020 and 53 – 58 % reductions in 2030, compared to the 2015 level, where buildings emit 16,880 tons of CO_2 emissions. With respect to the estimation of carbon emissions in 2008 [LEK 2008], the later were reduced from 24.000 tons of CO_2/year to lower than 19.000 CO_2/year.

All the observed scenarios show great promise in the fulfilling the regional contribution to national goals for the reduction of final energy use and GHG emissions. According to policy targets and EPISCOPE benchmark levels, shown in Table 54 are met in both the observed years – 2020 and 2030, and are in accordance with the long-term goals of Covenant of Mayors [Covenant of Mayors 2014].

Table 54: Summary Indicators <SI> Slovenia, municipality Kočevje

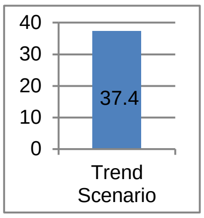
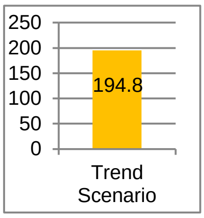
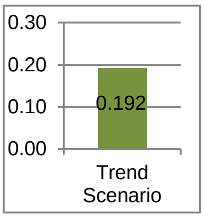
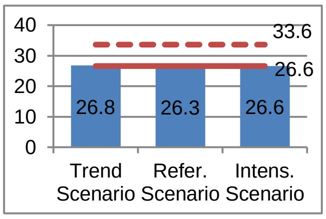
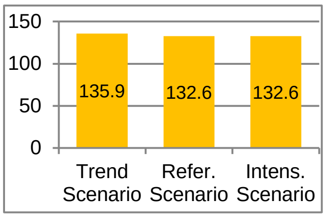
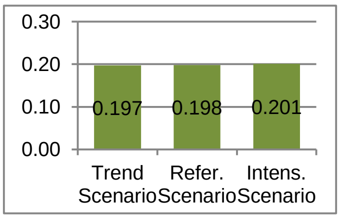
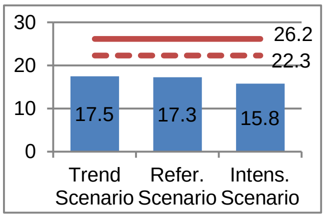
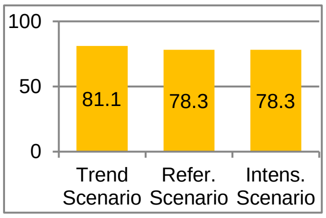
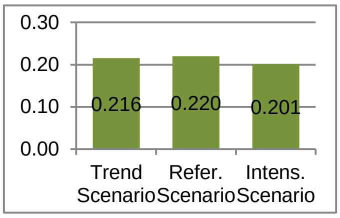
	EPISCOPE Ref. Area	CO_2 emissions	Total heat demand	CO_2 emission factor heat supply
	10^3 m²	kg/(m²yr)	kWh/(m²yr)	kg/kWh
2015	451			
2020	477			
2030	530			
2050				
Explanation				
		$m_{CO2,heat\ supply}$: annual carbon dioxide emissions (related to EPISCOPE reference area) $m_{CO2,heat\ supply} = q_{total} \times f_{CO2,heat\ supply}$ CO2 emissions heat supply CO2 emissions cooling EPISCOPE Benchmark Individual Benchmark	q_{total}: total heat demand (heat generation for space heating and DHW, related to EPISCOPE reference area)	$f_{CO2,heat\ supply}$: total CO_2 emission factor of heat supply
Comments				

Table 55: Final energy by fuel <SI> Slovenia, municipality Kočevje, gross calorific value [MWh/yr]

	2015	2020			2030			2050		
Absolute figures	Trend Scenario	Trend Scenario	Reference Scenario	Intensive Scenario	Trend Scenario	Reference Scenario	Intensive Scenario			
natural gas	1742	1723	1742	2009	909	953	1785			
liquid gas	2819	2791	2819	1639	935	914	1441			
oil	17407	16085	15302	6291	11820	10958	3406			
coal	760	220	220	220	220	220	220			
wood / biomass	48135	44131	43955	45882	29021	27492	28926			
district heating	19852	14383	15768	16534	9836	11034	11700			
electric energy (used for heat supply)	6809	6523	6556	10035	5527	5573	6667			
solar energy	328	251	222	580	1714	1566	2948			
geothermal energy	2803	1960	1879	3832	1714	1566	2948			

Figure 17 shows the reduction of primary energy for all scenarios, one of the focal points is the impact of the local energy policy implementation in practise (scenario C), where the expansion of local district grid is considered in 2016, 2020 and 2025. The primary energy is reduced for 14 %, 33 % and 44 %, respectively.

