(Contract XX)

SCIENTIFIC REPORT

IEE TABULA - Typology Approach for Building Stock Energy Assessment

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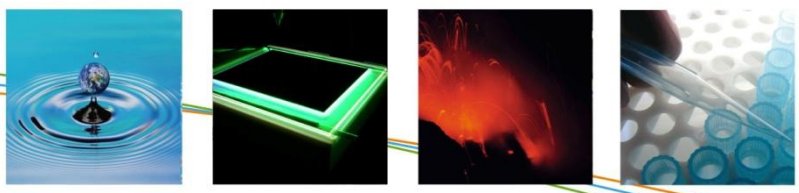
Scientific report composed within the framework of the IEE funded TABULA project
2011/TEM/R/091763

August 2011



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Introduction

This report describes the development of a Belgian housing typology by VITO, the Flemish Institute for Technological Research. This research activity is partly undertaken within the framework of the IEE project TABULA. The report outlines a modular work plan and is gradually compiled, starting with a state of the art of existing housing typologies, evolving towards a description of the structure and content of the typology and ending with a chapter focussing on key findings and conclusions.

The tasks that must be fulfilled within the European IEE project TABULA (2009-2012) are:

- The provision of typology data sets for "typical" Belgian dwellings types. These data sets will be included in the harmonised data structure developed at EU-level and managed by IWU (DE), the project co-ordinator for the TABULA project. All participating partners will fulfil this task for their respective countries, whereby helping to create a European overview. In this case, we can use the term "**harmonised European typology**";
- Compiling a national brochure about the Belgian housing typology. This typology will have a Belgian context, but will also include elements with regional origins, e.g. making use of the Flemish calculation method for the energy performance of buildings (EPB). The brochure offers an insight into energy consumption and the saving potential for a set of typical dwellings. In this context, we refer to this as the "**Belgian housing typology**" and the "**Belgian housing brochure**";
- In a third task, data sets which are representative for the Belgian housing stock, are provided for inclusion and processing in the harmonised European typology. This differs somewhat from the "typical dwellings". The average data sets for "**representative**" housing are used to perform scenario analyses at a Belgian and European scale. Average values are used to identify representative dwellings, which differ significantly from typical homes, in the sense that in this case, characteristic of the building geometry, construction elements and technical installations cannot, or can rarely, be mapped with a physical representation as found in an actual existing house.

Further information about the IEE project TABULA is available at www.building-typology.eu.

The development of a Belgian housing typology and the link to scenario analyses for the building stock, shows an important overlap with VITO activities outside the TABULA project. One of the current objectives for organised scientific research within the Unit Transition Energy and Environment at VITO, is to develop a representative model for the Belgian building stock. This model serves as the basis for monitoring energy consumption in the building stock and ex-ante and ex-post evaluations.

The compilation of a detailed typology at Belgian level is a challenging assignment. A major barrier here is the fact that Belgium is divided into various political regions (Flanders, Brussels and Walloon region) and lies in the shortage of useful statistics and data sources (this is an impediment common to all TABULA partners). Further, the distinction between "typical" housing, which offer an insight into energy consumption and saving potential for various individual housing types, and on the other hand a representative model of the housing stock for scenario analyses on Belgian or regional level, is essential. Therefore, the ambitions of VITO in the TABULA project are also clearly of a dual nature:

- To develop a widely available Belgian information brochure featuring the typical dwellings and directed to home owners, energy advisors, housing organisations, etc. ;
- To make an important contribution to the construction of a Belgian housing model for scenario analyses, in function of further policy-supporting research.

Furthermore, it is necessary to emphasise the importance of the harmonised European typology, in which all data sets – both for typical and representative housing – from all participating TABULA partners are collected. This database, with its integrated EU calculation method, is of significant importance for further policy-supporting research at European level. It is a unique data source, since previously data sets were only available per country, each with different underlying assumptions and different calculation methods impeding comparisons and analyses at EU level.

Chapter 1 A HOUSING TYPOLOGY APPROACH

1.1 What is a housing typology?

The 13 partners and 2 associated partners involved in the European TABULA project have committed themselves to develop a housing typology for their respective countries. The Belgian typology is first of all compiled at national level, and will then be translated towards the harmonised structure at European level. The harmonised version uses the same basic data, but preconditions, calculation methods and the level of detail differs from the national version in a number of areas. Various meanings can be given to the term "housing typology". For a more uniform interpretation, we define a typology for a particular segment of the building stock as a division into building types with shared and recognisable characteristics:

The Belgian housing typology is a set of building types related to the Belgian housing stock, organised within a specific system and for which a set of characteristics with relevance to the energy consumption for building operations is defined.

Note that this definition does not make the distinction between the "typical dwellings approach" and the construction of a model of the housing stock at regional or national scale. The literature study indeed reveals that the term housing typology is used for both approaches. For purposes of clarity, in those case where a clear distinction can be made, we use the term "model of the housing stock" with "representative dwelling types" to underline the difference with an approach focusing on "typical dwellings" common to a "typical dwellings approach".

The description of a typical dwelling is more difficult to establish. In any case, it is a fictional house that is composed of typical elements for the building envelope and the technical installation. In essence, a typical dwelling must be "recognisable" and "translatable" for ordinary citizens, in relation to actual existing housing. The focus when using typical dwellings will be placed on quantifying the energy consumption for building operations and the financial profitability of energy-saving measures. Therefore, for a typical dwelling various states can be defined: the original state of construction, the current state, taken into account typical renovation measures undertaken in the past, and possible future renovated conditions associated with an improvement in energy consumption.

1.2 Purpose and added value of the Belgian brochure with typical housing

The Belgian housing brochure aims to be a widely accessible and generally accepted information tool on energy consumption and the impact of energy-saving measures in residential buildings. The intention is to target a wide audience using a variety of approaches. First and foremost, the brochure is aimed at home owners. This target audience can be divided into private home owners (residents and landlords/letters) and tenants, legal bodies or public owners excluding social rental/sale, and legal bodies or

public owners specifically involved in social rental/sale. However, the brochure has multiple usage possibilities, which also makes it useful to many other parties involved in energy efficiency of housing:

1. First and foremost, the brochure is intended for **general distribution**, with the aim of providing information about and encouraging energy renovations. The brochure can be used within a general awareness campaign, but also allows private persons to zoom in on the dwelling type that best matches their specific situation and offers an insight into possible renovation measures, their impact and their financial appeal;
2. The brochure can be used by **energy advisors** when providing advice about potential energy-saving measures, their impact and related costs and savings. The housing fiches could e.g. be handed out by the EPC-advisor as extra information when an EPC is compiled;
3. The brochure offers a unique reference framework to **potential tenants/buyers/builders** of a house, which can help to support a decision of whether or not to buy or rent a house.
4. The brochure can be used for compiling forecasts for the energy consumption and possible energy renovation scenario's of **particular housing complexes**, for example, belonging to housing associations.
5. **Policy makers** at local, regional and national level are handed a set of housing types and related recommended energy-saving measures allowing to set up a targeted information campaign stimulating energy renovations.

Compared to tools that have been developed in the past, the Belgian housing typology offers clear benefits in a number of areas. The provided information is scientifically based, transparent, available to a wide audience and has been compiled by an independent research institute. The set of typical dwellings defined is extensive and covers a large part of the actual housing stock. The dwelling fiches are detailed, aimed at visual association with actual built situations, and it requires little effort to understand the typology and put it into use. An essential aspect for the relevance of the dwelling fiches in the brochure is the link to current regulations and official calculation methods applicable in Belgium[1], e.g. the EPB (new build) and/or EPC (existing buildings) procedures and their accompanying reference values, respectively the E-level and EPC-score. Finally, it is encouraged that other scientific organisations become familiar with the typology, add to it or even develop it further.

1.3 Work plan for developing the Belgian housing typology

The following paragraphs offer a brief introduction to the various steps in the work plan for realising a Belgian housing typology. In doing so, we have identified 5 modules, as shown *Figure 1* below.

[1] The energy-efficiency of housing regulations are handled at the regional level. The brochure will make use of the regulatory framework and calculation methods applicable in the Flemish region.

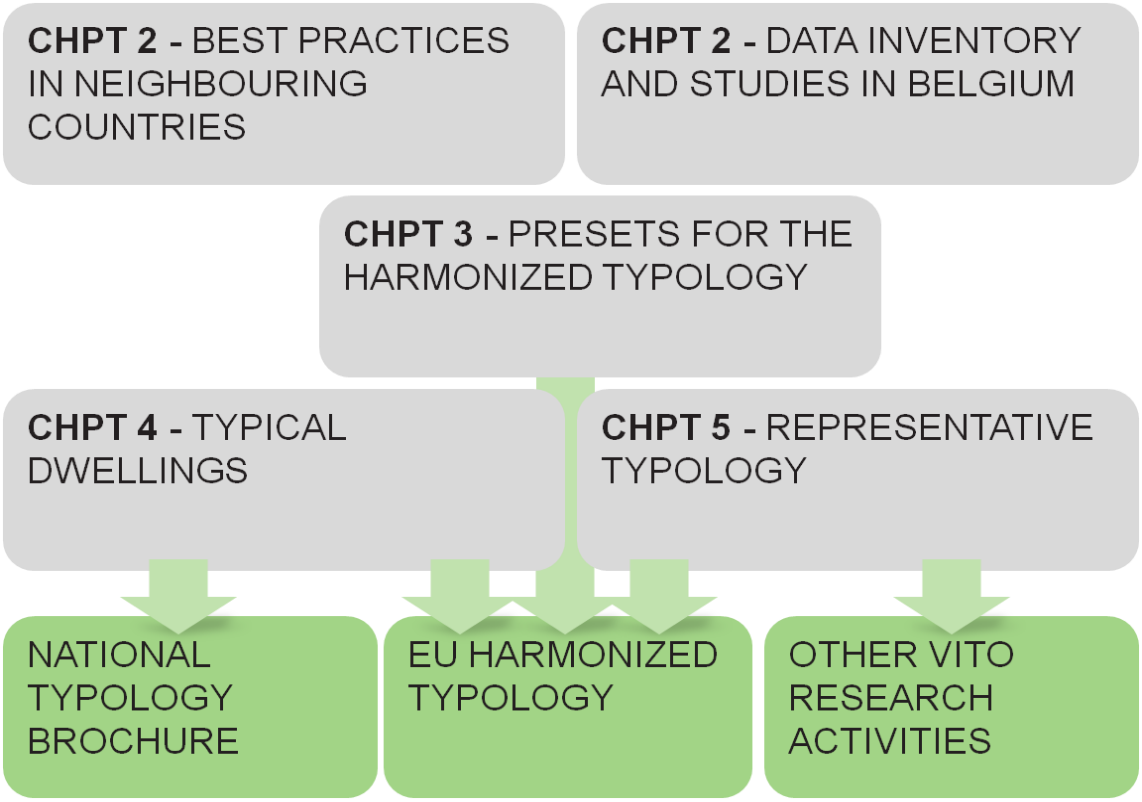


Figure 1: Overview of the 8 modules for developing the Belgian housing typology

In **Chapter 2** a state of the art and data inventory is undertaken where we discuss example typologies from the Netherlands and Germany. Secondly, an inventory of available data for Belgium is compiled and similar studies in Belgium, the Flemish, Brussels Capital and Walloon region are examined. In **Chapter 3** the presets, or conventions agreed upon by the TABULA partners for the EU harmonized typology are discussed. The actual typical dwellings and the representative typology are developed in **Chapters 4** and **5**. The results of which feed into the national typology brochure, the EU harmonized typology. In the case of the representative typology, there is a close link with various other research activities undertaken at VITO as outlined in Chapter 5. Chapters 4 and 5 logically close up with some key conclusions based on the typologies developed, on the research activity undertaken and on the availability of data sources.

Chapter 2 STATE OF THE ART AND DATA INVENTORY

2.1 Introduction

In the state of the art, we first and foremost compile an overview of best practices in neighbouring countries. This offers us the opportunity to learn from these best practices in terms of the methodology used, the dividing line between "typical" and "representative" housing typologies and the way in which results are presented in brochures, web applications, etc. We will pay closer attention to two cases from neighbouring countries, on the one hand the "Voorbeeldwoningen Bestaande Bouw 2007" (En: Dwelling examples existing buildings 2007) developed by the former SenterNovem (now called Agentschap NL, the Netherlands), and on the other hand the German building typology developed by the Institut Wohnen und Umwelt (IWU, Germany). The second part of this chapter addresses the data available for the Belgian context for defining both typical and representative housing types. We also address comparable studies that have been undertaken in Belgium in the past and examine what elements can be of use for the development of the Belgian typology.

2.2 Voorbeeldwoningen Bestaande Bouw 2007 – SenterNovem (the Netherlands)

2.2.1 Presentation

The Dutch reference dwellings can be consulted in a brochure available in digital format and, upon request to VROM, on a CD-rom along with extra information. Consultation of the brochure reveals an attractive and colourful layout. Information is furthermore presented in a simple manner. There is also a link to existing regulatory evaluation methods for building energy consumptions. A showcase to demonstrate possible applications and further use of the example dwellings however has not been included in the brochure.

Figure 2: Brochure of the SenterNovem "Voorbeeldwoningen bestaande bouw 2007 (Source: SenterNovem)

2.2.2 Aim and use

The reference dwellings developed by the former SenterNovem [SENT 2007] are intended both for policy advice purposes and building stock management. They are of use to local and national governments, owners of large housing estates, energy consultancy companies,... The example dwellings act as a theoretical basis, for which the building envelope and building services characteristics are described. Every example dwelling represents a particular segment of the Dutch housing stock. All dwelling examples together account for the entire Dutch housing stock up to the year 2000. An example reference dwelling is available for most of the existing housing types encountered in the Netherlands in building practice.

The dwelling examples can be used when **performing energy analyses on groups of houses**, for example the housing stock of a housing corporation. In this case both energy saving potentials as well as the financial costs and benefits can be calculated. For this purpose, it is important for the selected example dwellings to be sufficiently representative of the group of houses under study, and for it to be possible to estimate the energy consumption, energy savings potentials and related investments costs and financial savings. It is also possible to **use the dwelling examples as a reference for a part of, or for the entirety of the Dutch housing stock**. For this purpose, the representativity of the dwelling examples is a key issue. Following this approach, implications of current and future policy measures and regulations can be analysed in terms of their energy-savings, CO2 reduction potential and the related financial costs and benefits. The housing examples are not primarily intended for calculations on individual houses, individual customised advice or an EPC-calculation are considered the correct tool for this purpose in the Netherlands.

2.2.3 Method

When the dwelling examples were compiled, the aim was to reflect the Dutch housing stock as accurately as possible. To realise this, use was made of a survey that collected details of about **15,000 existing houses** up to the year 2000. This survey, which is called the "Kwalitatieve Woning Registratie" or KWR (En: Qualitative Housing Registration), describes the quality of the Dutch housing stock and was carried out by the Ministry of Housing, Spatial Planning and Environment [VROM 2000]. All 15,000 houses in the KWR have been analysed and divided into **eight different housing types and six construction periods**. This lead to the identification of 27 dwelling examples. A sub-division has been made within main housing type categories e.g. for terraced houses, maisonettes, high-rise flats,... The level of detail is high. Due to the further divisions into subtypes, the total number of dwelling examples adds up to 117. The brochure only shows the 27 most common dwelling examples for the Dutch context.

For each dwelling example, **four energy-efficiency levels** or dwelling states have been identified: original, current, comfort and comfort +. The 'original' state indicates the energy-efficiency level of the dwelling as originally constructed. Over the years, improvements may have been made. This improved and current situation corresponds to the 'current' level. Finally, 'comfort' and 'comfort +' correspond to two scenario's for energy upgrading of the dwelling. The brochure only addresses the 'current' and 'comfort' energy levels. The CD-rom contains a more comprehensive description, including the 'original' and 'comfort +' energy levels. For the 27 main dwelling types, the main building envelope and building services characteristics, indicative photos, energy renovation measures and related costs and savings are presented. The energy performance for the dwelling examples is calculated following the Dutch Energy Index Certificate calculation method and the EPA advice calculation method of December 2006.

2.2.4 Dwelling example fiches

The dwelling example fiches contain the following information:

- Description of the dwelling type and general dwelling characteristics;
- Main building envelope characteristics;
- Main building services characteristics;
- Energy-saving measures and corresponding investment costs;
- Energy-efficiency level for the 'current' and 'comfort' state;
- Estimated savings in fossil fuel consumption (expressed for gas in m^3/yr and for electricity in kWh/yr) and financial savings (Euro/yr).

3.1 Grote vrijstaande woning gebouwd voor 1966

De grotere vrijstaande woningen van voor 1966 vertegenwoordigen, met 206.000 woningen, ruim 3% van de Nederlandse woningvoorraad. Het merendeel, namelijk 91%, is in particulier bezit en ongeveer 8% wordt in de particuliere sector verhuurd. Onder een grotere woning wordt in dit geval verstaan dat de woning groter is dan 150 m² gebruiksoppervlakte. De woningen die in deze categorie vallen, hebben vaak vier kamers[1], een beloopbare zolder en een kelder. Vaak hebben deze woningen hoge vertrekken op de begane grond en een begane grondvloer die van hout is. Deze houten begane grondvloeren komen in dit type woningen zelfs tot eind jaren '70 voor.

Oorspronkelijke energetische niveau

In de periode tot 1966 werden er nog geen eisen aan de energiezuinigheid van woningen gesteld. De woningen werden daarom niet geïsoleerd. Tot circa 1930 werden er geen spouwmuren toegepast. In de woningen die voor 1960 gebouwd zijn, kwamen vaak stalen kozijnen met enkel glas voor, maar ook houten puien werden toegepast. Veel woningen werden in die tijd nog uitgerust met lokale gaskachels, elektrische boilers en natuurlijke ventilatie. Centrale verwarming werd op beperkte schaal toegepast.

Huidige energetische niveau van deze woningen

Veel van deze woningen zijn in de loop der jaren energetisch verbeterd. Het accent ligt hierbij op na-isolatie van de gevel, de begane grondvloer en het dak en kierdichting. Ook het plaatsen van dubbelglas, met name op de begane grondverdieping, is populair. Bij veel woningen in deze categorie zijn de gaskachels inmiddels vervangen door centrale verwarming. Dit leidt tot een hoger comfort, maar ook tot een hoger energiegebruik.

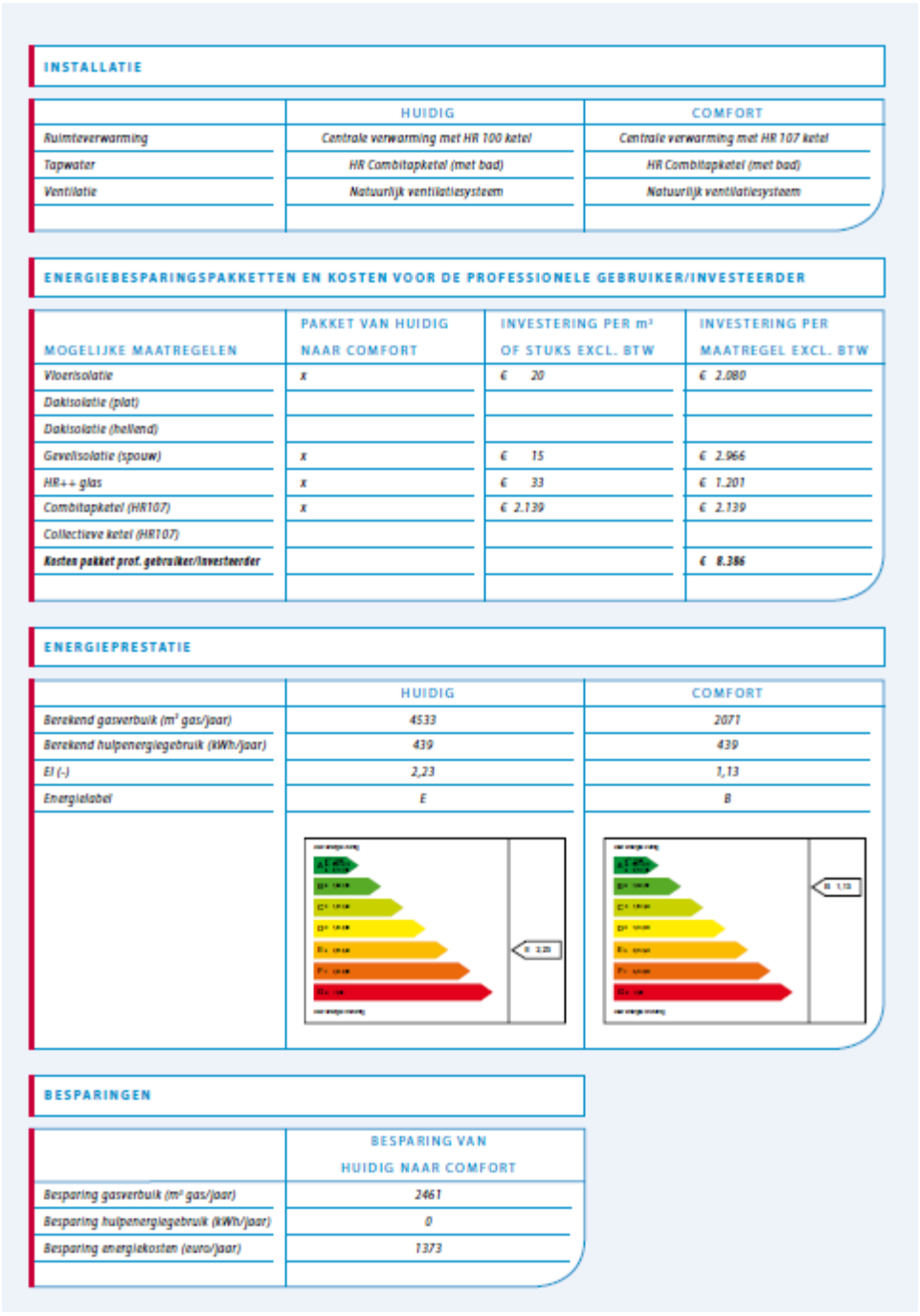
BOUWKUNDIGE KENMERKEN

Gebruiksoppervlakte (m²)	210,6
Aantal bewoners	3,2

		U-WAARDE (W/m²K)		RC WAARDE (m² K/W)	
BOUWDEEL	OPP. (m²)	HUIDIG	COMFORT	HUIDIG	COMFORT
Begane grondvloer	104,0	2,44	0,34	0,15	2,65
Dak hellend	147,1	0,47	0,47	1,97	1,97
Dak plat	-	-	-	-	-
Voorgevel gesloten	39,0	1,89	0,56	0,36	1,61
Voorgevel glassoort 1	5,7	5,10	2,00	-	-
Voorgevel glassoort 2	7,9	3,10	2,00	-	-
Achtergevel gesloten	39,0	1,89	0,56	0,36	1,61
Achtergevel glassoort 1	5,7	5,10	2,00	-	-
Achtergevel glassoort 2	7,9	3,10	2,00	-	-
Zijgevel gesloten	119,8	1,89	0,56	0,36	1,61
Zijgevel glassoort 1	3,8	5,10	2,00	-	-
Zijgevel glassoort 2	5,2	3,10	2,00	-	-



Figure 3: First page of a SenterNovem dwelling fiche, displaying a general description of the dwelling and building envelope characteristics for the 'current' and 'comfort' state (Source: SenterNovem)



INSTALLATIE

	HUIDIG	COMFORT
Ruimteverwarming	Centrale verwarming met HR 100 ketel	Centrale verwarming met HR 107 ketel
Tapwater	HR Combitapketel (met bad)	HR Combitapketel (met bad)
Ventilatie	Natuurlijk ventilatiesysteem	Natuurlijk ventilatiesysteem

ENERGIEBESPARINGSPAKKETTEN EN KOSTEN VOOR DE PROFESSIONELE GEBRUIKER/INVESTEERDER

MOGELIJKE MAATREGELEN	PAKKET VAN HUIDIG NAAR COMFORT	INVESTERING PER m² OF STUKS EXCL. BTW	INVESTERING PER MAATREGEL EXCL. BTW
Vloerisolatie	x	€ 20	€ 2.080
Dakisolatie (plat)			
Dakisolatie (hellend)			
Gevelisolatie (spouw)	x	€ 15	€ 2.966
HR++ glas	x	€ 33	€ 1.201
Combitapketel (HR107)	x	€ 2.139	€ 2.139
Collectieve ketel (HR107)			
Kosten pakket prof. gebruiker/investeerder			**€ 8.386**

ENERGIEPRESTATIE

	HUIDIG	COMFORT
Berekend gasverbuik (m³ gas/jaar)	4533	2071
Berekend hulpenergiegebruik (kWh/jaar)	439	439
EI (-)	2,23	1,13
Energielabel	E	B

BESPARINGEN

	BESPARING VAN HUIDIG NAAR COMFORT
Besparing gasverbuik (m³ gas/jaar)	2461
Besparing hulpenergiegebruik (kWh/jaar)	0
Besparing energiekosten (euro/jaar)	1373

Figure 4: Second page of a SenterNovem dwelling fiche, displaying building services characteristics for the 'current' and 'comfort' state, energy upgrade measures and their investment costs, energy efficiency levels for the 'current' and 'comfort' state and the savings achieved (Source: SenterNovem)

2.3 German building typology – Institut Wohnen und Umwelt (Germany)

2.3.1 Presentation

This description of the German building typology developed by IWU is based on a brochure entitled "Deutsche Gebäudetypologie: Systematik und Datensätze" from 2003 [IWU 2003] and on the first TABULA synthesis report [LOGA 2010]. The IWU brochure provides a summary of information about the actual typology and contains an overview matrix, text explanation, a literature list and the actual data sets for the houses. The document is clearly directed at policy makers and scientific experts rather than to a large audience. The presentation style is structured and simple.

The typical dwellings are again described in dwelling fiches. These two-page fiches are understandable, clear and yet comprehensive. The second page of the dwelling fiche contains a clear overview of the total energy balance and of the calculated impact of individual measures. The fiche also provides a cost estimate for the various renovation measures.

2.3.2 Aim and use

The German building typology was initially developed to serve as a representative model for the German building stock intended to calculate energy-saving potentials. The model makes a distinction between various regions in Germany. The typology was also used for initial energy advice on the individual building level by comparing existing building cases with the corresponding dwelling type from the typology. Besides the use for scenario analyses and in advice brochures, the regional building typologies are also used in software applications with sets of building examples. A screenshot of German Energy Advice software based on the typology, is presented in *Figure 5* below.

The first version of the national residential building typology was developed in the 1990s on the basis of energy audit reports. This typology was used to perform scenario analyses to determine the energy-saving potential of the German housing stock. The German building typology was regularly updated to cater for new developments, for example as a result of new energy guidelines, and the model was used to perform various studies commissioned by German government agencies at national or regional level. Over the decades, building typologies were also developed for German cities and provinces. For example, scenario analyses for CO2 reductions in the province of Hesse were carried out based on the Hesse building typology. Statistical data for these analyses was derived from the "Bautätigkeitsstatistik" (German statistics on building construction), which are the German building and construction statistics, and from the "Mikrozensus", which is a 1% sample of German households from which data is collected every four years about housing and heating systems commissioned by the Statistisches Bundesamt.

2.3.3 Method

The current version of the German building typology consists of 44 residential building types classified in terms of construction year and building size. The typology describes the buildings in their original condition. The data sets contain information on the basic building characteristics (e.g. surface area, number of apartments, etc.) and on the main

characteristic for the building envelope and services components related to the building energy performance.

Some useful information is not yet available from the statistical data sources, e.g. the number of buildings that have been subject to an energy renovation. Further information on the current state of the German housing stock has however recently come available from a statistical survey completed in 2010. The study "Datenerhebung zur energetischen Qualität und zu den Modernisierungstrends im Gebäudebestand", carried out by IWU and Bremer Energieinstitut, involved questioning 10,000 residential building owners about e.g. the condition of structural elements and the heating system. The energy performance certificates database from the German Energy Agency dena, will also be able to provide additional information for further refining of the German building typology. The data in the dena database are collected from the quality assurance processes for the energy certificate "Gütesiegel Energieausweis".

It is worth noting that the German building typology contains typical dwellings, and the typology therefore allows focussing on individual building cases. However, the typology is also used for analyses on the entire housing stock. The distinction between "typical" and "representative" dwelling types, that will be applied when developing the Belgian typology, is not applicable for the German typology developed by IWU. Detailed information is available on the typology main and sub-typology matrices and in the dwelling fiches, however, only few details on the general approach, the underlying assumptions and on the energy performance calculation methodology for the German building typology are provided.

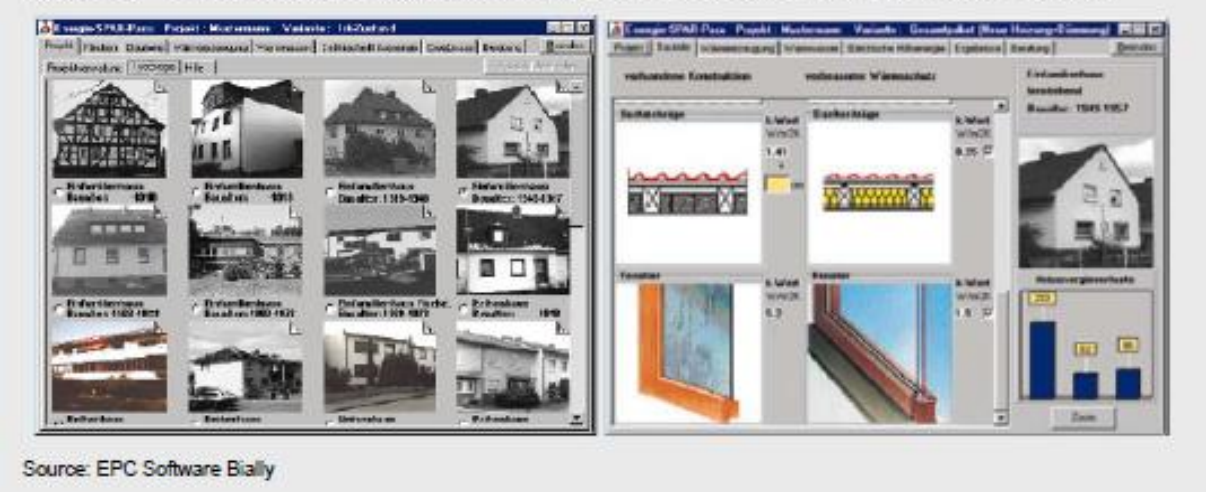


Figure 5: Housing typology in the German Energy Advice software (Source: IWU)

2.3.4 Main matrix, sub-typology matrices and dwelling example fiches

The main matrix of the building typology is displayed in *Figure 6*. The sub-typologies of building envelope and services components, are shown respectively in *Figure 7* and *Figure 8*. The actual dwelling fiches are similar in style and approach, providing a very recognisable and realistic insight. *Figure 9* shows an example dwelling fiche from the Hesse province typology.

Figure 6: Main matrix of the German housing typology (Source: IWU)

Außenwände			Ur-zustand	zusätzliche Dämmung						
				2 cm	5 cm	8 cm	12 cm	16 cm	20 cm	30 cm	40 cm
Bauart	typischer Erstellungs-zeitraum	typische Konstruktion	Pauschalwerte für den Wärmedurchgangskoeffizienten in W/(m²K)								
Mauerwerk	bis 1918		2,2	1,05	0,59	0,41	0,29	0,22	0,18	0,13	0,10
Fachwerk	bis 1918		2,0	1,00	0,57	0,40	0,29	0,22	0,18	0,13	0,10
Vollziegel-Mauerwerk	bis 1948		1,7	0,92	0,54	0,39	0,28	0,22	0,18	0,12	0,09
Vollziegel-Mauerwerk verbessert	bis 1948		1,4	0,82	0,51	0,37	0,27	0,21	0,18	0,12	0,09
leichtes Mauerwerk	1949 bis 1968		1,4	0,82	0,51	0,37	0,27	0,21	0,18	0,12	0,09
Bims-vollsteine	1949 bis 1968		0,9	0,62	0,42	0,32	0,24	0,20	0,16	0,12	0,09
leichtes Mauerwerk	1969 bis 1978		1,0	0,67	0,44	0,33	0,25	0,20	0,17	0,12	0,09
Betonfertigteile	1969 bis 1978		1,1	0,71	0,46	0,34	0,26	0,20	0,17	0,12	0,09
Fertighaus oder Holzbau	1969 bis 1978		0,6	0,46	0,34	0,27	0,21	0,18	0,15	0,11	0,09
leichtes Mauerwerk	1979 bis 1983		0,8	0,57	0,40	0,31	0,24	0,19	0,16	0,11	0,09
Porenbeton	1979 bis 1983		0,6	0,46	0,34	0,27	0,21	0,18	0,15	0,11	0,09
Betonfertigteile	1979 bis 1984		0,9	0,62	0,42	0,32	0,24	0,20	0,16	0,12	0,09
Fertighaus oder Holzbau	1979 bis 1983		0,5	0,40	0,31	0,25	0,20	0,17	0,14	0,11	0,08
leichtes Mauerwerk	ab 1984		0,6	0,46	0,34	0,27	0,21	0,18	0,15	0,11	0,09
Porenbeton	ab 1984		0,5	0,40	0,31	0,25	0,20	0,17	0,14	0,11	0,08

Explanations

U-values for different wall systems and construction cycles

yellow: without insulation

green: with insulation (variation of insulation layer thickness)

Figure 7: Sub-typology of the building envelope components (Source: IWU)

Hg	Heizwärme Erzeugung		Erzeuger-Aufwandszahl $e_{H,g}$ [-]			Hilfsenergiebedarf $q_{H,g,Hilf}$ [kWh/(m²a)]	
Kürzel	Name	Baualtersklasse	Wohnungsanzahl 1 bis 2	3 und mehr		Wohnungsanzahl 1 bis 2	3 und mehr
		Basiswert für f_Q	2,0	2,0			
		Basiswert für $Q_{P,a}$	24	500			
KTK88	Konstanttemperatur-Kessel	bis 1986	1,33	1,21		2,4	0,4
KTK84	Konstanttemperatur-Kessel	1987 bis 1994	1,29	1,18		2,4	0,4
KTK95	Konstanttemperatur-Kessel	ab 1995	1,28	1,14		2,4	0,4
NTK88	Niedertemperatur-Kessel	bis 1986	1,23	1,18		2,4	0,4
NTK84	Niedertemperatur-Kessel	1987 bis 1994	1,18	1,12		2,4	0,4
NTK95	Niedertemperatur-Kessel	ab 1995	1,12	1,08		2,4	0,4
BWK88	Brennwert-Kessel	bis 1986	1,11	1,07		2,4	0,4
BWK84	Brennwert-Kessel	1987 bis 1994	1,08	1,04		2,4	0,4
BWK95	Brennwert-Kessel	ab 1995	1,06	1,03		2,4	0,4
GT84	Gas-Therme (Umlaufwasserheizer)	bis 1994	1,16	1,16		2,4	0,4
GT95	Gas-Therme (Umlaufwasserheizer)	ab 1995	1,08	1,08		2,4	0,4
GBT84	Gas-Brennwert-Therme	bis 1994	1,07	1,07		2,4	0,4
GBT95	Gas-Brennwert-Therme	ab 1995	0,99	0,99		2,4	0,4
WPE84	Elektro-Wärmepumpe Erdreich oder Grundw.	bis 1994	0,32	0,32		1,4	1,0
WPE84mHS	Elektro-WP Erdreich oder Grundw. mit Heizstab	bis 1994	0,38	0,38		1,4	1,0
WPE95	Elektro-Wärmepumpe Erdreich oder Grundw.	ab 1995	0,29	0,29		1,4	1,0
WPE95mHS	Elektro-WP Erdreich oder Grundw. mit Heizstab	ab 1995	0,32	0,32		1,4	1,0
WPL84	Elektro-Wärmepumpe Außenluft	bis 1994	0,42	0,42		1,4	1,0
WPL84mHS	Elektro-Wärmepumpe Außenluft mit Heizstab	bis 1994	0,45	0,45		1,4	1,0
WPL95	Elektro-Wärmepumpe Außenluft	ab 1995	0,35	0,35		1,4	1,0
WPL95mHS	Elektro-Wärmepumpe Außenluft mit Heizstab	ab 1995	0,38	0,38		1,4	1,0
FWU	Fernwärme-Übergabestation	-	1,02	1,02		0,0	0,0
Oelofen	Ölbefeuerter Einzelofen mit Verdampfungsbr.	-	1,40	1,40		0,0	0,0
Ofen	Kohle- oder Holzofen	-	1,80	1,80		0,0	0,0
GRH	Gasraumheizer	-	1,40	1,40		0,0	0,0
ESz	zentraler Elektro-Speicher	-	1,00	1,00		0,0	0,0
ENSp	Elektro-Nachtspeicherheizung	-	1,00	1,00		0,0	0,0
EDHG	Elektro-Direktheizgeräte	-	1,00	1,00		0,0	0,0
TSA	Thermische Solaranlage	-	0,00	0,00		0,0	0,0

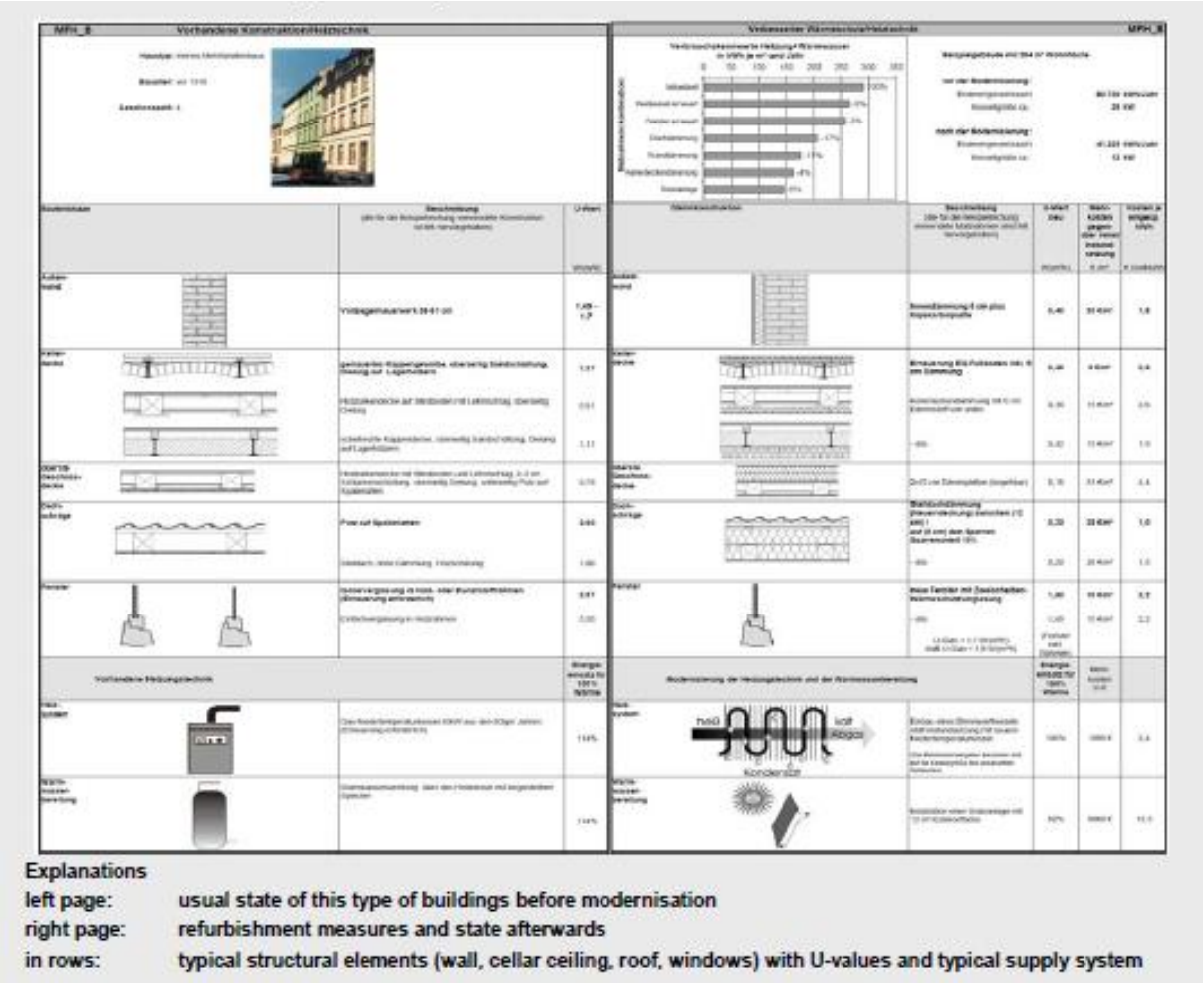
Explanations:

rows: different types of heat generators (boilers and heat pumps also arranged according to installation period)

columns yellow: expenditure factor (1/efficiency) of the generators when installed in single (left value) or multi-family houses (right value)

columns red: auxiliary electric energy demand per m² living space

Figure 8: Sub-typology of the building services components (Source: IWU)



Explanations

left page:	usual state of this type of buildings before modernisation
right page:	refurbishment measures and state afterwards
in rows:	typical structural elements (wall, cellar ceiling, roof, windows) with U-values and typical supply system

Figure 9: Example dwelling fiche from the housing typology for the Hesse province (Source: IWU)

2.4 Data inventory on the Belgian housing stock

In the following paragraphs, we offer an overview of the data available on the Belgian housing stock for defining data sets for typical and representative dwellings for the Belgian housing typology. We address the available data and data sources, after which the following section will highlight a few comparable studies that offer us information in the following domains:

- General data on dwellings ;
  - Housing types;
  - Construction periods;
  - Frequency of housing types depending on construction period and type;
- Geometrical characteristics of buildings and building envelopes;
  - Floor surface areas;
  - Dwelling volumes;
  - Number of storeys;
  - Surface areas for building envelope components: facades, floors, roofs, windows and doors;
  - Orientation of the building envelope components;
- Technical characteristics of the building envelope components;
  - Composition of the building component (materials, thicknesses);
  - Characteristics related to transmission heat losses (U values,..);
  - Characteristics related to infiltration losses (air tightness,…);
  - Characteristics related to solar heat gains (orientation, glazing type,…);
- Technical characteristics of the building services components;
  - Basic information about the heating system (decentralised system; centralised system; centralised collective system for several housing units);
  - Characteristics related to the generation, storage, distribution and dispersion by the heating system (efficiency coefficients,...);
  - Characteristics related to the generation, storage, distribution of the sanitary hot water system;
  - Characteristics related to on-site renewable energy production, e.g. by solar thermal heating systems;
  - Characteristics related to the ventilation heat losses and the performance of the ventilation system.

This chapter aims to identify which information is provided by the sources and the level of detail of the information available. We also address certain existing data sources that are not available to VITO for the development of the Belgian typology.

2.4.1 General data

A number of government authorities, including the National Institute for Statistics and the Land Registry, manage and collect statistical data about the Belgian building stock. The following general data sources are available and contain basic data about residential buildings (dwelling type, surface area, construction year, frequency, condition of the buildings, etc.) in Belgium.

- Land registry statistics for the building stock;
- NIS statistics containing data from building permit procedures;
- NIS General Socio-economic Survey 2001 [VANN 2007];
- NIS General Population and Housing Censuses of 1981 and 1991.

These data sources allow the housing stock in Belgium, or per individual region, to be divided into classes dealing with:

- Dwelling types (detached, semi-detached, terrace houses, apartments);
- Construction periods;
- Dwelling surface area;
- Heating system;
- Energy carriers.

The sources also allow us to define dwelling frequencies for the different dwelling classes defined. Consequently, these data sources permit us to compose the main matrix of the housing typology. This main matrix is defined by various dwelling types (detached, semi-detached, terrace houses, apartments) and by various constructions periods. The matrix also specifies the dwelling frequencies, i.e. the number of dwellings as a fraction of the total Belgian housing stock. The General Socio-economic Survey of 2001 moreover indicates how many homes featured roof insulation, double glazing or wall insulation at that time. However, the data available in these sources for the building envelope and services components are not detailed enough –only providing a rough qualitative evaluation- to permit us the define the building envelope and building services sub-typologies for the TABULA sub-typology matrices. Furthermore, the General Socio-economic Survey dates from 2001, which means the data must be extrapolated to the current date to include renovation works undertaken since the year 2001. Furthermore, data for newly built dwellings since 2001 are to be added. To summarize the possibilities for use of the data provided by these general sources, we can conclude that within the TABULA project, we will rely on the above mentioned sources to establish general characteristics in the main matrix of the housing typology (type, construction period, frequencies).

2.4.2 Data related to the energy-efficiency of the building envelope and services systems

→ ***Targeted surveys***

A number of surveys and inspections have been carried out, from the 1990s up to the present day, in relation to the housing quality and the energy-efficiency of the dwellings. These surveys, mainly organized on a regional level and thus separately for the Flanders, Brussels or Walloon region, reveal data about the dwelling condition, the level of insulation of the building envelope and the type of heating systems installed. We have highlighted these surveys below, particularly mentioning their scope (Flemish, Brussels, Walloon region), the period in which they were carried out and the number of surveyed or inspected houses.

- SENVIVV VLIET study on the energy performance of 200 new-build dwellings in Flanders focussing on insulation, ventilation and heating systems [WTCB 1998];
- VIREG survey on the energy consumption of 1000 households in Flanders;
- Follow-up surveys commissioned by the Flemish Energy Agency carried out on a regular basis in Flanders since 2001 on 1000 households;
- Survey on housing quality in the Walloon region of 6000 dwellings carried out in 2006-2007;
- The “Woonsurvey en woonschouwing 2005”, a survey and home inspection reaching 5000 households in Flanders carried out in 2005 [HEYL 2007].

It is worth noting that these available surveys and studies in most cases evaluate the dwelling envelope and services on a qualitative basis, rather than by a quantitative approach. These studies often do not provide data on e.g. thicknesses and types of insulation materials or a U-value, but rather provide a rough estimate of the condition of the construction component (original, renovated, insulated or not, etc.). Therefore, the data provide by these surveys and studies do not permit to calculate an estimation for the

primary energy consumption of the dwelling or the total thermal heat losses through the envelope[2]. Secondly, only a limited segment of the housing stock is examined. The SENVIVV study, for instance, only considers new-build dwellings. When compiling the TABULA sub-typologies, these sources have therefore only been used to support certain hypotheses if appropriate, and with consideration for the limitations of the sources.

→ ***Building energy performance regulations***

The history of building regulations since the 1990s also serve as a reference for determining building envelope and services characteristics. In 1992, the **Flemish Insulation Decree ('92)** was imposed and from 2006 the **Energy Performance of Buildings Regulations** is in force as a regulatory framework. We know from the SENVIVV study, amongst others, that the thermal requirements imposed in the '92 Flemish Insulation Decree were only poorly implemented in practice due to a lack of a governmental control system. Therefore, the necessary correction factors will be applied in order to reflect actual building practice, rather than building regulations in the housing typology.

