Comprehensive study of building energy renovation activities and the uptake of nearly zero-energy buildings in the EU

Annex to final report

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Table of Contents

1. Definitions

This section provides insights into the partial overhaul of definitions which partly already existed from the EU Building Observatory. For the purpose of this study, also new definitions were developed.

1.1. Renovation & uptake of NZEB

<table>
<tr><th colspan="2">Renovation & uptake of NZEB</th></tr>
<tr><td>Energy renovation</td><td>An energy renovation means the change of one or more building elements, according to EPBD Art. 2, 9 (i.e. building envelope and technical building systems), having the potential to significantly affect the calculated or measured amount of energy needed to meet the energy demand associated with one or several of the following building services (according to ISO 52000-1) which correspond to a typical use of the assessed building;
▪ Space heating and cooling;
▪ Hot water;
▪ Ventilation (incl. humidification and dehumidification);
▪ (built-in) Lighting
▪ Auxiliary energy needed by TBS to provide these services is also included.

In the following we call such change of a building element a “technical measure”.

Affected building floor area: The building floor area affected by an energy renovation is the floor area affected by a specific technical measure. For a proper use of this indicator in subsequent calculations of renovation rates, it needs to be known whether a technical measure just affects one (or more) building unit(s) (e.g. one apartment) or the whole building, as the respective floor area needs to be considered.

Effective date of energy renovation: A renovation measure is assigned to the calendar year, where the measure has been completed. In case one measure is completed in January of a calendar year and another measure in December of the same calendar year, the cumulated impact of both measures is assigned to that calendar year and treated as one package, even if both measures are decoupled from a technical perspective.

Depth of energy renovation: Four renovation depths are defined that represent different ranges of primary energy savings achieved with a specific measure or package of measures that has/have been implemented in a calendar year:
▪ Below threshold (x < 3% savings)
▪ Light renovations (3% ≤ x ≤ 30% savings)
▪ Medium renovations (30% < x ≤ 60% savings)
▪ Deep renovations (x > 60% savings)

The different depths by definition do not necessarily need to cover a specific minimum number of measures but are just classified depending on the savings achieved compared to the primary energy performance level of the building in the calendar year before the energy renovation.</td></tr>
</table>

	Step-by-step energy renovations: In case a building or building unit undergoes energy renovation measures in one calendar year that represent only a part of a multi-calendar year renovation (e.g. following an individual building energy renovation roadmap, i.e. a package consisting of a series of technical measures aiming at higher savings), only the technical measures and its specific savings will be assigned to the calendar year x where that individual technical measure has been completed. Measures realised in other calendar years will also just be counted in the year the measures have been completed. **Rate of energy renovation:** This is the cumulated affected building floor area [m^2] of all buildings that underwent an energy renovation in calendar year x (e.g. 2013) divided by the total floor area [m^2] of the building stock in the same period. The rate of energy renovation can be further split up geographically (e.g. EU28, each EU Member State), by building type (e.g. residential and non-residential buildings) or by depth of energy renovation. The unit is [%]. The total energy renovation rate is defined as the sum of all renovation rates of the covered depths "below threshold", "light", "medium" and "deep". Other measures for the rate of energy renovation can be derived from that approach: the cumulated affected building floor area [m^2] of all buildings that underwent an energy renovation in calendar year x (e.g. 2013) can be transformed into an estimation of the number of buildings/building units that underwent an energy renovation when there is useful information or reasonable assumptions can be made about the average floor area of all buildings that underwent an energy renovation.
Non-energy renovation	Non-energy renovations are those that do not affect building elements according to EPBD Art. 2, 9 (i.e. building envelope and technical building systems) and thus do not have the potential to significantly affect the calculated or measured amount of energy needed as described for "energy renovation". Examples: electric installations, interior wall painting and plastering, interior flooring, new tiles, new kitchen, new bathroom, new carpets etc.
Energy renovations below threshold	An energy renovation is classified as a renovation "below threshold" in cases in which the primary energy demand of a building (based on calculated or measured performance) has been reduced by $x < 3\%$ savings compared to the primary energy demand of the building in the calendar year before the energy renovation. It was decided to include this minimum threshold in order to a) avoid misleadingly large numbers of light renovations (caused by including technical measures like e.g. replacing a few light bulbs in a non-residential building) and b) separate out and highlight those renovations, where significant lost-opportunities have been created as for improving the energy performance (e.g. full painting of all exterior walls without using the opportunity to improve the energy performance by adding /thick enough) insulation).
Light renovation	An energy renovation is classified as light renovation in cases in which the primary energy demand of a building (based on calculated or measured performance) has been reduced by $3\% \leq x \leq 30\%$ savings compared to the primary energy demand of the building in the calendar year before the energy renovation.
Medium renovation	An energy renovation is classified as medium renovation in cases in which the primary energy demand of a building (based on calculated or measured performance) has been reduced by $30\% < x \leq 60\%$ compared to the primary energy demand of the building in the calendar year before the energy renovation.

Deep renovation	An energy renovation is classified as deep renovation in cases in which the primary energy demand of a building (based on calculated or measured performance) has been reduced by x > 60% compared to the primary energy demand of the building in the calendar year before the energy renovation.
Weighted energy renovation rate	This is the cumulated saved primary energy consumption [kWh] of all buildings that underwent an energy renovation (i.e. the sum of all "below threshold", "light", "medium" and "deep" renovations) in calendar year x (e.g. 2013) divided by the total primary energy consumption [kWh] of the building stock in the same period. The weighted energy renovation rate can be further split up geographically (e.g. EU28, each EU Member State), or by building type (e.g. residential and non-residential buildings). The unit is [%]. The total energy renovation rate is defined as the sum of all renovation rates of the covered depths "below threshold", "light", "medium" and "deep".
NZEB uptake	To respect official national definitions for NZEB (new buildings and renovations) that might be available in the Member States, NZEB are not defined based on a specific uniform primary energy saving threshold (like above with light, medium and deep renovation), but official national NZEB renovation definitions will be used to track NZEB renovations under "NZEB uptake". Official NZEB definitions are considered as such when there has been an official Member States publication until 31 December 2017 which includes the final national NZEB definition. Also, similar definitions if their specifications are unambiguously covered by the official national NZEB definition will be included within NZEB uptake if published before 31 December 2017. In countries without a NZEB definition in place till 31 December 2017, market actors will be asked for proxy standards that in their view meet the definition given in EPBD (2010) Art. 2, 2: "a building that has a very high energy performance […] The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby". Due to the period covered by the survey (2012—2016) when almost no official definitions have been in place and market actors have not been familiar with the NZEB concept, NZEB uptake will be quantified rather based on qualitative information sources (such as the surveys undertaken). However, in cases in which the number of NZEBs has been tracked on an official level and this information is available until end of 2018, this data will be used as well.

1.2. Building type characterisation and used reference buildings for measuring renovation activities

Residential building types and information on reference buildings used

As further described in section 3.5, each of the surveyed persons (residential cases) has been allocated to a reference building from the TABULA/EPISCOPE project. By taking this approach, several questions about the building or dwelling the respective respondent is referring to could be avoided. The TABULA/EPISCOPE project provides a complex database of different residential building types of different construction periods in the majority of EU countries. The database contains information about the geometry of these buildings, including window fractions, number of dwellings and floor area, but also about the energetic reference situation. Accordingly, in the surveys, the respondent is asked to select the main building category s/he is referring to, including the construction period. This information has later been used to clearly allocate each case to one of the TABULA/EPISCOPE reference buildings. The main building types provided as options in the questionnaires are presented in the overview below.

Building type	Description	Example pictures [IWU, 2015 & VITO, 2011] [1]
Single family house (SFH), detached	Detached residential buildings with one or two dwelling units.	  
Semi-detached SFH	One-sided attached residential building type with one or two dwelling units constructed as row end house, duplex house or similar.	  
Terraced / row single-family house (TH)	Two-sided attached residential building type with one or two dwelling units constructed as row house.	 
Small multi-family house (MFH)	Residential building type with 3-6 dwellings	  
Medium MFH	Residential building type with 7-12 dwellings	 

1 http://www.building-typology.eu/downloads/public/docs/brochure/DE_TABULA_TypologyBrochure_IWU.pdf
http://episcope.eu/fileadmin/tabula/public/docs/scientific/BE_TABULA_ScientificReport_VITO.pdf

Large MFH / Apartment Block (AB)	Residential building type with 13 or more dwellings	

Table 1 presents which residential reference buildings have been used during the data processing stage for the calculations. The different construction periods per country have been embedded in the questionnaires to be able to directly allocate the specific case (respondent) to a specific reference building according to the TABULA/EPISCOPE building typology. In case of countries that are not covered in TABULA/EPISCOPE, based on an analysis of the climate (heating degree days) and GDP, the most suitable TABULA/EPISCOPE target country with data has been identified. The reference buildings of this "comparable" country have later been used for data processing for this country.

Table 1: List of addressed reference building parameters used in the surveys

Country	Single family house (SFH), detached	Semi-detached SFH	Terraced / row single-family house (TH)	Small multi-family house (MFH)	Medium MFH	Large MFH / Apartment Block (AB)	If not covered in TABULA/EPISCOPE, data taken from country
Austria	… 1919 1919 - 1944 1945 - 1960 1961 - 1980 1981 - 1990 1991 - 2000 2001 - 2009 2010 …	-	… 1919 1919 - 1944 1945 - 1960 1961 - 1980 1981 - 1990 1991 - 2000 2001 - 2009 2010 …	-	… 1919 1919 - 1944 1945 - 1960 1961 - 1980 1981 - 1990 1991 - 2000 2001 - 2009 2010 …	… 1919 1919 - 1944 1945 - 1960 1961 - 1980 1981 - 1990 1991 - 2000 2001 - 2009 2010 …	
Belgium	… 1945 1946 - 1970 1971 - 1990 1991 - 2005 2006 - 2011 2012 …	.. 1945 1946 - 1970 1971 - 1990 1991 - 2005 2006 - 2011 2012 …	… 1945 1946 - 1970 1971 - 1990 1991 - 2005 2006 - 2011 2012 …	… 1945 1946-1970 1971 - 1990 1991 - 2005 2006 - 2011 2012 …	… 1945 1946 - 1970 1971 - 1990 1991 - 2005 2006 - 2011 2012 …	… 1945 1946 - 1970 1971 - 1990 1991 - 2005 2006 - 2011 2012 …	
Bulgaria	… 1918 1919 - 1929 1930 - 1959 1960 - 1998 1999 - 2008 2009 …	-	… 1918 1919 - 1929 1930 - 1959 1960 - 1998 1999 - 2008 2009 …	-	… 1918 1919 - 1929 1930 - 1959 1960 - 1998 1999 - 2008 2009 …	.. 1918 1919 - 1929 1930 - 1959 1960 - 1998 1999 - 2008 2009 …	
Croatia	… 1918 1919 - 1929 1930 - 1959 1960 - 1998 1999 - 2008 2009 …	-	… 1918 1919 - 1929 1930 - 1959 1960 - 1998 1999 - 2008 2009 …	-	… 1918 1919 - 1929 1930 - 1959 1960 - 1998 1999 - 2008 2009 …	.. 1918 1919 - 1929 1930 - 1959 1960 - 1998 1999 - 2008 2009 …	Bulgaria 1) HDD per year: Croatia = 2798; Bulgaria = 2953
Cyprus	… 1980 1981 -2006 2007 - 2013 2014 …	-	… 1980 1981 -2006 2007 - 2013 2014 …	-	… 1980 1981 -2006 2007 - 2013 2014 …	-	
Czech Republic	… 1920 1921 - 1945 1946 - 1960	-	… 1920 1921 - 1945 1946 - 1960	-	… 1920 1921 - 1945 1946 - 1960	… 1920 1921 - 1945 1946 - 1960	