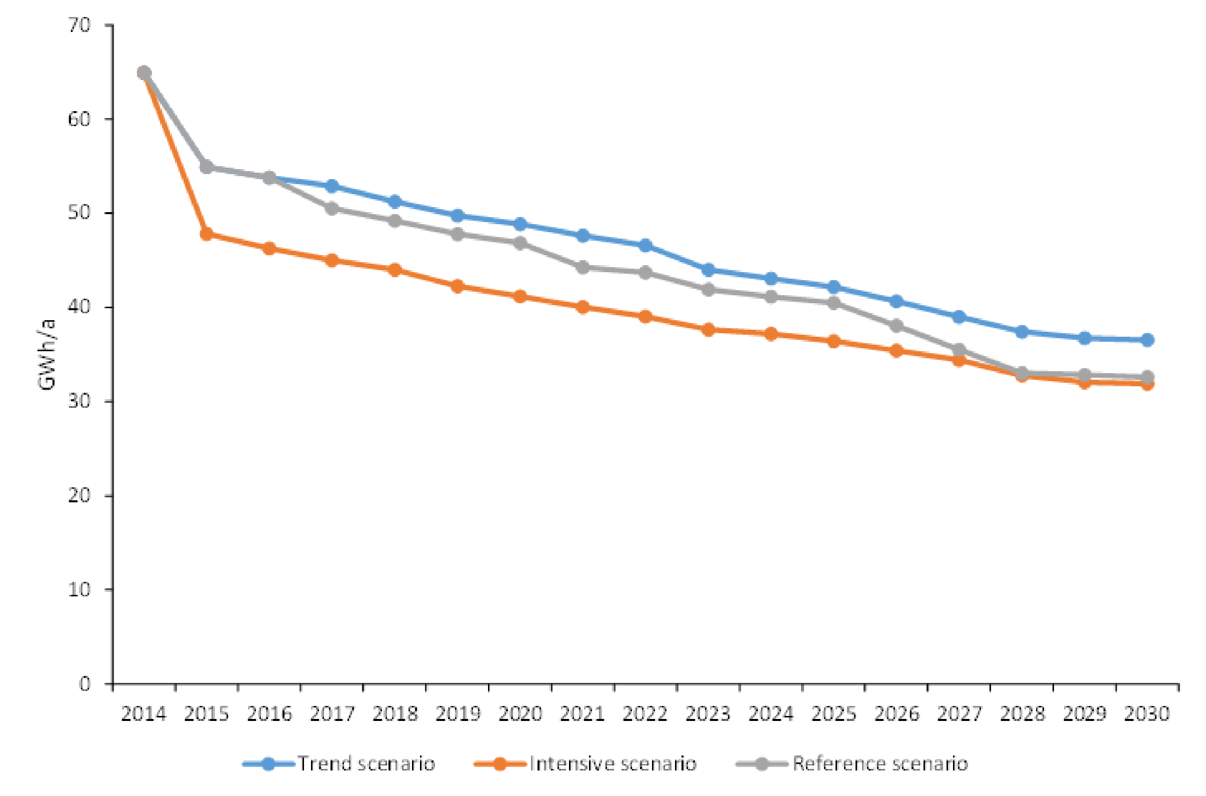


Figure 17: Total non-renewable primary energy for the building stock case study Kočevje

Conclusions

The overall findings of the scenario analyses indicate that, in addition to the positive effect of high energy standards of new buildings to be constructed in the future, renovation activities in the existing building stock will effectively contribute to large and highly needed overall reductions in future energy use and CO_2 emissions.

There is not a very large difference between the three scenarios, which was to be expected. One of the main outputs of this analysis for key actors is the result of the reference scenario, which is showing how the implementation of local energy action plans results on a building stock scale. Hence, it will be important to develop policy instruments that facilitate the implementation of ambitious renovation measures, i.e. expansion of the local grid, renovation rates of at least 1.75 % in the single-family house sector and above 2.00 % in multi-family houses. The analysis show the renovation rates are going to be met in single-family houses, since the current trend shows rates above 2 % (considering Table 53, other subsidies and rate of spontaneous renovations).