Furthermore, the metholodogies developed for the **EAP and EPC procedures** contain valuable default parameters for various construction elements and services systems. These default values can be used for determining the sub-typology characteristics for the building typology. VITO has been involved in the development of the EPC calculation procedures for energy certification of existing residential buildings in Flanders [VEA 2008] and Wallonia [RW 2009], together with partners such as the Belgian Building Research Institute (BBRI). Classifications for building envelope components specify default thermal characteristics, for example U-values of wall, floor and roof constructions, for various construction periods. Secondly, classifications for supply systems contain default parameters to determine the efficiency of e.g. a certain type of central heating boiler. Although these tables do not represent an overall subtypology of supply systems and building envelope components, they offer a suitable starting point to derive these subtypologies.

Type de chaudière	Chaudière mazout	Chaudière gaz
Chaudière sans label, < 1975	0.83	0.85
Chaudière sans label, de 1975 à 1984 inclus	0.86	0.87
Chaudière sans label, ≥ 1985	0.90	0.90
Chaudière avec label, indépendamment de l'année de fabrication	0.90	0.90
Les seuls labels considérés sont les labels OPTIMAZ pour les chaudières à mazout et BGV-HR ou HR-+ pour les chaudières gaz		

Table 1: Classification of boiler efficiencies from the EPC calculation procedures in Wallonia (Source: VITO)

[2] In Belgium this is expressed by a K-level that is generally used and well know in building practice.

Type de chaudière	Chaudière mazout	Chaudière gaz atmosphérique, sans ventilateur	Autre chaudière gaz
Chaudière sans label, < 1970	3.2	3.8	3.0
Chaudière sans label, de 1970 à 1979 inclus	2.2	2.8	2.0
Chaudière sans label, de 1980 à 1989 inclus	1.4	2.2	1.4
Chaudière sans label, ≥ 1990	1.0	1.5	0.7
Chaudière avec label, indépendamment de l'année de fabrication	1.0	1.5	0.7
Les seuls labels considérés sont les labels OPTIMAZ pour les chaudières à mazout et BGV-HR ou HR-+ pour les chaudières gaz			

Table 2: Classification of boiler standstill percentages from the EPC calculation procedures of existing residential buildings in Wallonia (Source: VITO)

→ ***Energy Advice Procedure (EAP) and Energy Performance Certificate databases***

The **EAP databases** for Flanders and Wallonia contain detailed information about dwellings for which the owners or residents have commissioned an energy audit, carried out by a qualified energy expert in the past years. The EAP database of the Flemish Energy Agency contains data on approximately 1000 energy audits. The Walloon database contains data on approximately 10,000 audits. The Brussels Institute for Environment Management IBGE/BIM manages the data obtained from Energy Audits carried out in Brussels. This database for the Brussels region could not be made accessible by IBGE/BIM within the time frame of the TABULA project. This gives us detailed data on the energy performance and building envelope and services characteristics for a total of approximately 11,000 inspected houses in the Flemish and Walloon regions.

The EAP databases contain detailed information, provided a qualified energy experts, on the building dimensions (building envelope and floor surface areas, protected volume), the building envelope (insulation thickness, estimation of the U-value) and the heating and hot water systems installed. The expert calculates the characteristic energy consumption of the house for heating and hot water production following the EAP-procedure and then provides customised energy-savings advice. Considering that these audits were commissioned by owners or residents, we are aware of the fact that the EAP-databases do not contain a representative sample of the actual housing stock. However, the data from the EAP-databases are of use to derive average geometrical characteristics for both the various typical and representative dwelling types and building envelope components. The geometrical characteristics in question include average roof, floor, façade, window and door surface areas, either bordering an outside environment or bordering a heated or unheated indoor space, as well as protected volume and gross floor surface area. Furthermore, the EAP data offer an insight into the average orientation of the glazed surfaces. Finally, the data allow to determine average construction and services characteristics for various building periods and dwelling types. For example, average U-values can be derived, which are primarily useful for defining the representative dwelling types characteristics intended for scenario analyses on the total housing stock.

In the upcoming years, it is expected that data originating from the mandatory **Energy Performance Certificates** issued upon sale or rental of residential buildings, will become accessible providing data on a much larger fraction of the housing stock. The EPC database is considered by researchers as a particularly valuable information source offering the opportunity to create a much more representative sample. The EPC-procedure for residential buildings is mandatory in Flanders since November 2008 when selling a dwel-

ling, and since January 2009 when putting a dwelling on the market for rent. In Flanders just over 140,000 certificates were compiled for residential units in around one year's time. At this moment in time the EPC database for Flanders is not (yet) available for scientific research. The EPC-procedure for Wallonia and Brussels has only come into force at a more recent date than in de Flemish region.

The screening for available data sources dealing with the thermal performance of the building envelope and the performance of the services systems, shows that the sources mentioned offer valuable information for constructing the building envelope and building services sub-typologies. However, the available sources do not allow to uniformly define typical constructions for roofs, floors and walls, and to assign typical installation components for the various construction periods. Clearly, it is necessary to base the sub-typologies for the typical building envelope and services components both on available external data as well as on expert judgement by VITO itself.

2.4.3 Data related to the overall energy consumption of the residential sector

→ ***Energy Balances for Flanders, Brussels and Wallonia***

The Energy Balances for the Flanders, Brussels and Walloon regions are an additional source of information dealing with the total energy consumption of, amongst others, the residential sector. VITO compiles the yearly Energy Balance for Flanders commissioned by the Flemish government [AERN 2008]. The Energy Balance is made available via the EMIS VITO web platform[3]. The Flemish Energy Balance is one of the foundation stones for compiling the Flemish contribution to the Belgian greenhouse gas inventory, which is being internationally reported as part of the Kyoto protocol. The balances for the Walloon Region and the Brussels Capital Region are independently calculated by ICEDD [ICED 2008] [ICED 2007].

The energy balances are intended to monitor the evolution of the gross energy consumption of the main sectors and end users, offering a clear inventory of the energy flows for a particular region in a particular year. The most commonly used format to highlight energy flows and energy data in a particular area is a balance that lists all flows per energy carrier (stocks, productions, import, export, consumption). VITO's long-established energy balances expertise is used within and outside the framework of this particular study in the development of the representative model for the Belgian housing stock. Following an iterative process, the housing stock model is refined until correspondence is reached with the energy flow within the energy balances.

[3] www.emis.vito.be

2.5 Similar studies carried out in Belgium

An inventory of previous studies and research programmes reveals that there currently is no generally accepted or referable Belgian building typology for residential buildings, nor for other types of buildings, which can be used for purposes like energy advice or scenario analyses. One of the reasons for this lies in the fact that Belgium is a federal state which consists of three political entities, i.e. the Flemish, the Walloon and the capital region of Brussels. Since energy in buildings is a regional authority, Belgium also has more or less 3 different ways of policymaking (e.g. implementation of the EPBD). The consequence is that there are only few data sources at the Belgian level and there is most often no consistency between surveys carried out and databases available for the different regions. This evidently impedes the development of housing typology at the Belgian level. Another issue explaining the lack of a Belgian typology, lies in the fact that research projects are often commissioned by one of the regions, which implies focus on the regional level rather than on Belgium as a whole.

However, the inventory reveals several research projects where reference buildings and building typologies were derived. Too often unfortunately, the application or usability of those typical buildings doesn't go much further than the initial project scope. Usually these typical buildings are based on the few common data sources available and thus in fact the same work is repeated over and over again. The following paragraphs take a closer look at the main studies and research projects making use of building typologies carried out in Belgium the past. This overview provides valuable insights in both the development and application uses for building typologies for the Flemish, Brussels, Walloon or Belgian context. We will examine the methodology used for determining dwelling types and for selecting the building envelope and services characteristics. Again, we make a distinction between two different identifiable approaches:

- **The representative dwelling types approach** involves modelling a set of fictional buildings based on average values. This set of fictional buildings is used to model the entire building stock. The established parameters are then iteratively adjusted to correspond to energy consumption for the total building stock known e.g. from energy balances.
- **The typical dwellings approach** involves composing a set of typical dwellings closely related to existing buildings and existing building components, chosen for their reference value compared to the examined stock. Considering that actual buildings and building characteristics are used as a basis, it is possible to examine the impact of various saving measures on a specific individual dwelling type.

For some of the studies discussed below, it is clear that a distinct choice was made to adhere to one of the two paths described above. In other cases, the distinction between "representative dwelling types" and "typical dwellings" has not been made and a hybrid approach has been followed. This was also the case, as we saw in paragraph 2.3, for the German building typology developed by IWU.

2.5.1 Representative Belgian housing model - Hugo Hens, KU Leuven (1990-)

The model of the Belgian housing stock which was developed by professor Hugo Hens of the Katholic University of Leuven, is used as the basis in various follow-up studies carried out between the late 1990s up to the current day. The model involves fictional buildings for scenario analyses, consistent with the above mentioned representative dwelling types approach. The main follow-up studies based on the Hens model are the Electrabel-SPE study [HENS 1997], the Isoterra study [DOOM 2008] and the SuFiQuad project [SUFI 2011].

An closer examination of the Isoterra study is possible because detailed information is available for this case. On the orginal Hens model, there is less information available. The model in the Isoterra study consists of a set of fictional square-footprinted single-family houses with 1, 2 or 3 storeys and appartment buildings with 3, 4 or 5 storeys for which the characteristics have been established on a bottom-up basis. Further division into classes takes place according to 3 different housing type (detached, semi-detached, terraced) and according to 5 classes for the floor surface area, which results in 30 types of single-family houses (3 types x 10 variants).

Variant	***Floor surface aera***	***Number of storeys***	**Frequencies**
1	*< 45 m²*	*1 storey*	*100%*
2	*45 – 64 m²*	*1 storey*	*100%*
3	*65 – 104 m²*	*1 storey*	*50%*
4		*2 storeys*	*50%*
5	*105 – 124 m²*	*1 storey*	*33%*
6		*2 storeys*	*33%*
7		*3 storeys*	*33%*
8	*> 125 m²*	*1 storey*	*33%*
9		*2 storeys*	*33%*
10		*3 storeys*	*33%*

Table 3: Different variants for single-family houses in the Isoterra study (Source: 3E/Provinciale Hogeschool Limburg)

In addition, a set of 15 different types of fictional apartments is defined (3 apartment types x 5 variants). Once again, simple volumes and a square-footprinted layouts are used. These fictional apartments are then combined to flat blocks with 3, 4 or 5 storeys, in a ratio of 20%, 30% and 50% respectively. Due to this division, 100 flat blocks contain a total of 430 apartments. Of these, 100 are rooftop apartments, 100 ground floor apartments and 230 are apartments located on the storeys in between. Overall, for apartments, this provides the distribution shown in the table below.

Variant	***Living surface***	***Type***	**Division**
1	*< 45 m²*	*Ground floor*	*23%*
2		*Middle storey*	*54%*
3		*Rooftop*	*23%*
4	*45 – 64 m²*	*Ground floor*	*23%*
5		*Middle storey*	*54%*
6		*Rooftop*	*23%*
7	*65 – 104 m²*	*Ground floor*	*23%*
8		*Middle storey*	*54%*
9		*Rooftop*	*23%*
10	*105 – 124 m²*	*Ground floor*	*23%*
11		*Middle storey*	*54%*
12		*Rooftop*	*23%*

13	*> 125 m²*	*Ground floor*	*23%*
14		*Middle storey*	*54%*
15		*Rooftop*	*23%*

Table 4: Different apartment types for collective residential buildings in the Isoterra study (Source: 3E/Provinciale Hogeschool Limburg)

The share of the various types within the different age classes (<1945; 1946–1970; 1971–1980; 1981–1990; 1991–2000; 2001–2005) is derived from the NIS statistics. Thereafter, the average building envelope and services components characteristics (average U-values, average air tightness, average efficiency of the heating system,…) are established for each age class.

The method described above results in a model containing 960 representative dwelling types. The energy consumption of the 960 representative dwelling types multiplied by the frequencies for each type, represents the total energy consumption for building operations for the Belgian housing stock. The bottom-up model is then refined and adjusted, to match with the energy consumption and CO_2-emissions from the Energy Balances of the Flanders, Wallonia and the Brussels Capital Region.

The Isoterra study provides an estimate of the savings potential in CO_2-emissions related to the energy consumption for heating, hot tap-water and electricity consumption of the Belgian housing patrimony. Three reference years were chosen for which the CO_2 emissions were calculated: 1990, 2000 and 2005. This is followed by an examination of the savings potential of various energy-saving measures for the period 2006-2020. It is clear from the description provided above that the Hens model consists of a set of fictional dwelling types with accompanying fictional building characteristics determined on the basis of average values.

2.5.2 Flemish model for energy consumption of households – VITO (2003-)

On the regional level, the Flemish model for energy consumption of households is an extensive calculation model used for energy prognosis for space heating and domestic hot water consumption [BRIFF 2010]. The model was initially developed by VITO for the Flemish government in 2003 and recently updated with new data and specifications in 2009. The model contains a characterisation of the Flemish dwelling stock as in 2006 and is used for prognosis up to 2020. The model is used in policy-supporting research to examine the impact of various energy policy scenarios up to 2020 on the household energy consumption, and the related CO2-emissions, for space heating and domestic hot water. The model therefore serves as a poliy-support instrument in defining future paths for tightening energy-efficiency legislations and for defining measures for the Energy Renovation Programme ERP2020. The impact of the energy policy measures is addressed in detail, which involves insights per housing category and per measure.

The *General Socio-economic Survey* of 2001 [VANN 2007] is used as a starting point for the development of a model of the Flemish housing stock for the year 2001, with houses being assigned into categories based on data available in the census. In a second step, the model is adapted to account for the housing stock evolution from 2001 onto 2006. This involves modelling demolitions that have taken place, additional housing added between 2001 and 2006, and various renovation measures undertaken in that period, e.g. changes in fuel, boiler replacements, insulation measures,… In a third step, new houses built after 2006 –the year the Energy Performance of Buildings Regulation was introduced in Flanders- are added to the housing model. Subsequently, the impact of various

scenarios for renovation and demolition of existing houses, as well as for additional new-build houses up to 2020 are examined.

The Flemish model for energy consumption of households is an abstract calculation model, consisting of large data tables with average values. Due to the numerous sub-divisions and the high level of detail, leading to up to more than 200 dwelling variations, it is not directly transferable into a typology. Due to the fact that the model is reprentative for the entire Flemish building stock, is does not permit to focus on savings potentials and costs-benefits for individual dwelling types. The Belgian Socio-economic survey from 2001 [VANN 2007] is the main data source which is further completed with data from the Flemish Energy Balance [AERN 2008] and the energy advice procedure database [CYX 2009]. Recent research at VITO, undertaken partly within the TABULA project, involves the expansion of the model from its original focus on Flanders, to a model for the entire Belgian housing stock. More details on these developments is given in Chapter 5.

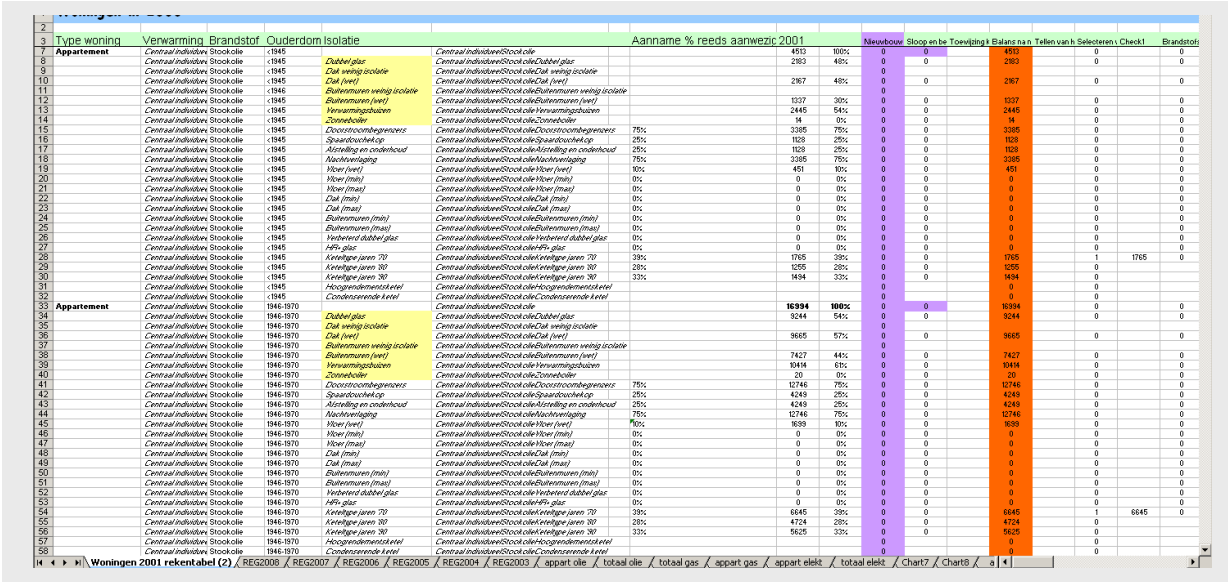


Table 5: Printscreen of the Flemish calculation model for energy consumption in households (Source: VITO)

2.5.3 Energy savings – complete report. How to save 30% on construction and renovation without paying more money - 3E and KU Leuven (2006)

Under assignment from the Brussels Institute for Environment Management (IBGE/BIM), 3E and the KU Leuven performed a study into the technical-economic feasibility of energy-savings measures for buildings in the Brussels capital region [DECO 2006]. By analysing possible energy-saving investments, a level of potential reduction in energy consumption with economical feasibility was determined for several building types. New-build and renovation scenarios were examined, for typical residential as well as non-residential buildings. The part of the study focusing on residential buildings examined 4 cases: a typical new-build terraced house, a renovation of a manor house and a small and a large apartment building. The study first and foremost was commissioned for providing policy-support, allowing IBGE/BIM to establish minimum energy-efficiency requirements that could be imposed for various building types. Alternatively, the study also offers a practical insight into the best order in which to undertake energy upgrading measures in order to realise maximum energy-savings with minimum investment costs.

The research team makes the distinction, somewhat parallel to the approach proposed by VITO as outlined above, between a bottom up and top down approach. The bottom up approach implies choosing existing buildings as reference cases of further study based on their relevance compared to a fraction of the entire housing stock. The top down approach involves building fictious dwelling types based on average values derived for a fraction of the housing stock. Examining the underlying methodology that was followed for the study of the residential buildings reveals that, on the basis of an analysis of statistical data for the Brussels Capital Region, various characteristics were derived, considered typical for the various building types. In a subsequent selection process actual buildings were selected as reference cases because of their close correspondence to these typical characteristics. For these actual buildings the optimization for maximum energy-savings with minimum investment costs was carried out via pareto front analyses. The main data sources upon which the study is based are the NIS statistics, the Housing census of 1991, the General Socio-economic Survey of 2001, Iristat statistics for the Brussels Capital Region and Statistics from the Land Registry.

2.5.4 The application of the passive house principles in the Brussels Capital Region - CERAA (2008)

The objective of this study carried out by CERAA and commissioned by the Brussels capital government, IRSIB and IBGE/BIM, is to evaluate the potential of the passive housing principles for new building and renovation of buildings in the Brussels Capital Region [THIE 2008]. The study first and foremost aimed to develop a building typology and a projection for the future evolution of the Brussels building stock. For the residential stock, 9 existing residential buildings were withheld for further analysis. These buildings were chosen for their reference value within the Brussels residential building stock and are claimed to allow evaluting the potential of the passive housing principles at the level of the entire Brussels housing patrimony. Main data sources are the Sitex statistics, the Brussels Capital Energy Balance, data derived from the 410 buildings studied within the défi-énergie and from 62 energy audits by the Brussels Energy Agency (ABEA).

AGE :		≤ 1918	1919-1944	1945-1970	1971-1980	1981-1990	1991-2000(1)	2001-2006	En 2007
CONFIGURATIONS :	Maisons 2F	28.938 log. - Maison bourgeoise de 1914	47.854 log. - Maison de 1939 - Maison du LOGIS de 1933	30.126 log.	1.940 log.	1.777 log. - Maison de 1989	944 log.	570 log.	112.149 log.
	Maisons 3F	3.735 log.	6.176 log.	10.593 log.	1.104 log.	930 log.	557 log.	329 log.	23.424 log.
	Maisons 4F	5.646	9.337	8.655	1.301	956	557	257	26.709
	Appartements	34.721 log.	57.416 log. - Immeuble social Cité Moderne - Immeuble collectif Comte de Flandre	124.087 log. - Résidence Plasky de standing moyen - Immeuble Villa Ganshoren	47.041 log.	12.476 log.	22.162 log.	13.033 log. - Résidence Brew-Loft dans une Ancienne brasserie	310.936 log.
Totaux		73.040 log.	120.783 log.	173.461 log.	51.386 log.	16.139 log.	24.220 log.	14.189 log.	473.218 log.

Figure 10: Distribution of the Brussels housing stock according to 8 age classes and 4 housing types (Source: CERAA)

The Brussels Capital Region has in recent years developed the BatEx programme (i.e. Batiments Exemplaires) stimulating and subsidizing demonstration projects compliant with verly low energy and passive house principles. *Figure 11*, stemming from the CERAA study, compares the annual energy consumption for space heating for the 9 residential

buildings withheld as typical residential buildings with values achieved in the BatEx residential demonstration projects.

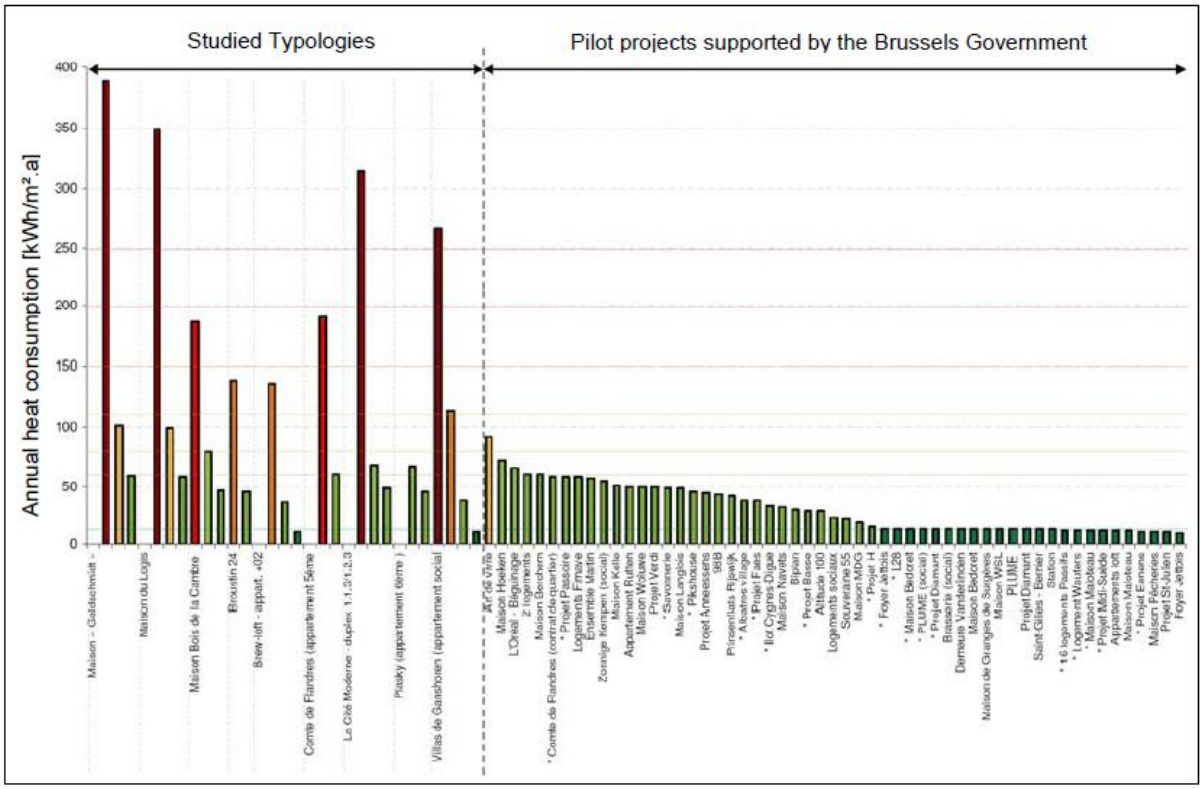


Figure 11: Energy consumption for space heating in BatEx d*emonstration projects compared with 9 actual residential buildings selected as typical for the residential housing stock in the Brussels Capital Region (Source: CERAA)*

2.5.5 La rénovation énergétique et durable des logements wallons and Low Energy Housing Retrofit - UCL (2008-)

The study *"La rénovation énergétique et durable des logements wallons. Analyse du bâti existant et mise en évidence de typologies de logements prioritaires"* [KINT 2008] was carried out by the Architecture and Climate research cel of the Université Catholique de Louvain and has a specific focus on the Walloon building stock. The study was co-funded by the Walloon government and is related to the activities of the UCL within the IEA SHC Task 37 and with the Belspo-funded LEHR project (Low Energy Housing Retrofit. BBRI, UCL, PHP; 2007-2009) [HILD 2010].

The study addresses the basic properties of the Walloon housing stock (dwelling types, surface areas, construction years, frequencies, etc.) and various parameters related to the housing quality. The study moreover defines typical building envelope constructions for the Walloon Region for various historical construction periods. Based on these elements, 8 typical dwelling types are defined for which the main characteristics and their respective shares within the entire Walloon housing stock have been identified. There was only few information available on the methodology used to select these 8 typical dwellings.

In a subtask report of the LEHR project an analysis of the existing Walloon building stock is made emphasising the most urgent building types with respect to the energy saving potential. Important data sources for both studies by UCL discussed above were the General Socio-economic survey from 2001 [VANN 2007], the Walloon energy balance [ICED 2007] and a survey the survey about the housing conditions in Wallonia stemming from 2006-2007 [RW 2007].

Figure 12: Overview of the 8 typicaldwelling types defined in the study "La rénovation énergétique et durable des logements wallons" for the Walloon region (Source: UCL)

2.5.6 SuFiQuad - Sustainability, Financial and Quality evaluation of Dwelling Types – KU Leuven, VITO and BBRI (2007-2011)

During the course of the SuFiQuaD project, a BELSPO-funded joint project by KU Leuven, VITO and BBRI, one of the tasks consisted also in deriving a Belgian housing typology. The acronym stands for Sustainability, Financial and Quality evaluation of Dwelling Types [SUFI 2011]. Within the course of the project an integrated assessment method was developed to evaluate both the life cycle environmental impacts, life cycle financial costs and quality aspects for different dwelling types in Belgium. The SuFiQuad calculation model allows optimization of the life cycle environmental and financial costs for different dwelling types and for various possible construction materials and technical services systems that can be applied in a building.

The underlying SuFiQuad building typology makes a distinction between 4 categories of housing types, namely freestanding, semi-detached, terraced houses and flats. Secondly, 4 age classes or construction periods were defined, respectively corresponding to the periods pre 1946, 1946-1970, 1971-1990 and 1990-2007. This results in a typology with 16 dwellings types. A distribution of these dwellings types adding up to a representation of the total housing stock in Belgium is given in *Table 6* below. At the main matrix level,

no differentiation is made between the Flanders, Walloon Region and Brussels Capital Region. At a lower level and for certain characteristics, e.g. when determining floor areas for the building types, a differentiation between the various regions was made.

BELGIUM	freestanding			semi-detached			terraced			flats		
<1945	5,95%	20,29%	269.771	8,26%	41,56%	375.000	16,90%	66,12%	766.884	6,86%	27,15%	311.066
1946-1970	6,82%	23,26%	309.263	6,08%	30,57%	275.838	5,35%	20,95%	242.952	6,32%	25,03%	286.826
1971-1990	9,84%	33,58%	446.481	3,48%	17,52%	158.123	1,93%	7,56%	87.706	4,96%	19,65%	225.136
1991-2007	6,70%	22,87%	304.057	2,06%	10,35%	93.345	1,37%	5,37%	62.307	7,12%	28,18%	322.897
total	29,30%	100%	1.329.572	19,88%	100%	902.306	25,56%	100%	1.159.849	25,25%	100%	1.145.925
FLANDERS	**freestanding**			**semi-detached**			**terraced**			**flats**		
<1945	4,76%	14,75%	125.772	5,58%	27,33%	147.381	13,97%	57,50%	368.916	4,27%	18,55%	112.769
1945-1970	8,19%	25,38%	216.419	7,54%	36,94%	199.174	6,18%	25,46%	163.328	5,57%	24,21%	147.202
1971-1990	11,42%	35,38%	301.722	4,50%	22,03%	118.810	2,48%	10,20%	65.452	4,68%	20,33%	123.631
1990-2007	7,90%	24,49%	208.790	2,79%	13,69%	73.827	1,66%	6,84%	43.858	8,50%	36,92%	224.471
total	32,28%	100,00%	852.703	20,41%	100%	539.192	24,29%	100%	641.554	23,02%	100%	608.074
WALLOON REG.	**freestanding**			**semi-detached**			**terraced**			**flats**		
<1945	9,60%	35,23%	142.105	14,96%	60,81%	221.483	21,14%	68,03%	313.027	6,65%	38,94%	98.524
1945-1970	6,10%	22,38%	90.267	4,69%	19,09%	69.517	3,99%	12,84%	59.075	3,49%	20,40%	51.614
1971-1990	7,83%	28,75%	115.961	3,05%	12,38%	45.103	2,89%	9,31%	42.850	2,90%	17,00%	43.006
1990-2007	3,71%	13,63%	54.991	1,90%	7,72%	28.123	3,05%	9,81%	45.150	4,04%	23,67%	59.886
total	27,24%	100%	403.325	24,60%	100%	364.226	31,07%	100%	460.102	17,09%	100%	253.030
BCR	**freestanding**			**semi-detached**			**terraced**			**flats**		
<1945	0,45%	33,18%	1.894	1,46%	39,97%	6.136	20,27%	77,52%	84.941	27,12%	39,41%	113.636
1946-1970	0,62%	45,15%	2.577	1,71%	46,56%	7.147	4,90%	18,75%	20.549	24,27%	35,27%	101.699
1971-1990	0,18%	13,23%	755	0,27%	7,46%	1.146	0,48%	1,83%	2.000	9,41%	13,67%	39.409
1991-2007	0,11%	8,44%	482	0,22%	6,00%	921	0,50%	1,90%	2.077	8,03%	11,66%	33.627
total	1,36%	100%	5.708	3,66%	100%	15.350	26,15%	100%	109.567	68,82%	100%	288.370

Table 6: 16 representative dwellings and their respective distribution within the total Belgian housing stock from the SuFiQuad project (Source: KUL, VITO and BBRI)

During the SuFiQuaD project also, a valuable classification of building services components for heating, domestic hot water and ventilation for the various housing types and age classes was derived. The construction element characteristics originate from the representative Belgian housing model developed by Hugo Hens discussed in 2.5.1. Only the main thermal characteristics are specified for the various building age classes. There are no details provided on building element compositions and construction methods typical for the various construction periods. An overview of the general characterstics (respectively floor surface areas and number of storeys) and the U-values of the construction elements (respectively floor, facade, roof, window) for the dwelling types is offered in *Table 7*.

Algemene parameters						Bouwfysische parameters			
Bouwperiode	type bebouwing	Opp Vloer Verwarmd		Aantal bouwlagen		U Vloer boven kruipruimte	U Gevel	U Dak	U Raam
		VL- WALL	Brussel	VL- WALL	Brussel				
		m²	m2			W/m²K	W/m²K	W/m²K	W/m²K
<1945	open bebouwing	137	137	1	2 à 3	1,33	2	1,6	4,6
1946-1970	open bebouwing	134	134	1	2 à 3	1,33	1,5	1,6	4,6
1971-1980	open bebouwing	136	136	1	2 à 3	1,33	1,5	0,6	2,92
1981-1990	open bebouwing	138	138	1	2 à 3	1	0,75	0,6	2,92
1991-2007	open bebouwing	140	140	1	2 à 3	0,67	0,7	0,5	1,86
<1945	halfopen bebouwing	137	84,5	2 à 3	2 à 3	1,33	2	1,6	4,6
1946-1970	halfopen bebouwing	134	84,5	2 à 3	2 à 3	1,33	1,5	1,6	4,6
1971-1990	halfopen bebouwing	136	84,5	2 à 3	2 à 3	1,33	1,5	0,6	2,92
1981-1990	halfopen bebouwing	138	84,5	2 à 3	2 à 3	1	0,75	0,6	2,92
1991-2007	halfopen bebouwing	140	84,5	2 à 3	2 à 3	0,67	0,7	0,5	1,86
<1945	rijwoning	84,5	84,5	2 à 3	2 à 3	1,33	2	1,6	4,6
1946-1970	rijwoning	84,5	84,5	2 à 3	2 à 3	1,33	1,5	1,6	4,6
1971-1990	rijwoning	84,5	84,5	2 à 3	2 à 3	1,33	1,5	0,6	2,92
1981-1990	rijwoning	84,5	84,5	2 à 3	2 à 3	1	0,75	0,6	2,92
1991-2007	rijwoning	84,5	84,5	2 à 3	2 à 3	0,67	0,7	0,5	1,86
<1945	appartement	?	?	?	?	1,33	2	1,6	4,6
1946-1970	appartement	?	?	?	?	1,33	1,5	1,6	4,6
1971-1990	appartement	?	?	?	?	1,33	1,5	0,6	2,92
1981-1990	appartement	?	?	?	?	1	0,75	0,6	2,92
1991-2007	appartement	?	?	?	?	0,67	0,7	0,5	1,86

Table 7: SuFiQuaD overview typical buildings with corresponding geometrical properties and U-values (Source: KUL, VITO and BBRI)

In addition to the afore-mentioned studies, we can also mention, for information purposes, the research activities on modeling the Flemish housing stock undertaken at the Antwerp University by the STEM research group, although they are not further addressed in this report.

2.5.7 Conclusions

→ ***Distinction between representative and typical approach***

The examination undertaken in this chapter reveals a clear distinction in certain studies between an approach defining typical dwellings, contrary to an approach constructing a representative model of the housing stock. It is clear that a representative model such as the Hens model discussed in 2.5.1 is not intended for analysis of individual housing types and does not intend to deliver a set of dwellings serving as a reference for comparison with actual dwellings. On the other hand, the German building typology discussed in 2.3, is intented both as a set of typical dwellings and also serves as a representative model for the entire housing stock. In this case, the distinction outlined above is not valid. VITO has been involved in various studies on housing typologies e.g. the Flemish model for energy consumption of households and the SuFiQuad projcect (see paragraphs 2.5.2 and 2.5.6). Giving our background and experiences, we have decided on a dual approach. On the one hand, VITO will deliver a set of typical dwellings (see 0) , on the other hand, the existing Flemish model for energy consumption of households will be expanded towards a Belgian model (see Chapter 5).

→ ***Distinction between Flanders, Brussels and Walloon region. Developing one typology for Belgium or 3 typologies, one for each region?***

Giving the knowledge that certain regional differences in construction methods and dwelling types exists, it would be preferable to develop 3 regional typologies of typical dwellings. For the representative model, the regional difference are considered to be of less importance. However, to be able to construct regional typologies, more data and knowledge should be available, both from surveys undertaken in all 3 regions and via preliminary research on dwelling types, constructions methods and thermal performancre undetaken for all 3 regions. This research field is for now, to a large extend unexplored territory. VITO has a broad knowledge on the Flemish housing context. In addition, the studies performed by 3E/KUL, CERAA and the UCL offer important information and insights into the housing stock and typical housing in Brussels and Wallonia. These studies, as discussed in 2.5.3, 2.5.4 and 2.5.5, however cannot serve as a basis for developing regional typical dwelling sets because consistency between approaches is very low. Consequently, both for the typical dwellings, as for the representative housing stock model, one Belgian typology is delivered, instead of 3 regional typologies. It is also worth mentioning that VITO has not found precedents at Belgian level for compiling a set of typical dwellings.

→ ***Data sources summary***

Evaluation of the various studies and available data demonstrates that sufficient data sources are available for the general building characteristics. This data includes data from the NIS, the Land Registry and the General Socio-economic survey of 2001. We have also noticed that the various studies discussed in this chapter consistently rely on these

specific sources. For the geometric characteristics of the building and building envelope, the best available data sources are the EAP databases for Flanders and Wallonia. For modelling the construction and thermal performance of the building envelope components per particular housing type, we rely on the limited sources that are available, in addition to our own expert judgement concerning construction methods in various construction periods. The available data sources are the SENVIVV study, the EPC default values and the EAP databases. Further, the maximum U values in the Flemish Insulation Decree ('92) and the EPB regulations (2006) serve as a reference. The study *"La rénovation énergétique et durable des logements wallons"* [KINT 2008] provides additional relevant information for the Walloon context. The energy systems for the various housing types are modelled in accordance with the EPC calculation method for technical installations for spatial heating and hot water preparation in Flanders. This method was, as mentioned above, developed by VITO under assignment from VEA.

The KU Leuven model for the Belgian housing stock (Hugo Hens) acts as the basis and is further developed in various relevant studies for scenario analysis at Belgian level. In recent years, VITO has developed a more refined and up-to-date model of the Flemish housing stock, primarily commissioned by the Flemish Energy Agency. Within the TABULA project, this model is extended to include data from the Brussels and Walloon regions, whereby creating a model of the Belgian housing stock.

Chapter 3 PRESETS FOR THE EUROPEAN HARMONISED TABULA TYPOLOGY

In this chapter, we will discuss the presets, i.e. the conventions and approach as agreed between the TABULA project partners for the development of the European harmonized typology. The German building typology database and calculation files developed by IWU and discussed in chapter 2.3 have been used as a basis for the TABULA typology. For the Belgian case, both data sets for typical dwellings and for representative dwelling types will be defined and uploaded to the European typology database. The development of these Belgian data sets will be discussed in 0 and Chapter 5.

The aim of discussing the harmonised TABULA typology in this chapter is to gain an insight into the logic behind the typology structure and calculation methods. Secondly we examine what Belgian data will eventually have to be supplied for insertion in the harmonised European typology.

3.1 The TABULA approach to a housing typology

The housing typology consists of a number of main components, i.e.

- the main matrix of the typology;
- the sub-typologies for the building envelope and services systems;
- the dwelling fiches.

The main matrix and the sub-typology matrices are to be filled with the basic data for the typology and for its dwelling types. The calculation methodology is another essential component. The following diagram shows the components and how they interact with one another:

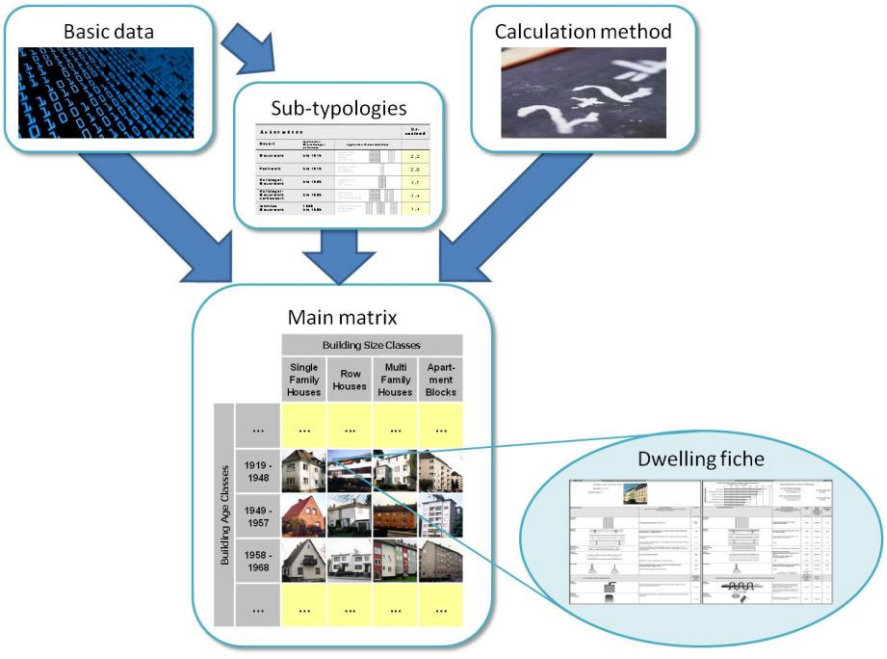


Figure 13: Overview of main components of the TABULA housing typology

3.1.1 Main matrix

The main matrix offers an overview of the dwelling types included in the housing typology. The main matrix can be regarded as the central nervous system of the typology. All dwelling types are bundled in this structure in accordance with a layout and classification matrix that is common for all partners. The dwelling types are characterised by a number of parameters that are not immediately visible in the main matrix.

The matrix contains the following **matrix axes**:

- Construction period or age class;
- Housing type;
- It is also possible to define regional variations.

A **matrix cell** of the main matrix shows the following details:

- Unique code of the cell;
- Picture(s) representing the dwelling type;
- Frequency, i.e. fraction reflecting the presence of the dwelling type compared to the entire housing stock;
- Total building envelope surface area;
- Total energy consumption for space heating and hot water consumption;

3.1.2 Sub-typologies

Two types of sub-typologies are defined in the context of the TABULA-project, i.e. firstly for construction elements and secondly for the services systems. A sub-typology provides a historical overview of construction techniques and common services systems for the various age classes and includes the component's characteristics related to the thermal and energetic performance. The renovation measures for 2 energy upgrading scenarios (basic and advanced energy upgrade) are also included in the sub-typologies. A sub-typology contains, so to speak, the building blocks used to construct a dwelling type.

- The **sub-typology for construction elements** describes the historical evolution of the constituent elements and the thermal performance of the various building envelope fractions (roof, floor, façade, windows and doors). Possible renovation measures for the building envelope components include installment of insulation or replacement of single with double glazing. Renovation measures for the building envelope in other words can involve both renovation/adaption or replacement of a building envelope component.
- The **sub-typology for services systems** has a similar structure, describing the historical evolution of the system components used for spatial heating and for sanitary hot water and specifying the energy performance characteristics. Contrary to the construction elements, renovation measures only involve replacement of an existing component with a more recent system variant or additions to an existing heating or hot water system e.g. installment of solar thermal panels.

3.1.3 Dwelling fiches

An overview of the charachteristics and detailed calculation results for the individual dwelling types are displayed in the dwelling fiches. A dwelling type is defined for each relevant combination of a particular construction period and a particular housing type (detached, semi-detached, terraced, flat). A dwelling fiche should allow readers to make the link between an actual house and the corresponding dwelling type and relate the dwelling type information to the actual situation.

The dwelling fiches contain:

- Picture(s) representing the dwelling type;
- General characteristics (construction period, location, housing type, description of the dwelling type);
- Geometric characteristics;
    - Floor surface area;
    - Protected volume;
    - Surfaces areas of building envelope;
- Characteristics of the construction elements;
- Characteristics of the services systems for space heating and hot water production;
- Proposed energy-saving measures for the standard and advanced energy upgrade scenarios;
- Calculated results in terms of energy consumption and cost-benefits.

Note that the concept of dwelling fiches is mainly relevant for typical dwellings closely corresponding to actual as-build situations, rather than to dwelling types based on average values.

3.2 The TABULA Excel workbook

3.2.1 Structure of the workbook

Currently the harmonised typology database and calculation engine consists of an Excel workbook. This workbook will form the basis for a more broadly available TABULA web application to be developed later on. The TABULA Excel is intended for internal use amongst partners and will allow detailed analyses of various existing building types and renovation scenarios. The Excel workbook first of all functions as a **database** for collecting typological data from all partipacting countries. It furthermore performs an **energy balance calculation** for space heating and domestic hot water consumption, determining on the one hand the net energy demand for space heating and, on the other hand, the delivered energy, primary energy consumption, non-renewable primary energy consumption, carbon dioxide emissions and energy costs for space heating and hot water production. Thirdly, the workbook has **operational modules** for verifying completeness and validity of the input data delivered and it serves as a data source for the future development of the TABULA web tool.

The figure below provides an overview of the tab sheets in the TABULA Excel, used for inputting the national data, respectively for the building envelope, heating system and domestic hot water system. The Belgian data on housing types, construction periods, building sizes, frequencies, relevant characteristics of the building envelope and the services systems for heating and hot water production, are entered into the corresponding tables. The calculation results are presented in the **Calc.Demo.Refurbish**, **Calc.Demo.Building** and **Calc.Demo.System** tabs respectively dealing with transmission losses (e.g.U values) for the original and refurbished building envelope, with net energy demand for space heating and with primary energy consumption, carbon dioxide emissions and energy costs both for space heating and hot water production.

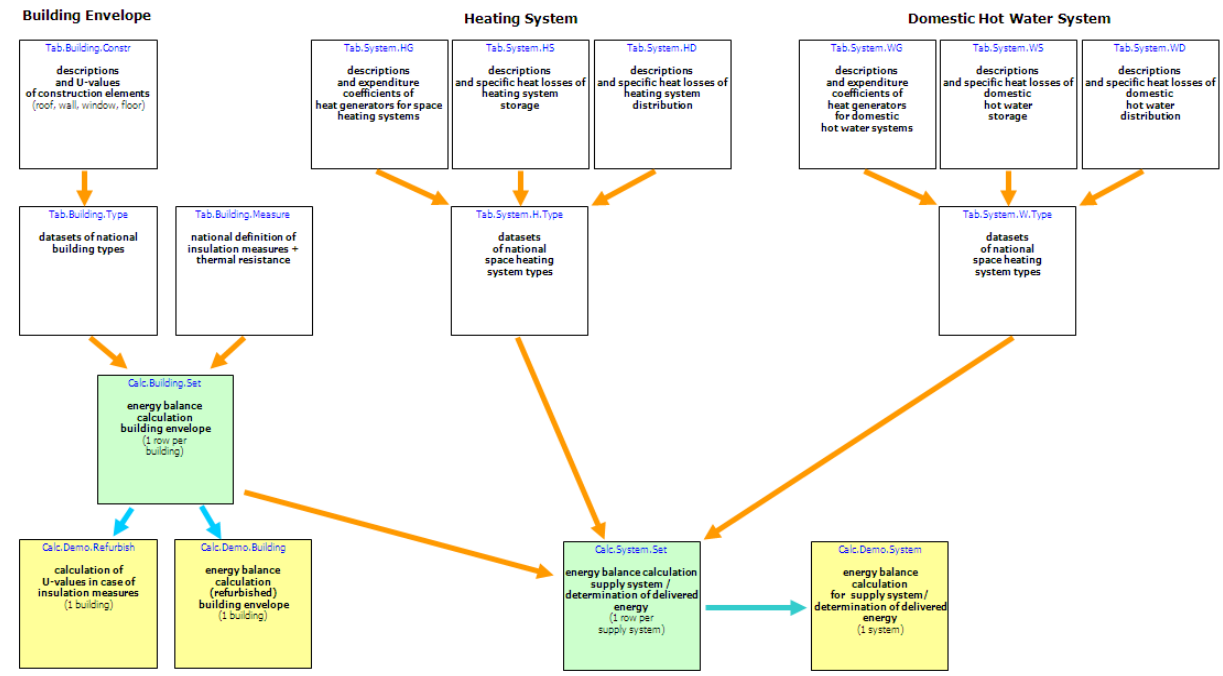


Figure 14: Tab sheets for national data input in the TABULA Excel workbook (Source: IWU)

3.2.2 Calculation methodology

The energy balances before and after renovation are calculated using a harmonized calculation method developed by the TABULA lead partner, IWU. The calculation module performs a stationary energy balance calculation consistent with relevant CEN norms whilst allowing the specification of default values e.g. for climatic parameters at the national or regional level. The European harmonized calculation methodlogy is a continuation of the work performed within the IEE project DATAMINE.