Country	Single family house (SFH), detached	Semi-detached SFH	Terraced / row single-family house (TH)	Small multi-family house (MFH)	Medium MFH	Large MFH / Apartment Block (AB)	If not covered in TABULA/EPISCOPE, data taken from country
	1961 - 1980 1981 - 1994 1995 - 2010 2011 ...		1961 - 1980 1981 - 1994 1995 - 2010 2011 ...		1961 - 1980 1981 - 1994 1995 - 2010 2011 ...	1961 - 1980 1981 - 1994 1995 - 2010 2011 ...	
Denmark	... 1850 1851 - 1930 1931 - 1950 1951 - 1960 1961 - 1972 1973 - 1978 1979 - 1998 1999 - 2006 2007 - 2010 2011 ...	-	... 1850 1851 - 1930 1931 - 1950 1951 - 1960 1961 - 1972 1973 - 1978 1979 - 1998 1999 - 2006 2007 - 2010 2011 ...	-	-	... 1850 1851 - 1930 1931 - 1950 1951 - 1960 1961 - 1972 1973 - 1978 1979 - 1998 1999 - 2006 2007 - 2010 2011 ...	
Estonia	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	-	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	-	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	Poland 1) GDP per capita: Estonia = 13651; Poland = 12409 2) HDD per year: Estonia = 4731; Poland = 3725
Finland	... 1960 1961 - 1975 1976 - 1985 1986 - 1995 1996 - 2005	-	-	-	... 1960 1961 - 1975 1976 - 1985 1986 - 1995 1996 - 2005	-	Sweden 1) GDP per capita: Finland = 43052; Sweden = 49587 2) HDD per year: Finland = 5251; Sweden = 4496
France	...1914 1915 - 1948 1949 - 1967 1968 - 1974 1975 - 1981 1982 - 1989 1990 - 1999 2000 - 2005 2006 - 2012 2012 ...	-	...1914 1915 - 1948 1949 - 1967 1968 - 1974 1975 - 1981 1982 - 1989 1990 - 1999 2000 - 2005 2006 - 2012 2012 ...	-	...1914 1915 - 1948 1949 - 1967 1968 - 1974 1975 - 1981 1982 - 1989 1990 - 1999 2000 - 2005 2006 - 2012 2012 ...	...1914 1915 - 1948 1949 - 1967 1968 - 1974 1975 - 1981 1982 - 1989 1990 - 1999 2000 - 2005 2006 - 2012 2012 ...	
Germany	... 1859 1860 - 1918 1919 - 1948 1949 - 1957 1958 - 1968 1969 - 1978 1979 - 1983 1984 - 1994 1995 - 2001 2002 - 2009 2010 - 2015 2016 ...	-	... 1859 1860 - 1918 1919 - 1948 1949 - 1957 1958 - 1968 1969 - 1978 1979 - 1983 1984 - 1994 1995 - 2001 2002 - 2009 2010 - 2015 2016 ...	-	... 1859 1860 - 1918 1919 - 1948 1949 - 1957 1958 - 1968 1969 - 1978 1979 - 1983 1984 - 1994 1995 - 2001 2002 - 2009 2010 - 2015 2016 ...	... 1859 1860 - 1918 1919 - 1948 1949 - 1957 1958 - 1968 1969 - 1978 1979 - 1983 1984 - 1994 1995 - 2001 2002 - 2009 2010 - 2015 2016 ...	
Greece	...1980 1981 - 2000 2001 - 2010 2011 ...	-	-	-	...1980 1981 - 2000 2001 - 2010 2011 ...	-	
Hungary	...1944 1945 - 1979 1980 - 1989 1990 - 2005 2006 ...	-	-	-	...1944 1945 - 1979 1980 - 1989 1990 - 2005 2006 ...	...1944 1945 - 1979 1980 - 1989 1990 - 2005 2006 ...	

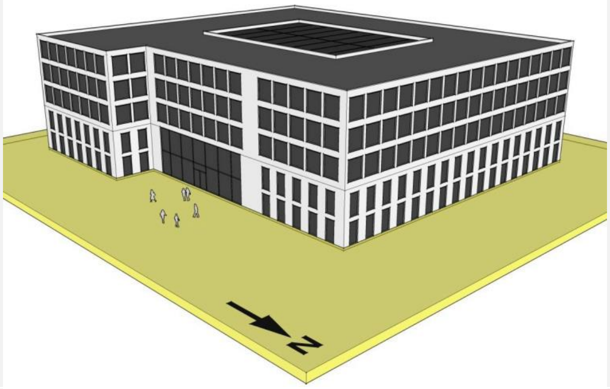
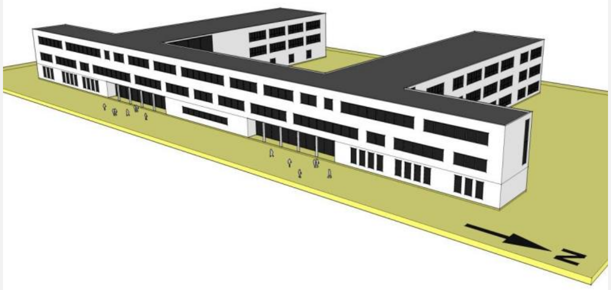
Country	Single family house (SFH), detached	Semi-detached SFH	Terraced / row single-family house (TH)	Small multi-family house (MFH)	Medium MFH	Large MFH / Apartment Block (AB)	If not covered in TABULA/EPISCOPE, data taken from country
Ireland	... 1899 1900 - 1929 1930 - 1949 1950 - 1966 1967 - 1977 1978 - 1982 1983 - 1993 1994 - 2004 2005 - 2010 2011 ...	-	... 1899 1900 - 1929 1930 - 1949 1950 - 1966 1967 - 1977 1978 - 1982 1983 - 1993 1994 - 2004 2005 - 2010 2011 ...	-	-	... 1899 1900 - 1929 1930 - 1949 1950 - 1966 1967 - 1977 1978 - 1982 1983 - 1993 1994 - 2004 2005 - 2010 2011 ...	
Italy	... 1900 1901 - 1920 1921 - 1945 1946 - 1960 1961 - 1975 1976 - 1990 1991 - 2005 2006 ...	-	... 1900 1901 - 1920 1921 - 1945 1946 - 1960 1961 - 1975 1976 - 1990 1991 - 2005 2006 ...	-	... 1900 1901 - 1920 1921 - 1945 1946 - 1960 1961 - 1975 1976 - 1990 1991 - 2005 2006 ...	... 1900 1901 - 1920 1921 - 1945 1946 - 1960 1961 - 1975 1976 - 1990 1991 - 2005 2006 ...	
Latvia	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	-	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	-	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	Poland 1) GDP per capita 2018: Latvia = 10731; Poland = 12409 2) HDD per year: Latvia = 4566; Poland = 3725
Lithuania	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	-	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	-	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	Poland 1) GDP per capita: Lithuania = 11671; Poland = 12409 2) HDD per year: Lithuania = 4311; Poland = 3725
Luxem-bourg	... 1964 1965 - 1974 1975 - 1991 1992 - 2005 2006 - 2014 2015 ...	... 1946 1965 - 1974 1975 - 1991 1992 - 2005 2006 - 2014 2015 ...	... 1964 1965 - 1974 1975 - 1991 1992 - 2005 2006 - 2014 2015 ...	-	... 1964 1965 - 1974 1975 - 1991 1992 - 2005 2006 - 2014 2015 ...	... 1964 1965 - 1974 1975 - 1991 1992 - 2005 2006 - 2014 2015 ...	Netherlands 1) HDD per year: Luxembourg = 3290; Netherlands = 3125
Malta	...1980 1981 - 2000 2001 - 2010 2011 ...	-	-	-	...1980 1981 - 2000 2001 - 2010 2011 ...	-	Greece 1) GDP per capita 2018: Malta = 18473; Greece = 20485
Nether-lands	... 1964 1965 - 1974 1975 - 1991 1992 - 2005 2006 - 2014 2015 ...	... 1946 1965 - 1974 1975 - 1991 1992 - 2005 2006 - 2014 2015 ...	... 1964 1965 - 1974 1975 - 1991 1992 - 2005 2006 - 2014 2015 ...	-	... 1964 1965 - 1974 1975 - 1991 1992 - 2005 2006 - 2014 2015 ...	... 1964 1965 - 1974 1975 - 1991 1992 - 2005 2006 - 2014 2015 ...	
Poland	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	-	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	-	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	... 1945 1946 - 1966 1967 - 1985 1986 - 1992 1993 - 2002 2003 - 2008 2008 ...	

Country	Single family house (SFH), detached	Semi-detached SFH	Terraced / row single-family house (TH)	Small multi-family house (MFH)	Medium MFH	Large MFH / Apartment Block (AB)	If not covered in TABULA/EPISCOPE, data taken from country
Portugal	...1980 1981 - 2000 2001 - 2010 2011 ...	-	-	-	...1980 1981 - 2000 2001 - 2010 2011 ...	-	Greece 1) GDP per capita 2018: Portugal = 19629; Greece = 20485 2) HDD per year: Portugal = 1364; Greece = 1644
Romania	... 1918 1919 - 1929 1930 - 1959 1960 - 1998 1999 - 2008 2009 ...	-	... 1918 1919 - 1929 1930 - 1959 1960 - 1998 1999 - 2008 2009 ...	-	... 1918 1919 - 1929 1930 - 1959 1960 - 1998 1999 - 2008 2009 ...	.. 1918 1919 - 1929 1930 - 1959 1960 - 1998 1999 - 2008 2009 ...	Bulgaria 1) GDP per capita 2018: Romania = 5844; Bulgaria = 7079 2) HDD per year: Romania = 3320; Bulgaria = 2953
Slovakia	... 1920 1921 - 1945 1946 - 1960 1961 - 1980 1981 - 1994 1995 - 2010 2011 ...	-	... 1920 1921 - 1945 1946 - 1960 1961 - 1980 1981 - 1994 1995 - 2010 2011 ...	-	... 1920 1921 - 1945 1946 - 1960 1961 - 1980 1981 - 1994 1995 - 2010 2011 ...	... 1920 1921 - 1945 1946 - 1960 1961 - 1980 1981 - 1994 1995 - 2010	Czech Republic 1) GDP per capita 2018: Slovakia = 17630; Czech Republic = 16650 2) Used to be one country until 1992 3) HDD per year: Slovakia = 3864; Czech Republic = 3794
Slovenia	... 1945 1946 - 1970 1971 - 1980 1981 - 2001 2002 - 2008 2009 ...	-	... 1945 1946 - 1970 1971 - 1980 1981 - 2001 2002 - 2008 2009 ...	-	... 1945 1946 - 1970 1971 - 1980 1981 - 2001 2002 - 2008 2009 ...	... 1945 1946 - 1970 1971 - 1980 1981 - 2001 2002 - 2008 2009 ...	
Spain	... 1900 1901 - 1936 1937 - 1959 1960 - 1979 1980 - 2006 2007 ...		... 1900 1901 - 1936 1937 - 1959 1960 - 1979 1980 - 2006 2007 ...		... 1900 1901 - 1936 1937 - 1959 1960 - 1979 1980 - 2006 2007 ...	... 1900 1901 - 1936 1937 - 1959 1960 - 1979 1980 - 2006 2007 ...	
Sweden	... 1960 1961 - 1975 1976 - 1985 1986 - 1995 1996 - 2005	-	-	-	... 1960 1961 - 1975 1976 - 1985 1986 - 1995 1996 - 2005	-	
United Kingdom	... 1918 1919 - 1944 1945 - 1964 1965 - 1980 1981-1990 1991 - 2003 2004 - 2009 2010 ...	-	... 1918 1919 - 1944 1945 - 1964 1965 - 1980 1981-1990 1991 - 2003 2004 - 2009 2010 ...	-	... 1918 1919 - 1944 1945 - 1964 1965 - 1980 1981-1990 1991 - 2003 2004 - 2009 2010 ...	... 1918 1919 - 1944 1945 - 1964 1965 - 1980 1981-1990 1991 - 2003 2004 - 2009 2010 ...	