In order to reach the policy targets that are represented by the EPISCOPE or individual benchmark levels in this study, other types of measures than technical improvements in the building envelope components have to be taken. Changes in the general heat supply structure foresees replacement of old oil/coal/gas boiler for heating and/or DHW with new gas condensing boiler or with connection to the local district biomass heating (Figure 18). Implementation of energy efficiency measures for achieving the goals can be summarised in:

- Subsidies play an essential role in achieving the goals: old building contribute a large part of final energy use and CO_2 emissions, increasing the subsidies fund can further trigger more renovations.
- Focus on renovation to increase the rate – especially among the buildings built before 1980s – by increasing consultancy in energy efficiency measures, increasing the subsidies for the major renovations optimising the insolation thickness in relation to the life cycle of the building,
- Replacing fossil energy carriers through renewables systems, with the most promising being biomass boiler and heat pumps,
- Accelerate the trainings for the professionals for energy efficient and sustainable heating systems and constructors,
- Implementation of regular inspecting and optimising the heating systems,
- Increasing information campaigns not only for the energy efficiency in buildings and building compliances but also users' behaviour.

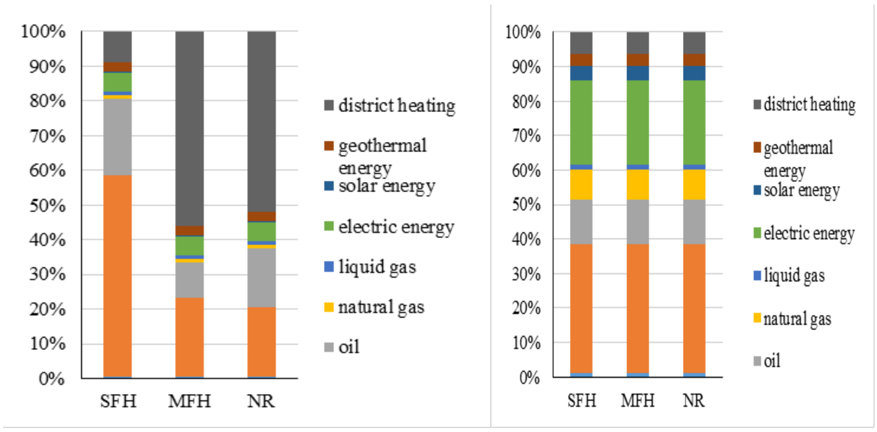


Figure 18: Share of used energy carriers for space heating (left) and domestic hot water (right) for single-family houses (SFH), multi-family houses (MFH) and non-residential buildings (NR)

Additionally a movement to lower carbon society on a national scale will be needed to reduce the current electricity carbon factor. Further analysis, on either local or national level, can be carried out through visual presentation of analysis results, to further identify the best candidates in the national stock for refurbishment, which would help to inform the details of policies moving forward to help meet the carbon dioxide reductions required.

Geographic Information Systems (GIS) offer the opportunity to characterize building stocks in some systematic dimensions using geo-referenced information for buildings. The main objective of this is to present building stock's profile (e.g. consumption, potential and savings) through a GIS-based approach. To this goal, ZRMK developed an application with Google maps API, which enables a powerful way of presenting the energy balance of the building stock. For case study Kočevje, an application was developed which shows several aspects of the building stock, resulting from the analyses.

Web application available at www.energetskaizkaznica.si\map shows the potential for renovation of thermal envelope's components. The buildings where roof, façade and windows are potential for renovation are marked as red with radius 3. Buildings with 2 components for renovation have radius 2, and buildings with potential for renovation of 1 component – radius 1. Such imaging reveals that the vast majority of the buildings have a big potential for renovation on thermal envelope.

Sources / References <SI> Slovenia

Table 56: Sources / References <SI> Slovenia

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[Covenant of Mayors 2014]	Konvencija županov (2014): Zaveze občine Kočevje pri pristopu h Konvenciji županov. Available at: http://www.kocevje.si/upload/doc/1591_Zaveza_.pdf [2015-07-21]	Covenant of Mayor commitments of Municipality of Kočevje
[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]	Ministerstvo za infrastruktoro (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.
[LEK 2008]	Eco Consulting d. o. o., Energija, Okolje, Ekonomija, Ljubljana (2008): Lokalni energetski concept občina Kočevje 2008	Local energy concept of the Municipality of Kočevje. Kočevje, Slovenia.
[MzI 2015a]	Republika Slovenija Ministrstvo za infrastrukturo (2015): Akcijski načrt za energetsko učinkovitost za obdobje 2014–2020 (AN URE 2020). Available at: http://www.energetika-portal.si/fileadmin/dokumenti/publikacije/an_ure/an_ure_2020_sprejet_maj_2015.pdf [2015-07-21]	National Action Plan for Energy Efficiency for 2014-2020.