The level of detail of the calculation methodology is determined by a number of factors. On the one hand, it is of vital importance to take into account differences in approach between various European countries to guarantee the relevance of the calcuatlion method. On the other hand, attempts have been made to define a simple calculation method to ensure a practical and workable approach.

In the following chapters we will discuss the development of the data sets for both the typical and representative dwelling types for the Belgian typology.

Chapter 4 THE TYPICAL DWELLINGS

4.1 Introduction

4.1.1 What can we learn from typical dwellings?

In this chapter we will develop the typology for typical dwellings for the national typology brochure and for the harmonized EU typology. Key questions we aim to answer by performing energy balance calculations on typical dwellings are the following: Can we distinguish dwelling types that need to be addressed with higher priority because of the high energy consumption related to these specific dwelling types? What key conclusions can be drawn in terms of variations in savings potentials and cost-benefit analyses for various typical dwellings? Which energy upgrade renovation measures are to be recommended, are they constant for all dwelling types and what are the practical impediments to overcome when implementing these measures?

4.1.2 Difference EU harmonized approach versus national brochure

There are some important differences between the harmonized approach and the methodology followed at the national level.

- **Object under study: apartment blocks versus individual flats**
  In Belgium, the energy performance of dwellings is determined at the housing unit level. Calculations are performed at the level of the individual flat, rather than at the apartment block level. For the EU harmonized typology however, the apartment block is the object under study. This distinction between the national an EU approach will be reflected in the main matrix of the typologies. Naturally, for individual dwellings the difference in approach is of no importance.

- **Calculation methodology: Flemish EPW versus harmonized EU methodology**
  The calculations for the national brochure follow the local EPBD calculation methdology rather than the harmonized EU methodology. This allows us to refer to the building regulation energy requirements in place in Belgium (expressed in an E-level for new build and an EPC-score for existing buildings). There are various calculation methdologies in place in Belgium, e.g. already three different approaches for EPBD calculations for new buildings for the Flemish, Brussels and Walloon region. For compiling the national brochure, the Flemish EPW-methodology for new build dwellings is followed.

- **Extra information in national brochure e.g. on cost-benefits, including correction to reflect actual energy consumption**
  The national brochure contains a financial assessment of the suggested energy savings measures, defining investment costs and annual cost savings due to a lower energy consumption per dwelling type. In order to perform a realistic cost-benefit analysis, it is necessary to define a correction factor for the translation from theoretical energy consumption (e.g. assuming an 18° interior temperature for the entirety of the building) towards a more accurate estimate of real energy consumption.

4.1.3 Defining the typical dwellings

The literature study revealed differences in approaches for defining typologies for typical dwellings on the one hand, and for representative dwellings for a housing stock model on the other hand. Although, in quite a few cases, there is no distinction found and typologies are considered both to be containing "typical dwellings" and representative for the entire housing stock. When looking at the cases where a clear distinction is in fact made, we can notice that defining typical dwellings is not an easy task. How are we to define what people in general consider to be typical? Recalling the definition we provided in Chapter 2, a **typical dwellings approach** involves *composing a set of typical dwellings closely related to existing buildings and existing building components, chosen for their reference value compared to the examined stock.*

In the studies examined in Chapter 2 defining typical dwellings (see paragraphs 2.5.3 and 2.5.4), is done by selecting actual buildings closely corresponding with what is consider to be typical. The characteristics under study are then the actual building characteristics. As outlined below, we will however follow a different approach when defining the typical TABULA dwellings.

4.1.4 Chapter 4 outline

In this chapter, we will first and foremost discuss the input data feeding into the typology for the typical dwellings. Secondly, the financial assessment for the typical dwellings will be discussed. Lastly, we will present the national brochure and aim to draw general conclusions and discuss some main tendencies revealed by the typological analyses.

- **Input data for the dwelling types**
  - Main matrix – age classes and housing types
  - Geometrical data for the typical dwellings and building envelope components
  - Sub-typologies for construction elements (current and renovated state)
  - Sub-typologies for services systems (current and renovated state)
- **Correction factor for actual energy consumption**
- **The national brochure**
  - General layout
  - Financial assessment
- **Key conclusions and main tendencies**

4.2 Input data for the dwelling types

4.2.1 Main matrix – age classes and housing types

→ ***EU harmonized typology***

The main typology matrix provides the overview of the number and the defining characteristics of the typical dwellings. For the harmonised European typology, VITO has identified **29 typical dwellings** for the Belgian context, defined by the combination of **5 age classes and 6 housing types,** minus one. The age classes (pre 1946; 1946-1970; 1971-1990; 1991-2005; post 2005) are commonly used in various Belgian dwelling studies, as demonstrated in the literature study. First of all, a distinction is made between the era before and after World War II. A second key historical moment is the 1970s oil crisis, which lead to a distinguishing change in building practice. Thirdly, the 1990s

brought the first building energy regulations which were, lastly, significantly severed after 2005, at the moment of the implementation of the EPBD.

The 6 housing types defined consist of 3 single family housing types, i.e. the detached house, the semi-detached house and the terraced house. This distinction is commonly used in Belgian dwelling studies. Secondly, we have defined 3 multi-family housing types: i.e. the small apartment building (less than 4 storeys), the medium-height apartment building (between 4 and 8 storeys) and the high rise apartment building (more than 8 storyes). The pre 1946 high rise apartment building is considered irrelevant for the Belgian context, which leads to 29 typical dwellings in the EU harmonized typology (at the building level and not focusing on housing untis).

The possibility to incorporate regional diversification is mainly used in the TABULA project for countries with different climate zones. Regional variations have not been made of the Belgian case, although further division of the main matrix of the typology per region (Flemish, Brussels, Walloon) has been considered for Belgium. This would make it possible to provide variants for e.g. specific building styles that are particular to certain regions. However, do to an absence of data permitting such variants to be clearly defined, a decision was made not to adopt a region-based division.

The main division into 29 housing types determined by 5 age classes and 6 building types continues to apply to the representative housing stock model discussed in Chapter 5.

→ ***National typology and brochure***

For the national typology brochure, focus lies on housing units rather than on the building as a whole. This leads to certain changes in the typology matrix. The **5 age classes** (pre 1946; 1946-1970; 1971-1990; 1991-2005; post 2005) remain unchanged. However, for the national typology **5 housing unit types** are defined. The 3 single family housing types, i.e. the detached house, the semi-detached house and the terraced house remain valid. But, the size and height of the apartment building is not defining for the energy performance at the level of the individual apartments. A key element influencing the energy performance at the apartment level is the surface area of the building envelope. The total transmission loss area for apartments greatly depends on the location of the apartment in the building. In this study, we make a distinction between 2 apartment types, namely an enclosed and an exposed apartment. The enclosed apartment only has a front and back façade, the exposed apartment has two extra building envelope surfaces, a side façade and an exterior roof. We thus take into consideration two extremes, the results for E-level and energy consumption in the other possible variants will lie somewhere between these two extremes.

In short, for the national typology brochure, **25 typical dwelling units** are defined by the combination of 5 age classes and 5 housing unt types.

→ ***Main matrix***

Table 8 presents the main matrix of the Belgian housing typology following the harmonized TABULA approach. For the 29 typical dwellings in the matrix, a photographical representation of an actual building is included. The relation between the characteristics of the actual buildings under display and the characteristics defined for the 29 typical dwellings will be addressed in the following paragraphs.

Main matrix of the Belgian housing typology								
	Region	**Construction Year Class**	**Single Family House - Detached**	**Single Family House – Semi detached**	**Single Family House - Terraced**	**Multi-Family House - Small**	**Multi-Family House - Medium**	**Multi-Family House - Large**
1	national (Belgium)	... 1945	 BE.N.SFH.01.deta	 BE.N.TH.01.semi	 BE.N.TH.01.terr	 BE.N.MFH.01.small	 BE.N.MFH.01.medium	
6	national (Belgium)	1946 - 1970	 BE.N.SFH.02.deta	 BE.N.TH.02.semi	 BE.N.TH.02.terr	 BE.N.MFH.02.small	 BE.N.MFH.02.medium	 BE.N.MFH.02.large
12	national (Belgium)	1971 - 1990	 BE.N.SFH.03.deta	 BE.N.TH.03.semi	 BE.N.TH.03.terr	 BE.N.MFH.03.small	 BE.N.MFH.03.medium	 BE.N.MFH.03.large
18	national (Belgium)	1991 - 2005	 BE.N.SFH.04.deta	 BE.N.TH.04.semi	 BE.N.TH.04.terr	 BE.N.MFH.04.small	 BE.N.MFH.04.medium	 BE.N.MFH.04.large
24	national (Belgium)	2006 ...	 BE.N.SFH.05.deta	 BE.N.TH.05.semi	 BE.N.TH.05.terr	 BE.N.MFH.05.small	 BE.N.MFH.05.medium	 BE.N.MFH.05.large

Table 8: Main matrix of the Belgian housing typology following the harmonized TABULA approach

4.2.2 Geometrical data for the typical dwellings and building envelope components

→ ***EU harmonized typology***

The geometrical characteristics to be determined for the 29 typical dwellings are:

- Floor surface area (gross floor surface and energy reference surface area);
- Number of storeys of the building;
- Number of housing units;
- Protected volume;
- Transmission loss area of the opaque building envelope components (roof, floor, facades, doors) bordering the outdoor environment, unheated areas,... ;
- Transmission loss area and orientation (N, S, E, W) of transparent building envelope components (windows, doors) bordering the outdoor environment, unheated areas,...

For the single-family dwelling types, these parameters are derived from EAP data for Flanders and Wallonia. We discussed this data source in paragraph 2.4.2. Analysis of data from approximately 11,000 EAP audits delivers some 9,600 suitable data sets. Analyses of these data sets allows us to derive average geometrical characteristics for the 15 single-family dwelling types in the typology (3 housing types – detached, semi-detached, terraced – combined with 5 age classes). Using these average geometrical characteristics, we create fictional dwelling types, not corresponding to actual buildings. These dwelling types are however considered typical, being closely related to existing buildings and possessing a reference value, i.e. they are easily recognizable and comparable with actual houses.

Considering that the EAP databases only contain data for single-family housing, another approach was needed to establish the geometric characteristics for the multi-family houses. In order to define these characteristics for the multi-family dwelling types, we have selected 14 actual existing multi-family buildings and apartment blocks considered typical and recognizable for the housing stock within the 3 housing types (small apartment building with less than 4 storeys, medium-height apartment building with 4 to 8 storeys and high rise building with more than 8 storyes) and the 5 age classes. For the selection of actual multi-family buildings for the 3 less recent age classes (pre 1946; 1946-1970; 1971-1990), the Inventory by the Institute for Architectural Heritage (http://inventaris.vioe.be) was used as a data source. For the 2 more recent construction periods (1991-2005 and post 2005), the selection was based on a self-performed screening of residential building projects for these periods. After selecting the 14 actual multi-residential buildings, the concerned geometric characteristics could directly be derived. A list of the 14 selected multi-residential buildings can be found in Annex 1.

→ ***National typology and brochure***

To derive the geometrical characteristics for the enclosed and exposed typical apartments for the 5 age classes, yet another approach was needed. Based on the Socio-Economic Survey of 2001 [VANN 2007] and the NIS statistics, we were able to deduce that the average surface area of apartments remains fairly constant throughout the age classes defined. In other words, the geometrical characteristics do not significantly vary for these different age classes. This lead to an approach were geometrical characteristics were defined for two typical apartments, one enclosed, one exposed, valid for all

age classes. An average gross surface area of 100m² has been assumed, and a typical floor plan was selected for which the transmission loss surface area was determined both for the enclosed and for the exposed apartment type.

For the single-family dwelling types, the geometrical characteristics are derived from EAP data for Flanders and Wallonia, as outlined above for the EU harmonized approach.

4.2.3 Sub-typology of construction elements

→ ***Current state for the 5 age classes***

Within the TABULA project, sub-typologies are being defined for construction elements and energy services systems. A sub-typology for construction elements is a collection of typical construction elements (facade, roof and floor constructions, window and door types…) for which specific characteristics are specified, such as the structural composition of the element (various layers and thicknesses), the age class in which the element was frequently used, and the accompanying thermal characteristics (U-value, R-value, g-value of glazing,…). Therefore, when compiling the sub-typology for construction elements, the question we ask ourselves is: *which construction elements are typical, often encountered and recognisable for the housing stock at Belgian or regional level for the various age classes defined?*

A sub-typology is being compiled for the following construction elements;

- Roofs;
- Facades;
- Floors;
- Windows;
- Opaque doors.

The steps that must be taken to define a sub-typology are:

- Identification of typical construction elements for the various age classes;
- Determination of the thermal performance factors (U-value, R-value, g-value,…);
- Consulation of an expert panel.

The available data sources and studies that were used to compile the sub-typology have been addressed in chapter 2. In essence, various available data source were addressed, combined with our own expert judgement in case of lack of data. Of course, the sub-typology can be further refined using data/studies offering more detailed information about typical construction elements for typical housing. Currently, thermal bridges have also not been taken into account.

→ ***Renovation measures for the two energy upgrade scenarios***

The sub-typology of construction elements is also used to define renovation measures for the existing wall, roof, floor, window and door elements. Renovation measures (insulation measures, replacement of window frames or glazing,…) are determined to renovate the typical dwellings up to a typical energy upgrade level, i.e. the *EPB2010* level, on the one hand, and up to an advanced energy upgrade level, i.e. the *Low Energy* level on the other hand.

The definition of renovation and replacement measures involves the following tasks:

- Determination of the corresponding thermal performance factors (U-value, R-value, g-value,…) for the EPB 2010 and LE level;
- Defining renovation measures for the various typical roof, floor and facade structures, up to the EPB2010 and LE level;
- Defining replacement measures for the various window and door types, up to the EPB2010 and LE level.

The **EPB2010 level** is aimed at realising a package of measures that meets EPBD requirements for maximum U-values and minimum R-values for new buildings, which are currently in effect in Flanders (2010). The applicable EPBD building requirements for K-level and E-level will not necessarily be achieved with this package of measures. We have also simplified some of the legal requirements, and imposed a stricter U-value for windows bearing in mind that the current requirement does not correctly reflect building practices commonly used in 2010. Below is a summary of the U-values for the EPB2010 renovation measures:

- U facade: 0.4 W/m²K
- U floor: 0.4 W/m²K
- U roof: 0.3 W/m²K
- U window: 2 W/m²K
- U door: 2.9 W/m²K

Note that the EPB2010 upgrade measures are not applicable to the dwelling types for the age class after 2005 since these U-values are already achieved for these dwelling types.

The aim of the **Low Energy level** is to define a package of measures which are typical for low energy houses. Again, we are not aiming for a criterion at building level, for example, for the overall net energy requirement but have defined U- and R-values for the construction elements. Below is a summary of the U-values for the Low Energy renovation measures:

- U facade: 0.25 W/m²K
- U floor: 0.25 W/m²K
- U roof: 0.15 W/m²K
- U window: 1.6 W/m²K
- U door: 1.6 W/m²K

→ *In- and exfiltration rates*

Based on data stemming from various studies on air tightness of the building envelope for various construction periods [SENV 1998] [DG04], the following table with in- and exfiltration rates v50 (m³:hm²) for the various housing types and age classes was compiled. The table also displays to in- and exfiltration rate for the EPB 2010 and the Low Energy upgrade scenarios.

In/exfiltration at 50Pa [m³/h.m²]					
	Detached	**Semi-detached**	**Terraced**	**Enclosed apartment**	**Exposed apartment**
Before '71	18	18	14,9	14,9	14,9

71-'90	17,1	16,3	14,1	14,1	14,1
91-'05	12	12	10	10	10
After '05	6,1	6,3	6	6	6
EPB 2010 upgrade scenario	6	6	6	6	6
Low Energy upgrade scenario	2,5	2,5	2,5	2,5	2,5

Table 9: In/exfiltration rates at 50 Pa in m³/hm² for the various dwelling types

Table 10 displayed below presents the Belgian sub-typology for construction elements. The pictures included in the construction elements sub-typology in TABULA.xls have been derived from http://www.energieplus-lesite.be.

Sub-typology of construction elements			
Age class/State	**Facade construction elements**	**Description**	**U (W/m²K)**
Before 1946	Uninsulated massive outer wall	Uninsulated massive outer wall brick work approx. 30 cm	2,2
1946-1970	Uninsulated cavity wall	Outer brick leaf, air cavity 5 cm, inner brick leaf	1,7
1971-1990	Ventilated cavity wall - cavity wall insulation 2 cm	Outer brick leaf, ventilated air cavity with 2 cm mineral wool cavity wall insulation, inner brick leaf in perforated brick work	1
1991-2005	Ventilated cavity wall - cavity wall insulation 6 cm	Outer brick leaf, ventilated air cavity with 6 cm mineral wool cavity wall insulation, inner brick leaf in perforated brick work	0,6
After 2005	Ventilated cavity wall - cavity wal insulation 8 cm	Outer brick leaf, ventilated air cavity with 8 cm mineral wool cavity wall insulation, inner brick leaf in perforated brick work	0,4
EPB 2010	Cavity wal or exterior insulation - 8 cm	8 cm mineral wool cavity wall insulation or EPS exterior wall insulation	0,4
Low Energy	Cavity wal or exterior insulation - 15 cm	15 cm mineral wool cavity wall insulation or EPS exterior wall insulation	0,25
Age class/State	**Roof construction elements**	**Description**	**U (W/m²K)**
Before 1946	Uninsulated roof construction	Wooden roof construction with tiles or slates, no interior finishing, adjacent to unheated attic	1,7
1946-1970	Uninsulated roof construction	Wooden roof construction with tiles or slates, interior finishing	1,9
1971-1990	Insulated roof construction - roof insulation between rafters 4 cm	Wooden roof construction with tiles or slates, mineral wool roof insulation between rafters 4 cm, interior finishing	0,85
1991-2005	Insulated roof construction - roof insulation between rafters 8 cm	Wooden roof construction with tiles or slates, mineral wool roof insulation between rafters 8 cm, interior finishing	0,6
After 2005	Insulated roof construction - roof insulation between rafters 15 cm	Wooden roof construction with tiles or slates, mineral wool roof insulation between rafters 15 cm, interior finishing	0,3
EPB 2010	Roof insulation between rafters - 15 cm	Mineral wool roof insulation between rafters 15 cm	0,3
Low Energy	Roof insulation between rafters - 30 cm	Mineral wool roof insulation between rafters 30 cm	0,15
Age class/State	**Floor construction elements**	**Description**	**U (W/m²K)**
Before 1991	Uninsulated floor on soil	Uninsulated floor on soil	0,85
1991-2005	Floor on soil - floor screed 4 cm	Concrete structural floor, floor screed and floor finishing	0,7

After 2005	Floor on soil - floor insulation 5 cm	Concrete structural floor, 5 cm PUR floor insulation or insulated floor screed and floor finishing	0,4
EPB 2010	Floor insulation - 5 cm	5 cm PUR floor insulation or insulated floor screed	0,4
Low Energy	Floor insulation - 10 cm	10 cm PUR floor insulation or insulated floor screed	0,25
Age class/State	**Windows**		**U (W/m²K)**
Before 1971	Wooden window profiles - single glazing		5
1971-2005	Multi-chamber window profiles - double glazing		3,5
After 2005	Insulated window profiles - high thermal performance glazing Ug 1,1		2
EPB 2010	Insulated window profiles - high thermal performance glazing Ug 1,1		2
Low Energy	High thermal performance window profiles Uf 2 - high thermal performance glazing Ug 1,1		1,6
Age class/State	**Doors**		**U (W/m²K)**
Before 1991	Exterior door - uninsulated door leaf		4
1991-2005	Exterior door - uninsulated door leaf		3,5
After 2005	Exterior door - insulated door leaf		2,9
EPB 2010	Exterior door - insulated door leaf		2,9
Low Energy	High thermal performance door frame Uf 2 - high-insulated door leaf		1,6

Table 10: Belgian TABULA sub-typology of construction elements

4.2.4 Sub-typology of services systems

→ ***Current state for the 5 different age classes***

A sub-typology for services systems is a collection of typical services systems for space heating, hot water generation and ventilation, for which specific energy performance characteristics are specified, as well as the age class in which the services system components were frequently used. When compiling the sub-typology for services systems, the question we ask ourselves is: *which energy services systems for space heating, hot water preparation and ventilation are typical, often encountered and recognisable for the housing stock at Belgian or regional level for the various age classes defined?*

A sub-typology is being compiled for the following energy services system components;

- Space heating;
- Hot tap water generation;
- Ventilation systems.

The steps that must be taken to realise a sub-typology are:

- Identification of typical services system components for the various age classes;
- Determination of the energy performance factors (energy carrier, production yield, storage losses,...);
- Consulation of an expert panel.

Table 11 provides an insight into the detailed sub-typology for energy systems. In total, 13 sub-typologies for combined energy systems for heating, hot water production and ventilation were established and linked to the dwelling types defined in the main matrix. The available data sources and studies that were used to compile the sub-typology have been addressed in chapter 0. In essence, various available data source were addressed, combined with our own expert judgement in case of lack of data:

Establishing parameters for the services systems sub-typology primarily takes place using basic data from the EPC calculation method for Flanders, which was developed by VITO under assignment from the Flemish Energy Agency (VEA). This data is generally consistent with the EPC calculation method for Wallonia and with the EAP Energy advice procedure methodology. For some components of the energy services systems, these regional energy performance methods deliver the desired yields (e.g. for boilers), but for others, these methods deliver partial parameters that must be further combined in order to establish a production yield. For boilers, the production yield is determined using the Renaud formula on the EPC data and other default values. Further use is made of relevant EN norms, manufacturer's data and other available literature such as Recknagel, ASHRAE and other handbooks. All these data sources provide basic data. The characteristics of the various components are first entered into the calculation file for the harmonised European typology, they are then combined to form systems for space heating, hot water production and ventilation. Eventually, these are used to construct complete energy systems for the various typical dwellings.

→ ***Renovation measures for the two energy upgrade scenarios***

The sub-typology of services systems is also used to define renovation measures for the space heating, hot tap water generation and ventilation services components. Renovation measures, e.g. boiler replacement, installation of a mechanical ventilation system with heat recovery, are defined to renovate the typical dwellings up to the typical, i.e. *EPB2010* level and the advanced, i.e. *Low Energy,* level.

The definition of replacement measures involves the following tasks:

- Defining replacement measures for the space heating, hot tap water and ventilation services components up to the EPB2010 and LE level;
- Determination of the corresponding energy performance factors for the EPB 2010 and LE level.

The **EPB2010 level** is aimed at realising a package of measures that meets EPBD requirements for maximum U-values and minimum R-values for new buildings, which are currently in effect in Flanders (2010). It is not intended that the applicable EPBD building requirements for K-level and E-level are achieved with the package of renovation measures. Consequently, the EPB2010 energy upgrade package for the services systems consists of a set of measures that are not legally obligatory, but that reflect common Belgian building practice in 2010:

- Space heating and hot water production condensation combi boiler on gas;
- Exhaust air ventilation system.

Thus, the EPB2010 upgrade measures are not applicable to the dwelling types for the age class after 2005 since these services systems are already in place for these dwelling types.

The aim of the **Low Energy level** is to define a package of measures reflecting common Belgian low energy building practice in 2010:

- Space heating and hot water production condensation combi boiler on gas;
- Combined with 5 m²solar thermal panels;
- Mechanical ventilation system with heat recuperation (η 0,8) with by-pass

This package of Low Energy upgrade measures applies to all dwelling types.

Table 11 displayed below presents the Belgian sub-typology for services systems. The pictures included in the services systems sub-typology in TABULA.xls have been derived from http://www.energieplus-lesite.be.

Sub-typology of services systems				
	TYPE 1 - Detached house <1971	**TYPE 2 - Semi-detached <1971**	**TYPE 3 - Terraced house <1971**	**TYPE 4 - Multi-family house <1971**
Heating	Stove- heating oil - before 1985 – η 0.72	Stove - gas - before 1985 – η 0.75	Stove - gas - before 1985 – η 0.75	Stove - gas - before 1985 – η 0.75
Hot water	Individual water heater with storage on electricity applied in sfh with medium to large pipe lengths (>5m/point)	Individual instant water heater on gas applied in sfh with medium to large pipe lengths (>5m/point)	Individual instant water heater on gas applied in sfh with small pipe lengths (<5m/point)	Individual instant water heater on gas applied in apartments
Ventilation	No ventilation system	No ventilation system	No ventilation system	No ventilation system
	TYPE 5 - Detached house '71- '90	**TYPE 5 - Semi-detached '71- '90**	**TYPE 6 - Terraced house '71- '90**	**TYPE 7 - Multi-family house '71- '90**
Heating	Individual, central heating on oil / 1976 – 1985 – η 0.7	Individual, central heating on oil / 1976 – 1985 – η 0.7	Individual, central heating on gas/ 1986-1995 – η 0.72	Collective, central heating on oil / 1976 – 1985 – η 0.72
Hot water	Individual fossil fuel boiler with storage vessel, applied in sfh with medium to large pipe lengths (>5m/point) - system coupled to space heating /<1990	Individual fossil fuel boiler with storage vessel, applied in sfh with medium to large pipe lengths (>5m/point) - system coupled to space heating /<1990	Individual instant water heater on gas applied in sfh with small pipe lengths (<5m/point)	Collective fossil fuel boiler without external plate heat exchanger with an apart storage vessel - system coupled to space heating /<1990
Ventilation	No ventilation system	No ventilation system	No ventilation system	No ventilation system
	TYPE 8 - Detached house '91- '05	**TYPE 8 - Semi-detached '91- '05**	**TYPE 9 - Terraced house '91- '05**	**TYPE 10 - Multi-family house '91- '05**
Heating	Individual, central heating on gas / 1996-2005 – η 0.76	Individual, central heating on gas / 1996-2005 – η 0.76	Individual, central heating on gas / 1996-2005 – η 0.76	Individual, central heating on gas / 1996-2005 – η 0.76
Hot water	Individual fossil fuel combi boiler without storage, applied in sfh with medium to large pipe lengths (>5m/point) - system coupled to space heating />1989	Individual fossil fuel combi boiler without storage, applied in sfh with medium to large pipe lengths (>5m/point) - system coupled to space heating />1989	Individual fossil fuel combi boiler without storage, applied in sfh with small pipe lengths (<5m/point) - system coupled to space heating />1989	Individual fossil fuel combi boiler without storage - system coupled to space heating />1989
Ventilation	No ventilation system	No ventilation system	No ventilation system	No ventilation system
	TYPE 11- Detached house >'05	**TYPE 11 - Semi-detached >'05**	**TYPE 12 - Terraced house >'05**	**TYPE 13 - Multi-family house >'05**
Heating	Individual, central heating on gas / >2005 – η 1.06	Individual, central heating on gas / >2005 – η 1.06	Individual, central heating on gas / >2005 – η 1.06	Individual, central heating on gas / >2005 – η 1.06
Hot water	Individual fossil fuel condensing combi boiler without storage, applied in sfh with medium to large pipe lengths (>5m/point) - system coupled to space heating />1989	Individual fossil fuel condensing combi boiler without storage, applied in sfh with medium to large pipe lengths (>5m/point) - system coupled to space heating />1989	Individual fossil fuel condensing combi boiler without storage, applied in sfh with small pipe lengths (<5m/point) - system coupled to space heating />1989	Individual fossil fuel condensing combi boiler without storage - system coupled to space heating />1989
Ventilation	Exhaust air ventilation system	Exhaust air ventilation system	Exhaust air ventilation system	Exhaust air ventilation system

Table 11: Belgian TABULA sub-typology of services systems

4.3 Correction factor for actual energy consumption

The energy consumption for space heating and domestic hot water production is calculated for the original dwellings and both renovation scenarios (EPB2010 and Low Energy level). The calculation methodology within the Tabula project as well as the Belgian EPB and EPC energy certification software relies on steady state monthly energy balances. We consider it necessary to make some corrections to this theoretically derived energy consumption figures. Especially for older buildings, the theoretical energy consumption tends to be much higher than the actual energy use. Using this unaltered values would lead to a great overestimation of the of the actual energy conservation resulting from renovation measures. Consequently the theoretically derived pay-back time of the energy conservation measures would be much shorter than the real life pay-back period the investor faces.

This is mostly due to the poor incorporation of actual occupant behavior in stationary building energy models. The theoretical models rely on some important assumptions which enable to evaluate a wide range of dwellings in a uniform way. Indeed, we are mostly interested in evaluating the energy performance of a building in standard conditions, disregarding the actual behavior of occupants, e.g. when compiling an energy performance certificate which is handed over to new tenants. A very important aspect is the assumption that a dwelling consists of one thermal zone which is constantly kept at an average indoor temperature of minimum 18 degrees Celcius. This may be a reasonable premise for well insulated contemporary buildings, but is seldom applicable to old and poorly insulated buildings. Maintaining a high indoor temperature in the entire building would lead to excessive utility bills, and therefore the temperature in many rooms such as bedrooms, corridors and storage rooms will be significantly lower. Furthermore ventilation rates in old buildings are often much lower than assumed in the energy calculations. In conclusion, old and badly insulated buildings often consume less energy than predicted, because occupants lower their desired comfort level (indoor temperatures, indoor air quality,…) in favor of lower utility bills. Vice Versa, the energy savings from energy renovation measures are often lower than expected: as the building and building systems become more energy efficient, occupants tend to increase their comfort demands, thus outweighing the expected energy conservations to a large extend. This mechanism is described in literature as the so-called "rebound effect" [HAAS 1998].

In order not to present unrealistic energy savings and payback periods, we choose to add a correction factor to the straightforward energy consumption calculated with the steady state energy balances. This correction factor was deduced from the extensive EAP database of 10.000 Walloon dwellings. This database incorporates both calculated energy performance according to the EAP steady state energy balance and a record of measured energy consumption (based on yearly energy bills). Disregarding the energy used for cooking, this data allowed us to correct the theoretically derived energy consumption for space heating and domestic hot water to match better with reality. Although the energy consumption of the buildings in the national brochure was calculated with the Flemish EPB software, we consider it fair to use the correction factor which is based on calculations with the Walloon EAP software, because both steady state calculation methods have many similarities.

A multifactor statistical analysis of the dataset resulted in a formula for a correction factor which depends on the average U-value of the building, the expenditure coefficient of the heating system, and to a lesser extend on both the surface of the exposed building enclosure and the internal volume of the building.

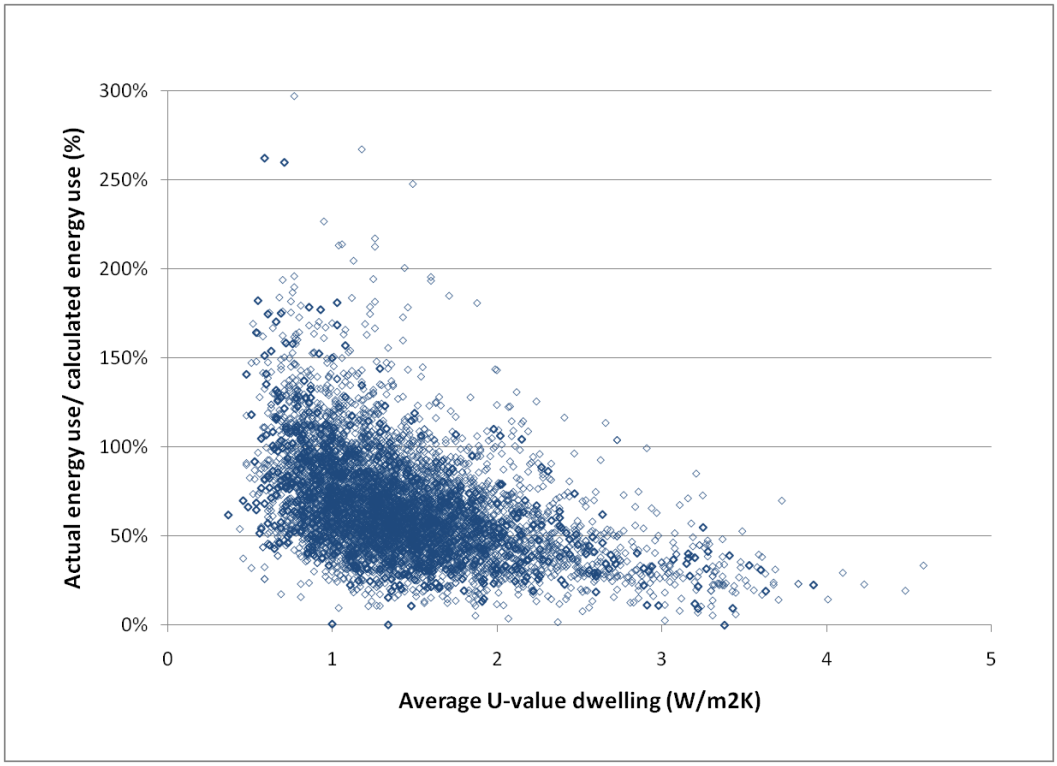


Figure 15: Ratio of actual energy use to calculated energy use in function of the average thermal transmittivity of the building enclosure.

Figure 15 depicts the great divergence between actual energy use and theoretically calculated energy consumption. For buildings with high U-values (poorly insulated), the actual energy use is consistently much lower than the calculated value. In general, the correction factor becomes smaller (and thus the deviation between actual energy use and predicted energy use becomes bigger) when buildings are bigger and less insulated. This is consistent with the presumption that occupants are prepared to give in on their comfort demands as the cost of the energy comsumption rises.

Table 12 summarises the correction factors used in the Belgian national typology brochure. The deviation between actual energy use and predicted energy use is bigger for the oldest buildings. For buildings erected after 2005, and for the renovated buildings according to EPB2010 level en Low Energy level, the correction factor is fixed to 100%, which means that the calculated energy use is supposed to match with the actual energy use.

CURRENT STATE	≤1945	1946-1970	1971-1990	1991-2005	>2005
Detached	34%	38%	45%	60%	100%
Semi-detached	41%	45%	50%	64%	100%
Terraced	42%	45%	52%	67%	100%
Apartment - enclosed	46%	48%	48%	59%	100%
Apartment - exposed	50%	51%	59%	81%	100%
Average correction factor	*41%*	*44%*	*49%*	*63%*	*100%*

Table 12: Correction factors for actual energy use in the Belgian national typology brochure (Current state)

4.4 The national brochure

The Belgian housing typology, with national typical housing folders, can be exposed to the public in two different manners, first of all as a text brochure made available in printed and digital format and, secondly, as an interactive web application. The development of a web application necessitates further funding and will therefore not be executed during the course of the TABULA project, but might take place at a later stage.

4.4.1 General layout

The national housing typology brochure is first of all developed in Dutch. In terms of content, the brochure contains the results of energy performance calculations and financial assessment for the 25 typical dwellings defined in the national typology. The brochures main sections are:

- An introduction to the national housing typology
- The housing fiches
- Background information

As explained above, the focus in the national brochure lies on housing units, thus we arrive that 25 dwelling types for which the current state and the typical and advanced renovation scenario results are displayed in the 25 housing fiches. As shown in *Table 13*, the EPB 2010 scenario is not applicable to the dwelling types from the post 2005 period (types 21, 22, 23, 24 and 25). This is due to the fact that the current state and the EPB 2010 state are identical for these dwelling types. Secondly, it is noteworthy to mention that the EPB 2010 and LE scenarios lead to identical results for the various enclosed apartement types (types 4, 9, 14, 19 and 24) and exposed apartment types (types 5, 10, 15, 20 and 25). This is due to the fact that the geometries of the apartment types are identical.

CURRENT STATE	≤1945	1946-1970	1971-1990	1991-2005	>2005
Detached	TYPE 1	TYPE 6	TYPE 11	TYPE 16	TYPE 21
Semi-detached	TYPE 2	TYPE 7	TYPE 12	TYPE 17	TYPE 22
Terraced	TYPE 3	TYPE 8	TYPE 13	TYPE 18	TYPE 23
Apartment - enclosed	TYPE 4	TYPE 9	TYPE 14	TYPE 19	TYPE 24
Apartment - exposed	TYPE 5	TYPE 10	TYPE 15	TYPE 20	TYPE 25

TYPICAL RENOVATION	≤1945	1946-1970	1971-1990	1991-2005	>2005
Detached	TYPE 1 – EPB 2010	TYPE 6 – EPB 2010	TYPE 11 – EPB 2010	TYPE 16 – EPB 2010	N/A
Semi-detached	TYPE 2 – EPB 2010	TYPE 7 – EPB 2010	TYPE 12 – EPB 2010	TYPE 17 – EPB 2010	N/A
Terraced	TYPE 3 – EPB 2010	TYPE 8 – EPB 2010	TYPE 13 – EPB 2010	TYPE 18 – EPB 2010	N/A
Apartment - enclosed	TYPE 4/19 – EPB 2010				N/A
Apartment - exposed	TYPE 5/20 – EPB 2010				N/A

ADVANCED RENOVATION	≤1945	1946-1970	1971-1990	1991-2005	>2005
Detached	TYPE 1 – LE	TYPE 6 - LE	TYPE 11 - LE	TYPE 16 - LE	TYPE 21 - LE
Semi-detached	TYPE 2 - LE	TYPE 7 - LE	TYPE 12 - LE	TYPE 17 - LE	TYPE 22 - LE
Terraced	TYPE 3 - LE	TYPE 8 - LE	TYPE 13 - LE	TYPE 18 - LE	TYPE 23 - LE
Apartment - enclosed	TYPE 4/24 - LE				

Apartment - exposed	TYPE 5/25 - LE

Table 13: Scenarios in the Belgian national typology brochure (Current state, EPB 2010 and Low Energy)

4.4.2 Financial assessment

→ ***Energy costs***

The energy costs for gas and electricity are based on the unitary energy prices of december 2010, as communicated by VREG (Flemish energy regulator; http://www.vreg.be/sites/default/files/uploads/eenheidsprijzen.doc) . These prices are the average of different energy suppliers, and are valid for a household with an average energy demand. The oil price is based on the unitary price published on http://www.energy.eu/#Domestic. Following unitary prices are used to calculate energy costs and payback times in the Belgian national typology brochure:

Oil - 0.08 Euro/kWh

Gas - 0.06 Euro/kWh

Electricity – 0.18 Euro/kWh.

The eventual rise in energy prices over time was not considered.

→ ***Investment costs***

Investment costs are determined reflecting prices for 2010, including material and placement costs and excluding VAT. Investment costs reflect the investments needed in energy upgrade measures, including necessary demolition works and directly related extra works (e.g. rafters for insulation between rafters). However, they do not include indirectly related extra costs (e.g. floor finishing in case of the instalment of floor insulation). In other words, we presume that investments in energy upgrade measures are combined with improvement work that were already planned to improve the general state of the house. Subsidies and tax benefits are not taken into consideration in the financial assessment, since these benefits vary largely according to the circumstances (dwelling age, state, location, region,…).

BUILDING ENVELOPE		
Roof - insulation up to U 0,3	22	€/m²
Facade - insulation up to U 0,4	22	€/m²
Floor on soil - insulation up to U 0,4	22	€/m²
Floor bordering unheated space - insulation up to U 0,4	22	€/m²
Replacement of windows and doors (including glazing) - U 2	450	€/m²
Replacement of glazing (without replacing frames) - Ug 1,1	200	€/m²
Roof - insulation up to U 0,15	30	€/m²
Facade - insulation up to U 0,25	30	€/m²
Floor on soil - insulation up to U 0,25	30	€/m²
Floor bordering unheated space - insulation up to U 0,25	30	€/m²
Replacement of windows and doors (including glazing) - U 1,6[4]	650	€/m²

[4] Including insulation and adaptions of the exterior wall opening.

SPACE HEATING AND HOT WATER PRODUCTION		
Condensing combi boiler	3500	€/pc
Adaptation of space heating control systems	10	€/m²
Installations of ducts and radiators	40	€/m²
Solar thermal system - 5m² solar thermal panels, all other components included	5500	€/pc
VENTILATION		
Exhaust air mechanical ventilation system - type C	2500	€/pc
Mechanical ventilation system with heat recuperation (η 0,8) , all components included	4500	€/pc

Table 14: Investment costs

4.4.3 Comfort indicator

Because of the above-mentioned correction factor on the energy comsumption, the payback time of energy renovation measures is longer than one would expect when comparing straightforward calculated energy consumptions. These prolongued payback periods should by no means imply that the energy renovation measures are not usefull: the energetic and monitary savings are less than expected, because the occupants initially compromised on thermal comfort and indoor air quality. In order to highlight the increased comfort of the renovated buildings, we have added a comfort indicator to the national brochure. By expert judgement, each dwelling is given a number of stars according to the level of comfort. The scale ranges from one star (lowest comfort level) to four stars (highest comfort level). *Tabel 15: Characteristics for the four defined comfort classesTabel 15* describes the comfort characteristics consistent with the four defined comfort classes.

COMFORT CLASS	CHARACTERISTICS
*	Residents decide not to heat hallways, corridors and secondary spaces because of high energy costs
	Large temperature differences between heated and unheated spaces: (general) thermal discomfort
	High radiant asymmetry (e.g. due to cold window surfaces or low floor surface temperatures): local thermal discomfort
	Draught through accidental gaps (e.g. in doors and windows)
	Uncontrolled air supplies through gaps leads to large heat wastes during the winter season
	Condensation on the inner glass pane of exterior windows
**	Residents decide not to heat hallways, corridors and secondary spaces because of high energy costs
	Large temperature differences between heated and unheated spaces: (general) thermal discomfort
	High radiant asymmetry (e.g. due to cold window surfaces or low floor surface temperatures): local thermal discomfort
	Draught through accidental gaps (e.g. in doors and windows)
	Uncontrolled air supplies through gaps leads to large heat wastes during the winter season
***	Small temperature differences between heated and unheated spaces: (general) thermal comfort
	Low radiant asymmetry from windows, wall or floor surfaces: local thermal comfort
	Draught through air supply vents in windows or walls
	Controlled air supplies (requires proper use and maintance of the ventilation system)
****	Temperature equilibrium in the different spaces of the house: (general) thermal comfort
	Low radiant asymmetry from windows, wall or floor surfaces: local thermal comfort
	Minimal/no draught

COMFORT CLASS	CHARACTERISTICS
	Highly controlled air quality and relative humidity is possible (requires proper control settings and monitoring of the ventilation system)
	Control of overheating risks requires specific measures (e.g. sunscreens, solar controlled glazing)

Tabel 15: Characteristics for the four defined comfort classes

The national housing typology brochure is included in its entirety in Annex 3.

4.5 Key conclusions and main tendencies

→ ***Can we distinguish dwelling types that need to be addressed with higher priority because of the high energy consumption related to these specific dwelling types?***

Analysis of the results in terms of the corrected primary energy consumption for the 25 dwelling types reveals that 8 dwelling types have an above average primary energy consumption, both specific (kWh/yr.m²) and in total (kWh/yr.m²). These 8 priority types are situated in the upper right hand side quadrant in *Figure 16* and *Figure 17*. Not surprisingly, these 8 types mainly include detached and semi-detached dwelling types:

- Type 1- Detached - pre '46
- Type 6 - Detached - '46-'70
- Type 11 - Detached - '71-'90
- Type 16 - Detached - '91-'05
- Type 2 - Semi-detached - pre '46
- Type 7 - Semi-detached - '46-'70
- Type 12 - Semi-detached - '71-'90
- Type 13 - Terraced - '71-'90

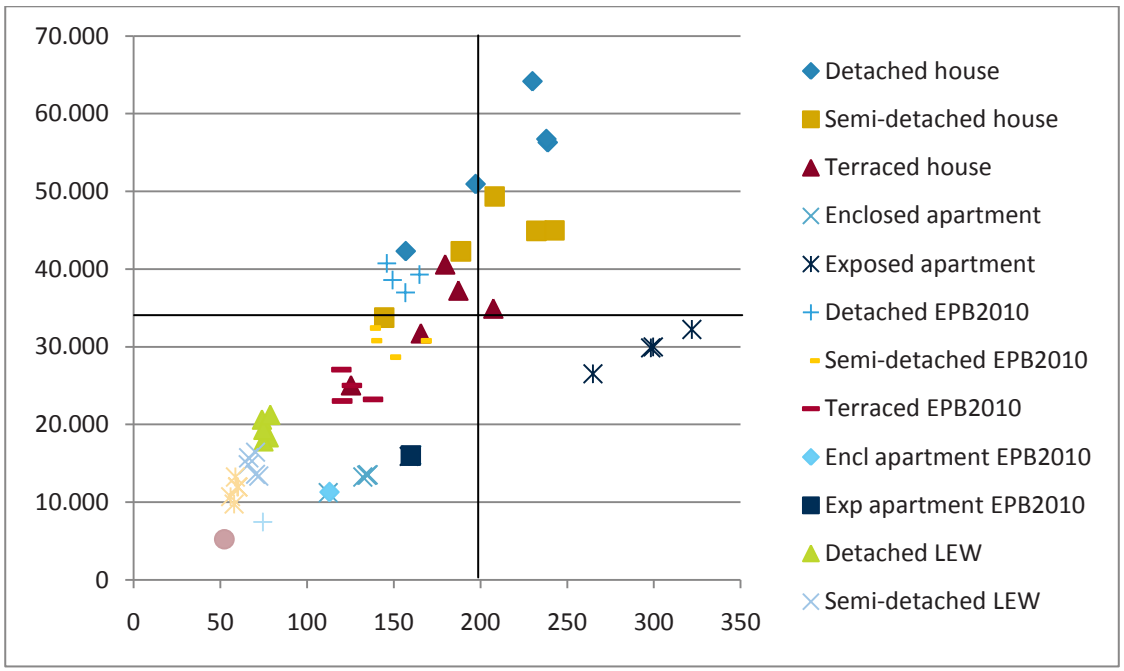


Figure 16: Corrected specific PE consumption (kWh/jr.m²) versus corrected PE consumption (kWh/jr) for the current state, EPB 2010 and LE scenarios for the 25 dwelling types

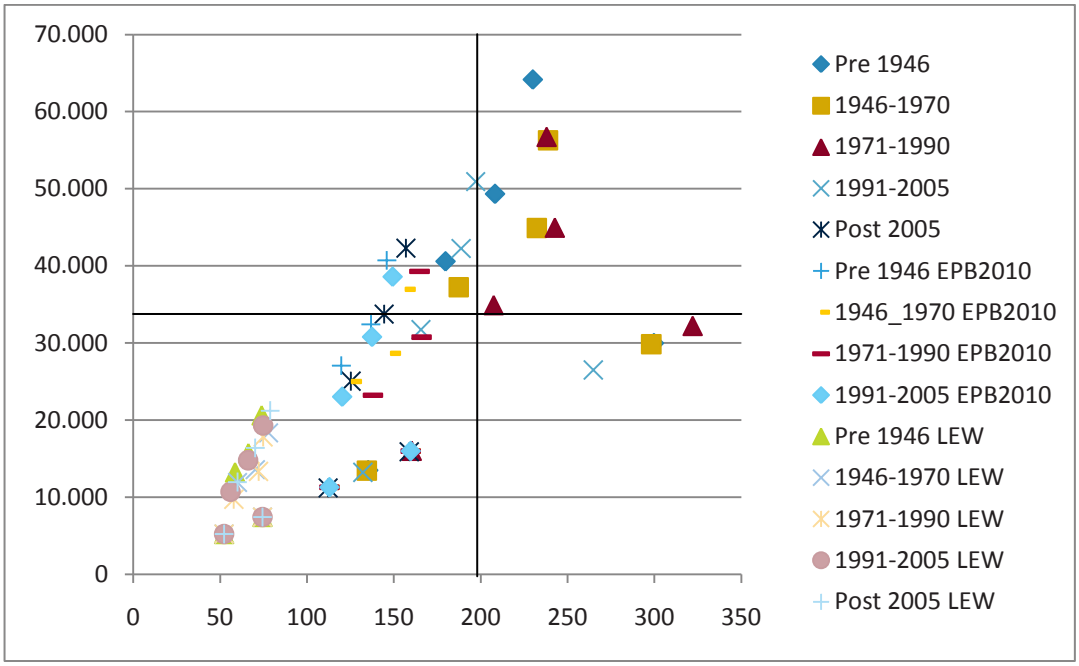


Figure 17: Corrected specific PE consumption (kWh/jr.m²) versus corrected PE consumption (kWh/jr) for the current state, EPB 2010 and LE scenarios for the 25 dwelling types

→ ***What key conclusions can be drawn in terms of variations in savings potentials for the various typical dwellings?***

The average reduction in primary energy consumption for space heating, hot water production and auxilary energy achieved with the EPB 2010 renovation scenario is 32%, i.e. about one third of the original primary energy consumption. With the Low Energy renovation scenario, an average reduction of 65% is achieved, i.e. about two thirds of the original consumption.