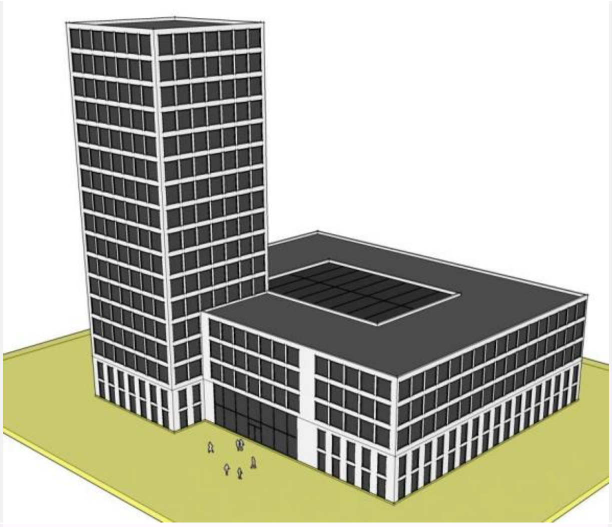
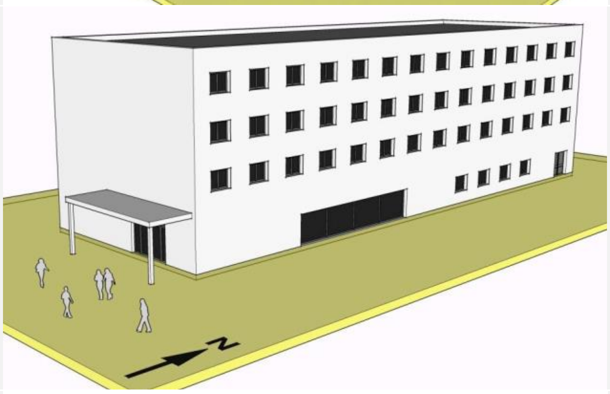
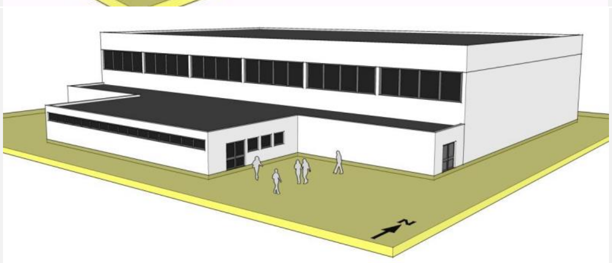
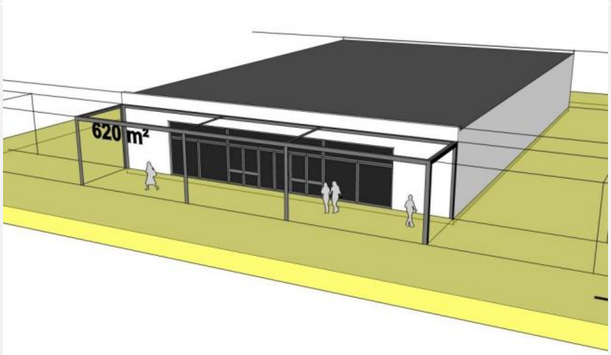
Non-residential building types and information on reference buildings used

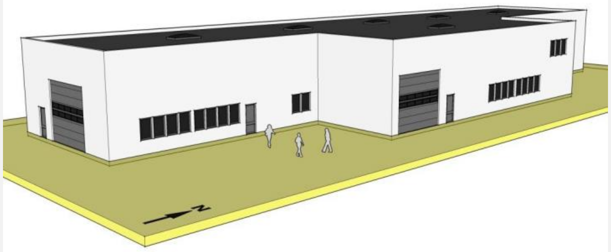
Based on EPBD Annex I, the following non-residential building types are used in this study:

- Offices;
- Educational buildings;
- Hospitals;
- Hotels and restaurants;
- Sports facilities;
- Wholesale and retail trade services buildings;
- Other types of energy-consuming buildings.

Building type	Abbreviation used in indicator list	Examples of model buildings for the different types[2]
Offices;	Office	
Educational buildings;	Education	

2 Source of pictures: Klauß & Maas (2010). It should be considered that the here presented picture for hospitals is used for the illustration of a specific type of office building in the original source

Hospitals;	Hospital		
Hotels and restaurants;	Hotel		
Sports facilities;	Sport		
Wholesale and retail trade services buildings;	Trade		

Other types of energy-consuming buildings.	Other		

For each of these building types, different reference building information exists on Member State level. Good guidance to deal with the complexity of this task is provided by Tsitsanis et al. (2017)[3]. Accordingly, there are two main horizontal sources of appropriate non-residential reference buildings; commercial reference building models as defined by the U.S. Department of Energy 4 and the reference buildings as used in the national cost-optimality calculations according to EPBD Article 4. For the purpose of this study, we focused on the European reference buildings as used in the national cost-optimality calculations.

Tsitsanis et al. (2017) analysed available non-residential reference building specifications from the 2013 round of cost-optimality reports.[5] Through an analysis of all published cost-optimality reports (country reports only available in national language have not been considered), useful reference building information has been collected but it became obvious that no consistency is provided from one MS to the other and in most cases, relevant details of the geometries were missing. Therefore, it was decided to use average building floor spaces per MS and building type from the H2020 project "Hotmaps Toolbox"[6] and combine them with average ratios of floor area to component area per building type from the cost-optimality reports to obtain the required level of detail.

1.3. Nearly zero-energy building definitions as used in the surveys

The following sources have been used for the compilation of NZEB definitions:

- BPIE (2015): Nearly zero-energy buildings definitions across Europe. Factsheet. S. 4-5
- EPBD (2016): Overview of national applications of the Nearly Zero-Energy Building (NZEB) definition. Detailed report. S. 6-9
- JRC (2017): Towards Nearly Zero-Energy Buildings in Europe: A Focus on Retrofit in Non-Residential Buildings. S. 7
- JRC (2016): Synthesis Report on the National Plans for Nearly Zero-Energy Buildings (NZEBs). S. 12-15
- CA EPBD (2015): Implementing the Energy Performance of Buildings Directive (EPBD). Featuring Country Reports.
- EPISCOPE (2014): Inclusion of New Buildings in Residential Building Typologies.

3 Tsitsanis Anastasios, Tsatsakis Konstantinos, Oxizidis Simeon, Bucur Mircea, Ring Daniel, Milne Caroline (2017). Report on typology of buildings suitable for dual energy services. Deliverable from Horizon 2020 project "New Buildings Energy Renovation Business Models incorporating dual energy services (Task 5.1)

4 https://www.energy.gov/eere/buildings/commercial-reference-buildings

5 However, also first reports from the 2018 round became available at https://ec.europa.eu/energy/en/topics/energy-efficiency/buildings

6 https://gitlab.com/hotmaps/building-stock/tree/master

- Attia et al. (2017): Overview and future challenges of nearly zero-energy buildings (NZEB) design in Southern Europe.
- JRC (2017), Country sheets for EU28 reflecting progress in implementing the EPBD and improving energy performance of buildings,
- D'Agostino et al., Synthesis Report on the National Plans for NZEBs; EUR 27804 EN
- Building Stock Observatory (for the year 2015 as historical data only. Maximum primary energy performance of nZEB)
- ZEBRA (2020): indicators for a sample of nZEB buildings and high efficient buildings estimated to be at NZEB level, built recently in selected European countries [Existing buildings only]
- Tzortzaki, A., Nearly Zero-Energy Buildings: Comparison of the targets set by the European countries and analysis of their diffusion

NZEB Definitions for new constructions

The following list summarises all information on national NZEB definitions for new constructions, status April 2018. Although the objective of the study was not to define national NZEBs in detail, for completeness reasons the last column in the table also contains indicative information about the range of primary energy requirements for new buildings based on a literature review. However, it should be noted that different calculation approaches might exist on national level, therefore values cannot easily be compared to each other.

Member state	Official NZEB definition declared by MS?	Applicability of NZEB definition on new constructions?	Overall regulation	Year of enforcement		Explanations	Official indicators (If no official NZEB definition in place)	Primary energy requirements according to literature review in kW·h/(m²•a) (Source indication 1-5)
				Public buildings	Non-public buildings			
Austria	Yes	Yes	1) OIB Guidelines 6; 2) National Plan	01.01.2019	01.01.2021	EPBD text of NZEB is implemented in OIB Guidelines 6 of 2015-03. NZEBs have been defined in the National Plan of 2014-03 and the negotiations with the Austrian Provinces are completed (OIB Guidelines 6).	-	160 – 170 1/2/3/5
Belgium-Brussels	Yes	Yes	The Brussels Air, Climate and Energy Code (COBRACE)	01.01.2019	01.01.2015	The NZEB definition is included in "The Brussels Air, Climate and Energy Code (COBRACE)". The 2015 in Brussels implemented "EPB-Passive Requirements 2015" is the transposition of the NZEB definition, which is based on the Passive House Standard and adapted to the Brussels context.	-	45 - 85 2/3/5

Belgium-Flanders	Yes	Yes	Regulation of the Flemish Government of 2013-11-29 regarding the energy performance of buildings	01.01.2019	01.01.2021	The NZEB definition is included in the "Regulation of the Flemish Government of 2013-11-29 regarding the energy performance of buildings". On November 29, 2013, the Flemish Government gave its final approval to the definition on NZEB level for residential buildings and offices and schools, called BEN (Bijna Energie Neutraal) which determined an E-Level at lower or equal to 30.	-	32 – 45 2/3
Belgium-Wallonia	Under development	Under development	National Plan	01.01.2019	01.01.2019	Interpretation of EPBD text in national plan, study contracted, definition will evolve. According the National Plan the energy performances will be close or equivalent to those of the passive standard in terms of the building envelope and by the renewable energy coverage as part of the consumption.	NZEB definition acc. National Plan (p.21): "Energy performances that are close or equivalent to those of the passive standard in terms of the building envelope and by the renewable energy coverage of part of the consumption"	95 (1)
Bulgaria	Yes	Yes	National Plan	01.01.2019	01.01.2021	Draft definition in National Plan for Nearly zero-energy buildings (BPIE study); national	-	30 – 50 2/3/5

						requirements defined by "Ordinance for heat retention and energy efficiency in buildings" (updated in 2009)		
Croatia	Yes	Yes	1) Technical regulation on energy and energy performance of buildings. (OG No. 97/14, 130/14); 2) National NZEB Plan	01.01.2019	01.01.2021	Definition for SFH in National Plan. Definition for various building categories in Technical Regulation on Energy Economy and Heat Retention in Buildings	-	30 – 80 1/2/3/5
Cyprus	Yes	Yes	Decree 366/2014 (Law for the Regulation of the Energy Performance of the Buildings of 2012, N.210 (I)/2012)	01.01.2019	01.01.2021	NZEB definition included in Decree 366/2014 (issued on 1 August 2014). NZEBs must have an Energy Performance Certificate class A according to the preliminary national methodology for energy performance of buildings.	-	100 1/2/3/5
Czech Republic	Yes	Yes	Regulation 78/2013 Coll. (Energy Performance of Buildings decree)	2016-2018 (depending on size)	2018-2020 (depending on size)	A provisory definition of NZEB is included in the new legislation (Regulation No. 78/2013 Coll.). The Czech Housing development fund (SFRB) is currently synchronizing the subsidy scheme with the new legislation and energy performance requirements.	-	43 – 51 (5)
Denmark	Yes	Yes	Building Regulations 2010 (BR10)	01.01.2019	01.01.2021	The Danish NZEB definition is implemented in the current Danish Building	-	20 1/2/3/5