Reference shortcut	Concrete reference (in respective language)	Short description (in English)
[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 učinkovitositi 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
[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
[UMAR 2013]	Urad za makroekonomske analize in razvoj (2013): Delovna projekcija prebivalstva Slovenije. Available at: http://www.umar.gov.si/fileadmin/user_upload/sporoci-la_za_javnost/2013/november/projekcije_prebivalstva.pdf [2015-07-21]	Institute of Macroeconomic Analysis and Development. Data on population projections.
[ZRMK 2012a]	Rakušček, Andraž; Šijanec Zavrl, Marjana (2012): Slovenia. In: Diefenbach. N./Loga, T. (ed.) (2012): Application of Building Typologies for Modelling the Energy Balance of the Residential Building Stock. TABULA Thematic Report No 2. Institut Wohnen und Umwelt Gmbh; Darmstadt. Available at: http://episcope.eu/fileadmin/tabula/public/docs/report/TABULA_TR2_D8_NationalEnergyBalances.pdf [2015-07-27]	Aplikacija tehnologij pri modeliranju energijske bilance stavbnega fonda
[ZRMK 2012b]	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]	Description of the typology approach for the assessment of the energy balance of building stock
[ZRMK 2014]	Šijanec Zavrl, Marjana; Rakušček, Andraž; Stegnar, Gašper (2014): Tipologija stavb energetska učinkovitost in tipične stavbe v Sloveniji. 2. Izdaja. Available at: http://episcope.eu/fileadmin/tabula/public/docs/brochure/SI_TABULA_TypologyBrochure_ZRMK.pdf [2015-07-21]	National typology brochure Slovenia, developed during the IEE Projects TABULA and EPISCOPE; Gradbeni inštitut ZRMK; Ljubljana / Slovenija 2011-2014

4 Summary

(by EPISCOPE partner IWU)

In the following, some main findings concerning the motivation of key actors, the building stock models especially concerning the analyses of the current state, energy saving measures for target achievement as well as some general conclusions are summarised.

Motivation and involvement of key actors

The local EPISCOPE case studies are focusing on the energy performance of housing stocks mostly located in specific municipalities. Some of them address portfolios of housing companies (CY, CZ, FR), others specific city districts (BE, IE) or complete housing stocks of municipalities (HU, RS, SI). In general, this was the first time that scenarios for the future development of the energy performance of these building stocks were calculated. Local key actors and / or policy makers were involved in the processes by supporting the necessary data collection as well as by discussing refurbishment targets and strategies.

In the absence of specific climate targets for local building stocks, European or national targets were applied. A special case is the City of Ghent (BE) where already individual municipal targets are existent. The key actors' interest was to get a clearer picture of the technological paths to minimise carbon dioxide emissions. Apart from climate protection a further motivation to discuss energy refurbishment strategies was the low quality of housing (poor thermal comfort in winter).

A specific set of energy performance indicators, the "summary indicators", were defined to enhance the communication about refurbishment targets, insulation strategies and decarbonisation of heat supply systems.

Apart from the information exchange with key actors also means of public information were developed and tested: Mapping tools displaying the existing state and the potentials for renovation (IE, SI) proved to be a useful instrument for raising attention and for assisting in retrofit strategy development and planning.

Building stock models – analyses of the current state

In general, local building stock models were not available. So, the first step was to make realistic as possible assessments of the energy flows for space heating and domestic hot water and the resulting consumption by energy carrier in the present state. As far as possible, calculations of the energy use were performed by using boundary conditions close to reality. In some cases also the measured energy consumption for parts of the building stocks was available (BE, CY, CZ: data from utility companies or real estate agency) which enabled a comparison and calibration of the calculation models.

Different types of existing information sources were used to define the current states of the building stocks. In case of the involved housing companies these were EPCs and administrative databases (CY, CZ, and FR). In other cases national data were examined by narrowing down on the specific local building stocks: EPC databases and databases of funding programmes proved useful for modelling the current refurbishment state (IE + SI). In two cases also architectural drawings of typical buildings were provided by the housing associations (CY, CZ).

For some case studies specific surveys were conducted (BE, CY, HU, IE, RS) to improve the knowledge about the refurbishment state of the building fabric and the type of heat supply. Partly also information about users (occupancies / family compositions + behavioural aspects) were collected (BE).

The models were designed individually following the specific needs and considering available calculation procedures. Some of the models are consisting of samples of real buildings which are extrapolated to the total stock. Alternatively, synthetical buildings were determined with average features representing the different building types included in the stock considered. In some cases the concept of TABULA building typologies and/or the TABULA calculation procedure was used as a basis (CY, CZ, FR, HU, and RS).

The individually calculated delivered energy for the current states of the building stocks is displayed in Figure 19: The large variation of the total delivered energy per m² reference area is due to different mixes of building types and refurbishment states, but it is also due to different climatic and utilisation conditions. Also the distribution of energy carriers is rather diverse.