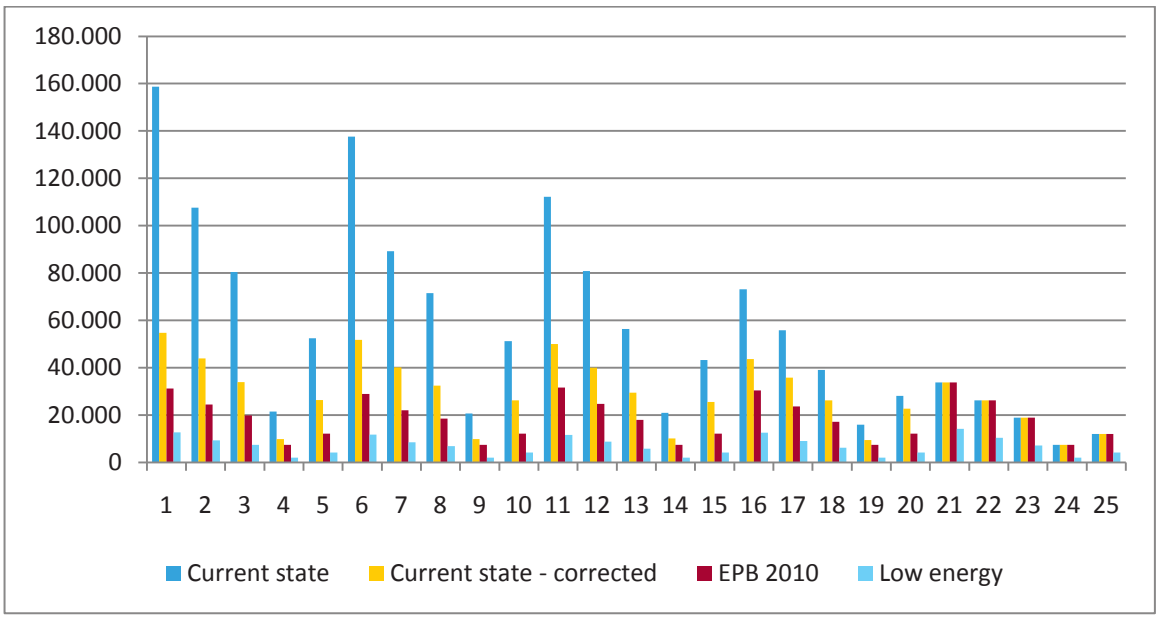


Figure 18: Primary energy consumption for space heating (kWh/jr)

When we focus only on space heating the reductions achieved are higher, respectively 39% and 76%. These reductions are logically partially annulled by the rise in auxiliary primary energy, therefore reductions are lower for the total primary energy consumption than for the primary energy consumption for space heating on its own.

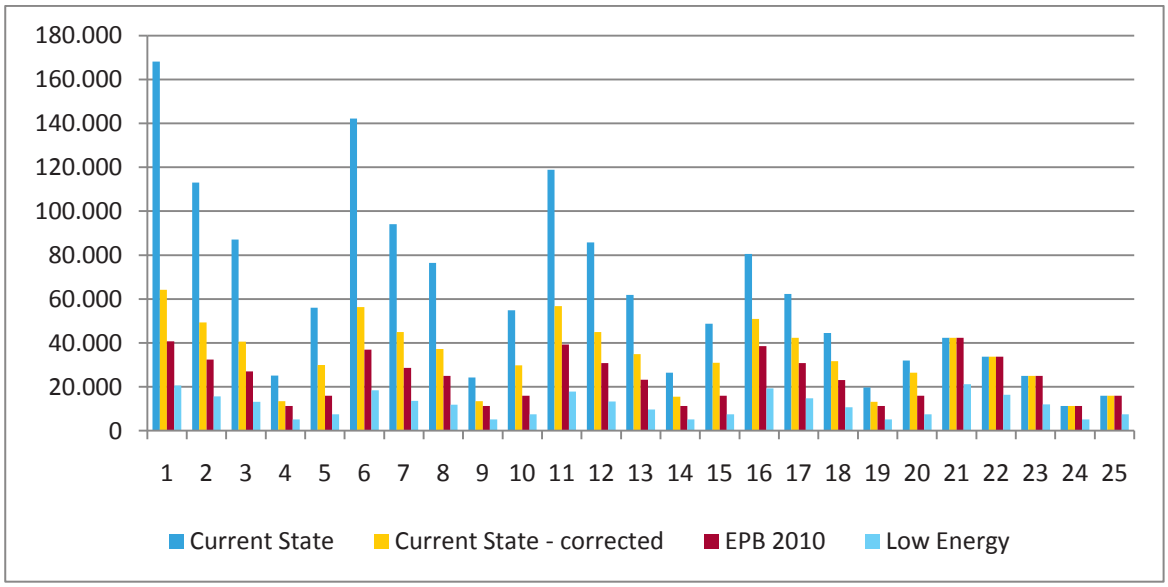


Figure 19: Primary energy consumption for space heating, hot water production and auxilary energy (kWh/jr)

Table 16 displays the reductions achieved in terms of primary energy consumption for space heating, hot water production and auxilary energy for the EPB 2010 and LE scenarios, ranged for the highest to the lowest values. The reductions achievable by implementing energy upgrade measures are the highest for the exposed apartment types (pre '46 until '05), respectively 40-48% for the EPB 2010 and 72-76% for the LE scenario.

EPB 2010 SCENARIO		**LOW ENERGY SCENARIO**	
EX AP '71-'90 (15)	48%	EX AP '71-'90 (15)	76%
EX AP <'46 (5)	47%	EX AP <'46 (5)	75%
EX AP '46-'70 (10)	46%	EX AP '46-'70 (10)	75%
EX AP '91-'05 (20)	40%	T '71-'90 (13)	72%
D <'46 (1)	37%	EX AP '91-'05 (20)	72%
SD '46-'70 (7)	36%	SD '71-'90 (12)	70%
D '46-'70 (6)	34%	SD '46-'70 (7)	70%
SD <'46 (2)	34%	D '71-'90 (11)	69%
T '71-'90 (13)	33%	SD <'46 (2)	68%
T <'46 (3)	33%	T '46-'70 (8)	68%
T '46-'70 (8)	33%	D <'46 (1)	68%
Average value	**32%**	T <'46 (3)	67%
SD '71-'90 (12)	32%	D '46-'70 (6)	67%
D '71-'90 (11)	31%	EN AP '71-'90 (14)	66%
T '91-'05 (18)	27%	T '91-'05 (18)	66%
EN AP '71-'90 (14)	27%	SD '91-'05 (17)	65%

SD '91-'05 (17)	27%	**Average value**	**65%**
D '91-'05 (16)	24%	D '91-'05 (16)	62%
EN AP <'46 (4)	16%	EN AP <'46 (4)	61%
EN AP '46-'07 (9)	16%	EN AP '46-'07 (9)	61%
EN AP '91-'05 (19)	15%	EN AP '91-'05 (19)	60%
		EN AP >'05 (24)	53%
		EX AP >'05 (25)	53%
		T >'05 (23)	52%
		SD >'05 (22)	51%
		D >'05 (21)	50%

Table 16: Reduction achieved in terms of primary energy consumption for space heating, hot water production and auxilary energy for the EPB 2010 and LE scenarios for the 25 dwelling types

- ***What key conclusions can be drawn in terms of cost-benefit analyses for the various typical dwellings?***

For the cost-benefit analyses, three classes for the payback time have been defined, i.e. a first class with a payback time of about 20 yrs (15-25 yrs), a second class with a payback time of about 30 years (25-35 yrs) and a third class with payback time above 35 years. *Figure* and *Figure 20* grafically display the payback time results for the EPB 2010 and LE scenarios. For most dwelling types, the LE scenario leads to a more beneficial payback time than the EPB 2010 scenario. The lowest payback time is 18 years.

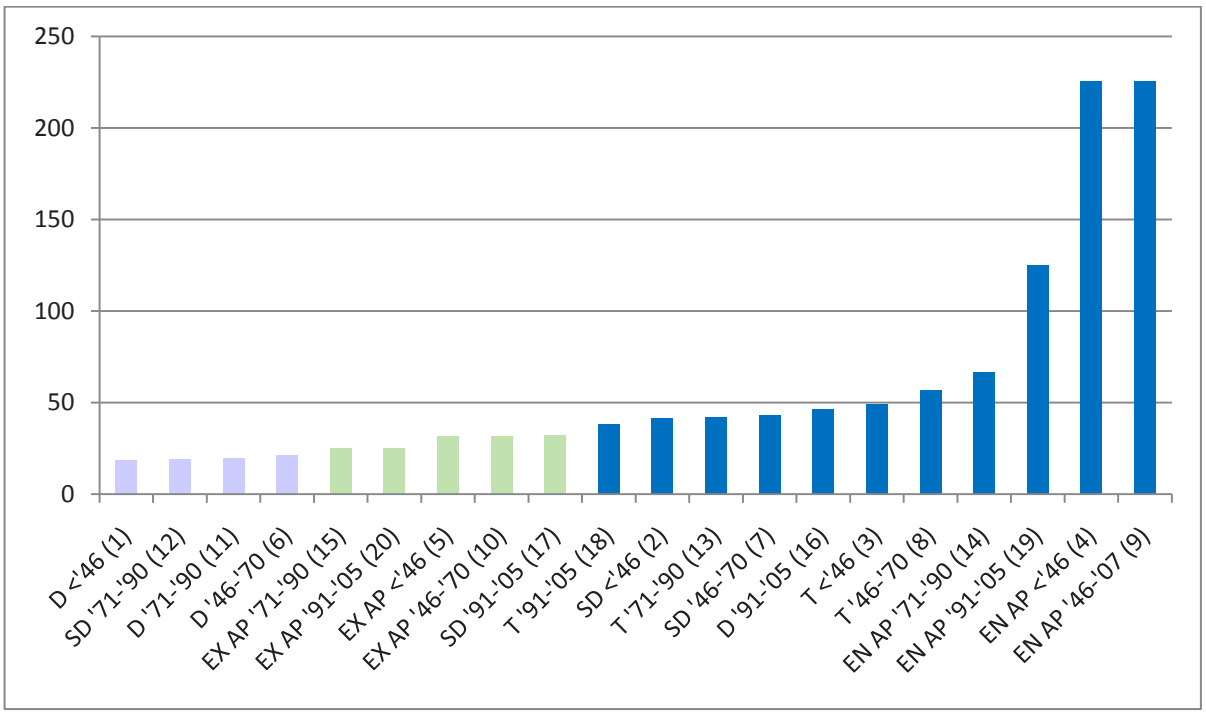


Figure 20: Payback time EPB 2010 scenarios (purple: around 20 yrs; green: around 30 yrs; blue: above 35 yrs)

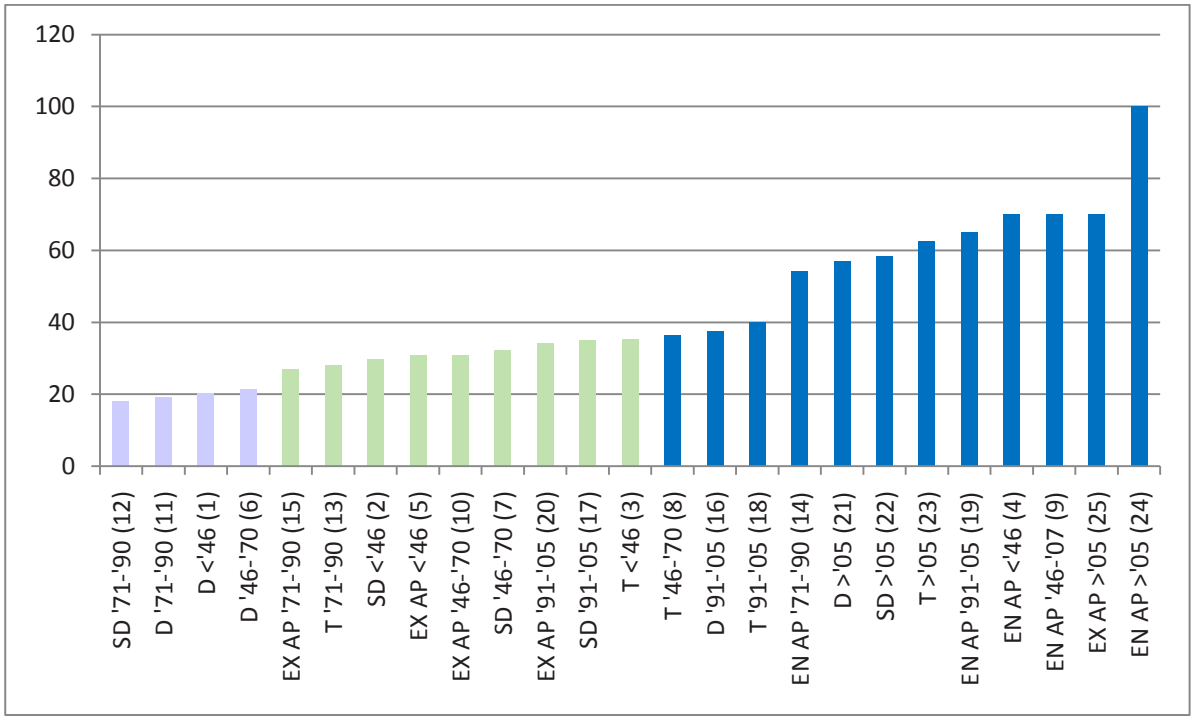


Figure 20: Payback time LE scenarios (purple: around 20 yrs; green: around 30 yrs; blue: above 35 yrs)

Four dwelling types end up within the payback time class around 20 years, both for the EPB 2010 and LE scenario. All four dwelling types belong to the priority types in terms of PE consumption as defined above (on page 58):

- Type 1- Detached - pre '46
- Type 12 - Semi-detached - '71-'90
- Type 11 - Detached - '71-'90
- Type 6 - Detached - '46-'70

EPB 2010 SCENARIO		**LOW ENERGY SCENARIO**	
D <'46 (1)	19	SD '71-'90 (12)	18
SD '71-'90 (12)	19	D '71-'90 (11)	19
D '71-'90 (11)	20	D <'46 (1)	20
D '46-'70 (6)	21	D '46-'70 (6)	21
EX AP '71-'90 (15)	25	EX AP '71-'90 (15)	27
EX AP '91-'05 (20)	25	T '71-'90 (13)	28
EX AP <'46 (5)	31	SD <'46 (2)	30
EX AP '46-'70 (10)	31	EX AP <'46 (5)	31
SD '91-'05 (17)	32	EX AP '46-'70 (10)	31
T '91-'05 (18)	38	SD '46-'70 (7)	32
SD <'46 (2)	41	EX AP '91-'05 (20)	34
T '71-'90 (13)	42	SD '91-'05 (17)	35
SD '46-'70 (7)	43	T <'46 (3)	35
D '91-'05 (16)	46	T '46-'70 (8)	36
T <'46 (3)	49	D '91-'05 (16)	37
T '46-'70 (8)	57	T '91-'05 (18)	40

Average value	**59**	**Average value**	**43**
EN AP '71-'90 (14)	67	EN AP '71-'90 (14)	54
EN AP '91-'05 (19)	125	D >'05 (21)	57
EN AP <'46 (4)	225	SD >'05 (22)	58
EN AP '46-'07 (9)	225	T >'05 (23)	62
		EN AP '91-'05 (19)	65
		EN AP <'46 (4)	70
		EN AP '46-'07 (9)	70
		EX AP >'05 (25)	70
		EN AP >'05 (24)	100

Table 17: Payback time for the EPB 2010 and LE scenarios for the 25 dwelling types

Chapter 5 REPRESENTATIVE HOUSING MODEL AND SCENARIO ANALYSES

Energy consumption in dwellings is determined by three elements, people and their expectations, climate and building characteristics. On a regional level, building characteristics and peoples expectations can be influenced by various sorts of policies, reduction measures or other external influences. The ideal projection model of should consider these three elements and meet the following requirements:

- be able to make a projection on the evolution of the needs for housing;
- be able to explore the reduction potential by various energy reduction measures;
- be able to evaluate the basic aspects of sustainable development in scenarios;
- be able to develop and evaluate long term scenarios (due to the large lifetime of buildings);
- be able to account for the two kind of rebound effects:
- rebound effects related to behaviour changes: this type of rebound effects can be considered as price reactions;
- non-voluntary rebound effects related to the physical properties of buildings.
- be able to account for climate differences and climate fluctuations (degree days);
- be able to quantify the effect of changing energy prices.

To estimate the impact of policy measures on the future, residential energy consumption of a region, e.g. Belgium, **policy scenario analysis** can be performed by different kind of projections methods. In the next paragraphs, different methodologies are described to forecast the residential energy use for heating and sanitary hot water SHW of a region [DUER2008]. The lower Tiers will result in rather simple models, the higher Tiers in very detailed models, but these methodologies will need a detailed knowledge of the building stock and its energy characteristics. The required data for the different Tier methods are presented in Figure 21.

At VITO, were are specialized in setting up detailed, building stock models (highest Tiers): **Optimization models and engineering models**. These models are able to incorporate a detailed representation of the building stock, so the impact of policies can be estimated. The modelled building stock of a region, e.g. Flanders or Belgium, represents the entire building stock. Average datasets for **representative housing** are used to identify representative dwellings, which differ significantly from typical homes, in the sense that characteristics of the building geometry, construction elements and technical installations cannot, or can rarely, be mapped with a physical representation as found in an actual existing house. In the next paragraphs we will also describe these VITO models more into detail.

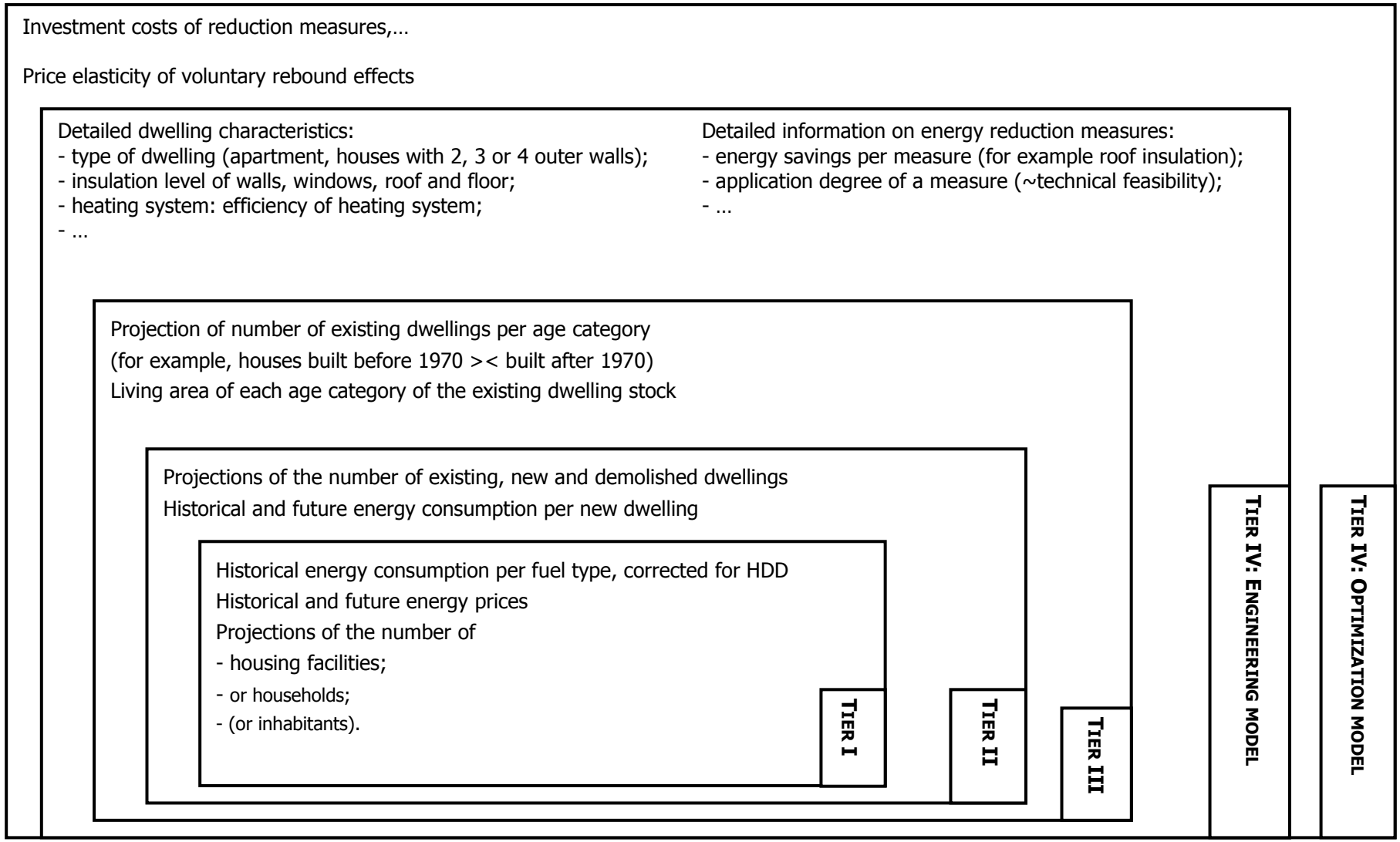


Figure 21. Policy scenario analysis: Tier levels to forecast residential energy consumption for heating and SHW of a region.

5.1 Tier methods for heating and SHW

In the next paragraphs, different Tier methodologies are described to estimate future residential energy use. The lower methods will result in rather simple models, the higher method in very detailed models, but this methodology will require a detailed knowledge of the building stock. Only a detailed model allows a good analysis of the impact of reduction measures. The simple Tier methods can be used to estimate the impact on energy consumption of some policies, like the EPBD for new dwellings, but the possibilities are very limited.

Whatever the level of detail of the Tier methodology, the projection methodology can always be reduced to one or more of the following pillars (see also Figure 21), as you will see in the next paragraphs:

- Demography;
- Building and installation characteristics;
- Influence of energy prices.

5.1.1 Tier I: Top-down projection based on demography

The most important variable of this projection methodology is demography. In general, the future energy consumptions will be estimated based on future projections of the number of households or the number of dwellings. Therefore, the average of the historical energy consumptions per dwelling (household or inhabitant) has to be calculated (corrected for heating degree days HDD). To make the energy projection, one can assumes a constant energy consumption per dwelling for the entire estimation period. Instead of a constant energy consumption per dwelling, it is also possible to linear extrapolate the trend observed in the historical data to the future. In the latter case, besides a projection of the number of dwellings, an extrapolation of the energy consumption per dwelling is also taken into account.

Changes in fuel prices is the second pillar which is also incorporated in the energy projection. To account for this impact, it is recommended to use price elasticity together with assumptions on the evolution of future fuel prices.

5.1.2 Tier II: Top-down projection based on demography: existing versus new dwellings

The Energy Performance of Buildings Directive (EPBD) has a different influence on the regulation of the new dwellings stock compared to the regulation of the existing dwellings. The typical housing characteristics of new dwellings will result in a lower energy levels. The impact of EPBD on the new building stock can be estimated by separating the existing and new dwelling stock. The evolution of the energy level of new dwellings can be kept constant or can decrease during the entire projection method. This depends on which policy a region would like to implement. In addition to the expected energy consumption per new dwelling, the number of new dwellings has to be estimated. The rise of the number of dwellings, corrected for demolition, between the start year and end year of the projections corresponds approximately to the number of new dwellings. The quality of the number of demolished dwellings is often limited. As a consequence, assumptions are often required. An example of an appropriate assumption is keeping the yearly amount of demolished dwellings constant.

Concerning the estimation of future energy consumption of existing dwellings and the impact of future energy prices, we refer to Tier I.

5.1.3 Tier III: Top-down projection based on demography: different age categories of the dwelling stock

Depending on the data availability, the existing building stock will be subdivided into at least two age categories. The new dwelling stock will also be considered as an individual age category. The surplus of this age division is the possibility to take a more accurate demolition of dwellings into account. This way, structural measures in the housing market, like the promotion of new dwellings coupled to an increase of the demolition of existing building, can be investigated.

When the existing building stock will be divided into two age categories, the separation year has to be an important year concerning the dwelling characteristics of houses. For example, in Belgium, the houses built before 1970 are less insulated than the houses built afterwards. The oil crisis of the seventies explains this change in dwelling characteristics. So, 1970 will be used as separation year for the existing stock in Belgium.

To obtain the historical, average energy consumption per dwelling for each age category, indicators like insulation degree, boiler efficiency, compactness, living area,... can be used to estimate the energy level. The average energy consumption per existing dwelling will be kept constant in the entire projection period. To estimate the effect of reduction measures, a more detailed projection method will be necessary: Tier IV: Bottom-up projection based on detailed housing stock information.

5.1.4 Tier IV: Bottom-up projection based on detailed, representative housing stock

As already mentioned in the introduction, an accurate model to project residential energy consumption of a region should meet different requirements. Engineering models and optimization models are very accurate models because they are able to:

- explore the reduction potential by various energy reduction measures;
- develop and evaluate long term policy scenarios because of the large lifetime of buildings;
- account for rebound effects.

Engineering models, as well as optimization models, calculate the energy consumption for space heating and hot water production bottom-up wise. They also use some calibration method to fit the global result with observed data from national energy balances. Both model types start from a detailed representation of the dwelling stock. The main advantage of such a detailed structure is that it allows to identify and quantify opportunities for improvement (scenario analysis).

In the following box we describe the general philosophy of these type of models which can be used to model the energy demand or supply of all energy sectors on a regional/global level.

Engineering models

These are usually for specific sectors such as the residential and the tertiary sector. The strengths of these models lie in the detail that can be included and their relative simplicity. Their formulation is not necessarily linked directly with past trends. The rep-

resentation of global policies and measures, particularly economic measures, is limited and feedback to the rest of the economy is not included. However, sector specific reduction measures can by assessed most appropriately.

The parameters needed for the models include activity data (eg. number of dwellings and types) plus technology data (eg. energy characteristics of dwellings). Frequently, engineering models are used in the preparation of a linear programming model.

Optimization models (Linear programming models)

Linear programming models are a popular instrument to develop energy and greenhouse gas scenario's. They represent the energy system of a region by a detailed set of technology options. These options are characterized by physical parameters such as energy efficiency (energy savings), lifetime of technology, fuel type and cost components. The demand for energy is determined exogenously in a reference scenario (basically corresponding to a without measures scenario). The model is solved by choosing the cheapest solution (choices of technologies) that satisfies the demand for energy in all subsectors and satisfying environmental and technological constraints. These models are useful for assessing and identifying efficiency/savings potentials and for assessing supply and demand-oriented policies to curb energy related emissions.

Although optimization models primarily focus on engineering aspects of energy systems and the results have some prescriptive nature due to the optimization procedure, some economic interpretation of the results can be given. Indeed, its optimization procedure simulates perfectly competition among technology options driven by demand in each subsector.

The two model types require not only projections of the number of existing and new dwellings, but also a detailed, representative dataset of the dwelling stock. The following dwelling characteristics are often considered:

- type of dwelling (apartment, houses with 2, 3 or 4 outer walls);
- floor space;
- insulation level of walls, windows, roof and floor;
- heating system:
- efficiency of heating system
- fuel type.
- age categories of the dwellings;
- …

There are different ways to get these data for a region, like national detailed dwellings surveys, energy certificates of the EPBD, … even information of chimney cleaners can be useful.

Besides the above mentioned data, other parameters have to be calculated to estimate the total future energy consumption. For instance, the energy savings of each reduction measure have to be known for each dwelling category. To his end, more detailed data of the dwellings may be required, like the surface of the walls and windows, etc. Another important input is the application degree of a reduction measure. Some dwellings can't implement every measure because of technical obstructions. For instance, the application of floor insulation has a lot of limitations, e.g. the height of the floor, risk for thermal bridges, etc. These technical limitations can be included into the model by using application degrees.

Optimization models need also reliable information on investment and operational costs of the technological options for saving energy. Because energy price effects are incorporated into this type of model, the evolution of energy prices (and price elasticity) are

inputs, in contrast to engineering models. The latter models don't consider this, so price effects have to be estimated after the energy projections, also by means of the same price elasticity.

Engineering models can only take un-voluntary rebound effects into account, in contrast to the optimization models which can incorporate un-voluntary as well as human related rebound effects. The latter rebound effect will be estimated by introducing a price elasticity. The un-voluntary rebound effect can be solved in every bottom-up model by correcting the energy savings attributed to the different reduction measures.

A general model structure, which can be used for every region, can't be defined, because each regon will have different kind of available data. As a consequence, every region has to build their own model structure so accurate energy projections will be possible.

5.2 Engineering and optimization models used for policy scenarios: Flemish model for residential energy consumption & Flemish Environmental Costing Model

To clarify the above theoretical recommendations, an example of an optimization model and an engineering model, used in Flanders to estimate the residential energy projections, will be explained in the next paragraphs.

5.2.1 Flemish model for residential energy consumption

We would like to remark that within TABULA the Flemish model is extended with the two other Belgian regions, namely Wallonia and Brussels. The extension and first results are briefly discussed in the TABULA report 'Use of Building Typologies for Modelling the Energy Balance of the Residential Building Stock - Belgium'. Within TABULA, we've performed the first steps in the development of the Belgian model, so further research is required to obtain more realistic results for Wallonia and Brussels.

VITO developed, under the authority of the Flemish Energy Agency [BRIFF2010] the engineering model 'Flemish model for residential energy consumption', to support energy policy through scenario analysis. This model estimates current and future final energy consumption and related CO_2 emissions of the Flemish households. The final energy consumption includes energy consumption for space heating, for sanitary hot water SHW as well as for cooking:

$$E_{final} = E_{space\ heating} + E_{SHW} + E_{cooking}$$

Based on an extensive database of housing characteristics, the model calculates the energy consumption for each dwelling category based on the method of degree days. Accordance with reality is aimed for by taking into account the impact of households' behaviour and by calibrating the model with residential energy consumption of the Flemish Energy Balance. With periods of 2 years, projections of energy consumption and related CO_2 emissions can be made over a time horizon up to 2020.

In the next paragraphis we will first describe the general methodology of the model and the consulted data sources. Afterwards, we will zoom in on how we take households' behaviour into account.

→ *General methodology and data sources*

The modelling of residential energy consumption can be subdived in different working steps. First of all, we map a detailed, representative dataset of the total dwelling stock of 2006 by subdiving the existing stock into 216 dwelling categories based on the following criteria:

- Dwelling age: <1945; 1946-1970; 1971-1990; 1990-2006;
- Type of dwelling: freestanding, semi-detached, terraced, flat;
- Type of heating installation: collective central, individual central, decentral ;
- Fuel type for space heating: natural gas, fuel oil, electricity, coal, LPG, wood.

The presence of each dwelling category (number of dwellings in Flanders) is mainly derived from the General Socio-economic Survey performed in 2001 by the National Institute of Statisticscs NIS [NIS2001]]. To map other energy characteristics of dwellings like insulation level (roof, wall, floor ,window), dimensions of the building envelope, system efficiencies of the heating installation, etc. information from other surveys and databases are required. A profound analysis of the Energy Advice Procedure database [EAP2011] completes largely the characterisation of the dwelling stock. Afterwards, the evolution of the existing housing stock from 2001 onto 2006 is simulated by modelling:

- demolitions that have taken place;
- building of new houses;
- various renovation measures undertaken in that period e.g.
  - fuel switch combined with boiler replacement;
  - boiler replacements;
  - insulation measures (roof, wall, glazing, floor);
  - …

The required statistics are derived from demolition and building permits, types and number of granted subsidies for REU measures, national sales statistics of boilers, number of households, etc.

As a result, the total residential stock of Flanders and its energy characteristics are modelled in a detailed manner.

The second step comprises the calculation of the total residential energy consumption for heating ans SHW starting from the representative housing stock, as illustrated in the next figure. For each dwelling category, the model calculates the final consumption according to the method of degree days and taking into account households' behaviour. We will explain later how the behaviour of households is derived and modelled. Besides behavior, a second correction of the calculated, theoretical consumptions is performed by calibrating the estimated natural gas consumption with the Flemish Energy Balance of 2006. To this purpose, the average sizes of dwellings are adjusted. So, we aim for a realistic as possible energy consumption for each dwelling category by:

- Estimation of realistic housing characterics of the dwelling stock;
- Incorporation of households' behaviour;
- Calibration with the Flemish Energy Balance of 2006.

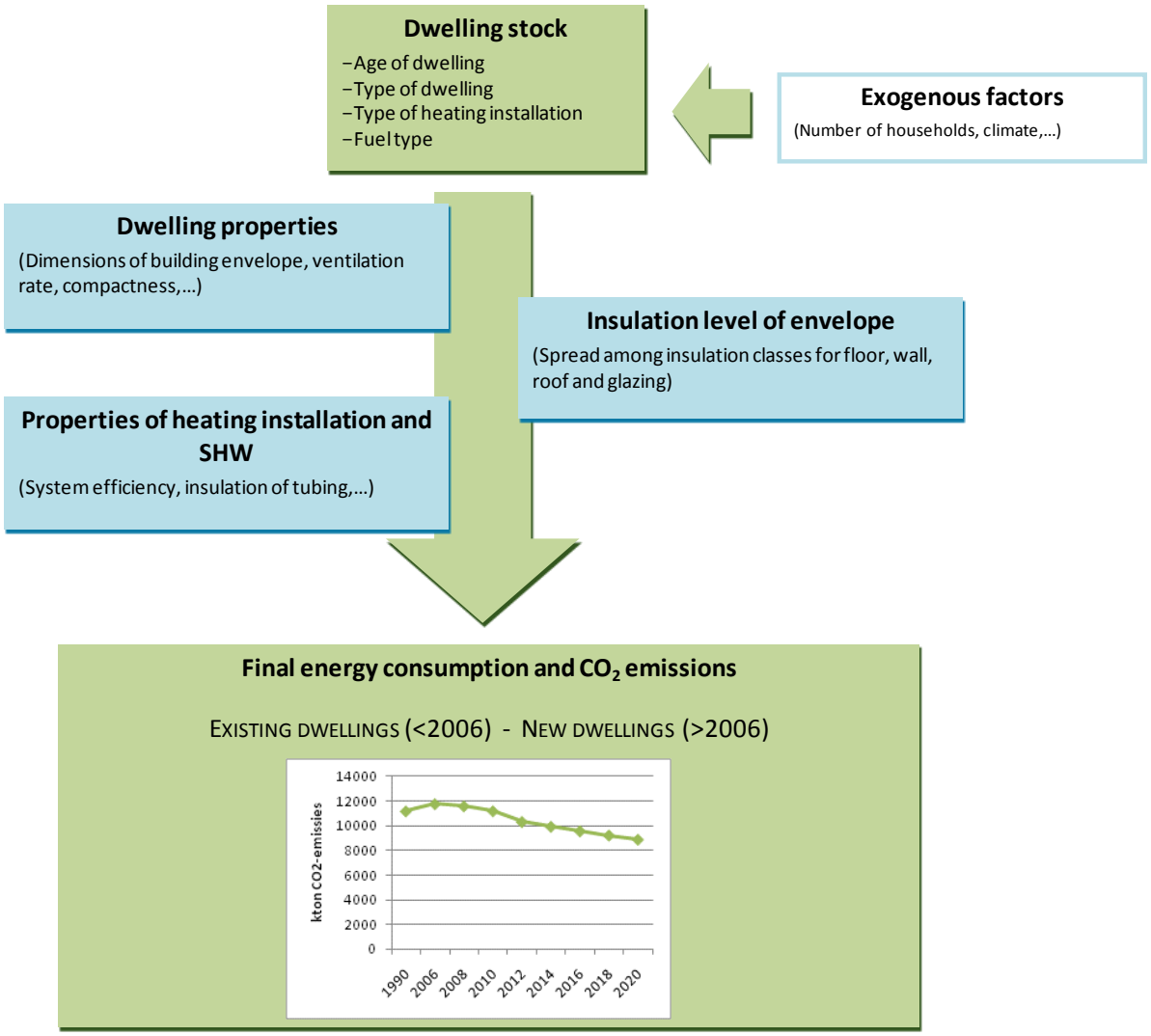


Figure 22. Flemish model of residential energy consumption.

Thirdly, new houses built after 2006 – the starting year of the Energy Performance of Buildings Regulation in Flanders - are added to complete the housing model. Subsequently, the impact of various scenarios for renovation and demolition of existing houses, as well as for additional new-build houses up to 2020 are examined. This impact analysis is simulated in exactly the same way we've constructed the dwelling stock for 2006 starting from 2001, namely by modelling of demolition, building of new houses and renovation measures. In contrast to the historic years, assumptions (no statistics) on future evolution of these driving forces are required. These assumptions are dependent on:

- evolution of the number of households;
- evolution of number of new dwellings;
- evolution of climate: usually, we assume a constant number of heating degree days to allow comparison between years;
- expected spontaneously implementation of reduction measures;
- expected, additional implementation of reduction measures driven by regional or European policy;
- ...

With periods of 2 years, projections of energy consumption and related CO_2 emissions are made over a time horizon up to 2020 (see Figure 22). The impact of the energy

measures is addressed in detail, which involves insights per dwelling category and per measure.

So, this way we can examine the impact of various energy policy scenarios up to 2020 on the households energy consumption, for space heating and domestic hot water, and related CO_2-emissions. The model therefore serves as a policy support instrument in defining future pathways for tightening energy-efficiency and climate legislations.

→ ***Modelling of households' behaviour***

As described in Paragraph 4.3, we consider it necessary to make some corrections to theoretically derived energy consumptions. Especially for older buildings, the theoretical energy consumption tends to be much higher than the actual energy use, due to households' behavior: As the building and building systems become more energy efficient, occupants tend to increase their comfort demands. This mechanism is described in literature as the so-called "rebound effect" [HAAS1998].

In order to present more realistic energy consumptions for the different dwelling categories, we choose to add a correction factor to the straightforward energy consumption calculated with the method of degree days.

For Flanders, this correction factor was deduced from the EAP database of 750 Flemish dwellings. The database incorporates both calculated energy performance according to the EAP steady state energy balance and a record of measured, real energy consumption (based on yearly energy bills). Figure 23 depicts the great difference between actual energy use and theoretically calculated energy consumption of Flemish dwellings in the EAP database. As a consequence, this data allows us to correct the theoretically derived energy consumptions to match better with reality. A multifactor statistical analysis of the dataset resulted in a formula for a correction factor which depends on the average U-value of the building, the efficiency of the heating system and on the protected volume of the building.

For Wallonia, we've performed the same analysis on the Walloon EAP database, which consists of 10.000 dwellings. In contrast to Flanders, the correction factor is also depended on the surface of the exposed building enclosure.

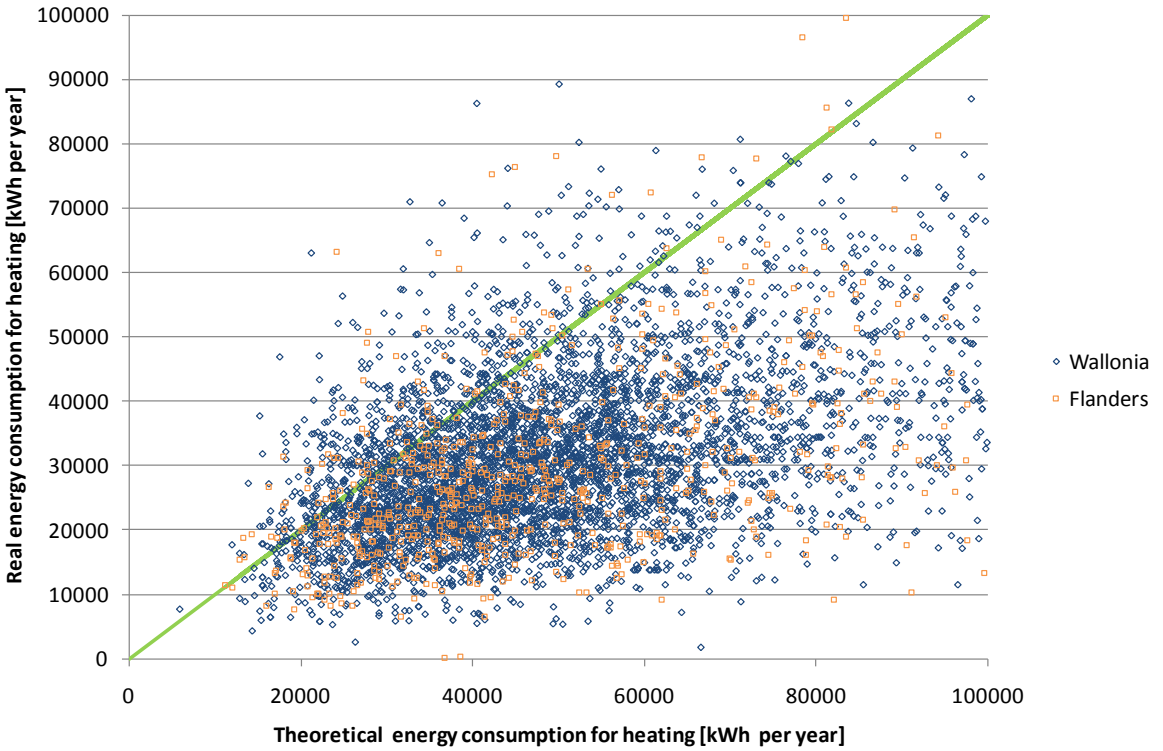


Figure 23. Theoretical energy consumption for heating according to the EAP steady state energy balance versus measured, real energy consumptions (based on yearly energy bills) of the Flemish and Walloon dwellings in the EAP database.

5.2.2 Flemish Environmental Costing Model ECM Households

VITO developed the Environmental Costing Model ECM for Flanders, under the authority of the Flemish department of Environment, Nature and Energy. This techno-economic optimisation model relies on the linear programming model MARKAL and as such estimates future energy consumption and emissions of air pollutants and greenhouse gases, based on the principle of cost optimization. The outcome of these scenarios are used to support the design and the implementation of a costefficient, integrated energy/climate/air policy. The model comprises the final energy demand sectors (e.g. the residential sector, industry) as well as the energy supply sectors (e.g. the electricity sector). For the entire energy system, techno-economic information, like investment costs and efficiency improvements of reduction measures, is assembled in a simple, but economically consistent way (MARKAL). The model can be applied for different time horizons (eg. 2030) and also on different scale levels (e.g. countries, firms, emission sources).

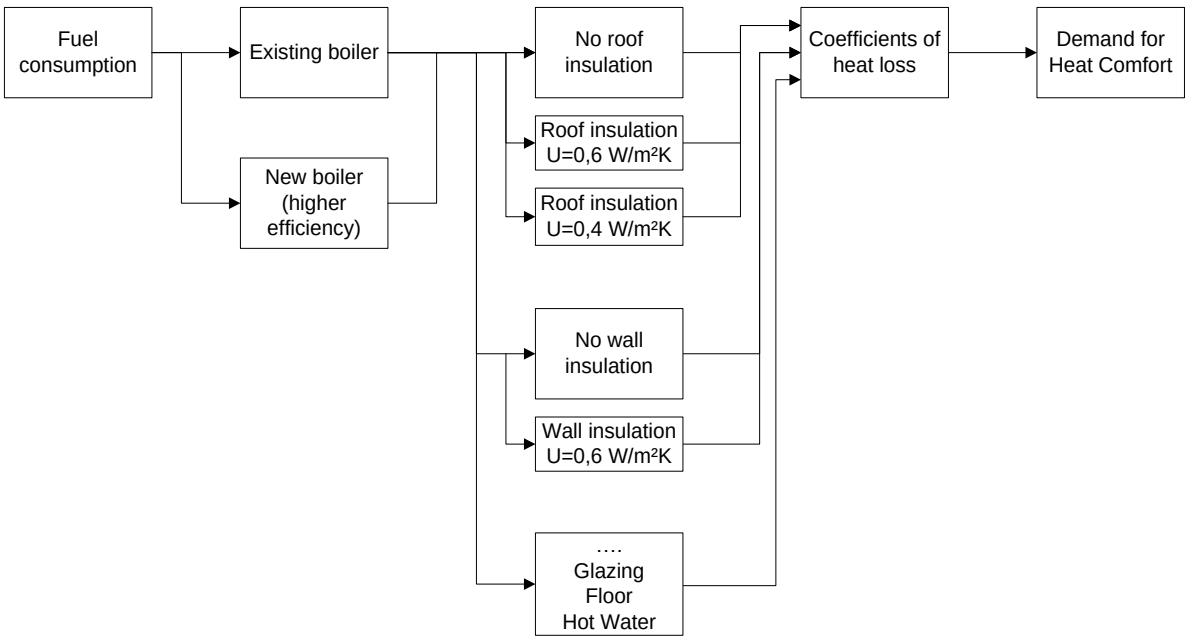
So, the model ECM isn't limited to energy and emission projections of the residential sector, but can support energy/climate/air policy related to all sectors. In the next paragraphs, we will focus on the residential section of the model – ECM Households - which is quite elaborated and detailled.

→ ***Model structure and data sources***

An appropriate model structure was defined so the total residential sector (existing and new dwellings) could be integrated and optimized. The existing stock of houses is rep-

resented by 24 dwelling categories (single houses and apartments, dwelling age <1970 & >1970, 6 fuel type) and differentiates between different levels of insulation for roofs, walls, floors, and windows. Furthermore the model differentiates between old boilers and more efficient heating installations. The model structure incorporates the possibility of additional insulating measures on different building components and some level of trade off between more efficient boilers and insulation, as represented in Figuur 24. Technological options are characterized by their investment cost, energy efficiency, current implementation degree and application degree. For each dwelling category, the model considers 5 boiler types (including fuel switch to natural gas, electricity (heat pump) and pellets), 3 levels of roof insulation, 3 glass qualities, 2 types of walls, 3 levels of floor insulation and an option for solar boiler for sanitary hot water production, leaving a lot of options for improvement for houses with the lowest energy efficiency. However, most houses do not start from the lowest efficiency levels as a number of measures have already been implemented (implementation degree). For new houses there are options for different levels of energy efficiency, starting by the minimum requirements defined by the Flanders energy performance legislation going to near zero energy buildings, without specifying the details of the different building components. The total demand for houses (existing and new houses) and corresponding heat comfort is determined by the evolution of the number of households.