						Regulations 2010 BR10.		
Estonia	Yes	Yes	Regulation 68:2012	01.01.2019	01.01.2021	NZEB definition included in regulation VV No 68:2012 "Energiatõhususe miinimumnõuded".	-	50 – 100 1/3/5
Finland	Under development	Under development	National Building Code of Finland	01.01.2018	01.01.2021	The detailed definition was planned to be finalised in the course of 2015 and the aim was to present the legislative proposal to the parliament in autumn 2016. It could not be finally clarified whether an official NZEB definition was adopted.	n/a	78 – 150 1/5
France	Yes	Yes	1) Méthode de calcul Th-BCE 2012; 2) Réglementation Thermique 2012 (RT 2012)	28.10.2011	01.01.2013	The calculation methodology for NZEB is provided in the Th-BCE 2012. All new buildings will be energy positive in 2020. Renovated buildings are considered NZEB if they reach a higher energy performance than the mandatory level defined in the Thermal Regulation for existing buildings (RT 2012).	-	40 – 105 1/2/3/5
Germany	Under development	Under development	Energy Conservation Regulation (EnEV 2009)	01.01.2019	01.01.2021	EPBD text implemented in energy saving act, detailed definition is being developed. Nearly zero-energy buildings (NZEBs) have not yet been officially defined, but there are rea-sons to assume that the best standard	KfW Efficiency House 40, 55 and 70	36 – 43,75 1/3

						currently supported by the KfW banking group may be an appropriate benchmark.		
Greece	Under development	Under development	Law 4122/2013	01.01.2019	01.01.2021	The NZEB definition was introduced to national legislation by amendment of the Law 3661 in June 2010 and is identical to the EPBD definition. This definition is also included in Law 4122/2013, which specifies that, after 1 January 2019, every new building of the public sector should be a NZEB. This obligation applies also to all new buildings constructed after 1 January 2021. However, the national NZEB definition has not yet been applied.	n/a	-
Hungary	Yes (Still to be approved)	Under development	Amended decree 7/2006 (V. 24.)	01.01.2019	01.01.2021	Draft definition included in Decree about Determination of Energy Efficiency of Buildings of 7/2006 (V.24), detailed definition is being developed. Nearly Zero-Energy Building (NZEB) requirements will come into force in 2019 and 2021 for public buildings and all new and majorly renovated buildings respectively.	-	50 – 72 1/2/5

Ireland	Yes	Yes	Technical Guidance Document (TGD) Part L (Conservation of Fuel and Energy - Dwellings)	01.01.2019	01.01.2021	The Irish Department of Environment, Community and Local Government set out the Irish NZEB definition for residential buildings in its policy document "Towards Nearly Zero Energy Buildings in Ireland – Planning for 2020 and beyond". A draft definition is included in the national NZEB plan. NZEB standard will achieve 70% re-duction in energy demand compared to reference dwelling set out in 2005 Building Regulations (TGD Part L).	-	45 2/3/5
Italy	Yes	Yes (Still to be approved)	1) Decree Law no. 63/90 of 2013; 2) Decree 26/06/2015			EPBD text in Decree Law no. 63/90 of 2013, new energy decree of June 26th includes detailed definition concerning new minimum requirements and methodology for calculating energy performance of buildings. Same requirements for new constructions and renovations.	-	15 – 20 & Class A1 2/3/5
Latvia	Yes	Yes	Regulation 383/2013 ("Regulations regarding Energy certifications of Buildings")	01.01.2019	01.01.2021	NZEB definition included in Cabinet Regulation No. 383/2013.	-	95 1/2/3/5
Lithuania	Yes	Yes	Regulation STR	01.01.2019	01.01.2021	NZEB definition	-	Energy Class

			2.01.09 :2012			included in Construction Technical Regulation STR 2.01.09:2012.		A++ 1/2/5
Luxembourg	Yes	Yes	1) RGD 2007, 2010, 2014; 2) National Plan	01.01.2019	01.01.2021	Interpretation of EPBD text included in national plan and in national legislation (RGD 2014), detailed definition not yet fixed. From 2017, all new residential buildings will have to fulfil in principle the A-A standard which is aimed to represent the NZEB standard once the proposed regulation enters into force. The fine-tuning of the exact calculation methodology and the NZEB definition for non-residential buildings is still in progress.	-	45 & Class A / Class AAA 1/2/5
Malta	Yes	Yes	LN 376/2012 (transposing Directive 2010/31)	01.01.2019	01.01.2021	NZEB definition included in LN 376/2012 (transposing Directive 2010/31).	-	55 – 115 2/5
Netherlands	Yes	Yes	NEN 7120: Energy performance of buildings - Determination method	01.01.2019	01.01.2021	A specific building performance assessment method according the NEN 7120 (2012) standard is used in the Netherlands. The resulting energy demand is shown in an energy performance coefficient (EPC) which must be nearly zero in 2018/2020.	-	0 – 25 2/3/5

Poland	Yes	Yes	Resolution No. 91/2015 of the Council of Ministers of 22 June 2015	01.01.2019	01.01.2021	Translation of the EPBD text in national plan. Detailed definition included in "Regulation of the Minister of Infrastructure on the technical conditions to be met by buildings and their location" (Journal of Laws No 75, pos. 690), amendment in 2013. The proposed definition of NZEB is based on an EP index and U values for building envelope elements.	-	65 – 75 1/2/5
Portugal	Under development	Under development	Decree-Law 118/2013, August 20th			Translation of the EPBD text in Decree law 118/2013, Article 16. Detailed definition not yet available.	n/a	33 (5)
Romania	Yes	Yes	National NZEB Plan	01.01.2019	01.01.2021	NZEB definition included in updated National Plan for NZEB (included in the 3rd National Energy Efficiency Action Plan (NEEAP)), approved by Governmental Decision no.122/2015. Content based on BPIE study "Implementing Nearly Zero-Energy Buildings (NZEB) in Romania"	-	93 – 117 1/2/3/5
Slovakia	Yes	Yes	MDVRR SR 364/2012 Coll.	01.01.2019	01.01.2021	Translation of EPBD text in Act No. 555/2012, NZEB requirements in MDVRR SR 364/2012 Coll.	-	32 – 54 1/2/5

Slovenia	Yes	Yes	1) Energetski zakon, Uradni list RS, št. 17/14; 2) National Action Plan for Nearly Zero-Energy Buildings Up to 2020 (AN sNES)			Translation of EPBD text in Energy Act of March 2014 (Energetski zakon, Uradni list RS, št. 17/14). National plan includes a detailed NZEB definition (approved by the Government on 22 April 2015).	-	50 – 80 1/2/3/5
Spain	Under development	Under development	Decree 235/2013			Translation of EPBD text in RD 235/2013 (pending final approval). Nearly zero-energy buildings (NZEBs) have not yet been officially defined, but there are rea-sons to assume that NZEB buildings would be equivalent to A class.	It is foreseen that buildings will need to comply with class A.	40 – 70 & Class A 2/5
Sweden	Yes	n/a	Building regulations BBR 2012 (BFS 2015:3, 1 March 2015)			Current energy performance requirements are based on BBR 22 (BFS 2015:3, 1 March 2015). Nearly-zero energy rules are introduced in the Building Agency's Building Regulations, BBR Section 9 Energy Conservation since July 1, 2017. Sharp requirements come into force in 2020.	-	30 – 75 2/3/5
United Kingdom (England)	Yes	Yes	Building Regulations Energy Efficiency Requirements: England (Part L); Wales (Part L);	01.01.2018 (from 2016 for residential buildings)	01.01.2019 (from 2016 for residential buildings)	The United Kingdom Government consider that the approach they are adopting for Zero Carbon Homes from 2016 will meet the	-	39 – 46 2/5

			Scotland (Section 6); Northern Ireland (Technical Booklet F)			definition of NZEB.		

NZEB Definitions for existing buildings

The following list summarises all information on national NZEB definitions for existing buildings, status April 2018. Although the objective of the study was not to define national NZEBs in detail, for completeness reasons the last column in the table also contains indicative information about the range of primary energy requirements for existing buildings based on a literature review. However, it should be noted that different calculation approaches might exist on national level, therefore values cannot easily be compared to each other.

Member state	Official NZEB definition declared by MS?	Applicability of NZEB definition on renovations?	Overall regulation	Year of enforcement		Explanations	Official indicators (If no official NZEB definition in place)	Primary energy requirements according to literature review in kW·h/(m²•a) (Source indication 1-5)
				Public buildings	Non-public buildings			
Austria	Yes	Yes	1) OIB Guidelines 6 2) National Plan	01.01.2019	01.01.2021	EPBD text of NZEB is implemented in OIB Guidelines 6 of 2015-03. NZEBs have been defined in the National Plan of 2014-03 and the negotiations with the Austrian Provinces are completed (OIB Guidelines 6).	-	85 – 260 1/2/4/5
Belgium-Brussels	Yes	Yes	The Brussels Air, Climate and Energy Code (COBRACE)	01.01.2019	01.01.2015	The NZEB definition is included in "The Brussels Air, Climate and Energy Code (COBRACE)". The 2015 in Brussels implemented "EPB-Passive Requirements	-	54 – 75 2/4

						2015" is the transposition of the NZEB definition, which is based on the Passive House Standard and adapted to the Brussels context.		
Belgium-Flanders	Yes	Yes	Regulation of the Flemish Government of 2013-11-29 regarding the energy performance of buildings	01.01.2019	01.01.2021	The NZEB definition is included in the “Regulation of the Flemish Government of 2013-11-29 regarding the energy performance of buildings". On November 29, 2013, the Flemish Government gave its final approval to the definition on NZEB level for residential buildings and offices and schools, called BEN (Bijna Energie Neutraal) which determined an E-Level at lower or equal to 30.	-	No distinction
Belgium-Wallonia	Under development	Under development	National Plan	01.01.2019	01.01.2019	Interpretation of EPBD text in national plan, study contracted, definition will evolve. According the National Plan the energy performances will be close or equivalent to those of the passive	Unofficial NZEB definition acc. National Plan (p.21): "Energy performances that are close or equivalent to those of the	No distinction

						standard in terms of the building envelope and by the renewable energy coverage as part of the consumption.	passive standard in terms of the building envelope and by the renewable energy coverage of part of the consumption"	
Bulgaria	Yes	Yes	National Plan	01.01.2019	01.01.2021	Nearly zero-energy buildings (BPIE study); national requirements defined by "Ordinance for heat retention and energy efficiency in buildings" (updated in 2009)	-	40 – 60 2/5
Croatia	Yes	Yes	1) Technical regulation on energy and energy performance of buildings. (OG No. 97/14, 130/14) 2) National NZEB Plan	01.01.2019	01.01.2021	Definition for SFH in National Plan. Definition for various building categories in Technical Regulation on Energy Economy and Heat Retention in Buildings	-	-
Cyprus	Yes	Yes	Decree 366/2014, Law 210(I)/2012 (Nearly Zero-Energy Buildings Action Plan)	01.01.2019	01.01.2021	NZEB definition included in Decree 366/2014 (issued on 1 August 2014). NZEBs must have an Energy Performance Certificate class A according to the	-	100 -125 1/2/5

						preliminary national methodology for energy performance of buildings.		
Czech Republic	Yes	Yes	Regulation 78/2013 Coll. (Energy Performance of Buildings decree)	2016-2018 (depending on size)	2018-2020 (depending on size)	A provisory definition of NZEB is included in the new legislation (Regulation No. 78/2013 Coll.). The Czech Housing development fund (SFRB) is currently synchronizing the subsidy scheme with the new legislation and energy performance requirements.	-	47 – 106 4/5
Denmark	Yes	Yes	Building Regulations 2010 (BR10)	01.01.2019	01.01.2021	The Danish NZEB definition is implemented in the current Danish Building Regulations 2010 BR10.	-	20 – 115 2/4
Estonia	Yes	No	Regulation 68:2012	01.01.2019	01.01.2021	NZEB definition included in regulation VV No 68:2012 "Energiatõhususe miinimumnõuded".	-	90 – 270 (5)
Finland	Under development	Under development	National Building Code of Finland	01.01.2018	01.01.2021	The detailed definition will be finalised in the course of 2015 and the aim is to present the legislative proposal to the	n/a	136 – 335 1/5