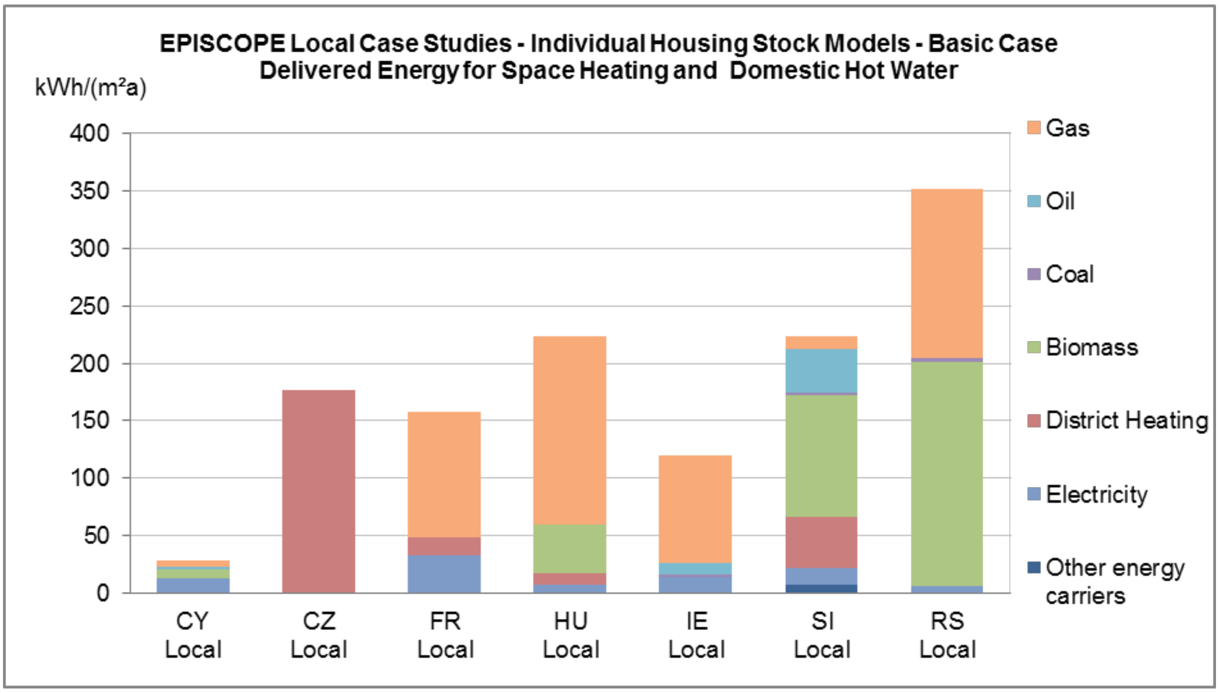


Figure 19: EPISCOPE local case studies –delivered energy for heating and DHW per m² TABULA/EPISCOPE reference floor area and year for the existing state (basic case)

The scenario analyses as well as the values included in Figure 19 have been determined by use of individual building stock models. To enable a comparison of input data and calculation results simplified building stock models have been defined for all case studies by use of the TABULA calculation procedure. These "average buildings" are being displayed by the TAUBLA WebTool[10].

Energy saving measures for target achievement

In general, energy saving measures were considered with regard to the achieve individual (local, regional, national) or EU climate and energy targets. In contrast to the trend development the more ambitious scenarios are based on the assumption that annual rates as well as the insulation levels will be increased. In some of the ambitious scenarios the levels are oriented explicitly at the passive house (CZ, FR) or future NZEB standards (CY).

Furthermore, transitions to heat supply systems which are more efficient or include more renewables were considered in different ways: e.g. by switching to electrical heat pumps (assuming a prospective increasing share of renewables in the electric grid), by installation of thermal solar systems or by expanding biomass based district heating systems.