As already mentioned in paragraph 5.1.4, engineering models are used in the preparation of a linear programming model. For ECM Households the same holds true, so a realistic as possible, representative dwelling stock and a correspondence with the Energy Balance in the base year (2005) are obtained thanks to the 'Flemish model for residential energy consumption'. But an aggregation of the database was necessary to restrict the solving time of ECM Households. For instance, the existing dwelling stock is subdivided into two age categories (<1970; >1970) instead of four categories.



Figuur 24. Model structure of ECM Households for Flanders.

→ ***Opportunities of cost optimisation***

Identifying cost-effective ranking of technologies by estimating marginal abatement cost curves

By means of a marginal abatement cost curve reduction measures are ranked and compared from the perspective of the additional social cost of an additional unit of emission reduction (e.g. ton reduction of CO_2). ECM compares the cost efficiency and impact of different technologies between and within different sectors from a social perspective. For instance, renewable technologies, such as pellet boilers in dwellings, are compared with energy saving measures, such as roof insulation. The marginal abatement cost curve presented below (see Figure 25) has been derived using increasing levels of CO2 tax (using a social discount rate of 4%) [LODE2008]. Assuming a certain evolution of energy prices, roof insulation, more efficient boilers and better glazing have negative marginal reduction costs MC. This means that the annualized investment costs (and operational costs) of these no-regret measures are smaller then their fuel savings (given the modelling assumptions). The efficiency gap (negative MC) is approximately 10%, either expressed as CO_2 emissions or fuel consumption. This gap shows that costefficiency is not the only decision criterion of households. The existence of no-regret measures is a market anomaly which has been observed in different studies on energy-efficiency in the residential sector. Studies released in the early 80s often explain this phenomenon by high implicit discount rates in energy efficiency investment, pointing to levels of 30 % and more (in contrast to the social discount rate of 4%). A more rational explanation is the uncertainty in future energy prices and the fact that energy saving investment are irreversible. Moreover, market failures related to asymmetric information, bounded rationality and transaction costs are major contributors to the so called "efficiency gap".

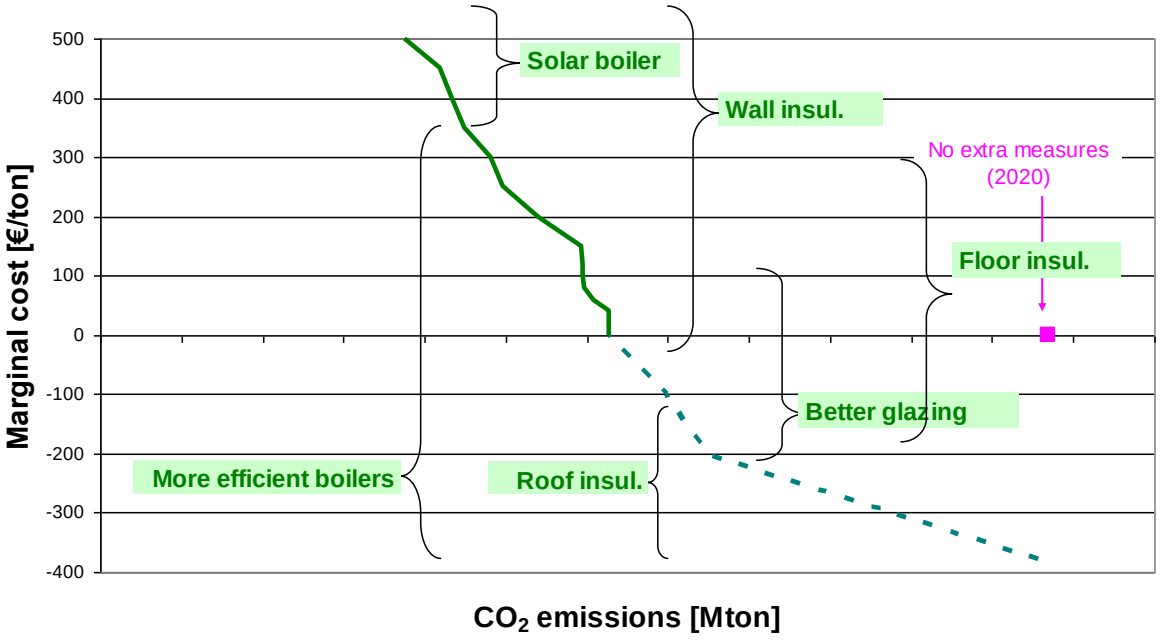


Figure 25. Marginal abatement cost curve of the Flemish residential sector: cost-effective ranking of technologies [LODE2008].

Policy scenarios: Projections of greenhouse gases and air pollutants

ECM is used to support policy makers in Flanders in implementing the post-Kyoto targets. The model calculates the optimal combination of energy services to satisfy energy demand, taking into account:

- policy objectives eg. Energy Renovation Program 2020 of Flanders, CO2 reduction goals for non-ETS sectors, renewables objectives;

- policy obligations eg. energy performance levels of new dwellings or
- policy stimulations eg. subsidies.
- The impact of climate and energy policy on emissions of air pollutants can also be determined. The outcome of these scenario runs are:
- marginal abatement cost curves (preceeding paragraph) or
- energy and emission projections over a time horizon up to 2020/2030 (with periods of 5 years).

These results are used to support the design and the implementation of a costefficient, integrated climate, energy and air policy.

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ANNEX 1 – MULTI-RESIDENTIAL TYPICAL BUILDINGS

→ ***Multi-Family Houses - Small***

Pre 1946: Cederlaan 18-20, Wilrijk

Multi-family house with three storeys and underground floor with garages, after a design by F. Van den Broeck and son (cf. also façade), no. 18 from 1937, no. 20 from 1938. Facade border bricks with protruding window bays and central shared staircase.

Link: http://inventaris.vioe.be/dibe/relict/11560

1946-1970: Sylvain Dupuisstraat 43, Knokke

1950s apartment with red brick façade, rounded, façade-length and continuous bay windows with open corner balconies; arched doors and rectangular cemented pillars in the window. Just like no. 27 and 44 after a design by arch. G. Vanwassenhove (Knokke); no. 43 realised by contractor A. Buysse (Knokke).

Link: http://inventaris.vioe.be/dibe/relict/58739

1971-1990: Hoekcomplex Kristus-Koningplein 11, Ekeren

Notary with apartment completing the mandatory building volume. Listed corner complex, built out of red brick, Belgian granite incorporated, after a design by Jef Van Oevelen from 1987; performed in 1989-1990; issued a Belgian Award in 1991 and with an Architectural prize. The creation of individual living entities inspired the design of the concept.

Link: http://inventaris.vioe.be/dibe/relict/11367

1991-2005: Houses Hemiksem

Design and realisation by Mys Bomans Architectuurkantoor. 36 new-build houses, 1999-2003. Client RSCO.

Link: http://www.mys-bomans.be/9817%20HEMIKSEM.html

Post 2005: Azalealei social housing, Merksem

Design and realisation by Mys Bomans Architectuurkantoor. Completed in 2009 under assignment from Onze Woning cvba. Due to structural failings, an existing corner building was replaced by 3 newly built duplex residential properties.

Link: http://www.mys-bomans.be/0506%20AZALEA.html

→ ***Multi-Family House- Medium***

Pre 1946: Carnotstraat 45, Antwerp

Apartment and commercial building with seven storeys, design by architect N. Kaplansky, ca. 1935. Said to be the first design for a high building by N. Kaplansky. Structure of reinforced concrete coated with decorative stone. Huge glazed bay window flanked by balconies with typical metal railing; original steel windows replaced by aluminium. Renewed shop window on the ground floor, with central access. Two flats per storey, with living room on the street side, neighbouring kitchen and maid's room on courtyard, an additional two bedrooms, pantry and bathroom. Central heating already featured in design.

Link: http://inventaris.vioe.be/dibe/relict/6605

1946-1970: Research centre for Nuclear Energy and accompanying residential estate, Boeretang, Mol

Belgian Nuclear Research Centre (SCK) with accompanying housing estate, located at "Achterbosse heide", with extensive coniferous forests, whereby the premises display an isolated, green character. The SCK was establish by the Belgian government in 1952; construction activities on "site 1" (cf. introduction), including the first core reactor and a few laboratories, were started in 1954. A second and third core reactor was built in 1961 and 1962 respectively. Besides the company buildings, like reactors, labs, experiment halls, workshops, offices, water towers, etc., social facilities like a school, sport and dining halls, a "club-house", cafeteria (first place in Prijs Van de Ven 1958), ... were also built , as well as accommodation for personnel, ranging from villas and grouped single-family houses to apartments. The housing estate originally dates from the 1950s, but was expanded considerably in the 1960s.

Two types of apartments were featured in the original design; one for young families with maximum two children, and the other for families; the latter finished in third place in the Van de Ven Annual Architecture Prize 1958.

Link: http://inventaris.vioe.be/dibe/relict/52789

1971-1990: Corner apartment building A. Ruzettelaan, Blankenberge

Corner apartment building from the 1970s. Four storeys under a flat roof and top storey with a roof sloping to the centre. Partly commercial use on the ground floor, bay windows on the upper storeys with protruding layout and stair light.

Link: http://inventaris.vioe.be/dibe/relict/44832

1991-2005: Canal houses Robbrecht and Daem, Coupure Rechts, Gent

Apartment building at the Coupure in Gent completed in 1997.

Link: http://www.robbrechtendaem.com/

Post 2005: Bert Verlackstraat 2-6, Antwerp

Apartment building with 33 apartments and underground parking after design by Tom Vercammen and Isabelle Urbain under assignment from social housing authority De Ideale Woning. Work started in 2008, completed in 2010.

Link: http://www.b-b.be/index.php?option=com_content&task=view&id=28&Itemid=49

→ ***Multi-Family House- Large***

1946-1970: Apartments De Vel, Tabakvest 5, Antwerp

At the start of 1959, Renaat Braem was hired by Etablissementen Gebroeders De Vel for a prestigious, speculative building project on the Antwerpse Leien, the boulevard on the route of the former city wall. The build started once planning permission was obtained and the building contract was signed with contractor Van De Mosselaer from Schelle in November 1959, and was completed at the end of 1961.

Link: http://inventaris.vioe.be/dibe/relict/212406

1971-1990: Chicagoblok, Ernest Claesstraat 10-16, Antwerp (Linkeroever)

The Chicagoblok (also known as the Europark) is an 81-meter high flat-block with 27 storeys, in the district Linkeroever, Antwerp. The building is one of the highest in Belgium. The Chicagoblok was built in 1970 and is home to over 6000 people.

Link: http://nl.wikipedia.org/wiki/Chicagoblok

1991-2005: Silvertop torens, Antwerp

The Silvertoptorens are three individual towers, each one 71 [1] meters high, located on the Kolonel Silvertoplaan in the Kiel district of Antwerp. They are clearly visible from the Antwerp ring road and the surrounding area. The towers are owned by the social housing authority Woonhaven.

The architect is Jul De Roover. Construction work on the building started in 1974 and took four years to complete. Renovation activities were started in 2004. By the start of 2010, two of the three towers had been fully renovated. Due to the renovation, the original visual characteristics of the buildings have more or less disappeared. After the renovation, the towers offered 525 social apartments, with communal areas, a shop and a community centre. The renovation on the Silvertop towers, after a design by architect/engineering team A33-Essa_Constructor and landscape architect Pauwels, is one of the biggest renovation projects within Flemish social housing.

Link: http://nl.wikipedia.org/wiki/Silvertoptorens en http://www.wilo.be

Post 2005: Anco torens - Grand Soleil, Turnhout

The Anco-Torens, the building project that was realised by project developer Wilma Project Development at the site of the former flour and dough factory Anco NV, is located on the banks of the Dessel-Schoten canal, level with the turning basin at the Nieuwe Kaai. The A2/Grand Soleil building has 11 storeys and contains 20 apartments. The building's simple and contemporary architecture is based on the old loft buildings. Together with the inflow of ample light, the extra high storeys help to create a special feeling of space. A unique 360° panoramic view is created thanks to large glazed areas on both sides of each apartment. This building is already fully sold out. The residents moved in the Spring of 2009.

Link: http://www.anco-torens.be/

ANNEX 2 –DATA AND CALCULATION RESULTS FOR TYPICAL DWELLINGS

		Number of housing units	Floor surface area per housing unit (m^2)	Protected volume (m^3)	Total building envelope area (m^2)	Roof (m^2)	Exterior wall (m^2)	Exterior wall bordering unheated neighboring spaces (m^2)	Floor on soil (m^2)	Floor bordering unheated neighboring spaces (m^2)	Floor bordering outdoor space (m^2)	Doors (m^2)	Windows - North side	Windows - East side	Windows - South side	Windows - West side
SFH	Detached - pre '46	1	279,0	766,0	599,2	158,4	228,9	26,9	87,3	47,0	0,0	9,5	10,8	9,3	12,2	8,9
SFH	Semi-detached - pre '46	1	237,0	651,8	447,1	119,9	158,2	27,2	61,9	40,6	0,0	9,5	7,5	7,3	7,6	7,4
SFH	Terraced - pre '46	1	225,9	621,3	323,0	90,0	92,0	24,3	41,4	34,3	0,0	9,5	8,4	7,9	8,1	7,1
MFH	Small - pre '46	6	75,0	1716,0	558,8	165,0	114,7	0,0	0,0	165,0	0,0	3,7	0,0	55,2	0,0	55,2
MFH	Medium - pre '46	12	96,0	5166,6	1112,7	215,0	292,5	0,0	0,0	207,0	8,0	4,2	0,0	137,9	80,0	168,0
SFH	Detached - '46-'70	1	235,8	648,5	538,8	158,2	183,0	19,9	56,3	70,4	0,0	9,5	9,5	9,7	12,7	9,7
SFH	Semi-detached - '46-'70	1	193,4	531,7	381,4	101,4	133,1	18,0	43,7	45,1	0,0	9,5	7,4	7,3	8,4	7,5
SFH	Terraced - '46-'70	1	198,8	546,6	296,8	90,8	79,1	13,1	35,7	38,8	0,0	9,5	6,8	7,6	7,8	7,6
MFH	Small - '46-'70	3	70,0	780,0	306,8	78,0	98,7	0,0	78,0	2,8	0,0	3,2	23,0	0,0	23,0	0,0
MFH	Medium - 46-'70	24	88,0	7335,2	3583,2	706,8	704,2	0,0	28,0	0,0	592,4	0,0	0,0	343,9	0,0	1207,9
MFH	Large - '46-'70	8	105,0	3087,4	830,7	115,2	272,3	0,0	104,4	0,0	10,8	0,0	0,0	164,0	0,0	164,0
SFH	Detached - '71-'90	1	238,4	655,7	548,8	170,0	159,4	23,5	54,8	91,6	0,0	9,5	8,6	9,5	11,9	10,2
SFH	Semi-detached - '71-'90	1	185,3	509,6	389,6	108,5	122,9	20,3	52,5	43,5	0,0	9,5	7,8	8,0	9,1	7,4
SFH	Terraced - '71-'90	1	168,3	462,8	256,9	78,6	70,1	12,5	34,9	27,1	0,0	9,5	5,7	6,3	5,9	6,5

MFH	Small - '71-'90	4	70,0	1160,3	485,3	128,0	156,7	0,0	110,5	0,0	0,0	3,6	0,0	47,8	38,6	0,0
MFH	Medium - '71-'90	13	125,0	3511,0	1124,0	255,2	296,8	0,0	243,0	0,0	0,0	6,0	219,0	74,3	29,8	0,0
MFH	Large - '71-'90	390	85,0	109350,0	22302,0	1350,0	5929,2	0,0	0,0	1350,0	0,0	0,0	2583,9	4252,5	2583,9	4252,5
SFH	Detached - '91-'05	1	258,4	710,5	558,1	161,6	183,4	17,6	50,7	88,1	0,0	11,5	9,9	11,1	13,0	11,4
SFH	Semi-detached - '91-'05	1	224,0	615,9	410,0	125,2	121,4	16,5	65,7	37,7	0,0	9,5	8,1	6,9	9,0	10,1
SFH	Terraced - '91-'05	1	191,6	526,9	264,5	80,9	75,2	9,0	37,9	25,3	0,0	9,5	6,2	6,5	6,1	7,9
MFH	Small - '91-'05	6	155,0	3168,0	1527,8	330,0	586,8	0,0	330,0	0,0	0,0	13,2	0,0	179,5	15,8	72,5
MFH	Medium - '91-'05	11	110,0	4076,8	1553,8	231,0	568,8	0,0	0,0	231,0	0,0	0,0	87,6	218,9	14,3	202,2
MFH	Large - '91-'05	197	105,0	76245,0	16358,0	1115,0	9579,4	0,0	0,0	1115,0	0,0	0,0	718,2	1556,1	718,2	1556,1
SFH	Detached - post '05	1	269,6	741,4	557,9	152,3	173,2	28,0	48,0	83,9	0,0	9,5	16,2	14,7	20,2	11,8
SFH	Semi-detached - post '05	1	233,7	642,7	407,9	118,0	118,3	16,9	62,2	35,8	0,0	9,5	13,4	9,2	13,9	10,6
SFH	Terraced - post '05	1	199,9	549,8	267,7	76,3	72,0	13,3	35,9	24,1	0,0	9,5	10,3	8,6	9,5	8,2
MFH	Small - post '05	3	75,0	780,3	362,1	76,5	156,8	0,0	76,5	0,0	0,0	2,9	0,0	36,4	13,0	0,0
MFH	Medium - post '05	33	96,0	10779,9	3455,6	632,4	1272,7	154,6	55,9	576,2	0,0	5,7	34,2	260,1	34,2	429,6
MFH	Large - post '05	30	121,3	11574,0	3262,8	360,0	890,0	0,0	360,0	0,0	0,0	0,0	626,9	133,0	626,9	266,0

Table 18: Geometrical data for the EU harmonized housing typology

		Floor surface area (m^2)	Protected volume (m^3)	Total building envelope area (m^2)	Roof (m^2)	Exterior wall (m^2)	Exterior wall bordering unheated neighboring spaces (m^2)	Floor on soil (m^2)	Floor bordering unheated neighboring spaces (m^2)	Doors (m^2)	Windows - North side	Windows - East side	Windows - South side	Windows - West side
Type1	Detached - pre '46	279,0	766,0	599,2	158,4	228,9	26,9	87,3	47,0	9,5	10,8	9,3	12,2	8,9
Type2	Semi-detached - pre '46	237,0	651,8	447,1	119,9	158,2	27,2	61,9	40,6	9,5	7,5	7,3	7,6	7,4
Type3	Terraced - pre '46	225,9	621,3	323,0	90,0	92,0	24,3	41,4	34,3	9,5	8,4	7,9	8,1	7,1
Type4	Enclosed apartment - pre '46	100,1	320,3	44,8	0,0	17,9	0,0	0,0	0,0	0,0	13,4	0,0	13,4	0,0
Type5	Exposed apartment - pre '46	100,1	320,3	190,7	100,1	63,7	0,0	0,0	0,0	0,0	13,4	0,0	13,4	0,0
Type6	Detached - '46-'70	235,8	648,5	538,8	158,2	183,0	19,9	56,3	70,4	9,5	9,5	9,7	12,7	9,7
Type7	Semi-detached - '46-'70	193,4	531,7	381,4	101,4	133,1	18,0	43,7	45,1	9,5	7,4	7,3	8,4	7,5
Type8	Terraced - '46-'70	198,8	546,6	296,8	90,8	79,1	13,1	35,7	38,8	9,5	6,8	7,6	7,8	7,6
Type9	Enclosed apartment - '46-'70	100,1	320,3	44,8	0,0	17,9	0,0	0,0	0,0	0,0	13,4	0,0	13,4	0,0
Type10	Exposed apartment - '46-'70	100,1	320,3	190,7	100,1	63,7	0,0	0,0	0,0	0,0	13,4	0,0	13,4	0,0
Type11	Detached - '71-'90	238,4	655,7	548,8	170,0	159,4	23,5	54,8	91,6	9,5	8,6	9,5	11,9	10,2
Type12	Semi-detached - '71-'90	185,3	509,6	389,6	108,5	122,9	20,3	52,5	43,5	9,5	7,8	8,0	9,1	7,4
Type13	Terraced - '71-'90	168,3	462,8	256,9	78,6	70,1	12,5	34,9	27,1	9,5	5,7	6,3	5,9	6,5
Type14	Enclosed apartment - '71-'90	100,1	320,3	44,8	0,0	17,9	0,0	0,0	0,0	0,0	13,4	0,0	13,4	0,0
Type15	Exposed apartment - '71-'90	100,1	320,3	190,7	100,1	63,7	0,0	0,0	0,0	0,0	13,4	0,0	13,4	0,0
Type16	Detached - '91-'05	258,4	710,5	558,1	161,6	183,4	17,6	50,7	88,1	11,5	9,9	11,1	13,0	11,4

Type17	Semi-detached - '91-'05	224,0	615,9	410,0	125,2	121,4	16,5	65,7	37,7	9,5	8,1	6,9	9,0	10,1
Type18	Terraced - '91-'05	191,6	526,9	264,5	80,9	75,2	9,0	37,9	25,3	9,5	6,2	6,5	6,1	7,9
Type19	Enclosed apartment - '91-'05	100,1	320,3	44,8	0,0	17,9	0,0	0,0	0,0	0,0	13,4	0,0	13,4	0,0
Type20	Exposed apartment - '91-'05	100,1	320,3	190,7	100,1	63,7	0,0	0,0	0,0	0,0	13,4	0,0	13,4	0,0
Type21	Detached - post '05	269,6	741,4	557,9	152,3	173,2	28,0	48,0	83,9	9,5	16,2	14,7	20,2	11,8
Type22	Semi-detached - post '05	233,7	642,7	407,9	118,0	118,3	16,9	62,2	35,8	9,5	13,4	9,2	13,9	10,6
Type23	Terraced - post '05	199,9	549,8	267,7	76,3	72,0	13,3	35,9	24,1	9,5	10,3	8,6	9,5	8,2
Type24	Enclosed apartment - post '05	100,1	320,3	44,8	0,0	17,9	0,0	0,0	0,0	0,0	13,4	0,0	13,4	0,0
Type25	Exposed apartment - post '05	100,1	320,3	190,7	100,1	63,7	0,0	0,0	0,0	0,0	13,4	0,0	13,4	0,0

Table 19: Geometrical data for the national housing typology

		Gross floor surface area	Net energy demand space heating	Net energy demand space heating	Net energy demand space heating	Correction factor - space heating	Primary energy consumption	Primary energy consumption - corrected value	Primary energy consumption	Primary energy consumption	Primary energy consumption space heating	Primary energy consumption space heating - corrected value	Primary energy consumption space heating	Primary energy consumption space heating
		m²	kWh/m²	kWh/m²	kWh/m²	%	kWh/m²	kWh/m²	kWh/m²	kWh/m²	kWh/m²	kWh/m²	kWh/m²	kWh/m²
			Current	EPB2010	LE	Current	Current	Current	EPB2010	LE	Current	Current	EPB2010	LE
Type 1	Detached - pre '46	279	334	94	39	34%	603	230	146	74	569	196	112	46
Type 2	Semi-detached - pre '46	237	295	87	33	41%	477	208	137	66	454	185	103	39
Type 3	Terraced - pre '46	226	231	74	28	42%	385	180	120	59	356	150	88	33
Type 4	Enclosed apartment - pre '46	100	140	62	17	46%	252	135	113	52	215	99	75	20
Type 5	Exposed apartment - pre '46	100	341	102	36	50%	560	300	160	74	524	263	121	42
Type 6	Detached - '46-'70	236	343	103	43	38%	603	239	157	78	584	219	122	50
Type 7	Semi-detached - '46-'70	193	300	96	37	45%	486	232	148	70	462	208	114	44
Type 8	Terraced - '46-'70	199	234	78	30	45%	384	187	126	60	360	163	93	35
Type 9	Enclosed apartment - '46-'70	100	134	62	17	48%	243	134	113	52	206	98	75	20
Type 10	Exposed apartment - '46-'70	100	333	102	36	51%	549	298	160	74	512	262	121	42
Type 11	Detached - '71-'90	238	238	101	42	45%	499	238	165	75	471	210	133	49
Type 12	Semi-detached - '71-'90	185	221	102	40	50%	463	243	166	72	436	216	133	47
Type 13	Terraced - '71-'90	168	167	81	30	52%	368	207	138	58	335	175	107	35

Type 14	Enclosed apartment - '71-'90	100	99	62	17	48%	264	156	113	52	209	101	75	20
Type 15	Exposed apartment - '71-'90	100	204	102	36	59%	488	310	160	74	433	255	121	42
Type 16	Detached - '91-'05	258	165	99	41	60%	311	197	149	75	283	169	118	49
Type 17	Semi-detached - '91-'05	224	145	88	35	64%	278	189	137	66	249	160	105	40
Type 18	Terraced - '91-'05	192	119	75	27	67%	232	166	120	56	204	137	89	32
Type 19	Enclosed apartment - '91-'05	100	93	62	17	59%	197	132	113	52	159	94	75	20
Type 20	Exposed apartment - '91-'05	100	163	102	36	81%	319	265	160	74	281	227	121	42
Type 21	Detached - post '05	270	103	103	45	100%	157	157	157	79	125	125	125	52
Type 22	Semi-detached - post '05	234	92	92	38	100%	144	144	144	70	113	113	113	44
Type 23	Terraced - post '05	200	77	77	31	100%	125	125	125	60	95	95	95	36
Type 24	Enclosed apartment - post '05	100	60	60	17	100%	112	112	112	52	74	74	74	20
Type 25	Exposed apartment - post '05	100	99	99	36	100%	159	159	159	74	121	121	121	42
	Average value	**174**	**189**	**87**	**32**	**61%**	**346**	**198**	**140**	**66**	**313**	**165**	**105**	**38**

Table 20: Energy performance calculation results - specific values (kWh/jr.m²)

		Gross floor surface area	Net energy demand space heating	Net energy demand space heating	Net energy demand space heating	Correction factor - space heating	Primary energy consumption	Primary energy consumption - corrected value	Primary energy consumption	Primary energy consumption	Primary energy consumption space heating	Primary energy consumption space heating - corrected value	Primary energy consumption space heating	Primary energy consumption space heating
		m²	kWh	kWh	kWh	%	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh
			Current	EPB2010	LE	Current	Current	Current	EPB2010	LE	Current	Current	EPB2010	LE
Type 1	Detached - pre '46	279	93.217	26.210	10.871	34%	168.154	64.147	40.721	20.634	158.747	54.740	31.290	12.748
Type 2	Semi-detached - pre '46	237	69.954	20.503	7.908	41%	113.042	49.337	32.420	15.713	107.639	43.934	24.477	9.273
Type 3	Terraced - pre '46	226	52.235	16.612	6.338	42%	87.013	40.594	27.067	13.240	80.375	33.956	19.832	7.432
Type 4	Enclosed apartment - pre '46	100	14.013	6.254	1.729	46%	25.198	13.528	11.298	5.236	21.563	9.892	7.466	2.028
Type 5	Exposed apartment - pre '46	100	34.096	10.186	3.619	50%	56.100	29.993	15.992	7.452	52.464	26.357	12.160	4.244
Type 6	Detached - '46-'70	236	80.818	24.184	10.066	38%	142.189	56.289	36.968	18.360	137.633	51.733	28.872	11.803
Type 7	Semi-detached - '46-'70	193	58.029	18.480	7.225	45%	94.052	44.914	28.671	13.580	89.290	40.151	22.062	8.473
Type 8	Terraced - '46-'70	199	46.494	15.553	5.902	45%	76.383	37.231	25.012	11.929	71.541	32.389	18.567	6.920
Type 9	Enclosed apartment - '46-'70	100	13.427	6.254	1.729	48%	24.299	13.459	11.298	5.236	20.661	9.820	7.466	2.028
Type 10	Exposed apartment - '46-'70	100	33.321	10.186	3.619	51%	54.907	29.848	15.992	7.452	51.272	26.212	12.160	4.244
Type 11	Detached - '71-'90	238	56.848	24.157	9.948	45%	118.889	56.727	39.287	17.840	112.202	50.040	31.687	11.665
Type 12	Semi-detached - '71-'90	185	40.960	18.840	7.460	50%	85.757	44.965	30.765	13.361	80.844	40.052	24.714	8.748
Type 13	Terraced - '71-'90	168	28.157	13.690	4.999	52%	61.933	34.917	23.228	9.744	56.431	29.416	17.958	5.862

Type 14	Enclosed apartment - '71-'90	100	9.900	6.254	1.729	48%	26.440	15.567	11.298	5.236	20.955	10.082	7.466	2.028
Type 15	Exposed apartment - '71-'90	100	20.466	10.186	3.619	59%	48.806	31.014	15.992	7.452	43.321	25.529	12.160	4.244
Type 16	Detached - '91-'05	258	42.544	25.469	10.711	60%	80.467	50.938	38.586	19.322	73.174	43.646	30.406	12.560
Type 17	Semi-detached - '91-'05	224	32.478	19.776	7.728	64%	62.363	42.272	30.787	14.812	55.861	35.770	23.609	9.062
Type 18	Terraced - '91-'05	192	22.719	14.336	5.264	67%	44.514	31.733	23.029	10.714	39.076	26.295	17.114	6.173
Type 19	Enclosed apartment - '91-'05	100	9.269	6.254	1.729	59%	19.759	13.230	11.298	5.236	15.942	9.413	7.466	2.028
Type 20	Exposed apartment - '91-'05	100	16.357	10.186	3.619	81%	31.950	26.510	15.992	7.452	28.133	22.693	12.160	4.244
Type 21	Detached - post '05	270	27.676	27.676	12.064	100%	42.308	42.308	42.308	21.239	33.800	33.800	33.800	14.147
Type 22	Semi-detached - post '05	234	21.531	21.531	8.853	100%	33.758	33.758	33.758	16.417	26.295	26.295	26.295	10.381
Type 23	Terraced - post '05	200	15.482	15.482	6.145	100%	25.054	25.054	25.054	11.983	18.908	18.908	18.908	7.206
Type 24	Enclosed apartment - post '05	100	6.053	6.053	1.729	100%	11.225	11.225	11.225	5.236	7.392	7.392	7.392	2.028
Type 25	Exposed apartment - post '05	100	9.886	9.886	3.619	100%	15.906	15.906	15.906	7.452	12.073	12.073	12.073	4.244
	Average value	**174**	**34.237**	**15.368**	**5.929**	**61%**	**62.019**	**34.218**	**24.558**	**11.693**	**56.624**	**28.824**	**18.702**	**6.953**

Table 21: Energy performance calculation results (kWh/jr.m²)

		Specific PE corrected	PE corrected	Specific PE	PE	Specific PE	PE
		kWh/jr.m²	kWh/jr	kWh/jr.m²	kWh/jr	kWh/jr.m²	kWh/jr
		Current	Current	EPB2010	EPB2010	LE	LE
Type 1	Detached - pre '46	230	64.147	146	40.721	74	20.634
Type 6	Detached - '46-'70	239	56.289	157	36.968	78	18.360
Type 11	Detached - '71-'90	238	56.727	165	39.287	75	17.840
Type 16	Detached - '91-'05	197	50.938	149	38.586	75	19.322
Type 21	Detached - post '05	157	42.308	-	-	79	21.239
Type 2	Semi-detached - pre '46	208	49.337	137	32.420	66	15.713
Type 7	Semi-detached - '46-'70	232	44.914	148	28.671	70	13.580
Type 12	Semi-detached - '71-'90	243	44.965	166	30.765	72	13.361
Type 17	Semi-detached - '91-'05	189	42.272	137	30.787	66	14.812
Type 22	Semi-detached - post '05	144	33.758	-	-	70	16.417
Type 3	Terraced - pre '46	180	40.594	120	27.067	59	13.240
Type 8	Terraced - '46-'70	187	37.231	126	25.012	60	11.929
Type 13	Terraced - '71-'90	207	34.917	138	23.228	58	9.744
Type 18	Terraced - '91-'05	166	31.733	120	23.029	56	10.714
Type 23	Terraced - post '05	125	25.054	-	-	60	11.983
Type 4	Enclosed apartment - pre '46	135	13.528	113	11.298	52	5.236
Type 9	Enclosed apartment - '46-'70	134	13.459	113	11.298	52	5.236
Type 14	Enclosed apartment - '71-'90	156	15.567	113	11.298	52	5.236
Type 19	Enclosed apartment - '91-'05	132	13.230	113	11.298	52	5.236
Type 24	Enclosed apartment - post '05	112	11.225	-	-	52	5.236
Type 5	Exposed apartment - pre '46	300	29.993	160	15.992	74	7.452
Type 10	Exposed apartment - '46-'70	298	29.848	160	15.992	74	7.452
Type 15	Exposed apartment - '71-'90	310	31.014	160	15.992	74	7.452
Type 20	Exposed apartment - '91-'05	265	26.510	160	15.992	74	7.452
Type 25	Exposed apartment - post '05	159	15.906	-	-	74	7.452

	Average value	**198**	**34.218**	**140**	**24.285**	**66**	**11.693**

Table 22: Specific primary energy consumption (kWh/yr.m²) and total primary energy consumption (kWh/yr) for the current state and EPB 2010 and LE scenarios

		Yearly energy cost - corrected	Total investment cost per m²	Yearly energy cost savings	Payback time	Total investment cost per m²	Yearly energy cost savings	Payback time
		€/yr	€/m²	€/yr	yrs	€/m²	€/yr	yrs
		Current	EPB2010	EPB2010	EPB2010	LE	LE	LE
Type 1	Detached - pre '46	5000	175	2600	19	275	3800	20
Type 2	Semi-detached - pre '46	3000	175	1000	41	250	2000	30
Type 3	Terraced - pre '46	2400	175	800	49	250	1600	35
Type 4	Enclosed apartment - pre '46	800	225	100	225	350	500	70
Type 5	Exposed apartment - pre '46	1800	250	800	31	400	1300	31
Type 6	Detached - '46-'70	4400	200	2200	21	300	3300	21
Type 7	Semi-detached - '46-'70	2600	200	900	43	300	1800	32
Type 8	Terraced - '46-'70	2200	200	700	57	275	1500	36
Type 9	Enclosed apartment - '46-'70	800	225	100	225	350	500	70
Type 10	Exposed apartment - '46-'70	1800	250	800	31	400	1300	31
Type 11	Detached - '71-'90	4600	175	2100	20	275	3400	19
Type 12	Semi-detached - '71-'90	3600	175	1700	19	275	2800	18
Type 13	Terraced - '71-'90	2200	175	700	42	250	1500	28
Type 14	Enclosed apartment - '71-'90	1000	200	300	67	325	600	54
Type 15	Exposed apartment - '71-'90	1800	225	900	25	375	1400	27
Type 16	Detached - '91-'05	3000	125	700	46	275	1900	37
Type 17	Semi-detached - '91-'05	2600	100	700	32	250	1600	35
Type 18	Terraced - '91-'05	2000	100	500	38	250	1200	40
Type 19	Enclosed apartment - '91-'05	800	125	100	125	325	500	65
Type 20	Exposed apartment - '91-'05	1600	150	600	25	375	1100	34
Type 21	Detached - post '05	2600				275	1300	57
Type 22	Semi-detached - post '05	2000				250	1000	58
Type 23	Terraced - post '05	1600				250	800	62
Type 24	Enclosed apartment - post '05	600				300	300	100
Type 25	Exposed apartment - post '05	1000				350	500	70
	Average value	**2232**	**181**	**915**	**59**	**302**	**1500**	**43**

Table 23: Financial assessment for the EPB 2010 and LE scenarios

ANNEX 3 –NATIONAL HOUSING TYPOLOGY BROCHURE

Belgische woningtypologie

Nationale brochure over de TABULA woningtypologie

Deliverable	D5.7
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Datum	Augustus 2011
Programma	IEE/08/495/SI2.528393

Supported by INTELLIGENT ENERGY EUROPE

Dit is een publieke brochure opgesteld door de Vlaamse Instelling voor Technologisch Onderzoek. Meer informatie is te verkrijgen bij marlies.vanholm@vito.be.

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Samenvatting

Deze brochure beschrijft de Belgische woningentypologie ontwikkeld door de Vlaamse Instelling voor Technologisch Onderzoek (VITO) in het kader van het Europese onderzoeksproject TABULA. Deze woningtypologie omvat een set van typische woningen voor de Belgische context waarvoor we het gebouwgebonden energieverbruik voor verwarming, warm waterconsumptie en hulpenergie voor de werking van de technische installaties in kaart brengen. Daarnaast worden voor elk woningtype twee renovatiescenario's uitgewerkt. We stellen verbetermaatregelen voor om het energieverbruik van de woning terug te dringen, enerzijds tot op het niveau van de huidige eisen voor nieuwbouw (EPB 2010) en anderzijds tot op het niveau van lage energiewoningen (LE). Voor deze twee renovatiescenario's geven we ook een inschatting van de investeringskosten, de verwachte besparing op de energiekosten en een indicatie van de terugverdientijd. Deze renovatiemaatregelen leiden voor heel wat woningtypes ook tot een aanzienlijke verhoging van het comfort in de woning. Om die reden geven we ook een comfortbeoordeling mee voor de huidige staat van de woningen en voor de twee verbeterscenario's.

Het ontwikkelen van een Belgische woningentypologie en het uitvoeren van analyses van het verbeterpotentieel op niveau van de individuele woning en van het totale gebouwenpark vertoont een belangrijke overlap met VITO-activiteiten buiten het TABULA-project. De Unit Transitie Energie en Milieu van VITO is betrokken in diverse projecten met focus op het energieverbruik van het Belgische gebouwenpark en scenario's om dit verbruik terug te dringen conform de EU-doelstellingen voor 2020 en 2050.

Meer info over het IEE-project TABULA is beschikbaar op **de VITO-website** (www.vito.be) en op **de TABULA-website** (www.building-typology.eu).

Inhoud

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HOOFDSTUK 1. Inleiding

1. Wat is een woningtypologie?

De 13 partners betrokken bij de Europese onderzoeksproject TABULA ontwikkelen elk een woningtypologie voor hun land. Voor de verdere eenduidige interpretatie van het begrip “woningtypologie” lichten we dit begrip even kort toe:

De **Belgische TABULA-woningtypologie** is een set van woningtypes die georganiseerd worden volgens een bepaalde systematiek en als “typisch” worden beschouwd voor de Belgische context. Voor de verschillende woningtypes worden karakteristieken met betrekking tot het gebouwgebonden energieverbruik in kaart gebracht.

Een definitie voor het begrip **“typische woning”** is minder eenvoudig op te stellen. Binnen de context van dit project gaat het om een fictieve woning die is opgebouwd uit typische elementen voor de bouwschil en de technische installaties. Deze typische woningen zijn “herkenbaar” en “vertaalbaar” in die zin dat men als woningeigenaar of –huurder de eigen woning kan identificeren met één van de woningtypes uit de typologie.

2. Wat is het doel van deze woningbrochure?

Deze woningbrochure is bedoeld als een breed toegankelijk en praktisch communicatiemiddel dat inzicht biedt in het energieverbruik en mogelijke energiebesparende maatregelen in woongebouwen. In eerste plaats richt de brochure zich tot woningeigenaars, zowel particulieren als eigenaars van een woningpatrimonium, zoals sociale huisvestingsmaatschappijen.
De brochure kent echter een veelheid aan gebruiksmogelijkheden en is vanuit die optiek ook relevant voor heel wat andere partijen betrokken bij de energie-efficiëntie van het woningpark:

- Eerst en vooral is de brochure bestemd voor **algemene verspreiding**, met als doel te sensibiliseren en te stimuleren tot renovatie. De brochure kan ingezet worden in het kader van algemene bewustmaking en laat particulieren toe om in te zoomen op het woningtype dat het best overeenkomt met hun specifieke situatie en biedt inzicht in mogelijke renovatiemaatregelen, hun impact en financiële aantrekkelijkheid;

- De brochure kan gebruikt worden door **energieadviseurs** bij het geven van advies naar mogelijke energiebesparende maatregelen, hun impact en kostprijs. De woningfiches kunnen ook als bijlage meegegeven worden bij de opmaak van een EPC;

- De brochure biedt **potentiële huurders/kopers/(ver)bouwers** van een woning een referentiekader dat mee kan bijdragen tot de beslissing om een woning al dan niet te kopen, te huren of te (ver)bouwen;

- De brochure laat toe om een eerste prognose op te maken van het energieverbruik en het verbeterpotentieel van een **bepaald woningpatrimonium**, bijvoorbeeld van huisvestingsmaatschappijen;

- **Beleidsmakers** op lokaal, gewestelijk of nationaal niveau hebben via deze brochure een set van woningtypes ter beschikking voor het testen en simuleren van de impact van energiebesparende maatregelen, bijvoorbeeld bij het uitwerken van mogelijke steunmaatregelen/subsidies.

3. De woningtypologie

In deze woningbrochure ligt de focus op wooneenheden, eerder dan op het gebouw als geheel. Dit onderscheid is vooral van belang voor appartementen, waarbij we dus focussen op het individuele appartement en niet op het gehele appartementsgebouw. In totaal zijn 25 woningtypes uitgewerkt. Er werden eerst en vooral 5 bouwperiodes afgebakend (voor 1946; 1946-1970; 1971-1990; 1991-2005; na 2005). En daarnaast werden 5 woningtypes bepaald. Het betreft drie types woningen (vrijstaande woning, halfopen bebouwing en rijwoning) en twee types appartementen (ingesloten appartement en blootgesteld appartement). Een factor met grote invloed op de energieconsumptie van een appartement is de totale oppervlakte van de buitenschil waarlangs het appartement in contact staat met de buitenomgeving. Om die reden maken we in de brochure een onderscheid tussen twee uiterste situaties, met name een appartement dat sterk is ingesloten is en daarnaast een appartement dat sterk is blootgesteld. De energieconsumptie voor appartementen die tussen deze twee situatie vallen, ligt dus tussen deze twee extremen in.

Huidige situatie	<1946	1946-1970	1971-1990	1991-2005	>2005
Vrijstaande woning	TYPE 1	TYPE 6	TYPE 11	TYPE 16	TYPE 21
Halfopen bebouwing	TYPE 2	TYPE 7	TYPE 12	TYPE 17	TYPE 22
Rijwoning	TYPE 3	TYPE 8	TYPE 13	TYPE 18	TYPE 23
Ingesloten appartement	TYPE 4	TYPE 9	TYPE 14	TYPE 19	TYPE 24
Blootgesteld appartement	TYPE 5	TYPE 10	TYPE 15	TYPE 20	TYPE 25

Tabel 1: De 25 woningtypes van de Belgische woningtypolgie

Voor deze 25 woningtypes worden telkens twee verbeterscenario's uitgewerkt, met name een standaard renovatie tot het niveau EPB 2010 en een meer doorgedreven renovatie tot lage energie. Het EPB 2010 scenario is echter niet van toepassing voor de woningtypes uit de periode na 2005 (types 21 tot 25) omdat de woningen uit die periode al vrij dicht aanleunen bij deze eisen. Daarnaast is het ook nuttig om mee te geven dat voor de appartementen de EPB 2010 en de lage energierenovatie tot identieke resultaten leidt ongeacht de bouwperiode. Dit komt omdat de geometrie van de appartementen identiek is verondersteld voor alle bouwperiodes.

Standaard renovatie	<1946	1946-1970	1971-1990	1991-2005	>2005
Vrijstaande woning	TYPE 1	TYPE 6	TYPE 11	TYPE 16	-
Halfopen bebouwing	TYPE 2	TYPE 7	TYPE 12	TYPE 17	-
Rijwoning	TYPE 3	TYPE 8	TYPE 13	TYPE 18	-
Ingesloten appartement	TYPE 4 = 9 = 14 = 19				-
Blootgesteld appartement	TYPE 5 = 10 = 15 = 20				-

Lage energierenovatie	<1946	1946-1970	1971-1990	1991-2005	>2005
Vrijstaande woning	TYPE 1	TYPE 6	TYPE 11	TYPE 16	TYPE 21
Halfopen bebouwing	TYPE 2	TYPE 7	TYPE 12	TYPE 17	TYPE 22
Rijwoning	TYPE 3	TYPE 8	TYPE 13	TYPE 18	TYPE 23
Ingesloten appartement	TYPE 4 = 9 = 14 = 19 = 24				
Blootgesteld appartement	TYPE 5 = 10 = 15 = 20 = 25				

Tabel 2: Verbeterscenario's voor de verschillende woningtypes (EPB 2010 en Lage Energie)

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4. Financiële beoordeling

Volgende **energieprijzen** worden gehanteerd in de berekening van energiekosten en van de terugverdientijden:
Stookolie: 0.08 Euro/kWh
Gas: 0.06 Euro/kWh
Elektriciteit: 0.18 Euro/kWh.

De energieprijzen voor gas en elektriciteit zijn gebaseerd op het eenheidsprijzen voor december 2010 gecommuniceerd door de Vlaamse Energieregulator VREG (http://www.vreg.be/sites/default/files/uploads/eenheidsprijzen.doc). Deze prijzen zijn een gemiddelde voor verschillende energieleveranciers en zijn van toepassing op huishoudens met een gemiddelde energieconsumptie in Vlaanderen. De olieprijs is gebaseerd op de eenheidsprijs gepubliceerd op Europe's Energy Portal (http://www.energy.eu/#Domesticn) eveneens voor december 2010 voor België. De verwachte toekomstige stijging van energieprijzen wordt in de berekeningen niet in rekening gebracht.

De **investeringskosten** voor de verschillende energiebesparende maatregelen zijn berekend volgens prijzen voor werkzaamheden in de bouw voor 2010. De ingeschatte investeringskosten zijn inclusief materiaal- en plaatsingskost en exclusief BTW. De investeringskost geeft de kostprijs van de energiebesparende maatregelen inclusief noodzakelijke afbraakwerken en extra uit te voeren werken die rechtstreeks verband houden met de energiebesparingsmaatregel (bv. voorzien van bijkomende kepers voor extra dakisolatie). De investeringskost omvat echter niet de onrechtsstreekse extra kosten (bv. plaatsen van een nieuwe vloerafwerking na het voorzien van vloerisolatie). We gaan er met andere woorden van uit dat energiebesparende maatregelen worden gecombineerd met, of enkel worden uitgevoerd indien ook overige renovatiewerken nodig zijn om de algemene staat van de woning te verbeteren. Ook subsidies en belastingvoordelen worden niet in rekening gebracht bij de financiële beoordeling omdat deze voordelen vaak contextafhankelijk zijn (bv. ligging van de woning, staat van de woning, inkomen van de woningeigenaar,…). De berekende terugverdientijden houden tot slot ook geen rekening met rente op leningen en verloren interest door het aanwenden van spaartegoeden voor de investeringen.