						parliament in autumn 2016. It could not be finally clarified whether an official NZEB definition was adopted.		
France	Yes	Yes	1) Méthode de calcul Th-BCE 2012 2) Réglementation Thermique 2012 (RT 2012)	28.10.2011	01.01.2013	The calculation methodology for NZEB is provided in the Th-BCE 2012. All new buildings will be energy positive in 2020. Renovated buildings are considered NZEB if they reach a higher energy performance than the mandatory level defined in the Thermal Regulation for existing buildings (RT 2012).	-	67 – 120 1/2/4/5
Germany	Under development	Under development	1) EnEG 2) EnEV 3) EEWärmeG	01.01.2019	01.01.2021	EPBD text implemented in energy saving act, detailed definition is being developed. Nearly zero-energy buildings (NZEBs) have not yet been officially defined, but there are rea-sons to assume that the best standard currently supported by the KfW banking group may be an appropriate benchmark.	KfW Efficiency House	27 (4)
Greece	Under	Under	Law	01.01.2019	01.01.2021	The NZEB definition	n/a	

	development	development	4122/2013			was introduced to national legislation by amendment of the Law 3661 in June 2010 and is identical to the EPBD definition. This definition is also included in Law 4122/2013, which specifies that, after 1 January 2019, every new building of the public sector should be a NZEB. This obligation applies also to all new buildings constructed after 1 January 2021. However, the national NZEB definition has not yet been applied.		
Hungary	Yes (Still to be approved)	Under development	Amended decree 7/2006 (V. 24.)	01.01.2019	01.01.2021	Draft definition included in Decree about Determination of Energy Efficiency of Buildings of 7/2006 (V.24), detailed definition is being developed. Nearly Zero-Energy Building (NZEB) requirements will come into force in 2019 and 2021 for public buildings and all new and majorly renovated buildings respectively.	-	72 (1)

Ireland	Yes	Under development	Technical Guidance Document (TGD) Part L (Conservation of Fuel and Energy - Dwellings)	01.01.2019	01.01.2021	The Irish Department of Environment, Community and Local Government set out the Irish NZEB definition for residential buildings in its policy document "Towards Nearly Zero-Energy Buildings in Ireland – Planning for 2020 and beyond". A draft definition is included in the national NZEB plan. NZEB standard will achieve 70% re-duction in energy demand compared to reference dwelling set out in 2005 Building Regulations (TGD Part L).	-	75 – 150 (2)
Italy	Yes	Yes	1) Decree Law no. 63/90 of 2013 2) Decree 26/06/2015			EPBD text in Decree Law no. 63/90 of 2013, new energy decree of June 26th includes detailed definition concerning new minimum requirements and methodology for calculating energy performance of buildings. Same requirements for new constructions and renovations.	-	16 & Class A1 2/4
Latvia	Yes	Yes	Regulation	01.01.2019	01.01.2021	NZEB definition	-	95

			383/2013 ("Regulations regarding Energy certifications of Buildings")			included in Cabinet Regulation No. 383/2013.		1/2/5
Lithuania	Yes	Yes	Regulation STR 2.01.09 :2012	01.01.2019	01.01.2021	NZEB definition included in Construction Technical Regulation STR 2.01.09:2012.	-	89 & Class A1 2/4
Luxembourg	Yes	No	1) RGD 2007, 2010, 2014 2) National Plan	01.01.2019	01.01.2021	Interpretation of EPBD text included in national plan and in national legislation (RGD 2014), detailed definition not yet fixed. From 2017, all new residential buildings will have to fulfil in principle the A-A standard which is aimed to represent the NZEB standard once the proposed regulation enters into force. The fine-tuning of the exact calculation methodology and the NZEB definition for non-residential buildings is still in progress.	-	60 – 93 4/5
Malta	Yes	n/a	LN 376/2012 (transposing Directive 2010/31)	01.01.2019	01.01.2021	NZEB definition included in LN 376/2012 (transposing Directive	-	< 220 (2)

						2010/31).		
Netherlands	Yes	Under development	NEN 7120: Energy performance of buildings - Determination method	01.01.2019	01.01.2021	A specific building performance assessment method according the NEN 7120 (2012) standard is used in the Netherlands. The resulting energy demand is shown in an energy performance coefficient (EPC) which must be nearly zero in 2018/2020.	-	76 (4)
Poland	Yes	n/a	Resolution No. 91/2015 of the Council of Ministers of 22 June 2015	01.01.2019	01.01.2021	Translation of the EPBD text in national plan. Detailed definition included in "Regulation of the Minister of Infrastructure on the technical conditions to be met by buildings and their location" (Journal of Laws No 75, pos. 690), amendment in 2013. The proposed definition of NZEB is based on an EP index and U values for building envelope elements.	-	65 – 95 1/4
Portugal	Under development	Under development	Decree-Law 118/2013,			Translation of the EPBD text in Decree	n/a	140

			August 20th			law 118/2013, Article 16. Detailed definition not yet available.		(5)
Romania	Yes	n/a	National NZEB Plan	01.01.2019	01.01.2021	NZEB definition included in updated National Plan for NZEB (included in the 3rd National Energy Efficiency Action Plan (NEEAP)), approved by Governmental Decision no.122/2015. Content based on BPIE study "Implementing Nearly Zero-Energy Buildings (NZEB) in Romania"	-	98 – 230 1/2/4
Slovakia	Yes	n/a	MDVRR SR 364/2012 Coll.	01.01.2019	01.01.2021	Translation of EPBD text in Act No. 555/2012, NZEB requirements in MDVRR SR 364/2012 Coll.	-	82 (4)
Slovenia	Yes	Yes	1) Energetski zakon, Uradni list RS, št. 17/14 2) National Action Plan for Nearly Zero-Energy Buildings Up to 2020 (AN sNES)			Translation of EPBD text in Energy Act of March 2014 (Energetski zakon, Uradni list RS, št. 17/14). National plan includes a detailed NZEB definition (approved by the Government on 22 April 2015).	-	65 – 95 1/2/5
Spain	Under development	Under development	Decree 235/2013			Translation of EPBD text in RD 235/2013 (pending final approval). Nearly zero-energy	It is foreseen that buildings will need to comply with class A.	87 (4)

						buildings (NZEBs) have not yet been officially defined, but there are rea-sons to assume that NZEB buildings would be equivalent to A class.		
Sweden	Yes	n/a	Building regulations BBR 2012 (BFS 2015:3, 1 March 2015)			Current energy performance requirements are based on BBR 22 (BFS 2015:3, 1 March 2015). Nearly-zero energy rules are introduced in the Building Agency's Building Regulations, BBR Section 9 Energy Conservation since July 1, 2017. Sharp requirements come into force in 2020.	-	64 (4)
United Kingdom (England)	Yes	Under development	Building Regulations Energy Efficiency Requirements: England (Part L); Wales (Part L); Scotland (Section 6); Northern Ireland (Technical Booklet F)	01.01.2018 (from 2016 for residential buildings)	01.01.2019 (from 2016 for residential buildings)	The United Kingdom Government consider that the approach they are adopting for Zero Carbon Homes from 2016 will meet the definition of NZEB.	In the United Kingdom, building regulations, first introduced in the 1960's, are being progressively tightened as it moves towards the introduction of the Zero Carbon Homes Standard.	99 (4)

2. Indicators

2.1. Approach of the quantitative indicator development

Although the different variables for creating the final grid of quantitative indicators was quite clear from the beginning, some details still needed to be elaborated and discussed in more detail. Such details especially comprise the exact definition of energy and non-energy renovations but also the different renovation depths to be considered and how to deal with the different definitions of nearly zero-energy buildings in the EU28 Member States or in MS where no definition has been implemented yet. For these aspects, the project team conducted an extensive analysis of existing definitions and their suitability to be adapted for this project. Part of this analysis was an evaluation of existing variables used in the "Building Stock Observatory" (BSO) project. The characteristics of covered quantitative indicators can be found in the data annex.

After having achieved clarity on the needed indicators and their definitions, the next task was to identify potential sources to be able to fill the indicators with content. For this purpose, the following approach was used:

1) Development of a methodology to create the information needed for filling the indicators with content (a detailed description of this methodology is presented in section 3).

2) Identification of relevant information that is available from publicly accessible literature, other projects (such as the BSO) and other potential sources.

3) Identification of relevant information that is available from sources that are not free of charge.

4) As a result, identification of data gaps that remain and therefore need to be filled with data from the surveys (new primary data).

This approach allowed to identify all relevant sources to be used later in the project to fill the indicators with content.

The full list of covered quantitative indicators can be found in the data Annex provided as separate Excel file.

2.2. Approach of the qualitative indicator development

The general approach of the qualitative indicator development is as follows.

<u>In a first step</u>, an extensive desk research has been conducted to get an up-to-date status of the discussion and theory about relevant drivers and barriers and to create a first inventory of relevant drivers and barriers and other determinants. For this study, the decision model based on Stieß et al. [Stieß et al., 2010] and the behavioural model based on Hermelink [Hermelink, 1996] have been used. Further studies have been consulted to enlarge the theoretical background and to identify a broad range of possible qualitative indicators which are suited for the analysis. These inputs have been synthesised and categorised to feed into the further development of the qualitative indicators.

<u>In a second step,</u> the scope of the current study (for the assessment of current drivers and barriers for energy renovation) has been identified. The current study covers various building types, clients and owners, landlords and tenants. This step is key to

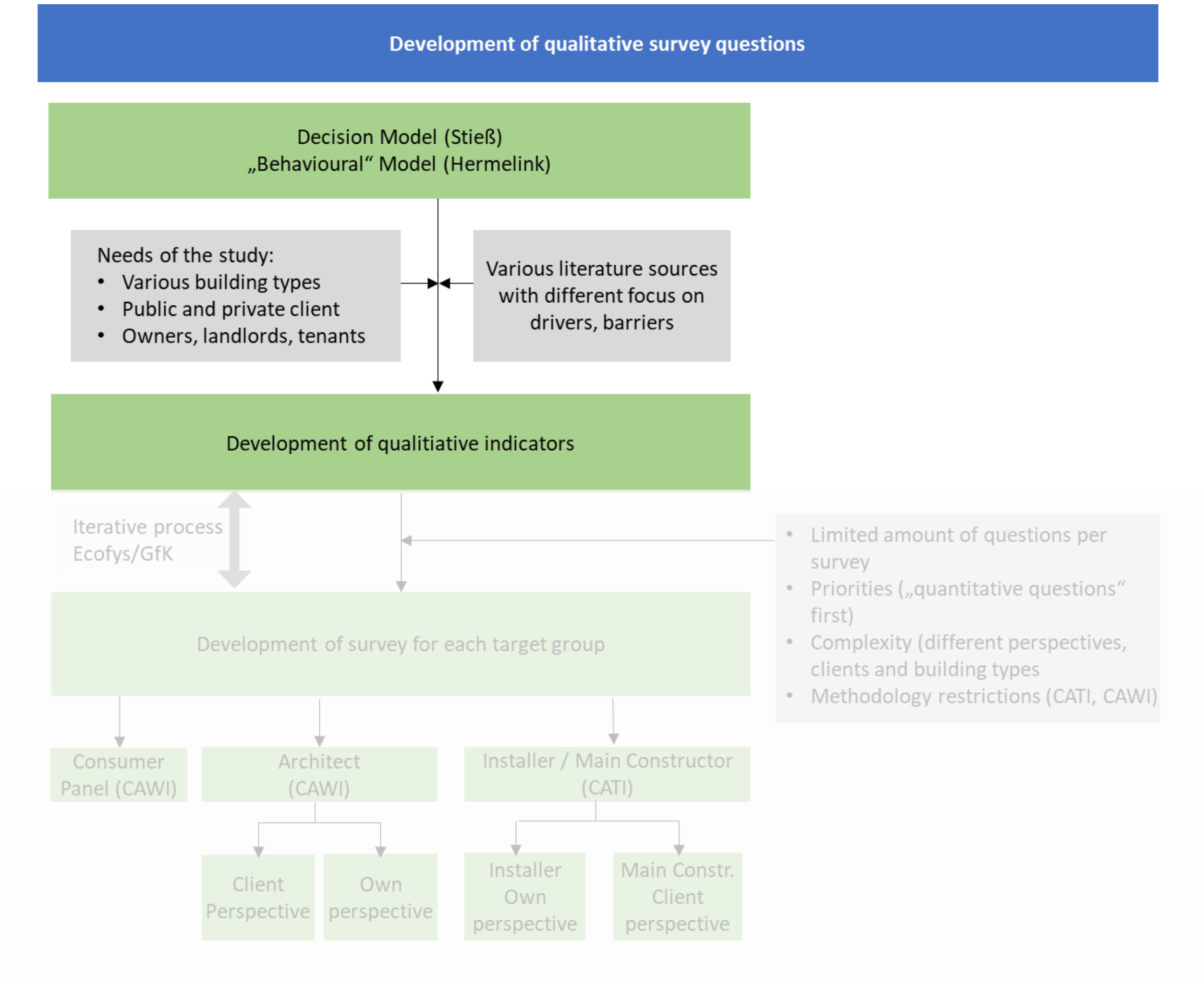
facilitate filtering and the adaptation of drivers and barriers to finally arrive at a tailor-made (if needed) set of qualitative indicators for different stakeholders and building types.