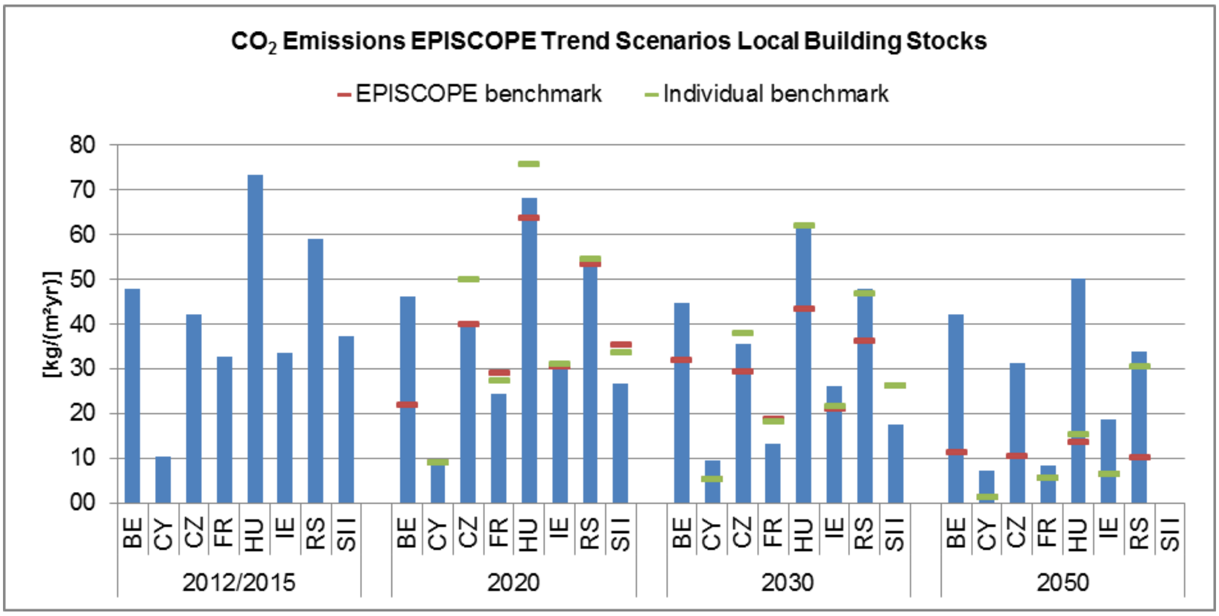
[10] TABULA WebTool area "Building Stocks": http://webtool.building-typology.eu

The discussion of the future building stock development also includes the aspect of demolition and the construction of new buildings. In the ambitious scenarios NZEB and passive house standards were assumed for newly built dwellings to minimise the effect of the increased total consumption caused by the reference area growth.

In some case studies (e.g. BE) poor thermal indoor conditions were assumed for the existing state in order to explain the measured energy consumption ("prebound effect"). In consequence, the insulation of the thermal envelope results also in an improvement of the thermal conditions and higher indoor temperatures after refurbishment need to be considered when calculating the possible energy savings.

In Figure 20 CO_2 emissions for space heating and domestic hot water per m² TABULA/EPISCOPE reference area (see section 3) are shown for all trend scenarios calculated for the different building stocks. Furthermore, EPISCOPE and individual benchmarks are displayed (description of benchmarks see beginning of chapter 3).

In nearly all cases (except SI) the current trend is not acceptable as a long term strategy and there is a necessity to apply more efficient and intense energy saving measures. This includes an augmentation of refurbishment rates, an augmentation of the share of deep refurbishments and a decarbonisation of the heat supply systems.



(note: for BE: CO_2 emissions for space heating only)

Figure 20: CO_2 emissions for space heating and domestic hot water according to the EPISCOPE trend scenarios for local building stocks, extrapolations of current improvement rates (in many cases partly based on assumptions)

Overview of partners' conclusions

For each case study individual conclusions and recommendations regarding refurbishment strategies but also methodical aspects have been eleaborated. They can be found in the individual national case study reports as well as (in summary) at the end of the respective case study section of this synthesis report. A more detailed discussion of the monitoring-related conclusions is also available in the EPISCOPE Synthesis Report N° 4 which is focused on building stock monitoring[11]. In the following an overview of the relevant key aspects mentioned by one or several partners is given:

Methodical questions

- The case studies have enabled the development of specific approaches that have proved to be a solid base for an energy related planning in the residential sector on local level.
- On the other hand, specific conditions valid for one local building stock are influencing the results and limiting transferable conclusions.
- The trend scenarios strongly depend on the current refurbishment rates, but in most cases there are rather large uncertainties. In the future these uncertainties should be quantified in form of an uncertainty range. This will also emphasise the need to determine the current rates with higher confidence.
- There is a necessity to setup, maintain, harmonise and extend local databases and registers. Also the possibilities for local evaluations of national databases should be improved.
- The basic data of the models published in the case study reports, in tables including energy performance indicators and by means of average buildings are available for future use (common knwoledge).[12] It is recommended to build on this information and to maintain it when scenarios are elaborated in the future.
- The development of the building stocks should be continuously tracked and compared with the different scenarios in order to find out if the running activities are sufficient to stay on the track.