Bouwschil	**Kostprijs**
Aanbrengen bijkomende dakisolatie tot U-waarde 0,3 W/m²K	22 €/m²
Aanbrengen bijkomende gevelisolatie tot U-waarde 0,4 W/m²K	22 €/m²
Aanbrengen bijkomende vloerisolatie tot U-waarde 0,4 W/m²K	22 €/m²
Vervanging van ramen en deuren inclusief de beglazing - U-waarde 2 W/m²K	450 €/m²
Vervaning van beglazing exclusief raamkaders - Ug-waarde 1,1 W/m²K	200 €/m²
Aanbrengen bijkomende dakisolatie tot U-waarde 0,15 W/m²K	30 €/m²
Aanbrengen bijkomende gevelisolatie tot U-waarde 0,25 W/m²K	30 €/m²
Aanbrengen bijkomende vloerisolatie tot U-waarde 0,25 W/m²K	30 €/m²
Vervanging van ramen en deuren inclusief de beglazing - U-waarde 1,6 W/m²K	650 €/m²
Verwarming en warm waterproductie	**Kostprijs**
Installatie van condenserende combiketel (verwarming en warm water)	3500 €/st
Aanpassingen aan verwarmingsregeling in functie van de condenserende ketel	10 €/m²
Installatie van leidingen en radiatoren in geval nog geen CV in de woning aanwezig	40 €/m²
Installatie van zonneboiler en zonthermische panelen 5m², inclusief alle toebehoren	5500 €/st
Ventilatie	**Kostprijs**
Installatie van mechanische afvoerventilatie - type C	2500 €/st
Installatie van balansventilatie (aan- en afvoerventilatie) met waterterugwinning met rendement 80% , inclusief alle toebehoren	4500 €/st

Tabel 3: Investeringskosten voor de verschillende energiebesparende maatregelen

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5. Comfortbeoordeling

Energiebesparende maatregelen hebben ook -zeker voor oudere woningen- een aanzienlijke verhoging van het thermisch comfort in de woning tot gevolg. De maatregelen op vlak van ventilatievoorzieningen verbeteren ook de binnenluchtkwaliteit in de woning. Naast de financiële beoordeling wordt in de woningfiches daarom ook een comfortbeoordeling uitgewerkt. Op basis van expert judgement kennen we de verschillende woningtypes een aantal sterren toe om het comfortniveau weer te geven, zowel voor de huidige situatie, als voor het standaard en lage energierenovatiescenario. Het aantal toegekende sterren varieert van één ster (laagste comfortklasse) tot vier sterren (hoogste comfortklasse). Hieronder lichten we kort toe welke comfortkarakteristieken overeenkomen met deze vier comfortklassen.

Comfortklasse	Karakteristieken
*	Hoge energiekosten noodzaken de gebruiker om circulatieruimtes niet te verwarmen
	Grote temperatuurverschillen tussen verblijfsruimtes en onverwarmde ruimtes: algemene thermische onbehaaglijkheid
	Koudestraling van vloeren, wanden en beglazing: lokale thermische onbehaaglijkheid
	Tocht door kieren en spleten (bv. in deuren en ramen)
	Overvloedige aanvoer van verse lucht; hoge energiekosten in de winter om deze aannvoer van koude buitenlucht te compenseren en de binnenruimtes op temperatuur te houden
	Condensatie aan de binnenzijde van de beglazing
**	Hoge energiekosten noodzaken de gebruiker om circulatieruimtes niet te verwarmen
	Vrij grote temperatuurverschillen tussen verblijfsruimtes en onverwarmde ruimtes: algemene thermische onbehaaglijkheid
	Koudestraling van vloeren, wanden en beglazing: lokale thermische onbehaaglijkheid
	Tocht door kieren en spleten (bv. in deuren en ramen)
	Overvloedige aanvoer van verse lucht; hoge energiekosten in de winter om deze aannvoer van koude buitenlucht te compenseren en de binnenruimtes op temperatuur te houden
***	Kleine temperatuurverschillen in de verschillende ruimtes van de woning: algemene thermische behaaglijkheid
	Kleine temperatuurverschillen tussen oppervlaktes en lucht: lokale thermische behaaglijkheid
	Kans op tocht door de luchttoevoerroosters
	Gecontroleerde aanvoer van verse lucht (maar noodzaakt verstandig gebruik van de ventilatievoorzieningen)
****	Evenwichtstemperatuur in de volledige woning: algemene thermische behaaglijkheid
	Kleine temperatuurverschillen tussen oppervlaktes en lucht: lokale thermische behaagelijkheid
	Minimale kans op tocht
	Sterk gecontroleerde luchtkwaliteit en vochtigheid mogelijk (noodzaakt goede regeling)
	Grotere kans op oververhitting noodzaakt doordachte oriëntatie van ramen en het voorzien van zonwerende maatregelen

Tabel 4: Karakteristieken voor de vier gedefinieerde comfortklassen

6. Berekening van het energieverbruik

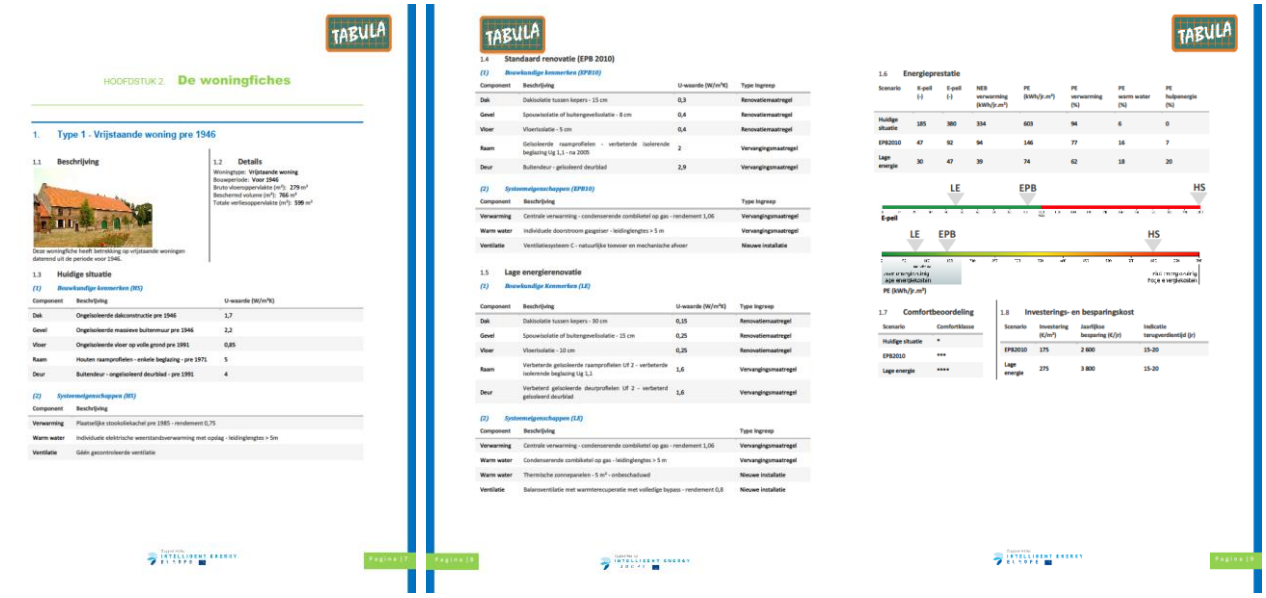
In de woningfiches wordt het energieverbruik voor verwarming en sanitair warm water weergegeven, zoals theoretisch berekend met de Vlaamse EPW-methode. Deze methode vormt de basis van de Vlaamse EPB-software waarmee energiecertificaten voor nieuwbouwwoningen opgesteld worden. In de woningfiches worden de resultaten van deze berekening weergegeven onder vorm van een K-peil, een E-peil (of energieprestatiepeil), en een energievraag per vierkante meter vloeroppervlak per jaar. Voor al deze kentallen geldt dat hoe lager de waarde, des te energiezuiniger de woning is.

De energievraag voor de verwarming en sanitair warm water wordt berekend onder standaardomstandigheden: er worden aannames gedaan over onder meer de buitentemperaturen, de hoeveelheid warm water die afgenomen wordt, de mate waarin de woning geventileerd wordt, de temperatuur waarop de woning verwarmd wordt, enzovoort. Uit onderzoek blijkt dat vooral in oude en weinig energiezuinige woningen het werkelijke verbruik sterk kan afwijken van dit theoretisch berekende verbruik. Om de energiefactuur van dergelijke woningen niet te hoog te laten oplopen, zullen veel bewoners energie trachten te besparen door niet de gehele woning te verwarmen, minder te ventileren, enzovoort. In de berekening van de terugverdientijden hebben we hier rekening mee gehouden. Als we zouden rekenen met de te hoog ingeschatte verbruikscijfers voor de oude woningen, zouden we immers een onrealistisch korte terugverdientijd uitkomen voor energiebesparende maatregelen. Op basis van meetgegevens van meer dan 10000 woningen werd daarom in dit onderzoek het energieverbruik van de niet gerenoveerde woningen gecorrigeerd om beter overeen te stemmen met de werkelijkheid. Bij de woningen van voor 1945 ligt het werkelijke energieverbruik bijvoorbeeld 59% lager dan theoretisch berekend werd. Er wordt aangenomen dat het berekende energieverbruik van een gerenoveerde woning (EPB 2010 of LE-scenario) wel overeenstemt met de werkelijkheid. Door de verminderde energiefactuur en de zuinige verwarmingsinstallaties is het nu bijvoorbeeld wel haalbaar om de ganse woning te verwarmen tot een voldoende hoge comforttemperatuur.

Door deze correctie van de theoretische energieverbruiken zijn de berekende terugverdientijden hoog, en met andere woorden vrij negatief, in vergelijking met vele andere studies. Dit betekent geenszins dat de energetische renovatiemaatregelen minder nuttig zijn. Na de renovatiemaatregelen wordt de woning immers veel comfortabeler. Verder is er uiteraard ook de meerwaarde die de gerenoveerde woning zou opbrengen bij verkoop of verhuur.

7. Toelichting bij de woningfiches

De standaard woningfiche telt drie pagina's. Op de eerste pagina worden de algemene kenmerken en de huidige situatie van de woning toegelicht. Op de tweede pagina komen de energiebesparende maatregelen voor de twee renovatiescenario's, met name de standaardrenovatie (EPB 2010) en de lage energierenovatie (LE), aan bod. Op de derde pagina worden de energieprestatie, de financiële en de comfortbeoordeling toegelicht. De verklarende woordenlijst en de lijst van afkortingen geven inzicht in de gebruikte terminologie en afkortingen.



Figuur 1: Voorbeeld van de TABULA woningfiche

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Verklarende woordenlijst

Beschermd volume	Het volume van de ruimtes in een woning die men thermisch wil beschermen tegen warmteverliezen naar de buitenomgeving, naar de grond en naar aangrenzend onverwarmde ruimtes (bijvoorbeeld een onverwarmde garage). Het beschermd volume omvat minstens alle ruimtes waarin zich een warmte-afgifte element bevindt.
Bruto-vloeroppervlakte	De totale vloeroppervlakte van een woning inclusief de grondoppervlakte van binnen- en buitenwanden
Totale verliesoppervlakte	De oppervlakte van alle scheidingsconstructies (wanden, vloeren, ramen…) die het beschermd volume van een woning omsluiten.
U-waarde	De U-waarde of warmtedoorgangscoëfficiënt is een maat voor de hoeveelheid warmte die verloren gaat doorheen een scheidingsconstructie (bv. een dak, raam, vloer). Hoe lager de warmteverliezen door de scheidingsconstructie, des te lager is de U-waarde.
E-peil	Het E-peil of energieprestatiepeil is een maat voor het energieverbruik van een woning. Hoe lager het energieverbruik van de woning, des te lager is het E-peil. Het E-peil houdt niet alleen rekening met hoe goed de woning geïsoleerd is, maar ook met bezonning en de kwaliteit van de technische installaties waarmee de woning verwarmd, gekoeld en geventileerd wordt en waarmee warm water wordt opgewekt. De huidige E-peileis bedraagt voor nieuwbouwwoningen E80 (2010).
Hulpenergie	De energie die nodig is om technische installaties te laten functioneren, bijvoorbeeld het gasverbruik voor de waakvlam van een verwarmingsketel of het elektriciteitsverbruik voor de ventilator van een ventilatiesysteem.
K-peil	Het K-peil of isolatiepeil wijst op de isolatiegraad van een volledige woning. Hoe beter de woning geïsoleerd is, des te lager is het K-peil. Bij de berekening van het K-peil wordt rekening gehouden met de warmte die verloren gaat door alle buitenmuren, daken, vloeren, vensters, deuren en poorten van de woning.
Standaardrenovatie (EPB 2010)	Hiermee wordt bedoeld de energetische renovatie van een woning tot het energieprestatieniveau van hedendaagse nieuwbouwwoningen in Vlaanderen. Meer bepaald worden de maximale U-waarden voor scheidingsconstructies toegepast zoals deze in 2010 verplicht waren voor nieuwbouwwoningen in Vlaanderen. Enkel voor de ramen worden striktere U-waarden nageleefd. We volgen de EPB-eisen uit 2010 voor de scheidingsconstructies, maar streven niet naar conformiteit met de eisen voor het E-peil en K-peil.
Lage energierenovatie (LE)	Dit type energetische renovatie gaat verder dan de standaardrenovatie, waardoor betere energieprestaties worden behaald. Meer bepaald worden aan de scheidingsconstructies maximale U-waarden opgelegd die overeenkomen met een lage energie nieuwbouwwoning. We streven niet naar conformiteit met bestaande criteria voor lage energiewoningen, bijvoorbeeld op vlak van de netto energiebehoefte voor verwarming.
Netto-energiebehoefte voor verwarming	De hoeveelheid energie die jaarlijks nodig is om de woning te verwarmen. In tegenstelling tot de bruto-energiebehoefte houdt de netto-energiebehoefte geen rekening met het systeemrendement (de warmteverliezen door de leidingen van het systeem).
Primair energieverbruik	Het jaarlijks eindenergieverbruik van de woning vermenigvuldigd met een primaire energieconversiefactor. Deze factor laat toe om verschillende types energie (bijvoorbeeld elektriciteit en energie uit gas of gasolie) bij elkaar op te tellen. De conventionele primaire energieconversiefactoren uit de EPB-regelgeving worden gebruikt.
Terugverdientijd	De tijd waarin de investering in een energiebesparende maatregel financieel wordt terugverdiend door de verlaagde energiekosten die ermee gepaard gaan. De terugverdientijd wordt statisch berekend. Dit houdt in dat we gebruik maken van de huidige kostprijzen van de renovatiemaatregelen en van de huidige energieprijzen. Er wordt geen rekening gehouden met verwachte toekomstige stijging van de energieprijzen.

Lijst van afkortingen

HS	Huidige situatie
EPB 2010	Renovatie conform de EPB-eisen in 2010
LE	Lage energierenovatie
NEB	Netto-energiebehoefte
PE	Primair energieverbruik
Ug	U-waarde van de beglazing

1. Type 1 - Vrijstaande woning pre 1946

1.1 Beschrijving

Deze woningfiche heeft betrekking op vrijstaande woningen daterend uit de periode voor 1946.

1.2 Details

Woningtype: Vrijstaande woning
Bouwperiode: Voor 1946
Bruto vloeroppervlakte (m²): 279 m²
Beschermd volume (m³): 766 m³
Totale verliesoppervlakte (m²): 599 m²

1.3 Huidige situatie

(1) Bouwkundige kenmerken (HS)

Component	Beschrijving	U-waarde (W/m²K)
Dak	Ongeïsoleerde dakconstructie pre 1946	1,7
Gevel	Ongeïsoleerde massieve buitenmuur pre 1946	2,2
Vloer	Ongeïsoleerde vloer op volle grond pre 1991	0,85
Raam	Houten raamprofielen - enkele beglazing - pre 1971	5
Deur	Buitendeur - ongeïsoleerd deurblad - pre 1991	4

(2) Systeemeigenschappen (HS)

Component	Beschrijving
Verwarming	Plaatselijke stookoliekachel pre 1985 - rendement 0,75
Warm water	Individuele elektrische weerstandsverwarming met opslag - leidinglengtes > 5m
Ventilatie	Géén gecontroleerde ventilatie

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1.4 Standaard renovatie (EPB 2010)

(1) Bouwkundige kenmerken (EPB 2010)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 15 cm	0,3	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 8 cm	0,4	Renovatiemaatregel
Vloer	Vloerisolatie - 5 cm	0,4	Renovatiemaatregel
Raam	Geïsoleerde raamprofielen - verbeterde isolerende beglazing Ug 1,1 - na 2005	2	Vervangingsmaatregel
Deur	Buitendeur - geïsoleerd deurblad	2,9	Vervangingsmaatregel

(2) Systeemeigenschappen (EPB 2010)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Individuele doorstroom gasgeiser - leidinglengtes > 5 m	Vervangingsmaatregel
Ventilatie	Ventilatiesysteem C - natuurlijke toevoer en mechanische afvoer	Nieuwe installatie

1.5 Lage energierenovatie

(1) Bouwkundige Kenmerken (LE)

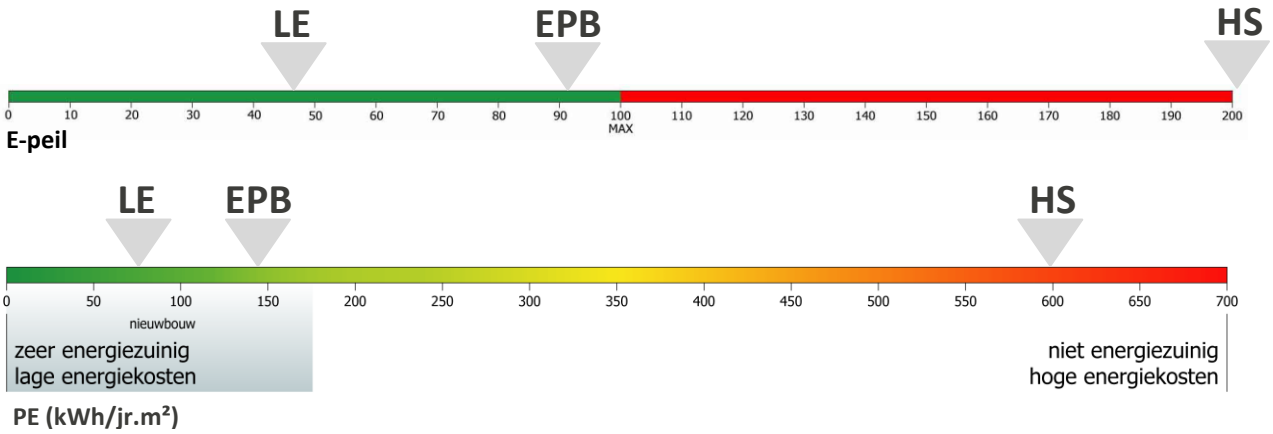
Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 30 cm	0,15	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 15 cm	0,25	Renovatiemaatregel
Vloer	Vloerisolatie - 10 cm	0,25	Renovatiemaatregel
Raam	Verbeterde geïsoleerde raamprofielen Uf 2 - verbeterde isolerende beglazing Ug 1,1	1,6	Vervangingsmaatregel
Deur	Verbeterd geïsoleerde deurprofielen Uf 2 - verbeterd geïsoleerd deurblad	1,6	Vervangingsmaatregel

(2) Systeemeigenschappen (LE)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m	Vervangingsmaatregel
Warm water	Thermische zonnepanelen - 5 m² - onbeschaduwd	Nieuwe installatie
Ventilatie	Balansventilatie met warmterecuperatie met volledige bypass - rendement 0,8	Nieuwe installatie

1.6 Energieprestatie

Scenario	K-peil (-)	E-peil (-)	NEB verwarming (kWh/jr.m²)	PE (kWh/jr.m²)	PE verwarming (%)	PE warm water (%)	PE hulpenergie (%)
Huidige situatie	185	380	334	603	94	6	0
EPB2010	47	92	94	146	77	16	7
Lage energie	30	47	39	74	62	18	20



1.7 Comfortbeoordeling

Scenario	Comfortklasse
Huidige situatie	*
EPB2010	***
Lage energie	****

1.8 Investerings- en besparingskost

Scenario	Investering (€/m²)	Jaarlijkse besparing (€/jr)	Indicatie terugverdientijd (jr)
EPB2010	175	2 600	15-20
Lage energie	275	3 800	15-20

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2. Type 2 - Halfopen bebouwing pre 1946

2.1 Beschrijving

Deze woningfiche heeft betrekking op driegevelwoningen daterend uit de periode voor 1946.

2.2 Details

Woningtype: Halfopen bebouwing
Bouwperiode: Voor 1946
Bruto vloeroppervlakte (m²): 237 m²
Beschermd volume (m³): 652 m²
Totale verliesoppervlakte (m²): 447 m²

2.3 Huidige situatie

(1) Bouwkundige kenmerken (HS)

Component	Beschrijving	U-waarde (W/m²K)
Dak	Ongeïsoleerde dakconstructie pre 1946	1,7
Gevel	Ongeïsoleerde massieve buitenmuur pre 1946	2,2
Vloer	Ongeïsoleerde vloer op volle grond pre 1991	0,85
Raam	Houten raamprofielen - enkele beglazing - pre 1971	5
Deur	Buitendeur - ongeïsoleerd deurblad - pre 1991	4

(2) Systeemeigenschappen (HS)

Component	Beschrijving
Verwarming	Plaatselijke gaskachel pre 1985 - rendement 0,75
Warm water	Individuele doorstroom gasgeiser - leidinglengtes > 5 m
Ventilatie	Géén gecontroleerde ventilatie

2.4 Standaard renovatie (EPB 2010)

(1) Bouwkundige kenmerken (EPB 2010)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 15 cm	0,3	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 8 cm	0,4	Renovatiemaatregel
Vloer	Vloerisolatie - 5 cm	0,4	Renovatiemaatregel
Raam	Geïsoleerde raamprofielen - verbeterde isolerende beglazing Ug 1,1 - na 2005	2	Vervangingsmaatregel
Deur	Buitendeur - geïsoleerd deurblad	2,9	Vervangingsmaatregel

(2) Systeemeigenschappen (EPB 2010)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas – leidinglengtes > 5m	Vervangingsmaatregel
Ventilatie	Ventilatiesysteem C - natuurlijke toevoer en mechanische afvoer	Nieuwe installatie

2.5 Lage energierenovatie

(1) Bouwkundige Kenmerken (LE)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 30 cm	0,15	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 15 cm	0,25	Renovatiemaatregel
Vloer	Vloerisolatie - 10 cm	0,25	Renovatiemaatregel
Raam	Verbeterde geïsoleerde raamprofielen Uf 2 - verbeterde isolerende beglazing Ug 1,1	1,6	Vervangingsmaatregel
Deur	Verbeterd geïsoleerde deurprofielen Uf 2 - verbeterd geïsoleerd deurblad	1,6	Vervangingsmaatregel

(2) Systeemeigenschappen (LE)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas – leidinglengtes > 5m	Vervangingsmaatregel
Warm water	Thermische zonnepanelen - 5 m² - onbeschaduwd	Nieuwe installatie
Ventilatie	Balansventilatie met warmterecuperatie met volledige bypass - rendement 0,8	Nieuwe installatie

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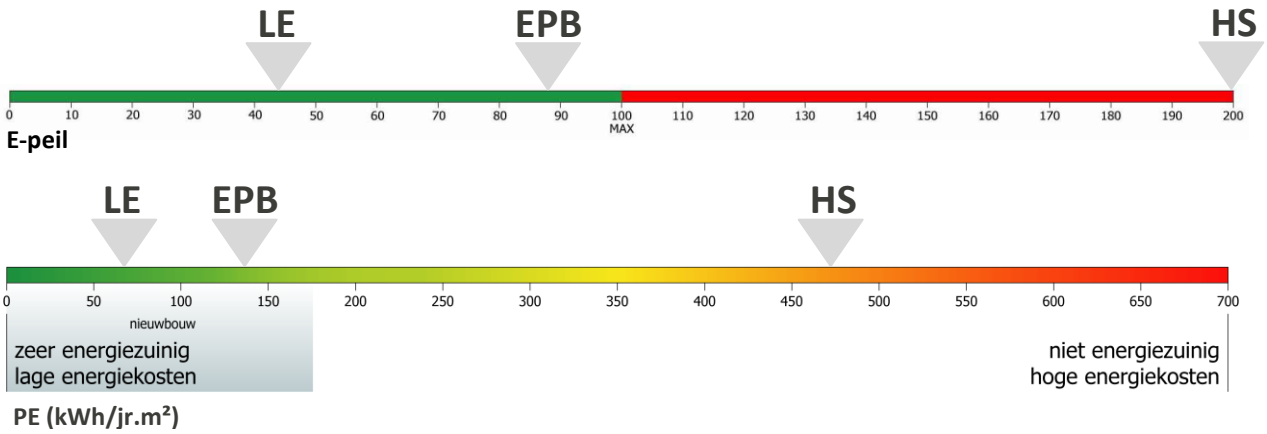
2.6 Energieprestatie

Scenario	K-peil (-)	E-peil (-)	NEB verwarming (kWh/jr.m²)	PE (kWh/jr.m²)	PE verwarming (%)	PE warm water (%)	PE hulpenergie (%)
Huidige situatie	175	310	295	477	95	4	1
EPB2010	45	89	87	137	76	16	8
Lage energie	29	44	33	66	59	19	22



2.7 Comfortbeoordeling

Scenario	Comfortklasse
Huidige situatie	*
EPB2010	***
Lage energie	****

2.8 Investerings- en besparingskost

Scenario	Investering (€/m²)	Jaarlijkse besparing (€/jr)	Indicatie terugverdientijd (jr)
EPB2010	175	1 000	>35
Lage energie	250	2 000	25-30

3. Type 3 - Rijwoning pre 1946

3.1 Beschrijving

Deze woningfiche heeft betrekking op rijwoningen daterend uit de periode voor 1946.

3.2 Details

Woningtype: Rijwoning
Bouwperiode: Voor 1946
Bruto vloeroppervlakte (m²): 226 m²
Beschermd volume (m³): 621 m³
Totale verliesoppervlakte (m²): 323 m²

3.3 Huidige situatie

(1) Bouwkundige kenmerken (HS)

Component	Beschrijving	U-waarde (W/m²K)
Dak	Ongeïsoleerde dakconstructie pre 1946	1,7
Gevel	Ongeïsoleerde massieve buitenmuur pre 1946	2,2
Vloer	Ongeïsoleerde vloer op volle grond pre 1991	0,85
Raam	Houten raamprofielen - enkele beglazing - pre 1971	5
Deur	Buitendeur - ongeïsoleerd deurblad - pre 1991	4

(2) Systeemeigenschappen (HS)

Component	Beschrijving
Verwarming	Plaatselijke gaskachel pre 1985 - rendement 0,75
Warm water	Individuele doorstroom gasgeiser - leidinglengtes < 5m
Ventilatie	Géén gecontroleerde ventilatie

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3.4 Standaard renovatie (EPB 2010)

(1) Bouwkundige kenmerken (EPB 2010)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 15 cm	0,3	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 8 cm	0,4	Renovatiemaatregel
Vloer	Vloerisolatie - 5 cm	0,4	Renovatiemaatregel
Raam	Geïsoleerde raamprofielen - verbeterde isolerende beglazing Ug 1,1 - na 2005	2	Vervangingsmaatregel
Deur	Buitendeur - geïsoleerd deurblad	2,9	Vervangingsmaatregel

(2) Systeemeigenschappen (EPB 2010)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m	Vervangingsmaatregel
Ventilatie	Ventilatiesysteem C - natuurlijke toevoer en mechanische afvoer	Nieuwe installatie

3.5 Lage energierenovatie

(1) Bouwkundige Kenmerken (LE)

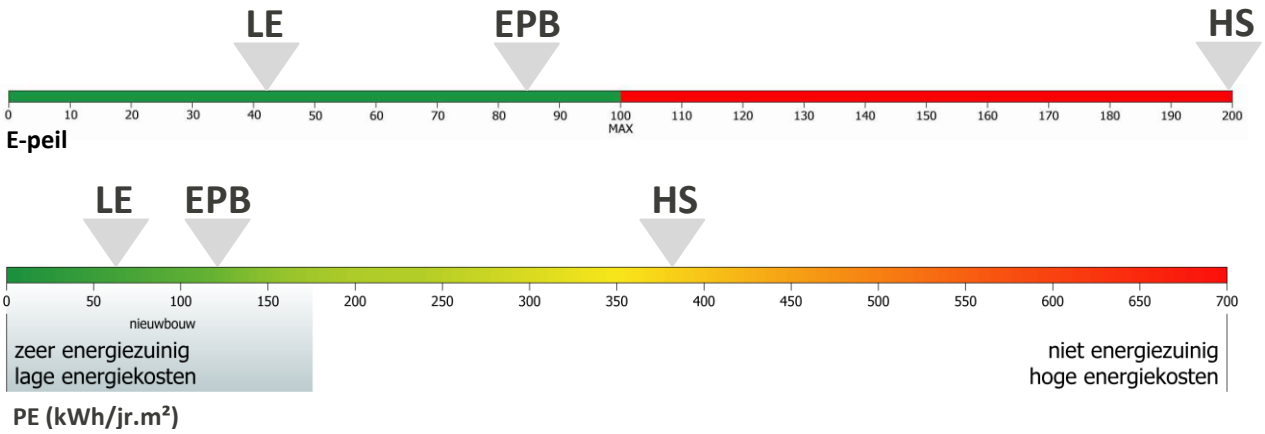
Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 30 cm	0,15	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 15 cm	0,25	Renovatiemaatregel
Vloer	Vloerisolatie - 10 cm	0,25	Renovatiemaatregel
Raam	Verbeterde geïsoleerde raamprofielen Uf 2 - verbeterde isolerende beglazing Ug 1,1	1,6	Vervangingsmaatregel
Deur	Verbeterd geïsoleerde deurprofielen Uf 2 - verbeterd geïsoleerd deurblad	1,6	Vervangingsmaatregel

(2) Systeemeigenschappen (LE)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m	Vervangingsmaatregel
Warm water	Thermische zonnepanelen - 5 m² - onbeschaduwd	Nieuwe installatie
Ventilatie	Balansventilatie met warmterecuperatie met volledige bypass - rendement 0,8	Nieuwe installatie

3.6 Energieprestatie

Scenario	K-peil (-)	E-peil (-)	NEB verwarming (kWh/jr.m²)	PE (kWh/jr.m²)	PE verwarming (%)	PE warm water (%)	PE hulpenergie (%)
Huidige situatie	161	274	231	385	92	4	3
EPB2010	45	86	74	120	73	18	9
Lage energie	29	42	28	59	56	18	25



3.7 Comfortbeoordeling

Scenario	Comfortklasse
Huidige situatie	*
EPB2010	***
Lage energie	****

3.8 Investerings- en besparingskost

Scenario	Investering (€/m²)	Jaarlijkse besparing (€/jr)	Indicatie terugverdientijd (jr)
EPB2010	175 €/m²	800 €/jr	> 35
Lage energie	250 €/m²	1 600 €/jr	30-35

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4. Type 4 - Ingesloten appartement pre 1946

4.1 Beschrijving

Deze woningfiche heeft betrekking op ingesloten appartementen daterend uit de periode voor 1946. Als buitenschil voor ingesloten appartementen veronderstellen we enkel een voor- en achtergevel. Vloer, plafond en zijgevels grenzen aan naburige appartementen.

4.2 Details

Woningtype: Appartement ingesloten
Bouwperiode: Voor 1946
Bruto vloeroppervlakte (m²): 100 m²
Beschermd volume (m³): 320 m³
Totale verliesoppervlakte (m²): 45 m²

4.3 Huidige situatie

(1) Bouwkundige kenmerken (HS)

Component	Beschrijving	U-waarde (W/m²K)
Gevel	Ongeïsoleerde massieve buitenmuur pre 1946	2,2
Raam	Houten raamprofielen - enkele beglazing - pre 1971	5

(2) Systeemeigenschappen (HS)

Component	Beschrijving
Verwarming	Plaatselijke gaskachel pre 1985 - rendement 0,75
Warm water	Individuele doorstroom gasgeiser - leidinglengtes < 5m
Ventilatie	Géén gecontroleerde ventilatie

4.4 Standaard renovatie (EPB 2010)

(1) Bouwkundige kenmerken (EPB 2010)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Gevel	Spouwisolatie of buitengevelisolatie - 8 cm	0,4	Renovatiemaatregel
Raam	Geïsoleerde raamprofielen - verbeterde isolerende beglazing Ug 1,1 - na 2005	2	Vervangingsmaatregel

(2) Systeemeigenschappen (EPB 2010)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m	Vervangingsmaatregel
Ventilatie	Ventilatiesysteem C - natuurlijke toevoer en mechanische afvoer	Nieuwe installatie

4.5 Lage energierenovatie

(1) Bouwkundige Kenmerken (LE)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Gevel	Spouwisolatie of buitengevelisolatie - 15 cm	0,25	Renovatiemaatregel
Raam	Verbeterde geïsoleerde raamprofielen Uf 2 - verbeterde isolerende beglazing Ug 1,1	1,6	Vervangingsmaatregel

(2) Systeemeigenschappen (LE)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m	Vervangingsmaatregel
Warm water	Thermische zonnepanelen - 5 m² - onbeschaduwd	Nieuwe installatie
Ventilatie	Balansventilatie met warmterecuperatie met volledige bypass - rendement 0,8	Nieuwe installatie

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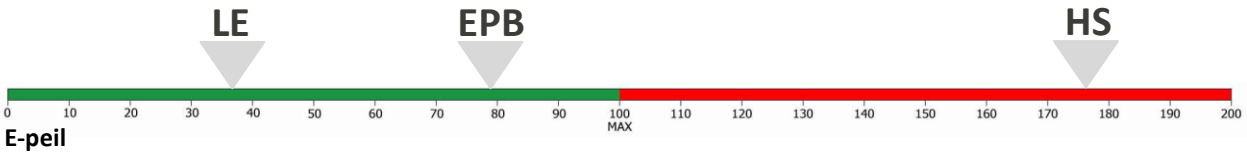
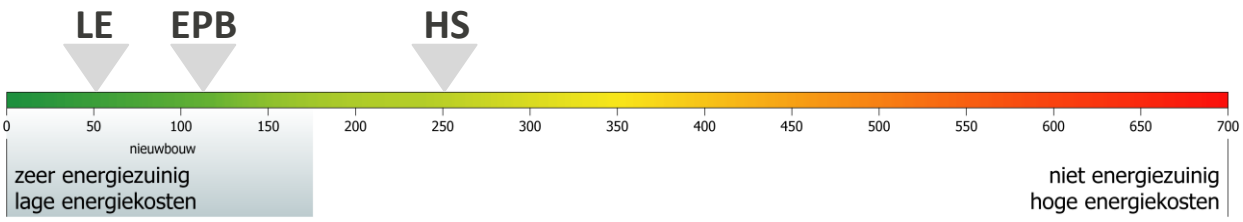
4.6 Energieprestatie

Scenario	K-peil (-)	E-peil (-)	NEB verwarming (kWh/jr.m²)	PE (kWh/jr.m²)	PE verwarming (%)	PE warm water (%)	PE hulpenergie (%)
Huidige situatie	-	179	140	252	86	9	6
EPB2010	-	80	62	113	66	23	11
Lage energie	-	37	17	52	39	15	46



E-peil



PE (kWh/jr.m²)

4.7 Comfortbeoordeling

Scenario	Comfortklasse
Huidige situatie	*
EPB2010	***
Lage energie	****

4.8 Investerings- en besparingskost

Scenario	Investering (€/m²)	Jaarlijkse besparing (€/jr)	Indicatie terugverdientijd (jr)
EPB2010	225	100	> 35
Lage energie	350	500	> 35

5. Type 5 - Blootgesteld appartement pre 1946

5.1 Beschrijving

Deze woningfiche heeft betrekking op blootgestelde appartementen daterend uit de periode voor 1946. Als buitenschil voor blootgestelde appartementen veronderstellen we een voor- en achtergevel, dakvlak en 1 zijgevel. Het vloervlak en de 2de zijgevel grenzen aan naburige appartementen.

5.2 Details

Woningtype: Appartement blootgesteld
Bouwperiode: Voor 1946
Bruto vloeroppervlakte (m²): 100 m²
Beschermd volume (m³): 320 m³
Totale verliesoppervlakte (m²): 191 m²

5.3 Huidige situatie

(1) Bouwkundige kenmerken (HS)

Component	Beschrijving	U-waarde (W/m²K)
Dak	Ongeïsoleerde dakconstructie pre 1946	1,7
Gevel	Ongeïsoleerde massieve buitenmuur pre 1946	2,2
Raam	Houten raamprofielen - enkele beglazing - pre 1971	5

(2) Systeemeigenschappen (HS)

Component	Beschrijving
Verwarming	Plaatselijke gaskachel pre 1985 - rendement 0,75
Warm water	Individuele doorstroom gasgeiser - leidinglengtes < 5m
Ventilatie	Géén gecontroleerde ventilatie

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5.4 Standaard renovatie (EPB 2010)

(1) Bouwkundige kenmerken (EPB 2010)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 15 cm	0,3	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 8 cm	0,4	Renovatiemaatregel
Raam	Geïsoleerde raamprofielen - verbeterde isolerende beglazing Ug 1,1 - na 2005	2	Vervangingsmaatregel

(2) Systeemeigenschappen (EPB 2010)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m	Vervangingsmaatregel
Ventilatie	Ventilatiesysteem C - natuurlijke toevoer en mechanische afvoer	Nieuwe installatie

5.5 Lage energierenovatie

(1) Bouwkundige Kenmerken (LE)

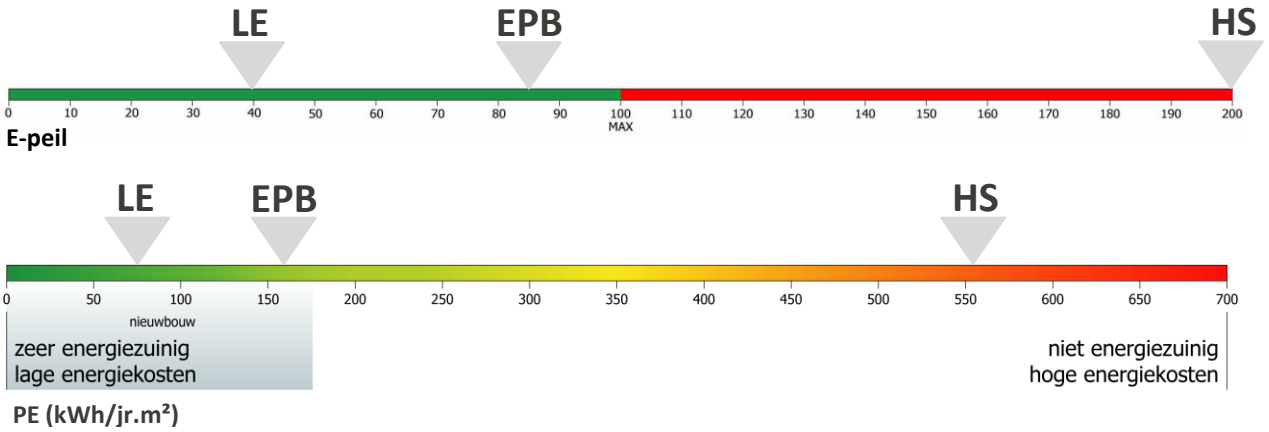
Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 30 cm	0,15	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 15 cm	0,25	Renovatiemaatregel
Raam	Verbeterde geïsoleerde raamprofielen Uf 2 - verbeterde isolerende beglazing Ug 1,1	1,6	Vervangingsmaatregel

(2) Systeemeigenschappen (LE)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m	Vervangingsmaatregel
Warm water	Thermische zonnepanelen - 5 m² - onbeschaduwd	Nieuwe installatie
Ventilatie	Balansventilatie met warmterecuperatie met volledige bypass - rendement 0,8	Nieuwe installatie

5.6 Energieprestatie

Scenario	K-peil (-)	E-peil (-)	NEB verwarming (kWh/jr.m²)	PE (kWh/jr.m²)	PE verwarming (%)	PE warm tapwater (%)	PE hulpenergie (%)
Huidige situatie	-	299	341	560	94	4	2
EPB2010	-	86	102	160	76	16	8
Lage energie	-	40	36	74	57	10	33



5.7 Comfortbeoordeling

Scenario	Comfortklasse
Huidige situatie	*
EPB2010	***
Lage energie	****

5.8 Investerings- en besparingskost

Scenario	Investering (€/m²)	Jaarlijkse besparing (€/jr)	Indicatie terugverdientijd (jr)
EPB2010	250	800	30-35
Lage energie	400	1 300	30-35

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6. Type 6 - Vrijstaande woning 1946-1970

6.1 Beschrijving

Deze woningfiche heeft betrekking op vrijstaande woningen daterend uit de periode 1946-1970.

6.2 Details

Woningtype: Vrijstaande woning
Bouwperiode: 1946-1970
Bruto vloeroppervlakte (m²): 236 m²
Beschermd volume (m³): 648 m³
Totale verliesoppervlakte (m²): 539 m²

6.3 Huidige situatie

(1) Bouwkundige kenmerken (HS)

Component	Beschrijving	U-waarde (W/m²K)
Dak	Ongeïsoleerde dakconstructie 1946-1970	1,9
Gevel	Ongeïsoleerde spouwmuur 1946-1970	1,7
Vloer	Ongeïsoleerde vloer op volle grond pre 1991	0,85
Raam	Houten raamprofielen - enkele beglazing - pre 1971	5
Deur	Buitendeur - ongeïsoleerd deurblad - pre 1991	4

(2) Systeemeigenschappen (HS)

Component	Beschrijving
Verwarming	Plaatselijke stookoliekachel pre 1985 - rendement 0,75
Warm water	Individuele elektrische weerstandsverwarming met opslag - leidinglenftes > 5m
Ventilatie	Géén gecontroleerde ventilatie

6.4 Standaard renovatie (EPB 2010)

(1) Bouwkundige kenmerken (EPB 2010)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 15 cm	0,3	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 8 cm	0,4	Renovatiemaatregel
Vloer	Vloerisolatie - 5 cm	0,4	Renovatiemaatregel
Raam	Geïsoleerde raamprofielen - verbeterde isolerende beglazing Ug 1,1 - na 2005	2	Vervangingsmaatregel
Deur	Buitendeur - geïsoleerd deurblad	2,9	Vervangingsmaatregel

(2) Systeemeigenschappen (EPB 2010)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Individuele doorstroom gasgeiser - leidinglengtes > 5 m	Vervangingsmaatregel
Ventilatie	Ventilatiesysteem C - natuurlijke toevoer en mechanische afvoer	Nieuwe installatie

6.5 Lage energierenovatie

(1) Bouwkundige Kenmerken (LE)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 30 cm	0,15	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 15 cm	0,25	Renovatiemaatregel
Vloer	Vloerisolatie - 10 cm	0,25	Renovatiemaatregel
Raam	Verbeterde geïsoleerde raamprofielen Uf 2 - verbeterde isolerende beglazing Ug 1,1	1,6	Vervangingsmaatregel
Deur	Verbeterd geïsoleerde deurprofielen Uf 2 - verbeterd geïsoleerd deurblad	1,6	Vervangingsmaatregel

(2) Systeemeigenschappen (LE)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m	Vervangingsmaatregel
Warm water	Thermische zonnepanelen - 5 m² - onbeschaduwd	Nieuwe installatie
Ventilatie	Balansventilatie met warmterecuperatie met volledige bypass - rendement 0,8	Nieuwe installatie

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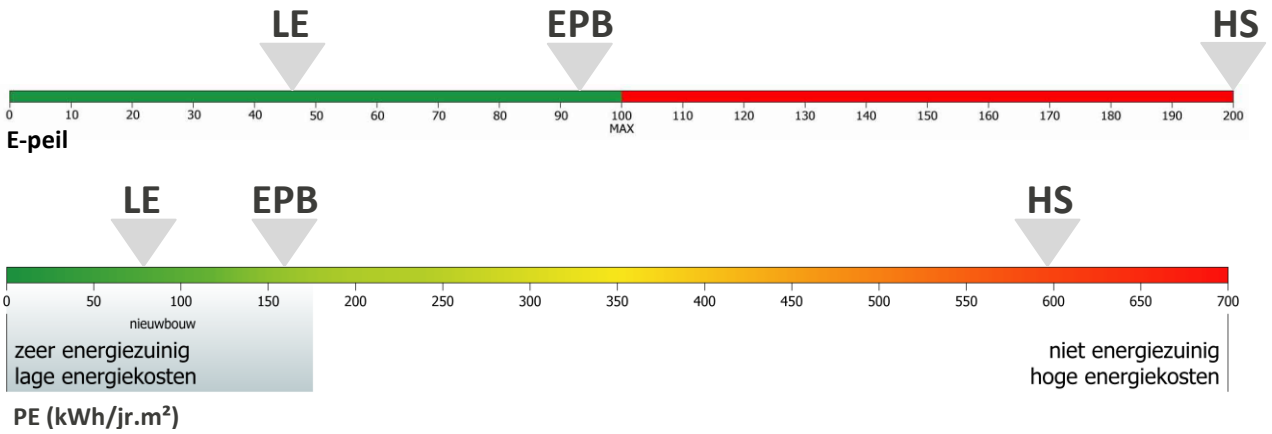
6.6 Energieprestatie

Scenario	K-peil (-)	E-peil (-)	NEB verwarming (kWh/jr.m²)	PE (kWh/jr.m²)	PE verwarming (%)	PE warm water (%)	PE hulpenergie (%)
Huidige situatie	181	369	343	603	97	3	0
EPB2010	49	94	103	157	78	15	7
Lage energie	32	47	43	78	64	17	19



6.7 Comfortbeoordeling

Scenario	Comfortklasse
Huidige situatie	*
EPB2010	***
Lage energie	****

6.8 Investerings- en besparingskost

Scenario	Investering (€/m²)	Jaarlijkse besparing (€/jr)	Indicatie terugverdientijd (jr)
EPB2010	200	2 200	20-25
Lage energie	300	3 300	20-25

7. Type 7 - Halfopen bebouwing 1946-1970

7.1 Beschrijving

Deze woningfiche heeft betrekking op driegevelwoningen daterend uit de periode 1946-1970.