In a third step, the qualitative indicators have been elaborated.

In a fourth step, the different survey questions and the logic of each of the different questionnaires have been elaborated. The third and fourth steps have been an interactive process in which Ipsos and Navigant worked closely together.

The process is visualised in the following graphic (Figure 1).

Figure 1: Illustration of the qualitative indicator development approach



A further explanation of the illustrated steps is given in the subsequent sections.

2.3. Theoretical background for the development of the qualitative indicators

This section summarises the theoretical background which has been set up to evaluate the drivers and barriers for energy renovation.

Several studies show that investment decisions regarding renovations is a complex strategic situation which is not only taken based on economic considerations. For this study the following literature has been used to investigate the determinants for energetic renovations:

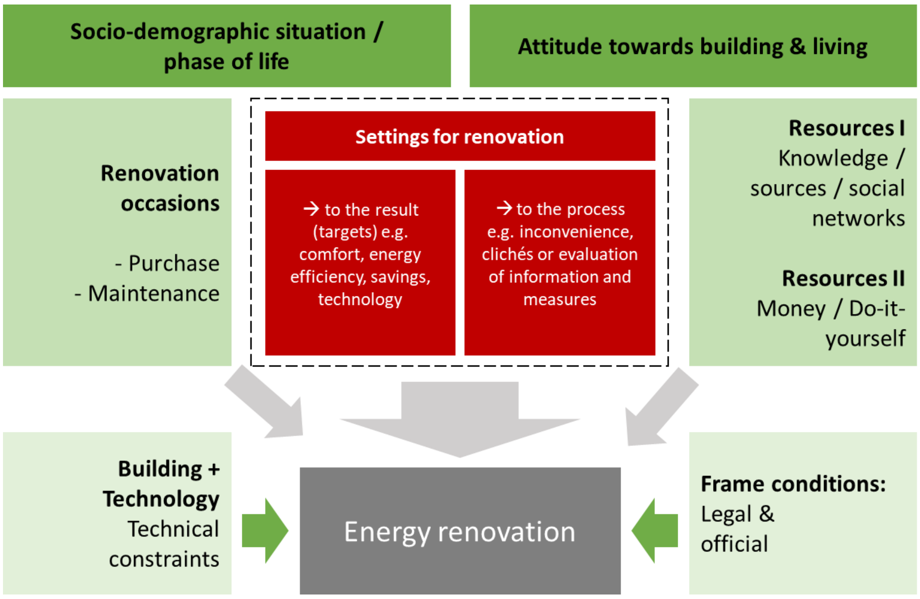
- JRC Science and policy reports (2014): Financing building energy renovations. Current experiences & ways forward. [JRC, 2014]
- D'Agostino, Delia; Cuniberti, Barbara; Bertoldi, Paolo (2017): Data on European non-residential buildings. [D'Agostino et al., 2017]
- Pillen, Nicole; Bertoldi, Paolo; Grether, Stefanie (2007): GreenBuilding - Europe wide renovations of non-residential buildings. DENA; JRC (ECEEE SUMMER STUDY). [Pillen et al., 2007]
- GBPN (2014): Reducing energy demand in existing buildings: learning from the best practice renovation policies. Technical report. [GBPN, 2014]
- Interreg Europe (2017): Improving energy efficiency in buildings. A policy brief from the Policy Learning Platform on low-carbon economy. [Interreg Europe, 2017]
- Artola, Irati; Rademaekers, Koen; Williams, Rob; Yearwood, Jessica (2016): Boosting Building Renovation: What Potential and Value for Europe? [Artola et al., 2016]
- Hermelink, Andreas (1996): Kosten-Nutzen-Analysen von DSM-Programmen im Sektor der privaten Haushalte unter besonderer Berücksichtigung des Anwenderverhaltens. Ergebnisse aus der Evaluierung des EU-PHARE-Fernwärmepilotprojektes in Eger (Ungarn). [Hermelink, 1996]
- Krémer, Zsolt; Liebernickel, Thomas; Ebert, Volkmar; Moosreiner, Stefan (2005): Abbau von Hemmnissen bei der energetischen Sanierung des Gebäudebestandes. [Krémer et al., 2005]
- Stieß, Immanuel; van der Land, Victoria; Birzle-Harder; Babara; Deffner, Jutta (2010): Handlungsmotive, -hemmnisse und Zielgruppen für eine energetische Gebäudesanierung. Ergebnisse einer standardisierten Befragung von Eigenheimsanierern. [Stieß et al., 2010]
- Maby, Catrin; Owen, Alice (2015): Installer Power - The key to unlocking low carbon retrofit in private housing. [Maby and Owen, 2015]

The studies focus on different topics, for example financial barriers and incentives, specific building types (e.g. residential building, non- residential buildings), building owners or landlords. Some studies analyse the whole range of policy instruments available.

The core of our theoretical framework for this analysis is based on two studies; the decision model from Stieß et al. [Stieß et al., 2010] and the "behavioural" model from Hermelink [Hermelink, 1996]. Stieß developed a decision model for energetic renovation and he focuses on residential buildings and building owners. Hermelink elaborated on the whole set of behavioural determinants for individual decisions about energy efficiency investments and (subsequent) energy efficient use of technology.

According to Stieß, the self-perception of the own situation and the resulting attitudes towards the process and the result of an energetic renovation are central for understanding these decisions. Stieß et a.l elaborate on the significance of the social situation as well as individual motivations for the renovation decision which is not solely based on objective economic criteria. Factors such as the socio-demographic situation and the respective phase of life as well as the attitudes toward building and living, which are closely linked with lifestyles, form the framework of the renovation decision. Limits are given by technical and structural constraints and the legal and regulatory framework. Triggers for (energy) renovation origin from an external impulse such as e.g. contact with an installer during maintenance, but also from circumstances such as the purchase of a building. Not only economic resources have an impact on the decision about (energy) renovation but also (access to) knowledge and sufficient information about energy recovery options and own capabilities [Stieß et al., 2010]. The described decision model is illustrated in Figure 2.

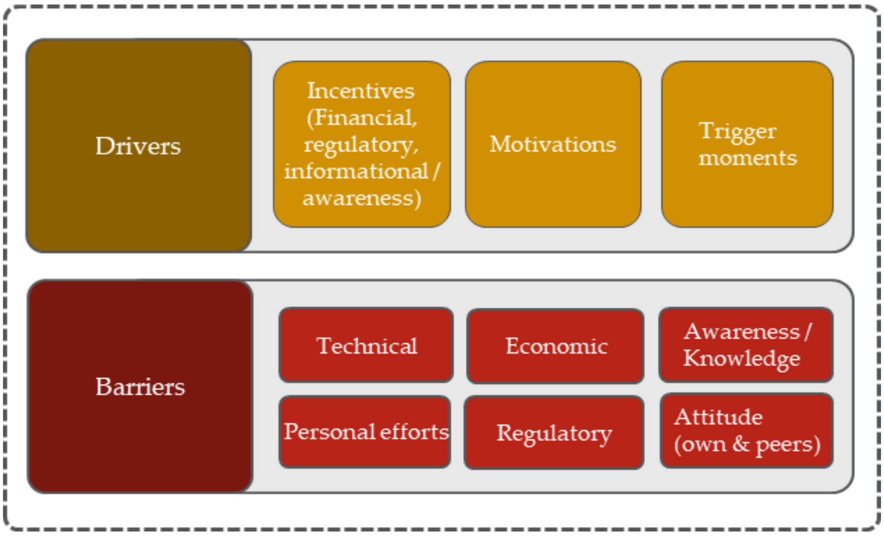
Figure 2: Decision model for energetic renovation (Source: Navigant adaptation from [Stieß et al., 2010])



Hermelink [Hermelink, 1996] explicitly builds his theory on the well-known Fishbein & Ajzen psychological theory of planned behaviour. According to this theory, behaviour is a function of "personal" variables (e.g. demographic variables (age, sex), psychological variables (attitudes, norms), skills …) and "ambient" variables (e.g. social environment (peer groups, regulations, prices …) and physical environment (the building, building systems, climate …). While Stieß provides a rather practical approach – yet focusing only on owners of single-family homes – Hermelink provides a broader theoretical framework that helped to transfer Stieß' insights to different combinations of stakeholders (architects, installers, owners, tenants) and building types as needed in this project.

The decision model based on Stieß et al. [Stieß et al., 2010] and Hermelink [Hermelink, 1996] was adapted considering the different studies mentioned above and was synthesised into a more flexible universal model. This model distinguishes drivers by incentives (financial, regulatory and informative), triggers and motivations. Furthermore, it distinguishes barriers by technical, economic, regulatory and informative barriers and also by attitude (own & peers) and personal efforts (which in the literature is also called transaction costs [JRC, 2014]). The approach is illustrated in Figure 3.

Figure 3: Applied categorisation of qualitative indicators ("drivers and barriers")



In addition to the above-mentioned drivers and barriers, the study analysed more aspects related to the process of energy renovation investments that do not directly belong to drivers and barriers but provide additional information about the context of the investment decision or the implementation of the measure: the involvement of stakeholders, the quality assurance and the funding of renovation projects. Apart from that, at a later stage some of these indicators were specifically dedicated to "very high energy performance" buildings (NZEB).

A major outcome of the models of Stieß et al. [Stieß et al., 2010] and Hermelink [Hermelink, 1996] is that questions about drivers and barriers should be asked as specifically as possible about energy renovation measures the respondent was involved in, rather than e.g. about general believes about environmental protection without concrete relation to energy renovation measures.

2.4. Needs of the current study related to qualitative indicators

While having the general assessment framework for barriers and drivers, it is important to understand that it had to be applied to various configurations of stakeholders and building types.

This project covers the energy renovation

- of the whole building stock (i.e. all building types covered within EPBD Annex I)
- including different stakeholders who take decisions or influence decisions (owners, tenants, architects, installers, public investors, corporate investors)
- collecting information according to the contract from surveys with consumers (household panel: owners and tenants), architects, installers and main contractors.

It can be assumed that depending on the building type – investor type combination, different divers and barriers will be relevant. Based on the desk research, an adequate selection of indicators from the inventory of drivers and barriers was performed that a) reflected the variety of building-investor combinations as good as possible, while b) keeping the differences between the different surveys and building-investor combinations as small as possible to be able to compare results also between different groups.