Technological paths

- To achieve the climate protection targets a dramatic improvement in the thermal insulation of the stock, a huge move away from fossil fuel-based heating systems, and significant investment in renewable technologies are required.
- In consequence, a considerable augmentation of the refurbishment rates and a transition to very ambitious measures are necessary.
- Low level refurbishments cause higher efforts for later improvement (lock-in effects). So the local authorities and stakeholders should aim for a policy that encourages in-depth energy renovations.
- Since the construction of new buildings is in general increasing the total energy consumption of the building stock, best available technology should be required by thermal regulations. At the same time there is the necessitiy to avoid ever increasing square meters of conditioned areas per person.

---

[11] EPISCOPE Synthesis Report No. 4 "Tracking of Energy Performance Indicators in Residential Building Stocks" http://episcope.eu/fileadmin/episcope/public/docs/reports/EPISCOPE_SR4_Monitoring.pdf

[12] All collected information is available at the "case study" pages of the EPISCOPE website: http://episcope.eu/monitoring/case-studies/

Implementation of refurbishment strategies

- Much higher subsidies than in the past and present are likely to be needed.
- This should be accompanied by increasing energy consultancies and information campaigns at local level.
- An important factor is the user behaviour. The improvement of thermal conditions by applying insulation and the reduction of costs for conditioning should not lead to wasteful demeanour. This could be addressed by local awareness raising campaigns and by monitoring activities.
- An acceleration of trainings for professionals for energy efficient and sustainable constructions and heating systems should be strengthened.
- Building pilot nearly-zero energy buildings (new build or refurbishments) in the city districts concerned would provide best practice and confidence in the technologies to the local players.

List of Figures

Figure 1: National 2013 and 2020 greenhouse gas emission limits under the Effort Sharing Decision, compared to 2005 emission levels [EEA 2014] 3

Figure 2: Timeline of key EU legislation affecting energy use in buildings [BPIE 2014]........ 5

Figure 3: Project area with indication of the building block in the district of Sint-Amandsberg; Map Data [© OpenStreetMap contributors] 13

Figure 4: Different subtypes of the annex [own creation]........14

Figure 5: Overview of the year of the last major renovation for the surveyed buildings [own creation]........16

Figure 6: Final energy consumption for space heating excl. RES (kWh/m²yr) - current dwelling compared to dwelling type averages for various energy performance levels and various occupant profiles [own creation]........20

Figure 7: Distribution of the building stock depending on the construction periods [POUGET Consultants 2014] 41

Figure 8: Share of the number of dwellings by construction periods, with the information of the share of refurbished dwellings and not yet refurbished dwellings [POUGET Consultants]........43

Figure 9: Evolution of energy carriers' CO2 contents considering two approaches: moderate and ambitious introduction of renewables energies [POUGET Consultants]........44

Figure 10: Evolution of the energy need for heating of the Observed Building Stock between 2015 and 2050 taking account the lock-in effect,, with a refurbishment rate of 2 % and three different energy performance levels ("business as usual", "BBC Rénovation", "passive") 46

Figure 11: Evolution of CO_2 emissions for the three different scenarios comparing a moderate evolution ("modéré") of renewable energies to an ambitious evolution ("amibitieux")........47

Figure 12: Surveyed building examples and a detail of the digital map from the historical centre of Budaörs [Domahidi 2013] 52

Figure 13: Current Wall U values; Map Data [© OpenStreetMap contributors] 64

Figure 14: EPC Map; Map Data [© OpenStreetMap contributors] 64

Figure 15: Building typology matrix for the municipality of Vršac. (top-down - white cell: left -percentage by number of buildings, right - percentage by area / bottom-up - grey cell: left-percentage by number, right –percentage by area)........71

Figure 16: Renovation rate for single – family houses (left) and multi – family houses (right) from 2015 – 2030 to the Slovenian national strategy [MzI 2015b]........77

Figure 17: Total non-renewable primary energy for the building stock case study Kočevje........81

Figure 18: Share of used energy carriers for space heating (left) and domestic hot water (right) for single-family houses (SFH), multi-family houses (MFH) and non-residential buildings (NR) 82

Figure 19: EPISCOPE local case studies –delivered energy for heating and DHW per m² TABULA/EPISCOPE reference floor area and year for the existing state (basic case) 86

Figure 20: CO_2 emissions for space heating and domestic hot water according to the EPISCOPE trend scenarios for local building stocks, extrapolations of current improvement rates (in many cases partly based on assumptions)....... 87