7.2 Details

Woningtype: Halfopen bebouwing
Bouwperiode: 1946-1970
Bruto vloeroppervlakte (m²): 193 m²
Beschermd volume (m³): 532 m³
Totale verliesoppervlakte (m²): 381 m²

7.3 Huidige situatie

(1) Bouwkundige kenmerken (HS)

Component	Beschrijving	U-waarde (W/m²K)
Dak	Ongeïsoleerde dakconstructie 1946-1970	1,9
Gevel	Ongeïsoleerde spouwmuur 1946-1970	1,7
Vloer	Ongeïsoleerde vloer op volle grond pre 1991	0,85
Raam	Houten raamprofielen - enkele beglazing - pre 1971	5
Deur	Buitendeur - ongeïsoleerd deurblad - pre 1991	4

(2) Systeemeigenschappen (HS)

Component	Beschrijving
Verwarming	Plaatselijke gaskachel pre 1985 - rendement 0,75
Warm water	Individuele doorstroom gasgeiser - leidinglengtes < 5m
Ventilatie	Géén gecontroleerde ventilatie

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7.4 Standaard renovatie (EPB 2010)

(1) Bouwkundige kenmerken (EPB 2010)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 15 cm	0,3	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 8 cm	0,4	Renovatiemaatregel
Vloer	Vloerisolatie - 5 cm	0,4	Renovatiemaatregel
Raam	Geïsoleerde raamprofielen - verbeterde isolerende beglazing Ug 1,1 - na 2005	2	Vervangingsmaatregel
Deur	Buitendeur - geïsoleerd deurblad	2,9	Vervangingsmaatregel

(2) Systeemeigenschappen (EPB 2010)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas – leidinglengtes > 5m	Vervangingsmaatregel
Ventilatie	Ventilatiesysteem C - natuurlijke toevoer en mechanische afvoer	Nieuwe installatie

7.5 Lage energierenovatie

(1) Bouwkundige Kenmerken (LE)

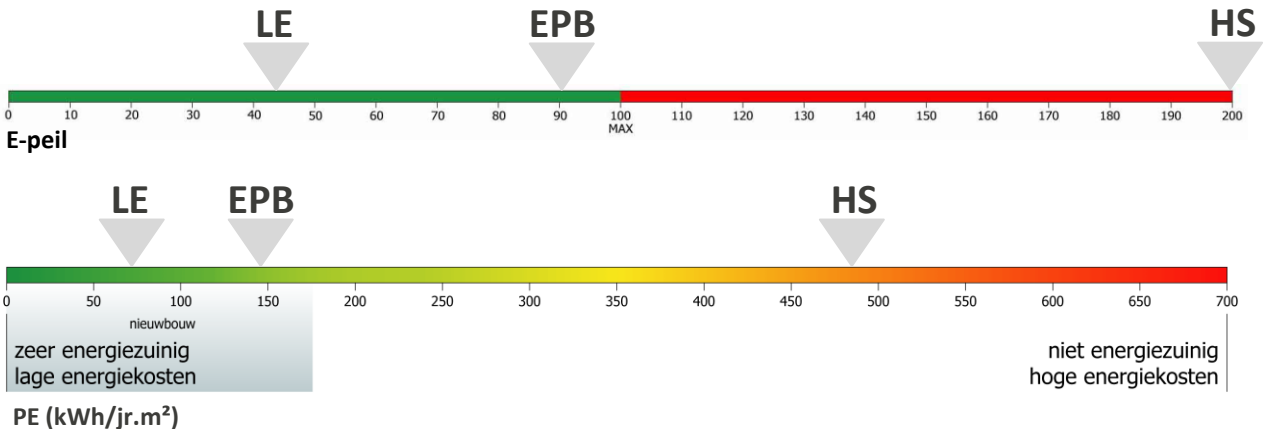
Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 30 cm	0,15	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 15 cm	0,25	Renovatiemaatregel
Vloer	Vloerisolatie - 10 cm	0,25	Renovatiemaatregel
Raam	Verbeterde geïsoleerde raamprofielen Uf 2 - verbeterde isolerende beglazing Ug 1,1	1,6	Vervangingsmaatregel
Deur	Verbeterd geïsoleerde deurprofielen Uf 2 - verbeterd geïsoleerd deurblad	1,6	Vervangingsmaatregel

(2) Systeemeigenschappen (LE)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas – leidinglengtes > 5m	Vervangingsmaatregel
Warm water	Thermische zonnepanelen - 5 m² - onbeschaduwd	Nieuwe installatie
Ventilatie	Balansventilatie met warmterecuperatie met volledige bypass - rendement 0,8	Nieuwe installatie

7.6 Energieprestatie

Scenario	K-peil (-)	E-peil (-)	NEB verwarming (kWh/jr.m²)	PE (kWh/jr.m²)	PE verwarming (%)	PE warm water (%)	PE hulpenergie (%)
Huidige situatie	172	302	300	486	95	4	1
EPB2010	49	92	96	148	77	16	7
Lage energie	32	44	37	70	62	16	21



7.7 Comfortbeoordeling

Scenario	Comfortklasse
Huidige situatie	*
EPB2010	***
Lage energie	****

7.8 Investerings- en besparingskost

Scenario	Investering (€/m²)	Jaarlijkse besparing (€/jr)	Indicatie terugverdientijd (jr)
EPB2010	200	900	> 35
Lage energie	300	1 800	30-35

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8. Type 8 - Rijwoning 1946-1970

8.1 Beschrijving

Deze woningfiche heeft betrekking op rijwoningen daterend uit de periode 1946-1970.

8.2 Details

Woningtype: Rijwoning
Bouwperiode: 1946-1970
Bruto vloeroppervlakte (m²): 199 m²
Beschermd volume (m³): 547 m³
Totale verliesoppervlakte (m²): 297 m²

8.3 Huidige situatie

(1) Bouwkundige kenmerken (HS)

Component	Beschrijving	U-waarde (W/m²K)
Dak	Ongeïsoleerde dakconstructie 1946-1970	1,9
Gevel	Ongeïsoleerde spouwmuur 1946-1970	1,7
Vloer	Ongeïsoleerde vloer op volle grond pre 1991	0,85
Raam	Houten raamprofielen - enkele beglazing - pre 1971	5
Deur	Buitendeur - ongeïsoleerd deurblad - pre 1991	4

(2) Systeemeigenschappen (HS)

Component	Beschrijving
Verwarming	Plaatselijke gaskachel pre 1985 - rendement 0,75
Verwarming	Individuele doorstroom gasgeiser - leidinglengtes < 5m
Ventilatie	Géén gecontroleerde ventilatie

8.4 Standaard renovatie (EPB 2010)

(1) Bouwkundige kenmerken (EPB 2010)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 15 cm	0,3	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 8 cm	0,4	Renovatiemaatregel
Vloer	Vloerisolatie - 5 cm	0,4	Renovatiemaatregel
Raam	Geïsoleerde raamprofielen - verbeterde isolerende beglazing Ug 1,1 - na 2005	2	Vervangingsmaatregel
Deur	Buitendeur - geïsoleerd deurblad	2,9	Vervangingsmaatregel

(2) Systeemeigenschappen (EPB 2010)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m	Vervangingsmaatregel
Ventilatie	Ventilatiesysteem C - natuurlijke toevoer en mechanische afvoer	Nieuwe installatie

8.5 Lage energierenovatie

(1) Bouwkundige Kenmerken (LE)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 30 cm	0,15	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 15 cm	0,25	Renovatiemaatregel
Vloer	Vloerisolatie - 10 cm	0,25	Renovatiemaatregel
Raam	Verbeterde geïsoleerde raamprofielen Uf 2 - verbeterde isolerende beglazing Ug 1,1	1,6	Vervangingsmaatregel
Deur	Verbeterd geïsoleerde deurprofielen Uf 2 - verbeterd geïsoleerd deurblad	1,6	Vervangingsmaatregel

(2) Systeemeigenschappen (LE)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m	Vervangingsmaatregel
Warm water	Thermische zonnepanelen - 5 m² - onbeschaduwd	Nieuwe installatie
Ventilatie	Balansventilatie met warmterecuperatie met volledige bypass - rendement 0,8	Nieuwe installatie

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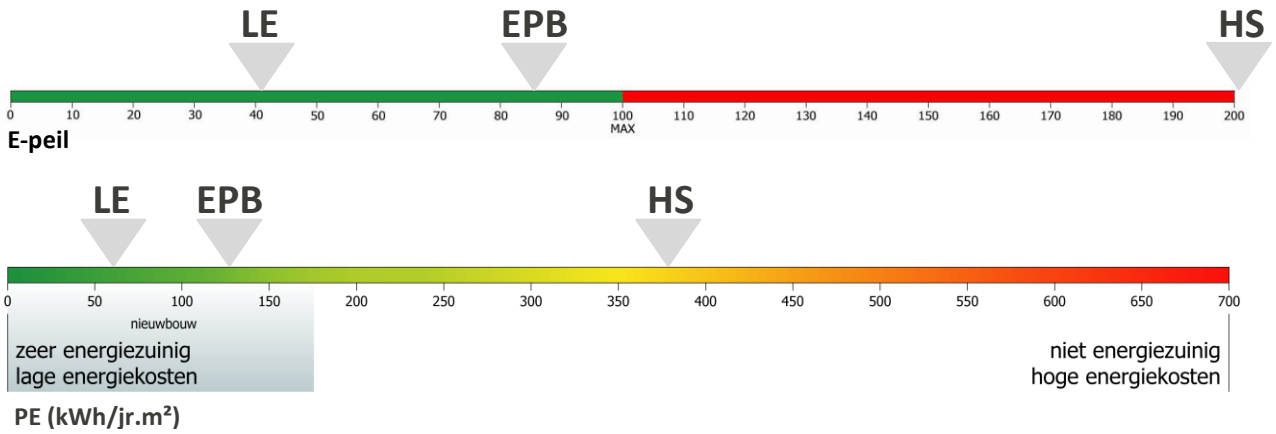
8.6 Energieprestatie

Scenario	K-peil (-)	E-peil (-)	NEB verwarming (kWh/jr.m²)	PE (kWh/jr.m²)	PE verwarming (%)	PE warm water (%)	PE hulpenergie (%)
Huidige situatie	158	265	234	384	94	5	2
EPB2010	47	87	78	126	74	17	9
Lage energie	30	42	30	60	58	17	25



8.7 Comfortbeoordeling

Scenario	Comfortklasse
Huidige situatie	*
EPB2010	***
Lage energie	****

8.8 Investerings- en besparingskost

Scenario	Investering (€/m²)	Jaarlijkse besparing (€/jr)	Indicatie terugverdientijd (jr)
EPB2010	200	700	> 35
Lage energie	275	1 500	> 35

9. Type 9 - Ingesloten appartement 1946-1970

9.1 Beschrijving


Deze woningfiche heeft betrekking op ingesloten appartementen daterend uit de periode 1946-1970. Als buitenschil voor ingesloten appartementen veronderstellen we enkel een voor- en achtergevel. Vloer, plafond en zijgevels grenzen aan naburige appartementen.

9.2 Details

Woningtype: Appartement ingesloten
Bouwperiode: 1946-1970
Bruto vloeroppervlakte (m²): 100 m²
Beschermd volume (m³): 320 m³
Totale verliesoppervlakte (m²): 45 m²

9.3 Huidige situatie

(1) Bouwkundige kenmerken (HS)

Component	Beschrijving	U-waarde (W/m²K)
Gevel	Ongeïsoleerde spouwmuur 1946-1970	1,7
Raam	Houten raamprofielen - enkele beglazing - pre 1971	5

(2) Systeemeigenschappen (HS)

Component	Beschrijving
Verwarming	Plaatselijke gaskachel pre 1985 - rendement 0,75
Verwarming	Individuele doorstroom gasgeiser - leidinglengtes < 5m
Ventilatie	Géén gecontroleerde ventilatie

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9.4 Standaard renovatie (EPB 2010)

(1) Bouwkundige kenmerken (EPB 2010)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Gevel	Spouwisolatie of buitengevelisolatie - 8 cm	0,4	Renovatiemaatregel
Raam	Geïsoleerde raamprofielen - verbeterde isolerende beglazing Ug 1,1 - na 2005	2	Vervangingsmaatregel

(2) Systeemeigenschappen (EPB 2010)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m	Vervangingsmaatregel
Ventilatie	Ventilatiesysteem C - natuurlijke toevoer en mechanische afvoer	Nieuwe installatie

9.5 Lage energierenovatie

(1) Bouwkundige Kenmerken (LE)

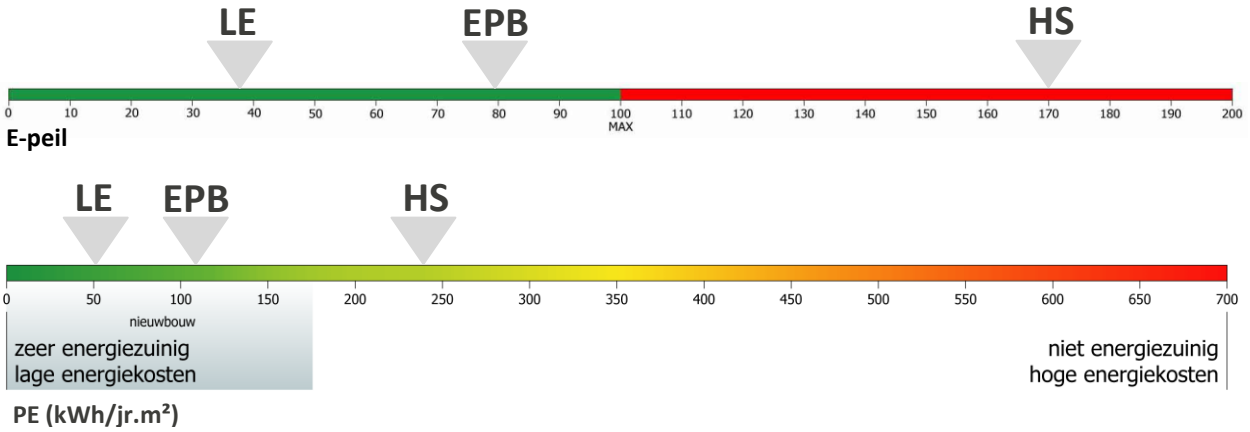
Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Gevel	Spouwisolatie of buitengevelisolatie - 15 cm	0,25	Renovatiemaatregel
Raam	Verbeterde geïsoleerde raamprofielen Uf 2 - verbeterde isolerende beglazing Ug 1,1	1,6	Vervangingsmaatregel

(2) Systeemeigenschappen (LE)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m	Vervangingsmaatregel
Warm water	Thermische zonnepanelen - 5 m² - onbeschaduwd	Nieuwe installatie
Ventilatie	Balansventilatie met warmterecuperatie met volledige bypass - rendement 0,8	Nieuwe installatie

9.6 Energieprestatie

Scenario	K-peil (-)	E-peil (-)	NEB verwarming (kWh/jr.m²)	PE (kWh/jr.m²)	PE verwarming (%)	PE warm water (%)	PE hulpenergie (%)
Huidige situatie	-	172	134	243	85	9	6
EPB2010	-	80	62	113	66	23	11
Lage energie	-	37	17	52	39	15	46



9.7 Comfortbeoordeling

Scenario	Comfortklasse
Huidige situatie	*
EPB2010	***
Lage energie	****

9.8 Investerings- en besparingskost

Scenario	Investering (€/m²)	Jaarlijkse besparing (€/jr)	Indicatie terugverdientijd (jr)
EPB2010	225	100	> 35
Lage energie	350	500	> 35

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10. Type 10 - Blootgesteld appartement 1946-1970

10.1 Beschrijving


Deze woningfiche heeft betrekking op blootgestelde appartementen daterend uit de periode 1946-1970. Als buitenschil voor blootgestelde appartementen veronderstellen we een voor- en achtergevel, dakvlak en 1 zijgevel. Het vloervlak en de 2de zijgevel grenzen aan naburige appartementen.

10.2 Details

Woningtype: Appartement blootgesteld
Bouwperiode: 1946-1970
Bruto vloeroppervlakte (m²): 100 m²
Beschermd volume (m³): 320 m³
Totale verliesoppervlakte (m²): 191 m²

10.3 Huidige situatie

(1) Bouwkundige kenmerken (HS)

Component	Beschrijving	U-waarde (W/m²K)
Dak	Ongeïsoleerde dakconstructie 1946-1970	1,9
Gevel	Ongeïsoleerde spouwmuur 1946-1970	1,7
Raam	Houten raamprofielen - enkele beglazing - pre 1971	5

(2) Systeemeigenschappen (HS)

Component	Beschrijving
Verwarming	Plaatselijke gaskachel pre 1985 - rendement 0,75
Verwarming	Individuele doorstroom gasgeiser - leidinglengtes < 5m
Ventilatie	Géén gecontroleerde ventilatie

10.4 Standaard renovatie (EPB 2010)

(1) Bouwkundige kenmerken (EPB 2010)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 15 cm	0,3	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 8 cm	0,4	Renovatiemaatregel
Raam	Geïsoleerde raamprofielen - verbeterde isolerende beglazing Ug 1,1 - na 2005	2	Vervangingsmaatregel

(2) Systeemeigenschappen (EPB 2010)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m	Vervangingsmaatregel
Ventilatie	Ventilatiesysteem C - natuurlijke toevoer en mechanische afvoer	Nieuwe installatie

10.5 Lage energierenovatie

(1) Bouwkundige Kenmerken (LE)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 30 cm	0,15	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 15 cm	0,25	Renovatiemaatregel
Raam	Verbeterde geïsoleerde raamprofielen Uf 2 - verbeterde isolerende beglazing Ug 1,1	1,6	Vervangingsmaatregel

(2) Systeemeigenschappen (LE)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m	Vervangingsmaatregel
Warm water	Thermische zonnepanelen - 5 m² - onbeschaduwd	Nieuwe installatie
Ventilatie	Balansventilatie met warmterecuperatie met volledige bypass - rendement 0,8	Nieuwe installatie

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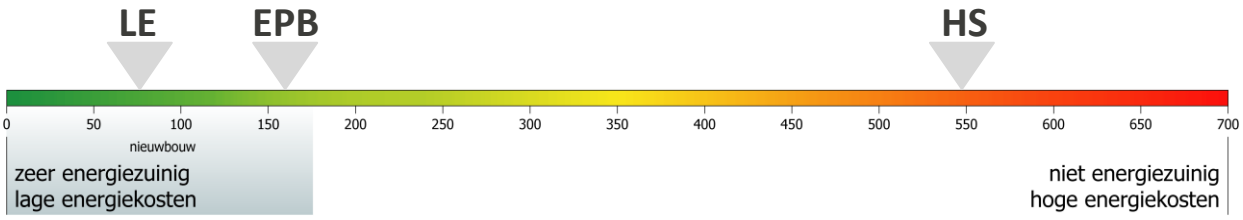
10.6 Energieprestatie

Scenario	K-peil (-)	E-peil (-)	NEB verwarming (kWh/jr.m²)	PE (kWh/jr.m²)	PE verwarming (%)	PE warm water (%)	PE hulpenergie (%)
Huidige situatie	-	292	333	549	93	4	3
EPB2010	-	86	102	160	76	16	8
Lage energie	-	40	36	74	57	10	33

E-peil



PE (kWh/jr.m²)

10.7 Comfortbeoordeling

Scenario	Comfortklasse
Huidige situatie	*
EPB2010	***
Lage energie	****

10.8 Investerings- en besparingskost

Scenario	Investering (€/m²)	Jaarlijkse besparing (€/jr)	Indicatie terugverdientijd (jr)
EPB2010	250	800	30-35
Lage energie	400	1 300	30-35

11. Type 11 - Vrijstaande woning 1971-1990

11.1 Beschrijving

Deze woningfiche heeft betrekking op vrijstaande woningen daterend uit de periode 1971-1990.

11.2 Details

Woningtype: Vrijstaande woning
Bouwperiode: 1971-1990
Bruto vloeroppervlakte (m²): 238 m²
Beschermd volume (m³): 656 m³
Totale verliesoppervlakte (m²): 549 m²

11.3 Huidige situatie

(1) Bouwkundige kenmerken (HS)

Component	Beschrijving	U-waarde (W/m²K)
Dak	Geisoleerde dakconstructie 1971-1990 - dakisolatie tussen kepers 4 cm	0,85
Gevel	Geventileerde spouwmuur 1971-1990 - spouwisolatie 2 cm	1
Vloer	Ongeïsoleerde vloer op volle grond pre 1991	0,85
Raam	Meerkamer raamprofielen - dubbele beglazing - 1971-2005	3,5
Deur	Buitendeur - ongeïsoleerd deurblad - pre 1991	4

(2) Systeemeigenschappen (HS)

Component	Beschrijving
Verwarming	Centrale verwarming - stookolie combiketel 1976-1985 - rendement 0,7
Warm water	Combiketel op stookolie met opslagvat pre 1990 - leidinglengtes > 5 m
Ventilatie	Géén gecontroleerde ventilatie

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11.4 Standaard renovatie (EPB 2010)

(1) Bouwkundige kenmerken (EPB 2010)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 15 cm	0,3	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 8 cm	0,4	Renovatiemaatregel
Vloer	Vloerisolatie - 5 cm	0,4	Renovatiemaatregel
Raam	Geïsoleerde raamprofielen - verbeterde isolerende beglazing Ug 1,1 - na 2005	2	Vervangingsmaatregel
Deur	Buitendeur - geïsoleerd deurblad	2,9	Vervangingsmaatregel

(2) Systeemeigenschappen (EPB 2010)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Individuele doorstroom gasgeiser - leidinglengtes > 5 m	Vervangingsmaatregel
Ventilatie	Ventilatiesysteem C - natuurlijke toevoer en mechanische afvoer	Nieuwe installatie

11.5 Lage energierenovatie

(1) Bouwkundige Kenmerken (LE)

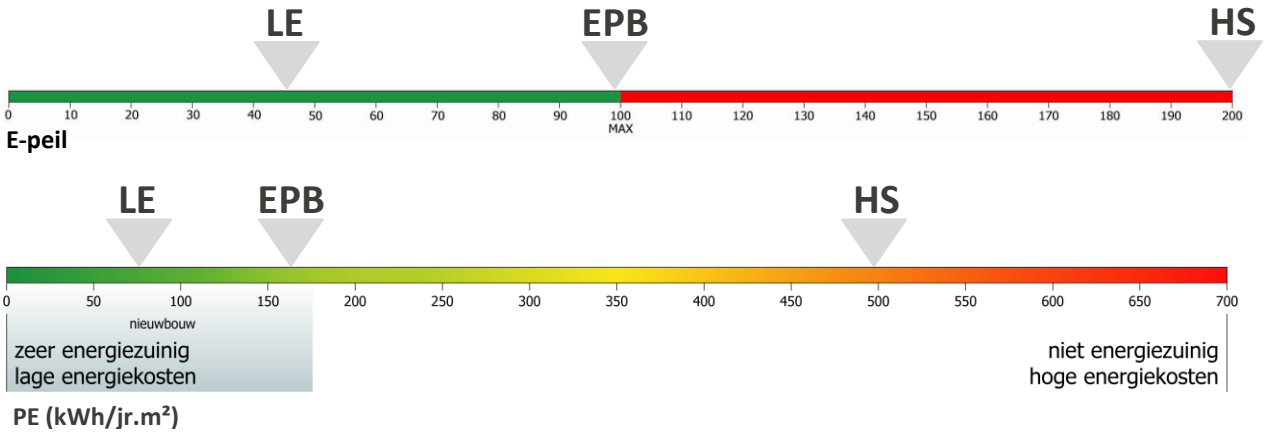
Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 30 cm	0,15	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 15 cm	0,25	Renovatiemaatregel
Vloer	Vloerisolatie - 10 cm	0,25	Renovatiemaatregel
Raam	Verbeterde geïsoleerde raamprofielen Uf 2 - verbeterde isolerende beglazing Ug 1,1	1,6	Vervangingsmaatregel
Deur	Verbeterd geïsoleerde deurprofielen Uf 2 - verbeterd geïsoleerd deurblad	1,6	Vervangingsmaatregel

(2) Systeemeigenschappen (LE)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m	Vervangingsmaatregel
Warm water	Thermische zonnepanelen - 5 m² - onbeschaduwd	Nieuwe installatie
Ventilatie	Balansventilatie met warmterecuperatie met volledige bypass - rendement 0,8	Nieuwe installatie

11.6 Energieprestatie

Scenario	K-peil (-)	E-peil (-)	NEB verwarming (kWh/jr.m²)	PE (kWh/jr.m²)	PE verwarming (%)	PE warm water (%)	PE hulpenergie (%)
Huidige situatie	117	299	238	499	94	5	1
EPB2010	48	99	101	165	81	13	7
Lage energie	31	45	42	75	65	15	20



11.7 Comfortbeoordeling

Scenario	Comfortklasse
Huidige situatie	*
EPB2010	***
Lage energie	****

11.8 Investerings- en besparingskost

Scenario	Investering (€/m²)	Jaarlijkse besparing (€/jr)	Indicatie terugverdientijd (jr)
EPB2010	175	2 100	15-20
Lage energie	275	3 400	15-20

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12. Type 12 - Halfopen bebouwing 1971-1990

12.1 Beschrijving

Deze woningfiche heeft betrekking op driegevelwoningen daterend uit de periode 1971-1990.

12.2 Details

Woningtype: Halfopen bebouwing
Bouwperiode: 1971-1990
Bruto vloeroppervlakte (m²): 185 m²
Beschermd volume (m³): 510 m³
Totale verliesoppervlakte (m²): 390 m²

12.3 Huidige situatie

(1) Bouwkundige kenmerken (HS)

Component	Beschrijving	U-waarde (W/m²K)
Dak	Geisoleerde dakconstructie 1971-1990 - dakisolatie tussen kepers 4 cm	0,85
Gevel	Geventileerde spouwmuur 1971-1990 - spouwisolatie 2 cm	1
Vloer	Ongeïsoleerde vloer op volle grond pre 1991	0,85
Raam	Meerkamer raamprofielen - dubbele beglazing - 1971-2005	3,5
Deur	Buitendeur - ongeïsoleerd deurblad - pre 1991	4

(2) Systeemeigenschappen (HS)

Component	Beschrijving
Verwarming	Centrale verwarming - stookolie combiketel 1976-1985 - rendement 0,7
Warm water	Combiketel op stookolie met opslagvat pre 1990 - leidinglengtes > 5 m
Ventilatie	Géén gecontroleerde ventilatie

12.4 Standaard renovatie (EPB 2010)

(1) Bouwkundige kenmerken (EPB 2010)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 15 cm	0,3	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 8 cm	0,4	Renovatiemaatregel
Vloer	Vloerisolatie - 5 cm	0,4	Renovatiemaatregel
Raam	Geïsoleerde raamprofielen - verbeterde isolerende beglazing Ug 1,1 - na 2005	2	Vervangingsmaatregel
Deur	Buitendeur - geïsoleerd deurblad	2,9	Vervangingsmaatregel

(2) Systeemeigenschappen (EPB 2010)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas – leidinglengtes > 5m	Vervangingsmaatregel
Ventilatie	Ventilatiesysteem C - natuurlijke toevoer en mechanische afvoer	Nieuwe installatie

12.5 Lage energierenovatie

(1) Bouwkundige Kenmerken (LE)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 30 cm	0,15	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 15 cm	0,25	Renovatiemaatregel
Vloer	Vloerisolatie - 10 cm	0,25	Renovatiemaatregel
Raam	Verbeterde geïsoleerde raamprofielen Uf 2 - verbeterde isolerende beglazing Ug 1,1	1,6	Vervangingsmaatregel
Deur	Verbeterd geïsoleerde deurprofielen Uf 2 - verbeterd geïsoleerd deurblad	1,6	Vervangingsmaatregel

(2) Systeemeigenschappen (LE)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas – leidinglengtes > 5m	Vervangingsmaatregel
Warm water	Thermische zonnepanelen - 5 m² - onbeschaduwd	Nieuwe installatie
Ventilatie	Balansventilatie met warmterecuperatie met volledige bypass - rendement 0,8	Nieuwe installatie

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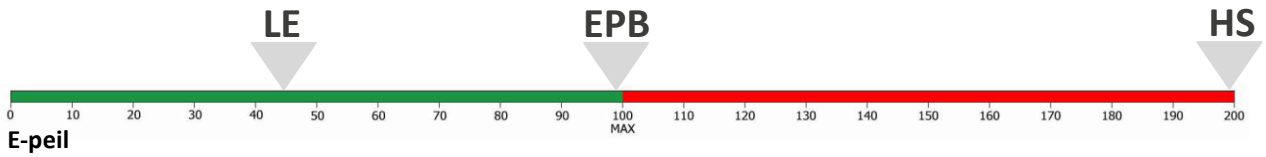
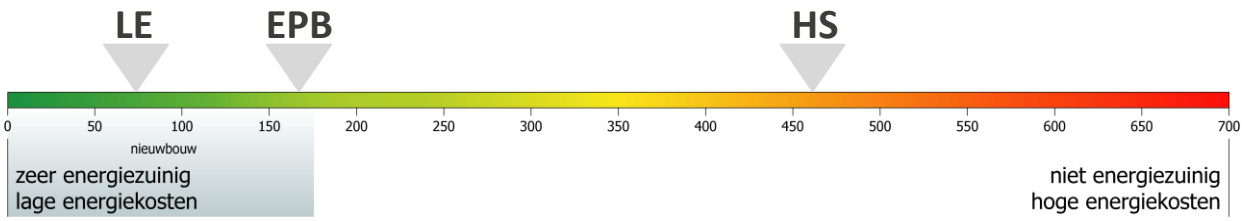
12.6 Energieprestatie

Scenario	K-peil (-)	E-peil (-)	NEB verwarming (kWh/jr.m²)	PE (kWh/jr.m²)	PE verwarming (%)	PE warm water (%)	PE hulpenergie (%)
Huidige situatie	115	279	221	463	94	5	1
EPB2010	50	100	102	166	80	13	7
Lage energie	33	44	40	72	65	14	21



E-peil



PE (kWh/jr.m²)

12.7 Comfortbeoordeling

Scenario	Comfortklasse
Huidige situatie	*
EPB2010	***
Lage energie	****

12.8 Investerings- en besparingskost

Scenario	Investering (€/m²)	Jaarlijkse besparing (€/jr)	Indicatie terugverdientijd (jr)
EPB2010	175	1 700	15-20
Lage energie	275	2 800	15-20

13. Type 13 - Rijwoning 1971-1990

13.1 Beschrijving

Deze woningfiche heeft betrekking op rijwoningen daterend uit de periode 1971-1990.

13.2 Details

Woningtype: Rijwoning
Bouwperiode: 1971-1990
Bruto vloeroppervlakte (m²): 168 m²
Beschermd volume (m³): 463 m³
Totale verliesoppervlakte (m²): 257 m²

13.3 Huidige situatie

(1) Bouwkundige kenmerken (HS)

Component	Beschrijving	U-waarde (W/m²K)
Dak	Geisoleerde dakconstructie 1971-1990 - dakisolatie tussen kepers 4 cm	0,85
Gevel	Geventileerde spouwmuur 1971-1990 - spouwisolatie 2 cm	1
Vloer	Ongeïsoleerde vloer op volle grond pre 1991	0,85
Raam	Meerkamer raamprofielen - dubbele beglazing - 1971-2005	3,5
Deur	Buitendeur - ongeïsoleerd deurblad - pre 1991	4

(2) Systeemeigenschappen (HS)

Component	Beschrijving
Verwarming	Centrale verwarming - gasketel 1986-1995 - rendement 0,72
Verwarming	Individuele doorstroom gasgeiser - leidinglengtes < 5m
Ventilatie	Géén gecontroleerde ventilatie

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13.4 Standaard renovatie (EPB 2010)

(1) Bouwkundige kenmerken (EPB 2010)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 15 cm	0,3	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 8 cm	0,4	Renovatiemaatregel
Vloer	Vloerisolatie - 5 cm	0,4	Renovatiemaatregel
Raam	Geïsoleerde raamprofielen - verbeterde isolerende beglazing Ug 1,1 - na 2005	2	Vervangingsmaatregel
Deur	Buitendeur - geïsoleerd deurblad	2,9	Vervangingsmaatregel

(2) Systeemeigenschappen (EPB 2010)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m	Vervangingsmaatregel
Ventilatie	Ventilatiesysteem C - natuurlijke toevoer en mechanische afvoer	Nieuwe installatie

13.5 Lage energierenovatie

(1) Bouwkundige Kenmerken (LE)

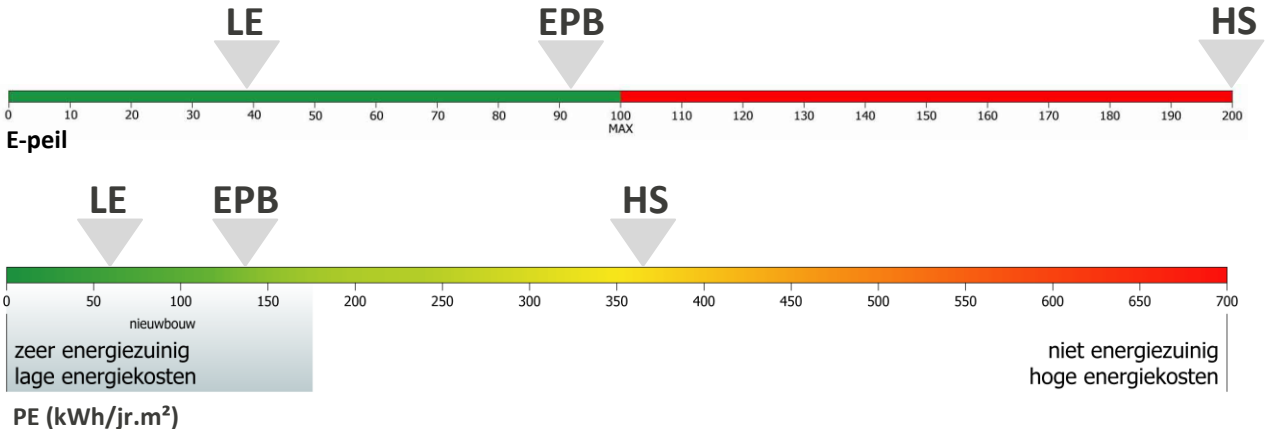
Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 30 cm	0,15	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 15 cm	0,25	Renovatiemaatregel
Vloer	Vloerisolatie - 10 cm	0,25	Renovatiemaatregel
Raam	Verbeterde geïsoleerde raamprofielen Uf 2 - verbeterde isolerende beglazing Ug 1,1	1,6	Vervangingsmaatregel
Deur	Verbeterd geïsoleerde deurprofielen Uf 2 - verbeterd geïsoleerd deurblad	1,6	Vervangingsmaatregel

(2) Systeemeigenschappen (LE)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m	Vervangingsmaatregel
Warm water	Thermische zonnepanelen - 5 m² - onbeschaduwd	Nieuwe installatie
Ventilatie	Balansventilatie met warmterecuperatie met volledige bypass - rendement 0,8	Nieuwe installatie

13.6 Energieprestatie

Scenario	K-peil (-)	E-peil (-)	NEB verwarming (kWh/jr.m²)	PE (kWh/jr.m²)	PE verwarming (%)	PE warm water (%)	PE hulpenergie (%)
Huidige situatie	105	246	167	368	91	5	4
EPB2010	47	92	81	138	77	15	8
Lage energie	31	39	30	58	60	14	26



13.7 Comfortbeoordeling

Scenario	Comfortklasse
Huidige situatie	*
EPB2010	***
Lage energie	****

13.8 Investerings- en besparingskost

Scenario	Investering (€/m²)	Jaarlijkse besparing (€/jr)	Indicatie terugverdientijd (jr)
EPB2010	175	700	> 35
Lage energie	250	1 500	25-30

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14. Type 14 - Ingesloten appartement 1971-1990

14.1 Beschrijving

Deze woningfiche heeft betrekking op ingesloten appartementen daterend uit de periode 1971-1990. Als buitenschil voor ingesloten appartementen veronderstellen we enkel een voor- en achtergevel. Vloer, plafond en zijgevels grenzen aan naburige appartementen.

14.2 Details

Woningtype: Appartement ingesloten
Bouwperiode: 1971-1990
Bruto vloeroppervlakte (m²): 100 m²
Beschermd volume (m³): 320 m³
Totale verliesoppervlakte (m²): 45 m²

14.3 Huidige situatie

(1) Bouwkundige kenmerken (HS)

Component	Beschrijving	U-waarde (W/m²K)
Gevel	Geventileerde spouwmuur 1971-1990 - spouwisolatie 2 cm	1
Raam	Meerkamer raamprofielen - dubbele beglazing - 1971-2005	3,5

(2) Systeemeigenschappen (HS)

Component	Beschrijving
Verwarming	Collectieve centrale verwarming - stookolie combiketel 1976-1985 - rendement 0,7
Warm water	Combiketel op stookolie met opslagvat pre 1990 - leidinglengtes > 5 m
Ventilatie	Géén gecontroleerde ventilatie

14.4 Standaard renovatie (EPB 2010)

(1) Bouwkundige kenmerken (EPB 2010)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Gevel	Spouwisolatie of buitengevelisolatie - 8 cm	0,4	Renovatiemaatregel
Raam	Geïsoleerde raamprofielen - verbeterde isolerende beglazing Ug 1,1 - na 2005	2	Vervangingsmaatregel

(2) Systeemeigenschappen (EPB 2010)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m	Vervangingsmaatregel
Ventilatie	Ventilatiesysteem C - natuurlijke toevoer en mechanische afvoer	Nieuwe installatie

14.5 Lage energierenovatie

(1) Bouwkundige Kenmerken (LE)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Gevel	Spouwisolatie of buitengevelisolatie - 15 cm	0,25	Renovatiemaatregel
Raam	Verbeterde geïsoleerde raamprofielen Uf 2 - verbeterde isolerende beglazing Ug 1,1	1,6	Vervangingsmaatregel

(2) Systeemeigenschappen (LE)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m	Vervangingsmaatregel
Warm water	Thermische zonnepanelen - 5 m² - onbeschaduwd	Nieuwe installatie
Ventilatie	Balansventilatie met warmterecuperatie met volledige bypass - rendement 0,8	Nieuwe installatie

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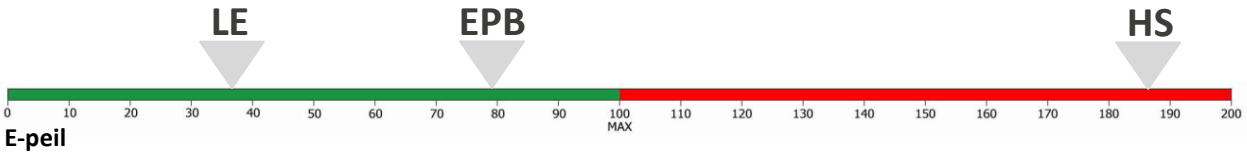
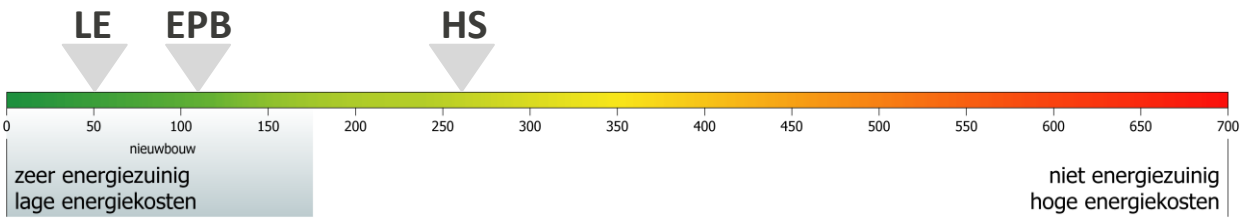
14.6 Energieprestatie

Scenario	K-peil (-)	E-peil (-)	NEB verwarming (kWh/jr.m²)	PE (kWh/jr.m²)	PE verwarming (%)	PE warm water (%)	PE hulpenergie (%)
Huidige situatie	-	187	99	264	79	17	4
EPB2010	-	80	62	113	66	23	11
Lage energie	-	37	17	52	39	15	46



E-peil



PE (kWh/jr.m²)

14.7 Comfortbeoordeling

Scenario	Comfortklasse
Huidige situatie	**
EPB2010	***
Lage energie	****

14.8 Investerings- en besparingskost

Scenario	Investering (€/m²)	Jaarlijkse besparing (€/jr)	Indicatie terugverdientijd (jr)
EPB2010	200	300	> 35
Lage energie	325	600	> 35

15. Type 15 - Blootgesteld appartement 1971-1990

15.1 Beschrijving

Deze woningfiche heeft betrekking op blootgestelde appartementen daterend uit de periode 1971-1990. Als buitenschil voor blootgestelde appartementen veronderstellen we een voor- en achtergevel, dakvlak en 1 zijgevel. Het vloervlak en de 2de zijgevel grenzen aan naburige appartementen.

15.2 Details

Woningtype: Appartement blootgesteld
Bouwperiode: 1971-1990
Bruto vloeroppervlakte (m²): 100 m²
Beschermd volume (m³): 320 m³
Totale verliesoppervlakte (m²): 191 m²

15.3 Huidige situatie

(1) Bouwkundige kenmerken (HS)

Component	Beschrijving	U-waarde (W/m²K)
Dak	Geisoleerde dakconstructie 1971-1990 - dakisolatie tussen kepers 4 cm	0,85
Gevel	Geventileerde spouwmuur 1971-1990 - spouwisolatie 2 cm	1
Raam	Meerkamer raamprofielen - dubbele beglazing - 1971-2005	3,5

(2) Systeemeigenschappen (HS)

Component	Beschrijving
Verwarming	Collectieve centrale verwarming - stookolie combiketel 1976-1985 - rendement 0,7
Warm water	Combiketel op stookolie met opslagvat pre 1990 - leidinglengtes > 5 m
Ventilatie	Géén gecontroleerde ventilatie

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15.4 Standaard renovatie (EPB 2010)

(1) Bouwkundige kenmerken (EPB 2010)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 15 cm	0,3	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 8 cm	0,4	Renovatiemaatregel
Raam	Geïsoleerde raamprofielen - verbeterde isolerende beglazing Ug 1,1 - na 2005	2	Vervangingsmaatregel

(2) Systeemeigenschappen (EPB 2010)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m	Vervangingsmaatregel
Ventilatie	Ventilatiesysteem C - natuurlijke toevoer en mechanische afvoer	Nieuwe installatie

15.5 Lage energierenovatie

(1) Bouwkundige Kenmerken (LE)

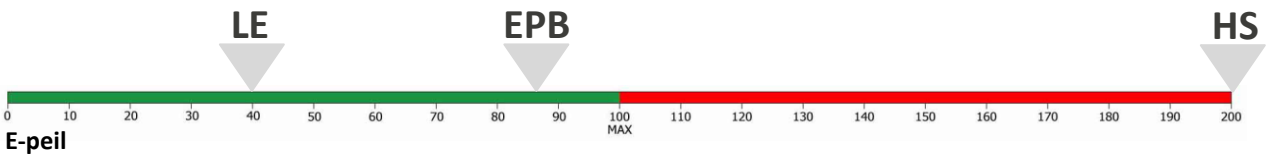
Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 30 cm	0,15	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 15 cm	0,25	Renovatiemaatregel
Raam	Verbeterde geïsoleerde raamprofielen Uf 2 - verbeterde isolerende beglazing Ug 1,1	1,6	Vervangingsmaatregel

(2) Systeemeigenschappen (LE)

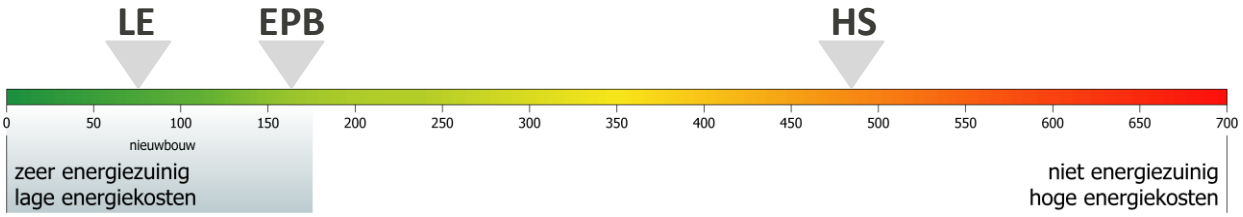
Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m	Vervangingsmaatregel
Warm water	Thermische zonnepanelen - 5 m² - onbeschaduwd	Nieuwe installatie
Ventilatie	Balansventilatie met warmterecuperatie met volledige bypass - rendement 0,8	Nieuwe installatie

15.6 Energieprestatie

Scenario	K-peil (-)	E-peil (-)	NEB verwarming (kWh/jr.m²)	PE (kWh/jr.m²)	PE verwarming (%)	PE warm water (%)	PE hulpenergie (%)
Huidige situatie	-	260	204	488	89	9	2
EPB2010	-	86	102	160	76	16	8
Lage energie	-	40	36	74	57	10	33



E-peil



PE (kWh/jr.m²)

15.7 Comfortbeoordeling

Scenario	Comfortklasse
Huidige situatie	**
EPB2010	***
Lage energie	****

15.8 Investerings- en besparingskost

Scenario	Investering (€/m²)	Jaarlijkse besparing (€/jr)	Indicatie terugverdientijd (jr)
EPB2010	225	900	20-25
Lage energie	375	1 400	25-30

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16. Type 16 - Vrijstaande woning 1991-2005

16.1 Beschrijving

Deze woningfiche heeft betrekking op vrijstaande woningen daterend uit de periode 1991-2005.