2.5. Development of qualitative indicators

Drivers

Drivers refer to incentives, triggers and motivations. From a more classical social science perspective, we identified indicators that allow us to map potentially relevant qualitative aspects. This basically follows the theory of planned behaviour (Fishbein/Ajzen) in its elements. This theory derives the intention to do something (e.g. to invest in new windows) from a person's attitude versus this specific action and the person's perceived social norm and the readiness to act according to that norm.

Motivations

Regarding the analysis of motivations, several aspects were included such as environmental or economic motivations, e.g. the increase of profit and reputation or the contribution to the protection from global warming and of the local environmental by energy renovation measures. Also, the long list of potential aspects for each target group were adapted or filtered. For instance, the set of an architects' major motivations to recommend energy renovation will most probably differ from a landlord's major motivations to invest in energy renovation. Motivations were split into major categories which were based on the literature (economic, personal (attitudes) and environmental and these key motivations were split up into various sub-aspects along the lines of Maslow's well-known hierarchy of motivations (economic, self-realisation & prestige, social/security/psychological desires), environmental, comfort & health benefits, knowledge about renovation works, and ability to do things (do it yourself).

Triggers

Triggers for (energy) renovation may origin from various events, e.g. the urgent repair of a defective component (boiler in winter), but also the change of a tenant or a recent purchase of a building. Different kinds of potential trigger moments for energy renovation were investigated such as repair, purchase of a building, but also the effect of different policies on renovation rate and depth. The study set up indicators for evaluating the role of European policies articles of the EPBD, the EED, the Eco-Design and the Energy Labelling Directives.

Incentives

Incentives are kind of a counterpart to the motivations and barriers as incentives mainly have two objectives: Foster favourable motivations or weaken unfavourable motivations, respectively, to enable overcoming barriers. The study distinguishes incentives by financial, regulatory and informational respective awareness incentives, i.e. the categories policy instruments are usually split into. As a follow-up to the questions on barriers, incentives to overcome these barriers were selected in a way that logically corresponded to the previous selection of barriers that were presented to the respondent.

Within the set of triggers and incentives to overcome barriers, a few very specific items were included which directly result from selecting the most prominent energy renovation related requirements from those EU Directives potentially having an impact on energy renovation:

Energy Performance of Buildings Directive:

- Did a national legal requirement for energy efficiency improvements (e.g. in case of major renovation) trigger energy renovation?

- Did (bad) rating on building energy performance certificate / desire to achieve better rating trigger energy renovation?
- Did recommendations on building energy performance certificate help overcome uncertainty about which energy renovation measures to take?

Energy Labelling Directive:

- Did (bad) rating on energy label of a component trigger energy renovation?

Energy Efficiency Directive:

- Did information (about high energy cost) on energy bill trigger energy renovation?

Barriers

In contrast to aspects that motivate or drive people to perform energy renovation, barriers address the various aspects that may hinder implementation of energy renovation. Like drivers, barriers may have their origin in “personal” (negative) determinants or “ambient” (negative) determinants. Consequently, technical, economic and regulatory barriers were investigated as well as (lack of) awareness or knowledge, (critical) attitudes or perceived norms (own & peers) and personal effort related to energy renovation, such as e.g. noise or dirt during renovation, administrative difficulties, etc.

Process related aspects and involved stakeholders

To complete the picture on drivers and barriers, several facts related to the concrete energy renovation measure that results from the individual context of the respondent were included in the set of indicators (where appropriate). Relative to installers, more specific questions on their drivers and relevance of energy renovation were included. They were identified as major influences for investors’ decisions during desk research [Maby and Owen, 2015].

Sources of funding: Own capital, Loan (market condition), Loan with a below-market interest rate (soft loan), Loan from friends & family, Grant

Main involved stakeholders

- for implementation: Professional installers, “do it yourself” - with family and/or friends
- for quality assurance: respondent, architect, main contractor (offers all installer services incl. planning services from architects and civil engineers, family member or friend, installer, other

Prominence of energy renovation: Main activities architects/installers spend most time on, including consultancy on energy renovation, frequency of requests from clients for energy innovation

Reasons for recommendations (of certain products/measures by installers such as e.g. reliability of product, easiness of installation, familiarity with product).

The full list of covered qualitative indicators can be found in the data Annex provided as separate Excel file.

3. Methodology

3.1. Renovation rates

The following table presents a summary of the approach for calculating the energy and non-energy related renovation rates per EU MS for the residential and non-residential building sector (for the residential sector, steps are numbered as Rx and for the non-residential sector NRx to allow clear references). More detailed descriptions of the more complex steps are provided in separate sub-sections following the table.

Table 2: Summary of the approach for calculating renovation rates

	Residential sector	Non-residential sector
Overall energy related renovation rate	R1) Calculation of component-specific renovation rates based on sold market volume in existing residential buildings. R2) Calculation of component-specific renovation rates based on household panel surveys and socio-demographic scaling factors. R3) Calculation of the ratio of the sum of component-specific renovation rates according to household panel survey to overall energy-related renovation rate considering overlaps of measures in the surveys. R4) Due to non-representativeness of household panel surveys, application of ratio to sum of component-specific renovation rates based on sold market volume in existing buildings (step R3).	NR1) Calculate component-specific renovation rates using total sales volume in existing non-residential buildings. NR2) Due to very small samples in the architect surveys, application of ratio to sum of component-specific renovation rates based on sold market volume in existing residential buildings (step R3) to the result of NR1.

Split of overall energy related renovation rate into renovation depths	R5) Use floor area shares per renovation depth from surveys.	NR3) Calculation of total investments in the non-residential renovation market using total sales volume per technology/measure and investigated costs per unit (see chapter 3.3). NR4) Combining results from steps NR5 and NR2 allows the calculation of average specific energy related renovation casts per m² [€/m²]. NR5) For countries with a minimum sample size (non-residential renovation cases) of 30, calculate the average specific renovation costs per renovation depth and calculate the ratios to the costs of the same depth in the residential sector. Calculate the average of the country specific ratios and apply to all EU28 MS using the specific renovation depth costs as basis. NR6) Using a developed solver model provides realistic indications about how the different depths need to be weighted to result in the before calculated overall average specific renovation costs (R5). NR7) These weighting shares are used to split the before calculated overall renovation rate (NR2) into different depths.

Non-energy related renovation rate	R6) Calculation of the ratio of non-energy related renovation rates according to household panel survey to overall energy-related renovation rate considering overlaps of measures in the surveys. R7) Application of ratio to overall energy related renovation rate calculated according to R4.	NR8) The before calculated total renovation costs for energy related renovations (NR3) have been compared with non-residential renovation runover from Euroconstruct & EECFA to calculate the average share of energy related renovation costs on all renovation costs for those countries covered by Euroconstruct & EECFA. This average share has been applied to all EU MS with the aim to calculate the total investments for non-energy related renovations. NR9) From the architect surveys, it was possible to calculate the average ratio of non-energy related specific renovation costs to energy related specific renovation costs (from countries with sample size >30). This average ratio has been applied to the specific energy related renovation costs as calculated under NR4 to calculate the specific non-energy related renovation costs for each EU MS. NR10) Dividing the results of NR8 by the results of NR9 allow the calculation of non-energy related renovation rates.

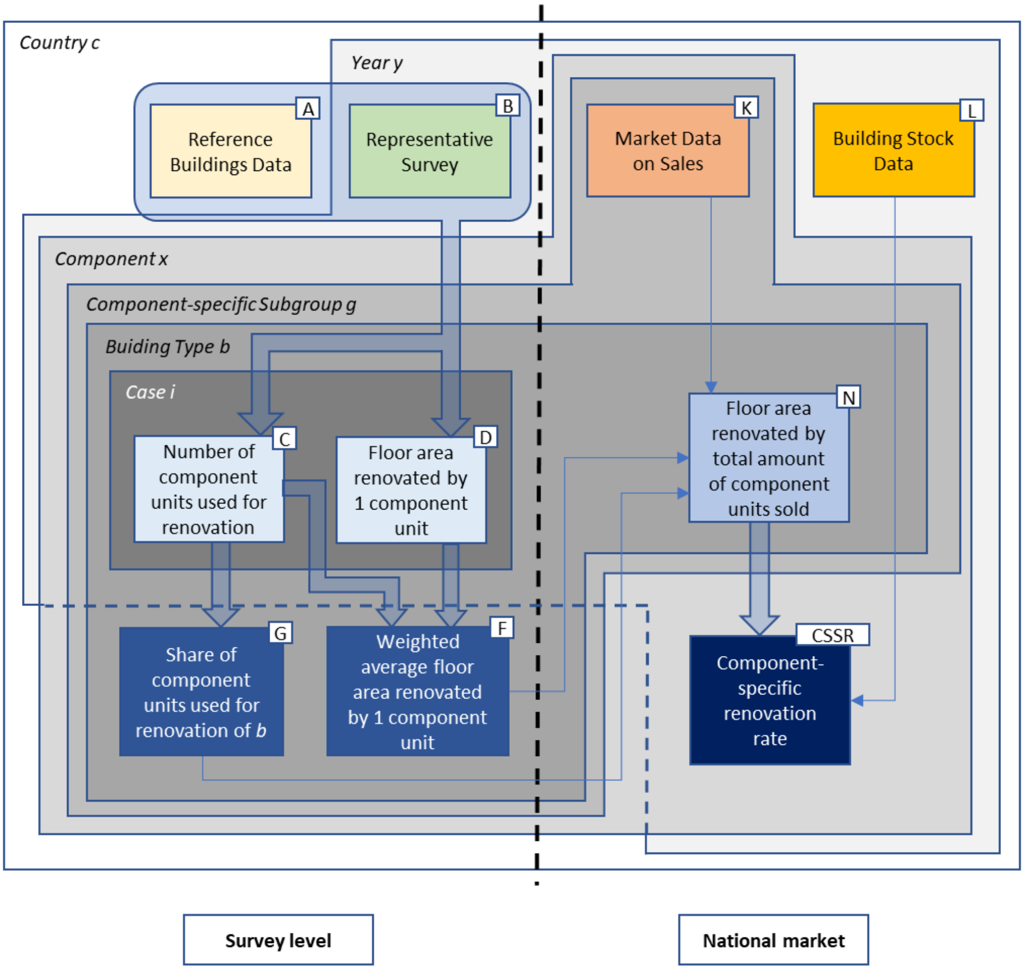
R1) Calculation of component-specific renovation rates based on sold market volume in existing residential buildings

The component-specific renovation rates (CSRR) have been calculated by combining a bottom-up with a top-down analysis. The basic idea of combining the two analysis methods is to link two independent data sources with each other in order to minimize biases that arise when only one data source is used. On the one hand, representative survey data is needed to calculate component specific indicators within a bottom-up analysis (e.g. average floor area renovated by one m³ wall insulation). These indicators then need to be extrapolated to national level using market data on renovation activities (e.g. sold wall insulation volume). Depending on the level of detail of the linkage of both data sources, market data may need to be split by a top-down analysis. For example, if the resulting indicators of the survey are split into renovations in different building types, market data should be available for renovations in different building types as well. In order to do so, representative survey data on installed components in different building types can be used to split market data within a top-down analysis. As there is no literature on this approach, it was developed in the framework of this project.

The used model has been developed during the Master Thesis work of Johannes Becker and is based on a combination of multiple data sources and therefore multiple analysis methods. On the one hand, the representative survey conducted by Ipsos has been used to collect information on renovation activities. In combination with reference building specifications, a bottom-up analysis enabled the calculation of values that represent renovation activities in residential buildings, such as the average floor area renovated by one component unit of each component. On the other hand, these values are extrapolated to whole market level using national market data on sold component units. Since this data does not provide any information on the installation of components in households of different residential building types, the representativeness of the survey allows to split up market data using a top-down approach. Finally, the floor area renovated by the total number of sold component units is put into relation to residential building stock data in order to calculate the CSRRs.

A visualisation of the approach is presented in the figure below.