List of Tables

Table 1:	Sources / References Introduction	2
Table 2:	2020 and 2030 energy and climate targets for the EU as a whole	3
Table 3:	Emissions in ETS and Non ETS sectors [EC 2011b]	4
Table 4:	EU Greenhouse gas emission reductions overall and in different economic sectors in different decarbonisation scenarios [EC 2011b]	4
Table 5:	Sources / References EU Climate and Energy Targets for the Building Sector	7
Table 6	Sources / References Introduction Scenario Results	12
Table 7:	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 action]	14
Table 8:	Energy consumption and cost and CO_2 emission, average values for 50 investigated dwellings	17
Table 9:	Summary Indicators housing blocks in the Sint-Amandsberg district of the city of Ghent	18
Table 10:	Sources / References <BE> Belgium	20
Table 11:	Scope of the observed building stock of CLDC [own elaboration from raw data provided by CLDC]	23
Table 12:	Scenarios description [own elaboration]	26
Table 13:	Summary Indicators Housing Stock of the Cyprus Land Development Corporation (CLDC)	27
Table 14:	Final energy by fuel of the CLDC building stock for 2005, 2015 and 2020, gross calorific value [GWh/yr]	28
Table 15:	Final energy by fuel of the CLDC building stock for 2030 and 2050, gross calorific value [GWh/yr]	28
Table 16:	Sources / References <CY> Cyprus	30
Table 17:	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]	33
Table 18:	Description of Trend Scenario, based on [MRA 3.2015]	36
Table 19:	Summary Indicators of the Municipal Housing Stock in Havířov	37
Table 20:	Final energy of the Havířov municipal housing stock, gross calorific value [GWh/yr]	37
Table 21:	Sources / References <CZ> Czech Republic	39
Table 22:	Scope of the observed building stock in France [OPH Montreuillois 2015]	41
Table 23:	Scope of the observed building stock in France [OPH Montreuillois 2015]	42
Table 24:	Limit level of refurbishment by construction elements [POUGET Consultants]	43

Table 25: Target values of the heat transfer coefficient U for each construction elements and depending on three levels [POUGET Consultants 2015].....45

Table 26: Summary Indicators for OPH Montreuillois' building stock.........................48

Table 27: Final energy by fuel for OPH Montreuillois' building stock, gross calorific value [GWh/yr] 48

Table 28: Sources / References <FR> France...49

Table 29: Scope of the observed residential building stock, Budaörs city [Földhivatal online 2015] 51

Table 30: Main characteristics of the 340 monitored building including retrofit levels...53

Table 31: Total and specific primary energy consumption and CO_2 emission results for the original state and per scenario on different time horizons ...55

Table 32: Summary Indicators of the residential building stock, Budaörs city...........56

Table 33: Final energy by fuel of the residential building stock, Budaörs, gross calorific value [GWh/yr] 56

Table 34: Sources / References <HU> Hungary 57

Table 35: Scope of the observed building stock in Dublin City [CSO 2012]...............59

Table 36: Aggregate Refurbishment Trends 60

Table 37: Energy Demand Reduction Target Predictions..61

Table 38: CO_2 Emissions Reductions Target Predictions..61

Table 39: Summary Indicators for Northside of Dublin City residential building stock 62

Table 40: Final energy by fuel Dublin City Northside, gross calorific value [GWh/yr]..63

Table 41: Sources / References <IE> Ireland 65

Table 42: Scope of the observed building stock in municipality of Vršac (results of bottom up methodology for development of municipal typology) 67

Table 43: Refurbishment actions influence on savings in total stock [%] (results of in fleld research) 68

Table 44: Energy needed for heating for new buildings in defined scenarios [kWh/m^2yr] 68

Table 45: Description of improvement measures on thermal envelope 69

Table 46: Distribution of energy carriers in municipality of Vršac – current state and projections [%] (results of in fled research)..69

Table 47: Variation of heating system efficiency factor throughout different scenarios [%] 69

Table 48: Summary Indicators for municipality of Vršac building stock 73

Table 49: Final energy by fuel for municipality of Vršac building stock, gross calorific value [GWh/yr] 73

Table 50: Sources / References <RS> Serbia 74

Table 51: Scope of the observed building stock in Municipality of Kočevje <SI> Slovenia [GURS 2015], [SURS 2015a]..75

Table 52: Share of recorded renovation rates on thermal envelope in the municipality Kočevje (percentages relate to usable floor area) [REN 2014] 78

Table 53: Share of subsidied recorded measures on thermal envelope in the municipality Kočevje (percentages relate to usable floor area) [Eko sklad 2009-2014] 79

Table 54: Summary Indicators <SI> Slovenia, municipality Kočevje 80

Table 55: Final energy by fuel <SI> Slovenia, municipality Kočevje, gross calorific value [MWh/yr] 80

Table 56: Sources / References <SI> Slovenia....83