16.2 Details

Woningtype: Vrijstaande woning
Bouwperiode: 1991-2005
Bruto vloeroppervlakte (m²): 258 m²
Beschermd volume (m³): 711 m³
Totale verliesoppervlakte (m²): 558 m²

16.3 Huidige situatie

(1) Bouwkundige kenmerken (HS)

Component	Beschrijving	U-waarde (W/m²K)
Dak	Geisoleerde dakconstructie 1991-2005 - dakisolatie tussen kepers 8 cm	0,6
Gevel	Geventileerde spouwmuur 1991-2005 - spouwisolatie 6 cm	0,6
Vloer	Vloer op volle grond 1991-2005 - uitvullaag 4 cm	0,7
Raam	Meerkamer raamprofielen - dubbele beglazing - 1971-2005	3,5
Deur	Buitendeur - ongeïsoleerd deurblad - 1991-2005	3,5

(2) Systeemeigenschappen (HS)

Component	Beschrijving
Verwarming	Centrale verwarming - combiketel op gas 1996-2005 - rendement 0,76
Warm water	Doorstroom combiketel op gas na 1989 - leidinglengtes > 5 m
Ventilatie	Géén gecontroleerde ventilatie

16.4 Standaard renovatie (EPB 2010)

(1) Bouwkundige kenmerken (EPB 2010)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 15 cm	0,3	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 8 cm	0,4	Renovatiemaatregel
Vloer	Vloerisolatie - 5 cm	0,4	Renovatiemaatregel
Raam	Geïsoleerde raamprofielen - verbeterde isolerende beglazing Ug 1,1 - na 2005	2	Vervangingsmaatregel
Deur	Buitendeur - geïsoleerd deurblad	2,9	Vervangingsmaatregel

(2) Systeemeigenschappen (EPB 2010)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Individuele doorstroom gasgeiser - leidinglengtes > 5 m	Vervangingsmaatregel
Ventilatie	Ventilatiesysteem C - natuurlijke toevoer en mechanische afvoer	Nieuwe installatie

16.5 Lage energierenovatie

(1) Bouwkundige Kenmerken (LE)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 30 cm	0,15	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 15 cm	0,25	Renovatiemaatregel
Vloer	Vloerisolatie - 10 cm	0,25	Renovatiemaatregel
Raam	Verbeterde geïsoleerde raamprofielen Uf 2 - verbeterde isolerende beglazing Ug 1,1	1,6	Vervangingsmaatregel
Deur	Verbeterd geïsoleerde deurprofielen Uf 2 - verbeterd geïsoleerd deurblad	1,6	Vervangingsmaatregel

(2) Systeemeigenschappen (LE)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m	Vervangingsmaatregel
Warm water	Thermische zonnepanelen - 5 m² - onbeschaduwd	Nieuwe installatie
Ventilatie	Balansventilatie met warmterecuperatie met volledige bypass - rendement 0,8	Nieuwe installatie

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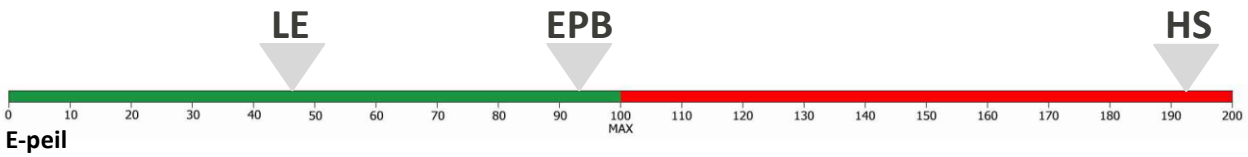
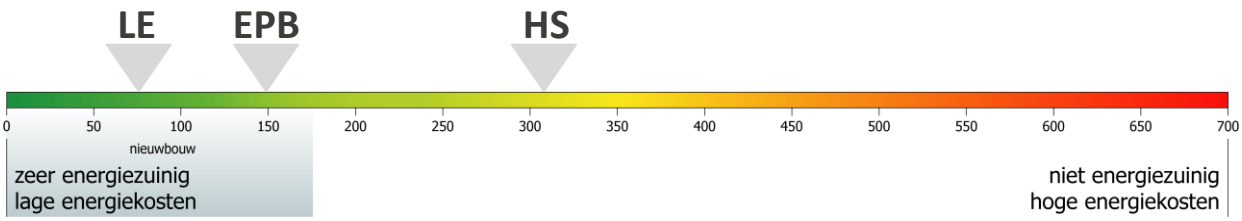
16.6 Energieprestatie

Scenario	K-peil (-)	E-peil (-)	NEB verwarming (kWh/jr.m²)	PE (kWh/jr.m²)	PE verwarming (%)	PE warm water (%)	PE hulpenergie (%)
Huidige situatie	84	194	165	311	91	7	2
EPB2010	49	93	99	149	79	14	7
Lage energie	32	47	41	75	65	15	20



E-peil



PE (kWh/jr.m²)

16.7 Comfortbeoordeling

Scenario	Comfortklasse
Huidige situatie	**
EPB2010	***
Lage energie	****

16.8 Investerings- en besparingskost

Scenario	Investering (€/m²)	Jaarlijkse besparing (€/jr)	Indicatie terugverdientijd (jr)
EPB2010	125	700	> 35
Lage energie	275	1 900	> 35

17. Type 17 - Halfopen bebouwing 1991-2005

17.1 Beschrijving

Deze woningfiche heeft betrekking op driegevelwoningen daterend uit de periode 1991-2005.

17.2 Details

Woningtype: Halfopen bebouwing
Bouwperiode: 1991-2005
Bruto vloeroppervlakte (m²): 224 m²
Beschermd volume (m³): 616 m³
Totale verliesoppervlakte (m²): 410 m²

17.3 Huidige situatie

(1) Bouwkundige kenmerken (HS)

Component	Beschrijving	U-waarde (W/m²K)
Dak	Geisoleerde dakconstructie 1991-2005 - dakisolatie tussen kepers 8 cm	0,6
Gevel	Geventileerde spouwmuur 1991-2005 - spouwisolatie 6 cm	0,6
Vloer	Vloer op volle grond 1991-2005 - uitvullaag 4 cm	0,7
Raam	Meerkamer raamprofielen - dubbele beglazing - 1971-2005	3,5
Deur	Buitendeur - ongeïsoleerd deurblad - 1991-2005	3,5

(2) Systeemeigenschappen (HS)

Component	Beschrijving
Verwarming	Centrale verwarming - combiketel op gas 1996-2005 - rendement 0,76
Warm water	Doorstroom combiketel op gas na 1989 - leidinglengtes > 5 m
Ventilatie	Géén gecontroleerde ventilatie

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17.4 Standaard renovatie (EPB 2010)

(1) Bouwkundige kenmerken (EPB 2010)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 15 cm	0,3	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 8 cm	0,4	Renovatiemaatregel
Vloer	Vloerisolatie - 5 cm	0,4	Renovatiemaatregel
Raam	Geïsoleerde raamprofielen - verbeterde isolerende beglazing Ug 1,1 - na 2005	2	Vervangingsmaatregel
Deur	Buitendeur - geïsoleerd deurblad	2,9	Vervangingsmaatregel

(2) Systeemeigenschappen (EPB 2010)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas – leidinglengtes > 5m	Vervangingsmaatregel
Ventilatie	Ventilatiesysteem C - natuurlijke toevoer en mechanische afvoer	Nieuwe installatie

17.5 Lage energierenovatie

(1) Bouwkundige Kenmerken (LE)

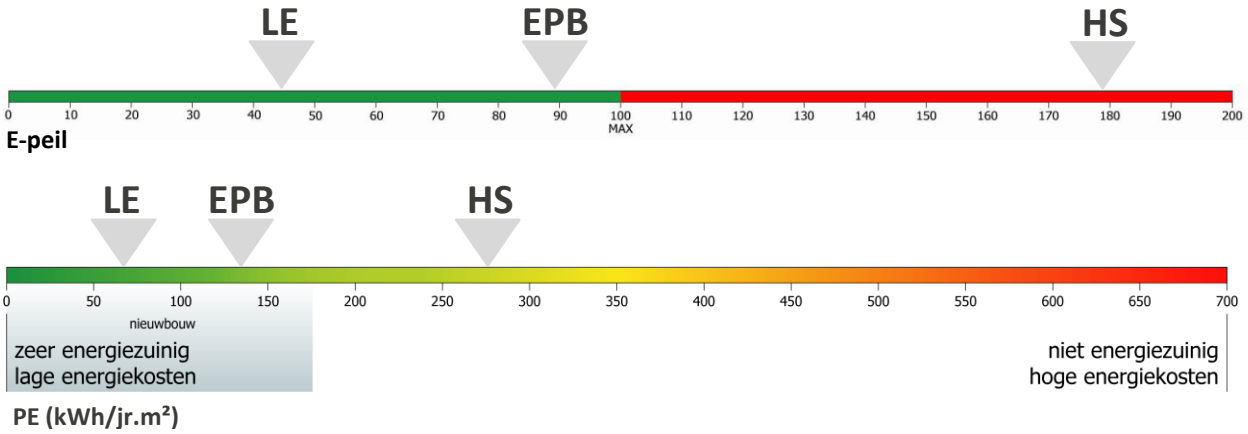
Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 30 cm	0,15	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 15 cm	0,25	Renovatiemaatregel
Vloer	Vloerisolatie - 10 cm	0,25	Renovatiemaatregel
Raam	Verbeterde geïsoleerde raamprofielen Uf 2 - verbeterde isolerende beglazing Ug 1,1	1,6	Vervangingsmaatregel
Deur	Verbeterd geïsoleerde deurprofielen Uf 2 - verbeterd geïsoleerd deurblad	1,6	Vervangingsmaatregel

(2) Systeemeigenschappen (LE)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas – leidinglengtes > 5m	Vervangingsmaatregel
Warm water	Thermische zonnepanelen - 5 m² - onbeschaduwd	Nieuwe installatie
Ventilatie	Balansventilatie met warmterecuperatie met volledige bypass - rendement 0,8	Nieuwe installatie

17.6 Energieprestatie

Scenario	K-peil (-)	E-peil (-)	NEB verwarming (kWh/jr.m²)	PE (kWh/jr.m²)	PE verwarming (%)	PE warm water (%)	PE hulpenergie (%)
Huidige situatie	80	182	145	278	90	8	2
EPB2010	47	90	88	137	77	15	8
Lage energie	31	44	35	66	61	16	22



17.7 Comfortbeoordeling

Scenario	Comfortklasse
Huidige situatie	**
EPB2010	***
Lage energie	****

17.8 Investerings- en besparingskost

Scenario	Investering (€/m²)	Jaarlijkse besparing (€/jr)	Indicatie terugverdientijd (jr)
EPB2010	100	700	30-35
Lage energie	250	1 600	30-35

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18. Type 18 - Rijwoning 1991-2005

18.1 Beschrijving

Deze woningfiche heeft betrekking op rijwoningen daterend uit de periode 1991-2005.

18.2 Details

Woningtype: Rijwoning
Bouwperiode: 1991-2005
Bruto vloeroppervlakte (m²): 192 m²
Beschermd volume (m³): 527 m³
Totale verliesoppervlakte (m²): 264 m²

18.3 Huidige situatie

(1) Bouwkundige kenmerken (HS)

Component	Beschrijving	U-waarde (W/m²K)
Dak	Geisoleerde dakconstructie 1991-2005 - dakisolatie tussen kepers 8 cm	0,6
Gevel	Geventileerde spouwmuur 1991-2005 - spouwisolatie 6 cm	0,6
Vloer	Vloer op volle grond 1991-2005 - uitvullaag 4 cm	0,7
Raam	Meerkamer raamprofielen - dubbele beglazing - 1971-2005	3,5
Deur	Buitendeur - ongeïsoleerd deurblad - 1991-2005	3,5

(2) Systeemeigenschappen (HS)

Component	Beschrijving
Verwarming	Centrale verwarming - combiketel op gas 1996-2005 - rendement 0,76
Warm water	Doorstroom combiketel op gas na 1989 - leidinglengtes < 5 m
Ventilatie	Géén gecontroleerde ventilatie

18.4 Standaard renovatie (EPB 2010)

(1) Bouwkundige kenmerken (EPB 2010)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 15 cm	0,3	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 8 cm	0,4	Renovatiemaatregel
Vloer	Vloerisolatie - 5 cm	0,4	Renovatiemaatregel
Raam	Geïsoleerde raamprofielen - verbeterde isolerende beglazing Ug 1,1 - na 2005	2	Vervangingsmaatregel
Deur	Buitendeur - geïsoleerd deurblad	2,9	Vervangingsmaatregel

(2) Systeemeigenschappen (EPB 2010)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m	Vervangingsmaatregel
Ventilatie	Ventilatiesysteem C - natuurlijke toevoer en mechanische afvoer	Nieuwe installatie

18.5 Lage energierenovatie

(1) Bouwkundige Kenmerken (LE)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 30 cm	0,15	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 15 cm	0,25	Renovatiemaatregel
Vloer	Vloerisolatie - 10 cm	0,25	Renovatiemaatregel
Raam	Verbeterde geïsoleerde raamprofielen Uf 2 - verbeterde isolerende beglazing Ug 1,1	1,6	Vervangingsmaatregel
Deur	Verbeterd geïsoleerde deurprofielen Uf 2 - verbeterd geïsoleerd deurblad	1,6	Vervangingsmaatregel

(2) Systeemeigenschappen (LE)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m	Vervangingsmaatregel
Warm water	Thermische zonnepanelen - 5 m² - onbeschaduwd	Nieuwe installatie
Ventilatie	Balansventilatie met warmterecuperatie met volledige bypass - rendement 0,8	Nieuwe installatie

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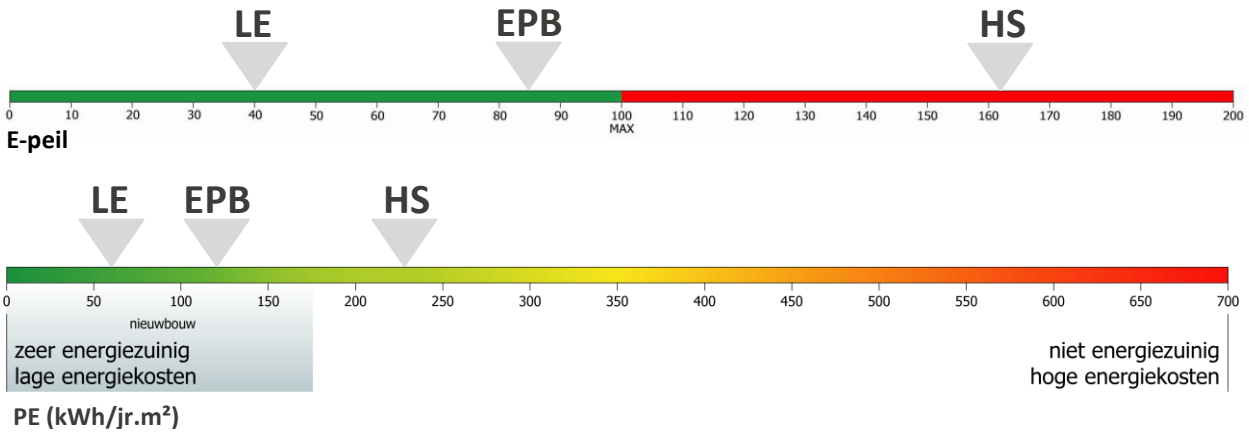
18.6 Energieprestatie

Scenario	K-peil (-)	E-peil (-)	NEB verwarming (kWh/jr.m²)	PE (kWh/jr.m²)	PE verwarming (%)	PE warm water (%)	PE hulpenergie (%)
Huidige situatie	77	163	119	232	88	9	3
EPB2010	46	85	75	120	74	17	9
Lage energie	30	40	27	56	58	16	26



18.7 Comfortbeoordeling

Scenario	Comfortklasse
Huidige situatie	**
EPB2010	***
Lage energie	****

18.8 Investerings- en besparingskost

Scenario	Investering (€/m²)	Jaarlijkse besparing (€/jr)	Indicatie terugverdientijd (jr)
EPB2010	100	500	> 35
Lage energie	250	1 200	> 35

19. Type 19 - Ingesloten appartement 1991-2005

19.1 Beschrijving

Deze woningfiche heeft betrekking op ingesloten appartementen daterend uit de periode 1991-2005. Als buitenschil voor ingesloten appartementen veronderstellen we enkel een voor- en achtergevel. Vloer, plafond en zijgevels grenzen aan naburige appartementen.

19.2 Details

Woningtype: Appartement ingesloten
Bouwperiode: 1991-2005
Bruto vloeroppervlakte (m²): 100 m²
Beschermd volume (m³): 320 m³
Totale verliesoppervlakte (m²): 45 m²

19.3 Huidige situatie

(1) Bouwkundige kenmerken (HS)

Component	Beschrijving	U-waarde (W/m²K)
Gevel	Geventileerde spouwmuur 1991-2005 - spouwisolatie 6 cm	0,6
Raam	Meerkamer raamprofielen - dubbele beglazing - 1971-2005	3,5

(2) Systeemeigenschappen (HS)

Component	Beschrijving
Verwarming	Centrale verwarming - combiketel op gas 1996-2005 - rendement 0,76
Warm water	Doorstroom combiketel op gas na 1989 - leidinglengtes < 5 m
Ventilatie	Géén gecontroleerde ventilatie

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19.4 Standaard renovatie (EPB 2010)

(1) Bouwkundige kenmerken (EPB 2010)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Gevel	Spouwisolatie of buitengevelisolatie - 8 cm	0,4	Renovatiemaatregel
Raam	Geïsoleerde raamprofielen - verbeterde isolerende beglazing Ug 1,1 - na 2005	2	Vervangingsmaatregel

(2) Systeemeigenschappen (EPB 2010)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m	Vervangingsmaatregel
Ventilatie	Ventilatiesysteem C - natuurlijke toevoer en mechanische afvoer	Nieuwe installatie

19.5 Lage energierenovatie

(1) Bouwkundige Kenmerken (LE)

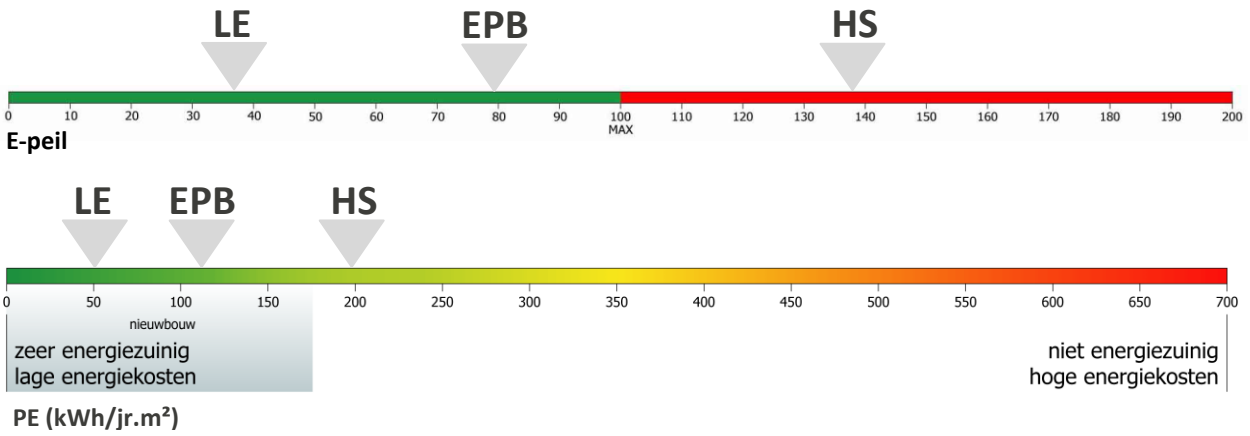
Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Gevel	Spouwisolatie of buitengevelisolatie - 15 cm	0,25	Renovatiemaatregel
Raam	Verbeterde geïsoleerde raamprofielen Uf 2 - verbeterde isolerende beglazing Ug 1,1	1,6	Vervangingsmaatregel

(2) Systeemeigenschappen (LE)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m	Vervangingsmaatregel
Warm water	Thermische zonnepanelen - 5 m² - onbeschaduwd	Nieuwe installatie
Ventilatie	Balansventilatie met warmterecuperatie met volledige bypass - rendement 0,8	Nieuwe installatie

19.6 Energieprestatie

Scenario	K-peil (-)	E-peil (-)	NEB verwarming (kWh/jr.m²)	PE (kWh/jr.m²)	PE verwarming (%)	PE warm tapwater (%)	PE hulpenergie (%)
Huidige situatie	-	140	93	197	81	13	6
EPB2010	-	80	62	113	66	23	11
Lage energie	-	37	17	52	39	15	46



19.7 Comfortbeoordeling

Scenario	Comfortklasse
Huidige situatie	**
EPB2010	***
Lage energie	****

19.8 Investerings- en besparingskost

Scenario	Investering (€/m²)	Jaarlijkse besparing (€/jr)	Indicatie terugverdientijd (jr)
EPB2010	125	100	> 35
Lage energie	325	500	> 35

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20. Type 20 - Blootgesteld appartement 1991-2005

20.1 Beschrijving

Deze woningfiche heeft betrekking op blootgestelde appartementen daterend uit de periode 1991-2005. Als buitenschil voor blootgestelde appartementen veronderstellen we een voor- en achtergevel, dakvlak en 1 zijgevel. Het vloervlak en de 2de zijgevel grenzen aan naburige appartementen.

20.2 Details

Woningtype: Appartement blootgesteld
Bouwperiode: 1991-2005
Bruto vloeroppervlakte (m²): 100 m²
Beschermd volume (m³): 320 m³
Totale verliesoppervlakte (m²): 191 m²

20.3 Huidige situatie

(1) Bouwkundige kenmerken (HS)

Component	Beschrijving	U-waarde (W/m²K)
Dak	Geisoleerde dakconstructie 1991-2005 - dakisolatie tussen kepers 8 cm	0,6
Gevel	Geventileerde spouwmuur 1991-2005 - spouwisolatie 6 cm	0,6
Raam	Meerkamer raamprofielen - dubbele beglazing - 1971-2005	3,5

(2) Systeemeigenschappen (HS)

Component	Beschrijving
Verwarming	Centrale verwarming - combiketel op gas 1996-2005 - rendement 0,76
Warm water	Doorstroom combiketel op gas na 1989 - leidinglengtes < 5 m
Ventilatie	Géén gecontroleerde ventilatie

20.4 Standaard renovatie (EPB 2010)

(1) Bouwkundige kenmerken (EPB 2010)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 15 cm	0,3	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 8 cm	0,4	Renovatiemaatregel
Raam	Geïsoleerde raamprofielen - verbeterde isolerende beglazing Ug 1,1 - na 2005	2	Vervangingsmaatregel

(2) Systeemeigenschappen (EPB 2010)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m	Vervangingsmaatregel
Ventilatie	Ventilatiesysteem C - natuurlijke toevoer en mechanische afvoer	Nieuwe installatie

20.5 Lage energierenovatie

(1) Bouwkundige Kenmerken (LE)

Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 30 cm	0,15	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 15 cm	0,25	Renovatiemaatregel
Raam	Verbeterde geïsoleerde raamprofielen Uf 2 - verbeterde isolerende beglazing Ug 1,1	1,6	Vervangingsmaatregel

(2) Systeemeigenschappen (LE)

Component	Beschrijving	Type Ingreep
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06	Vervangingsmaatregel
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m	Vervangingsmaatregel
Warm water	Thermische zonnepanelen - 5 m² - onbeschaduwd	Nieuwe installatie
Ventilatie	Balansventilatie met warmterecuperatie met volledige bypass - rendement 0,8	Nieuwe installatie

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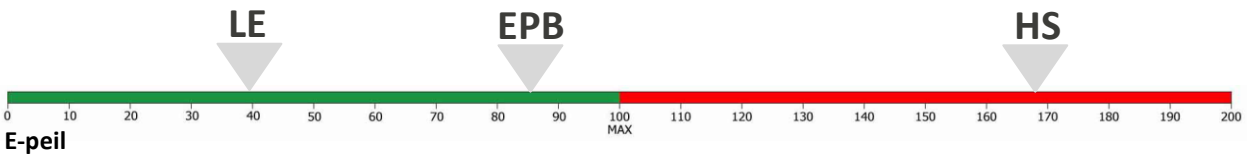
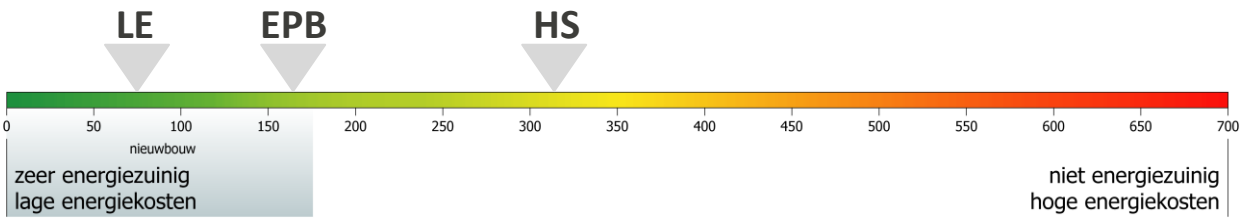
20.6 Energieprestatie

Scenario	K-peil (-)	E-peil (-)	NEB verwarming (kWh/jr.m²)	PE (kWh/jr.m²)	PE verwarming (%)	PE warm tapwater (%)	PE hulpenergie (%)
Huidige situatie	-	170	163	319	88	8	4
EPB2010	-	86	102	160	76	16	8
Lage energie	-	40	36	74	57	10	33



E-peil



PE (kWh/jr.m²)

20.7 Comfortbeoordeling

Scenario	Comfortklasse
Huidige situatie	**
EPB2010	***
Lage energie	****

20.8 Investerings- en besparingskost

Scenario	Investering (€/m²)	Jaarlijkse besparing (€/jr)	Indicatie terugverdientijd (jr)
EPB2010	150	600	20-25
Lage energie	375	1 100	30-35

21. Type 21 - Vrijstaande woning na 2005

21.1 Beschrijving

Deze woningfiche heeft betrekking op vrijstaande woningen daterend uit de periode na 2005.

21.2 Details

Woningtype: Vrijstaande woning
Bouwperiode: Na 2005
Bruto vloeroppervlakte (m²): 270 m²
Beschermd volume (m³): 741 m³
Totale verliesoppervlakte (m²): 558 m²

21.3 Huidige situatie

(1) Bouwkundige kenmerken (HS)

Component	Beschrijving	U-waarde (W/m²K)
Dak	Geisoleerde dakconstructie na 2005 - dakisolatie tussen kepers 15 cm	0,3
Gevel	Geventileerde spouwmuur na 2005 - spouwisolatie 8 cm	0,4
Vloer	Vloer op volle grond na 2005 - vloerisolatie 5 cm	0,4
Raam	Geïsoleerde raamprofielen - verbeterde isolerende beglazing Ug 1,1 - na 2005	2
Deur	Buitendeur - geïsoleerd deurblad - na 2005	2,9

(2) Systeemeigenschappen (HS)

Component	Beschrijving
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m
Ventilatie	Ventilatiesysteem C - natuurlijke toevoer en mechanische afvoer

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21.4 Lage energierenovatie

(1) Bouwkundige Kenmerken (LE)

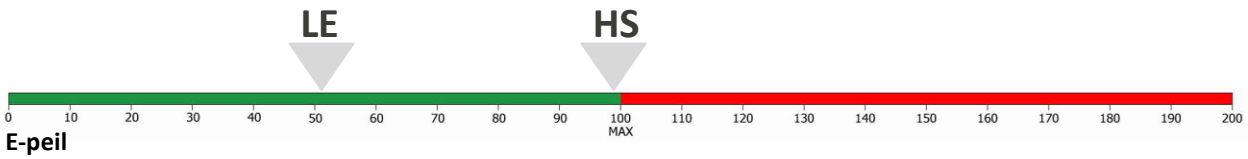
Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 30 cm	0,15	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 15 cm	0,25	Renovatiemaatregel
Vloer	Vloerisolatie - 10 cm	0,25	Renovatiemaatregel
Raam	Verbeterde geïsoleerde raamprofielen Uf 2 - verbeterde isolerende beglazing Ug 1,1	1,6	Vervangingsmaatregel
Deur	Verbeterd geïsoleerde deurprofielen Uf 2 - verbeterd geïsoleerd deurblad	1,6	Vervangingsmaatregel

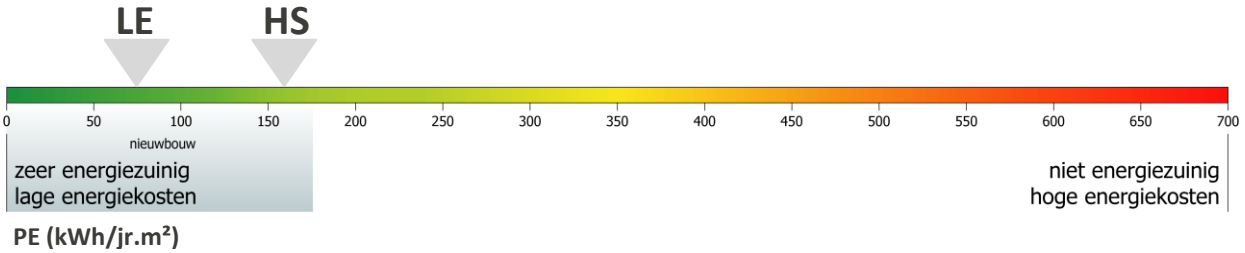
(2) Systeemeigenschappen (LE)

Component	Beschrijving	Type Ingreep
Warm water	Thermische zonnepanelen - 5 m² - onbeschaduwd	Nieuwe installatie
Ventilatie	Balansventilatie met warmterecuperatie met volledige bypass - rendement 0,8	Nieuwe installatie

21.5 Energieprestatie

Scenario	K-peil (-)	E-peil (-)	NEB verwarming (kWh/jr.m²)	PE (kWh/jr.m²)	PE verwarming (%)	PE warm water (%)	PE hulpenergie (%)
Huidige situatie	54	100	103	157	80	13	7
Lage energie	35	51	45	79	67	15	18





21.6 Comfortbeoordeling

Scenario	Comfortklasse
Huidige situatie	***
Lage energie	****

21.7 Investerings- en besparingskost

Scenario	Investering (€/m²)	Jaarlijkse besparing (€/jr)	Indicatie terugverdientijd (jr)
Lage energie	275	1 300	> 35

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22. Type 22 - Halfopen bebouwing na 2005

22.1 Beschrijving

Deze woningfiche heeft betrekking op driegevelwoningen daterend uit de periode na 2005.

22.2 Details

Woningtype: Halfopen bebouwing
Bouwperiode: Na 2005
Bruto vloeroppervlakte (m²): 234 m²
Beschermd volume (m³): 643 m³
Totale verliesoppervlakte (m²): 408 m²

22.3 Huidige situatie

(1) Bouwkundige kenmerken (HS)

Component	Beschrijving	U-waarde (W/m²K)
Dak	Geisoleerde dakconstructie na 2005 - dakisolatie tussen kepers 15 cm	0,3
Gevel	Geventileerde spouwmuur na 2005 - spouwisolatie 8 cm	0,4
Vloer	Vloer op volle grond na 2005 - vloerisolatie 5 cm	0,4
Raam	Geïsoleerde raamprofielen - verbeterde isolerende beglazing Ug 1,1 - na 2005	2
Deur	Buitendeur - geïsoleerd deurblad - na 2005	2,9

(2) Systeemeigenschappen (HS)

Component	Beschrijving
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m
Ventilatie	Ventilatiesysteem C - natuurlijke toevoer en mechanische afvoer

22.4 Lage energierenovatie

(1) Bouwkundige Kenmerken (LE)

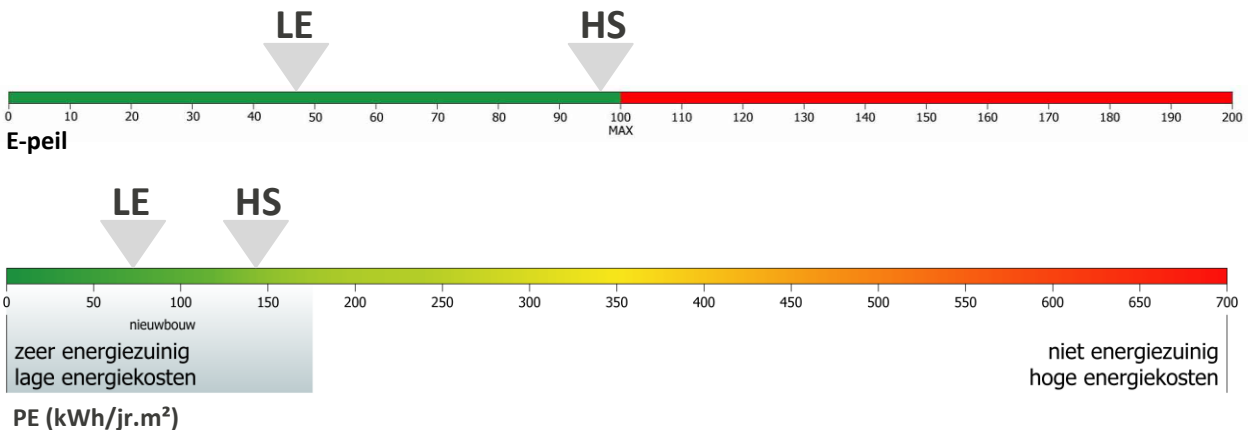
Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 30 cm	0,15	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 15 cm	0,25	Renovatiemaatregel
Vloer	Vloerisolatie - 10 cm	0,25	Renovatiemaatregel
Raam	Verbeterde geïsoleerde raamprofielen Uf 2 - verbeterde isolerende beglazing Ug 1,1	1,6	Vervangingsmaatregel
Deur	Verbeterd geïsoleerde deurprofielen Uf 2 - verbeterd geïsoleerd deurblad	1,6	Vervangingsmaatregel

(2) Systeemeigenschappen (LE)

Component	Beschrijving	Type Ingreep
Warm water	Thermische zonnepanelen - 5 m² - onbeschaduwd	Nieuwe installatie
Ventilatie	Balansventilatie met warmterecuperatie met volledige bypass - rendement 0,8	Nieuwe installatie

22.5 Energieprestatie

Scenario	K-peil (-)	E-peil (-)	NEB verwarming (kWh/jr.m²)	PE (kWh/jr.m²)	PE verwarming (%)	PE warm water (%)	PE hulpenergie (%)
Huidige situatie	52	97	92	144	78	15	7
Lage energie	34	47	38	70	63	16	21



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22.6 Comfortbeoordeling

Scenario	Comfortklasse
Huidige situatie	***
Lage energie	****

22.7 Investerings- en besparingskost

Scenario	Investering (€/m²)	Jaarlijkse besparing (€/jr)	Indicatie terugverdientijd (jr)
Lage energie	250	1 000	> 35

23. Type 23 - Rijwoning na 2005

23.1 Beschrijving

Deze woningfiche heeft betrekking op rijwoningen daterend uit de periode na 2005.

23.2 Details

Woningtype: Rijwoning
Bouwperiode: Na 2005
Bruto vloeroppervlakte (m²): 200 m²
Beschermd volume (m³): 550 m³
Totale verliesoppervlakte (m²): 268 m²

23.3 Huidige situatie

(1) Bouwkundige kenmerken (HS)

Component	Beschrijving	U-waarde (W/m²K)
Dak	Geisoleerde dakconstructie na 2005 - dakisolatie tussen kepers 15 cm	0,3
Gevel	Geventileerde spouwmuur na 2005 - spouwisolatie 8 cm	0,4
Vloer	Vloer op volle grond na 2005 - vloerisolatie 5 cm	0,4
Raam	Geïsoleerde raamprofielen - verbeterde isolerende beglazing Ug 1,1 - na 2005	2
Deur	Buitendeur - geïsoleerd deurblad - na 2005	2,9

(2) Systeemeigenschappen (HS)

Component	Beschrijving
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m
Ventilatie	Ventilatiesysteem C - natuurlijke toevoer en mechanische afvoer

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23.4 Lage energierenovatie

(1) Bouwkundige Kenmerken (LE)

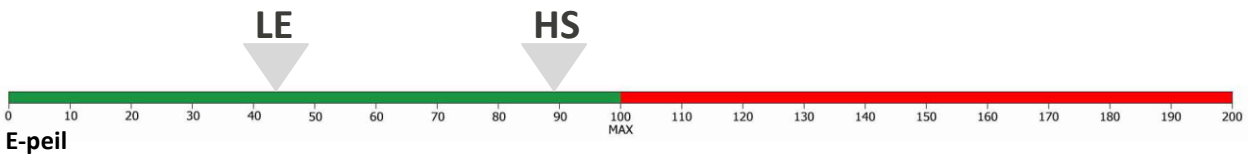
Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 30 cm	0,15	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 15 cm	0,25	Renovatiemaatregel
Vloer	Vloerisolatie - 10 cm	0,25	Renovatiemaatregel
Raam	Verbeterde geïsoleerde raamprofielen Uf 2 - verbeterde isolerende beglazing Ug 1,1	1,6	Vervangingsmaatregel
Deur	Verbeterd geïsoleerde deurprofielen Uf 2 - verbeterd geïsoleerd deurblad	1,6	Vervangingsmaatregel

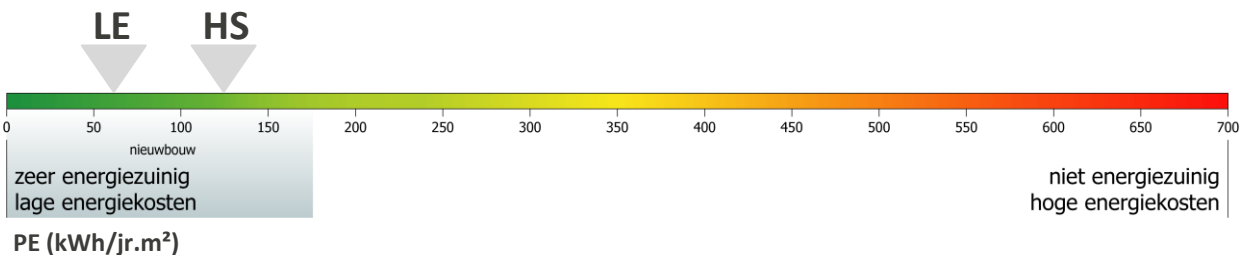
(2) Systeemeigenschappen (LE)

Component	Beschrijving	Type Ingreep
Warm water	Thermische zonnepanelen - 5 m² - onbeschaduwd	Nieuwe installatie
Ventilatie	Balansventilatie met warmterecuperatie met volledige bypass - rendement 0,8	Nieuwe installatie

23.5 Energieprestatie

Scenario	K-peil (-)	E-peil (-)	NEB verwarming (kWh/jr.m²)	PE (kWh/jr.m²)	PE verwarming (%)	PE warm water (%)	PE hulpenergie (%)
Huidige situatie	49	90	77	125	75	16	9
Lage energie	33	43	31	60	60	15	25





23.6 Comfortbeoordeling

Scenario	Comfortklasse
Huidige situatie	***
Lage energie	****

23.7 Investerings- en besparingskost

Scenario	Investering (€/m²)	Jaarlijkse besparing (€/jr)	Indicatie terugverdientijd (jr)
Lage energie	250	800	> 35

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24. Type 24 - Ingesloten appartement na 2005

24.1 Beschrijving

Deze woningfiche heeft betrekking op ingesloten appartementen daterend uit de periode na 2005. Als buitenschil voor ingesloten appartementen veronderstellen we enkel een voor- en achtergevel. Vloer, plafond en zijgevels grenzen aan naburige appartementen.

24.2 Details

Woningtype: Appartement blootgesteld
Bouwperiode: Na 2005
Bruto vloeroppervlakte (m²): 100 m²
Beschermd volume (m³): 320 m³
Totale verliesoppervlakte (m²): 45 m²

24.3 Huidige situatie

(1) Bouwkundige kenmerken (HS)

Component	Beschrijving	U-waarde (W/m²K)
Gevel	Geventileerde spouwmuur na 2005 - spouwisolatie 8 cm	0,4
Raam	Geïsoleerde raamprofielen - verbeterde isolerende beglazing Ug 1,1 - na 2005	2

(2) Systeemeigenschappen (HS)

Component	Beschrijving
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m
Ventilatie	Ventilatiesysteem C - natuurlijke toevoer en mechanische afvoer

24.4 Lage energierenovatie

(1) Bouwkundige Kenmerken (LE)

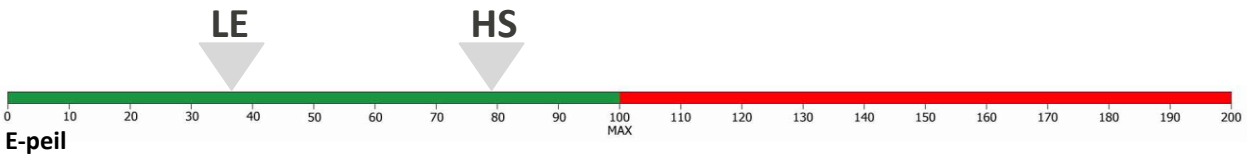
Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Gevel	Spouwisolatie of buitengevelisolatie - 15 cm	0,25	Renovatiemaatregel
Raam	Verbeterde geïsoleerde raamprofielen Uf 2 - verbeterde isolerende beglazing Ug 1,1	1,6	Vervangingsmaatregel

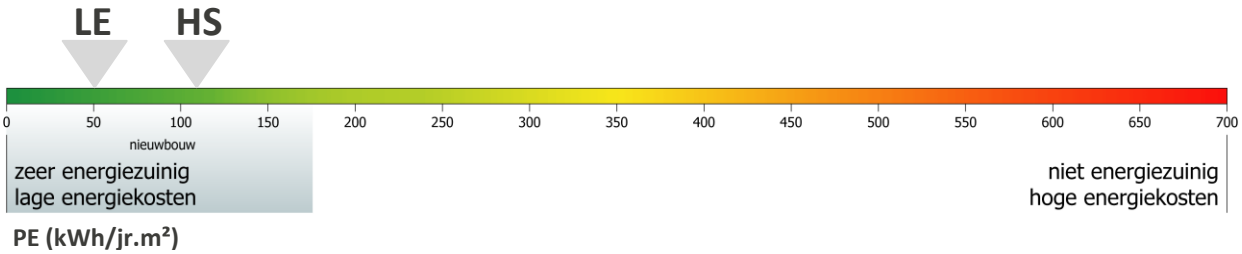
(2) Systeemeigenschappen (LE)

Component	Beschrijving	Type Ingreep
Warm water	Thermische zonnepanelen - 5 m² - onbeschaduwd	Nieuwe installatie
Ventilatie	Balansventilatie met warmterecuperatie met volledige bypass - rendement 0,8	Nieuwe installatie

24.5 Energieprestatie

Scenario	K-peil (-)	E-peil (-)	NEB verwarming (kWh/jr.m²)	PE (kWh/jr.m²)	PE verwarming (%)	PE warm water (%)	PE hulpenergie (%)
Huidige situatie	-	80	60	112	66	23	11
Lage energie	-	37	17	52	39	15	46





24.6 Comfortbeoordeling

Scenario	Comfortklasse
Huidige situatie	***
Lage energie	****

24.7 Investerings- en besparingskost

Scenario	Investering (€/m²)	Jaarlijkse besparing (€/jr)	Indicatie terugverdientijd (jr)
Lage energie	300	300	> 35

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25. Type 25 - Blootgesteld appartement na 2005

25.1 Beschrijving

Deze woningfiche heeft betrekking op blootgestelde appartementen daterend uit de periode na 2005. Als buitenschil voor blootgestelde appartementen veronderstellen we een voor- en achtergevel, dakvlak en 1 zijgevel. Het vloervlak en de 2de zijgevel grenzen aan naburige appartementen.

25.2 Details

Woningtype: Appartement blootgesteld
Bouwperiode: Na 2005
Bruto vloeroppervlakte (m²): 100 m²
Beschermd volume (m³): 320 m³
Totale verliesoppervlakte (m²): 191 m²

25.3 Huidige situatie

(1) Bouwkundige kenmerken (HS)

Component	Beschrijving	U-waarde (W/m²K)
Dak	Geisoleerde dakconstructie na 2005 - dakisolatie tussen kepers 15 cm	0,3
Gevel	Geventileerde spouwmuur na 2005 - spouwisolatie 8 cm	0,4
Raam	Geïsoleerde raamprofielen - verbeterde isolerende beglazing Ug 1,1 - na 2005	2

(2) Systeemeigenschappen (HS)

Component	Beschrijving
Verwarming	Centrale verwarming - condenserende combiketel op gas - rendement 1,06
Warm water	Condenserende combiketel op gas - leidinglengtes > 5 m
Ventilatie	Ventilatiesysteem C - natuurlijke toevoer en mechanische afvoer

25.4 Lage energierenovatie

(1) Bouwkundige Kenmerken (LE)

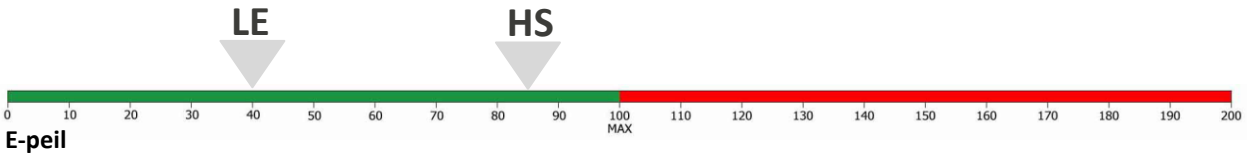
Component	Beschrijving	U-waarde (W/m²K)	Type Ingreep
Dak	Dakisolatie tussen kepers - 30 cm	0,15	Renovatiemaatregel
Gevel	Spouwisolatie of buitengevelisolatie - 15 cm	0,25	Renovatiemaatregel
Raam	Verbeterde geïsoleerde raamprofielen Uf 2 - verbeterde isolerende beglazing Ug 1,1	1,6	Vervangingsmaatregel

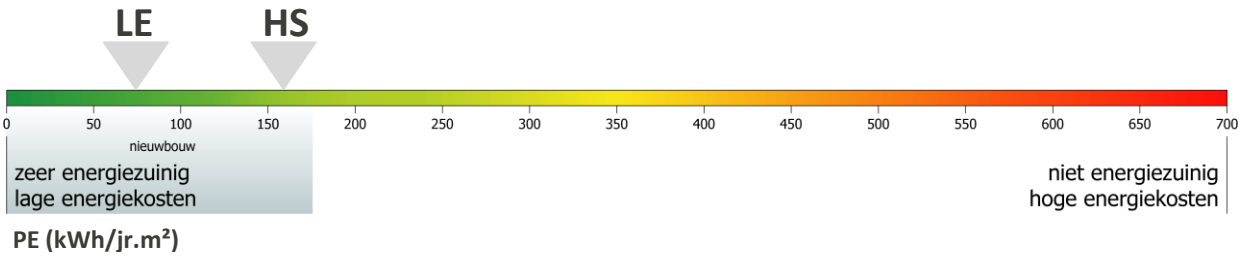
(2) Systeemeigenschappen (LE)

Component	Beschrijving	Type Ingreep
Warm water	Thermische zonnepanelen - 5 m² - onbeschaduwd	Nieuwe installatie
Ventilatie	Balansventilatie met warmterecuperatie met volledige bypass - rendement 0,8	Nieuwe installatie

25.5 Energieprestatie

Scenario	K-peil (-)	E-peil (-)	NEB verwarming (kWh/jr.m²)	PE (kWh/jr.m²)	PE verwarming (%)	PE warm water (%)	PE hulpenergie (%)
Huidige situatie	-	85	99	159	76	16	8
Lage energie	-	40	36	74	57	10	33





25.6 Comfortbeoordeling

Scenario	Comfortklasse
Huidige situatie	***
Lage energie	****

25.7 Investerings- en besparingskost

Scenario	Investering (€/m²)	Jaarlijkse besparing (€/jr)	Indicatie terugverdientijd (jr)
Lage energie	350	500	> 35

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ANNEX I. Referenties

De afbeeldingen bij de woningfiches zijn ten dele afkomstig uit de databank van het Vlaams Instituut van het Onroerend Erfgoed (http://inventaris.vioe.be).

Woningtype 4 en 5
Carnotstraat 45, Antwerpen

Woningtype 9 en 10
Residentiële wijk van het Studiecentrum voor Kernenergie, Boeretang, Mol
Appartmenten De Vel, Tabakvest 5, Antwerpen

Woningtype 14 en 15
Hoekappartementen A. Ruzettelaan, Blankenberge
Chicagoblok, Ernest Claesstraat 10-16, Antwerpen.

Woningtype 19 en 20
Kanaalhuizen Robbrecht and Daem, Coupure Rechts, Gent.
Silvertop torens, Antwerpen.

Woningtype 24 en 25
Bert Verlackstraat 2-6, Antwerpen.
Anco torens - Grand Soleil, Turnhout.

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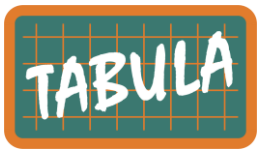
ANNEX II. Lijsten

Lijst van figuren

Lijst van tabellen



Projectgegevens

IEE TABULA - Typology Approach for Building Stock Energy Assessment
Duur: June 2009 – May 2012
Coördinator: Tobias Loga – Institut Wohnen und Umwelt (t.loga@iwu.de)

Partners

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Flemish Institute for Technological Research (VITO), Belgium
Sofia Energy Agency (SOFENA), Bulgaria
STU-K, a.s. (STK), Czech Republic
Danish Building Research Institute (DBI), Denmark
French Environment and Energy Management Agency (ADEME), France
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