Figure 4: Main Calculation Processes and Overview of the Calculation Approach



Data Sources

The model is based on four main data sources, which need to be linked to each other for generating CSRRs:

- Representative survey on renovation activities in the residential building stock (conducted by Ipsos within the course of the project)
- Reference building data for the usage of specific building characteristics [TABULA / EPISCOPE see section 1.2]
- Market data on sales for the extrapolation of survey data to country level
    - Windows: Interconnection Consulting, Windows in Europe
    - Façade: Interconnection Consulting, Thermal insulation market study
    - Roof: Interconnection Consulting, Thermal insulation market study
    - Ground Plate : Interconnection Consulting, Thermal insulation market study

  - Basement & Attics : Interconnection Consulting, Thermal insulation market study
  - Space heaters: BRG Building Solutions, European HVAC market study
  - Water heaters: BRG Building Solutions, European HVAC market study
  - Radiators : BRG Building Solutions, European HVAC market study
  - Mechanical ventilation systems: BRG Building Solutions, European HVAC market study
  - Space cooling systems: „Review of Regulation 206/2012 and 626/2011 Air conditioners and comfort fans", task 2 report prepared by Viegand Maagøe and ARMINES
  - Photovoltaics: Solar Power Europe`s annual "Global Market Outlooks for Solar Power"
  - Lighting: Preparatory Study on Light Sources for Ecodesign and/or Energy Labelling Requirements ('Lot 8/9/19'), task 2 report prepared by VITO in cooperation with VHK
- Building stock data for the comparison with the total floor area (see 4)

R2, R3 and R6 – Extracting information from household panel surveys

General observations

⇨ Altogether there are 30,118 data records (or HH = households)

⇨ Energy/non-energy renovation:

- 1,426 energy renovations only
- 16,876 energy and non-energy renovations => i.e. altogether 18,302 HH did some energy renovation between 2012-2016
- 5,962 non-energy renovations only => i.e. altogether 22,838 HH did some non-energy renovation
- 5,854 did not do anything => i.e. altogether 11,816 HH were screened out

Calculation of energy renovation rate

The sub-sample that did energy renovation is divided into two main groups based on the variable "Tenure_status"

A. People who occupy the building/apartment they report about: (3,164 + 13,536) / 18,302 = 91.25% of households in the sub-sample

B. People who rent out the building they report about. (1,602 / 18,302) = 8.75% of households in the sub-sample.

Based on a conducted analysis, only group A has been used for the calculations of energy renovation rates, as this group deemed to be representative for the renovation activities in the total population of households.

Upscaling of results from group "A" to total population

The standard approach to upscale the number of households (HH) in the sample to the total number of households in a country was as follows:

a. the shares of different household types in the sample deviate from the known distribution of household types in the total population

b. For each type of household it had to be assessed which number of households in the total population can be assigned to 1 household in the sample. Below an example for Germany:

c. For 2017, EU statistics provide a number of 40,722,600 households in Germany.

d. The total sample size for Germany was 2141 households.

e. Example for type SD = 2 (single adult without children). In the sample, this type is under-represented. The formula for calculating the "weighting factor" is: target % / reached % * total number of HH in Germany / number of German HH in sample, i.e. 41.2% / 28.0 % * 40,722,600 HH / 2,141 HH = 28,009.53 HH in total population per HH in sample.

Using this approach individual weighting factors have been calculated for all 6 different household groups in all 28 EU countries in the sample.

As only group A has been taken for doing this exercise another set of weighting factors had to be calculated after procedure that was just explained. For this purpose, factors from previous step need to be multiplied with a

- New variable A_B_factor = (A+B) / A

- Example for Germany (continuing above example):

    - 1,058 energy renovators in total, of which 113 landlords.

    - A_B_factor = 1,058 / (1,058 – 113) = 1.120;

    => all weighting factors as explained above have to be multiplied with this factor due to the virtually smaller size of the sample (2,141 * (1,058 – 113) / 1,058 = 1,912 (i.e. A_B_factor could also be calculated as 2,141 / 1,912).

It should be noted that respondents clearly struggled to properly remember when exactly between 2012-2016 individual measures had been implemented when being confronted with the complex matter of building energy renovations. Therefore validity of results would increase by applying a similar approach (panel survey) on an annual or bi-annual basis.

3.2. Energy savings

In recent years, Navigant developed and refined an in-house Building Energy Performance (BEP) Model based on ISO EN 13790, the relevant standard used in Europe for the calculation of heating and cooling energy demands of buildings. In several projects, the Navigant BEP Model provided realistic results based on a solid internationally applicable methodology. For the present project, the calculation core of the model has been updated to the new international standard ISO EN 52016:2017 "*Energy performance of buildings — Energy needs for heating and cooling, internal temperatures and sensible and latent heat loads*". ISO 52016 has superseded ISO 13790:2008 in 2017 and also incorporates aspects from other standards related to the energy performance of buildings.

The whole model is developed with MS Excel and contains several modules (illustrated in Figure 5) to serve all required aspects of this assignment. The model calculates the energy demand for heating and cooling on an hourly basis, leading to 8760 single calculations using hourly climate data extracted from METEONORM, considering the precise building specifications such as geometry and orientation of surfaces and local climate following the complex algorithms provided in the standard.

The calculation of energy needs according to ISO EN 52016 is complemented by a calculation module for technical building systems (HVAC-Model) to allow for the calculation of final energy demands for space heating, space cooling, hot water generation and air ventilation. Using national primary energy factors, the model converts the final energy demand per energy carrier into primary energy. The used primary energy factors have been extracted from ISO 52000-1[7] and for the sake of comparability of results applied to all Member States. The factors are presented in the following table.

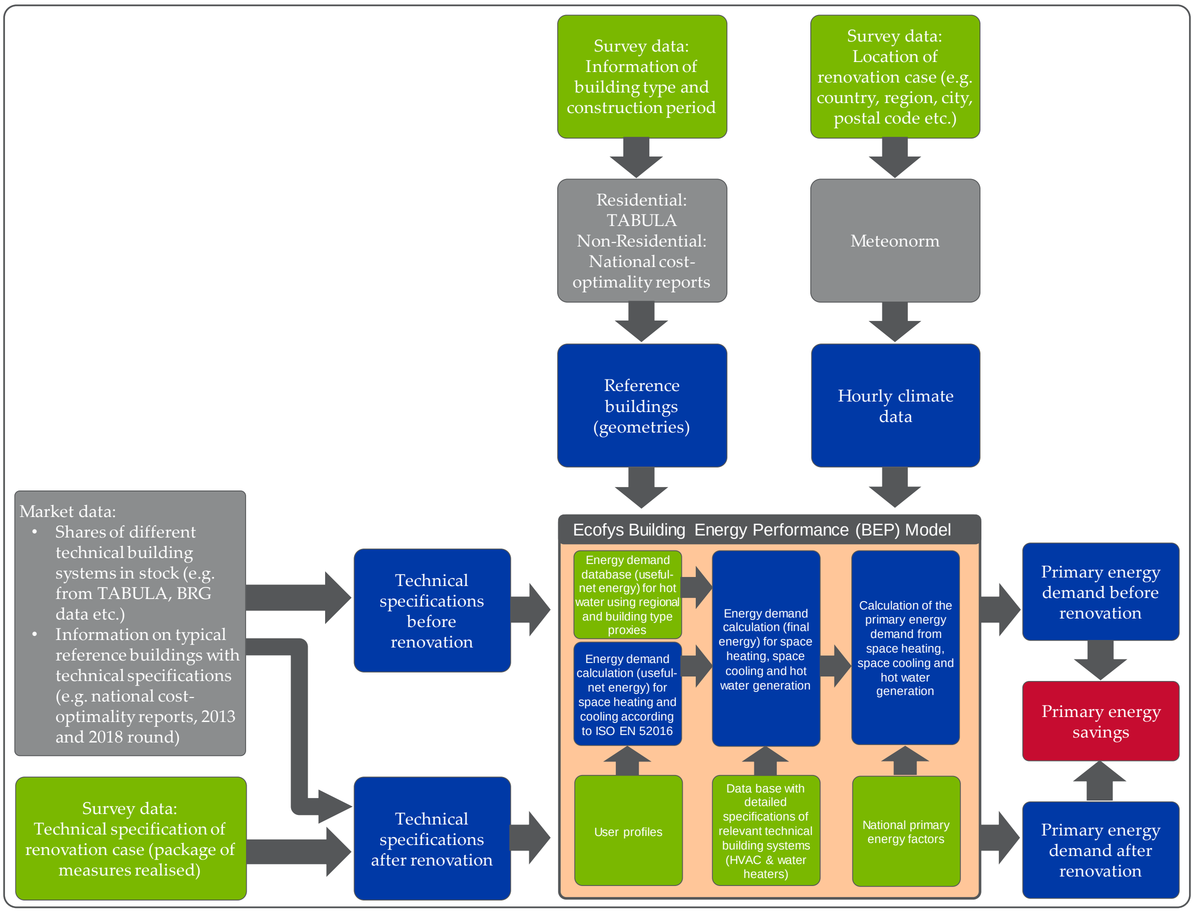
Table 3: Used primary energy and CO2e emission factors

	Electricity	Gas	Oil	Biomass	DH	Coal
Primary energy	2.3	1.1	1.1	0.2	1.3	1.1
CO2e	420	220	290	40	260	360

The entire overall approach of this task is illustrated in Figure 5 below, followed by a detailed description, including the specification of assumptions made.

7 Final Draft ISO/prFDIS 52000-1 - Energy performance of buildings — Overarching EPB assessment – Part 1: General framework and procedures - as forwarded for Formal Vote. Date of document: 2016-09-15

Figure 5: Approach for calculating energy savings



First, an additional Excel tool was used to extract the energy related data from the survey results. The relevant data for the energy savings calculation is which measures have been conducted and, if known, what types of new systems, insulations, windows, etc. were installed in the years 2012 to 2016. To consider the energy savings per year, each case of the consumer survey was evaluated in every year, hence five data sets per case were created. Additionally, a reference base is used to represent the building's condition before 2012, which leads to a total of six data sets per household.

This method not only allows to display the energy savings before and after the period under consideration but also the detailed development during these years. Therefore, the data set for each year is calculated individually, starting with the reference base. Subsequent years are calculated applying the renovation measures which have been conducted in the respective year. The impact of once implemented measures is continued in the following years. Since survey data is limited to systems and geometries renovated, the remaining components must be derived from the given information, hence default systems and reference geometries are used.

Data preparation

The survey delivers a classification of the building types and the construction time. This information is matched with the TABULA/EPISCOPE database which provides representative building geometries and U-values for each country. Therefore, the geometry of the reference buildings (before 2012) and U-values are taken from the TABULA/EPISCOPE database. If renovations were conducted, this part of the geometry is updated with the specific survey information, while the unrenovated components stay with the TABULA/EPISCOPE values. This allows the tool to consider only the measures recorded in the survey and calculate their energy savings impact. For residential buildings, the survey did not ask for specific U-values, but the types of windows or thickness of insulation installed. These qualitative answers were converted into typical specific numbers, whereas the non-residential survey directly provides the U-values for each renovated component.

Building geometries are used to calculate the useful energy demand. For this purpose, the team has used the reported climate locations that were used for the cost-optimality calculations of EU member states. In consequence, for the calculations of each country, the model used a country specific climate with different parameters for each of the 8760 hours per year. The data has been extracted from Meteonorm. Consequently, the heating, ventilation and air-conditioning systems (HVAC) are implemented as well to calculate the final energy demand. The Navigant Building Energy Performance (BEP) Model takes the energy needs following ISO 52016 standard and calculates the hourly energy use of all relevant heating, cooling and ventilation systems. The result is the final energy demand per energy carrier that is converted into primary energy demand using the primary energy factors as reported above. Depending on the calculated primary energy savings per renovation case and considering the definitions of renovation depths, each renovation case can directly be declared as "below threshold", "light", "medium" or "deep renovation".

3.3. Investment costs

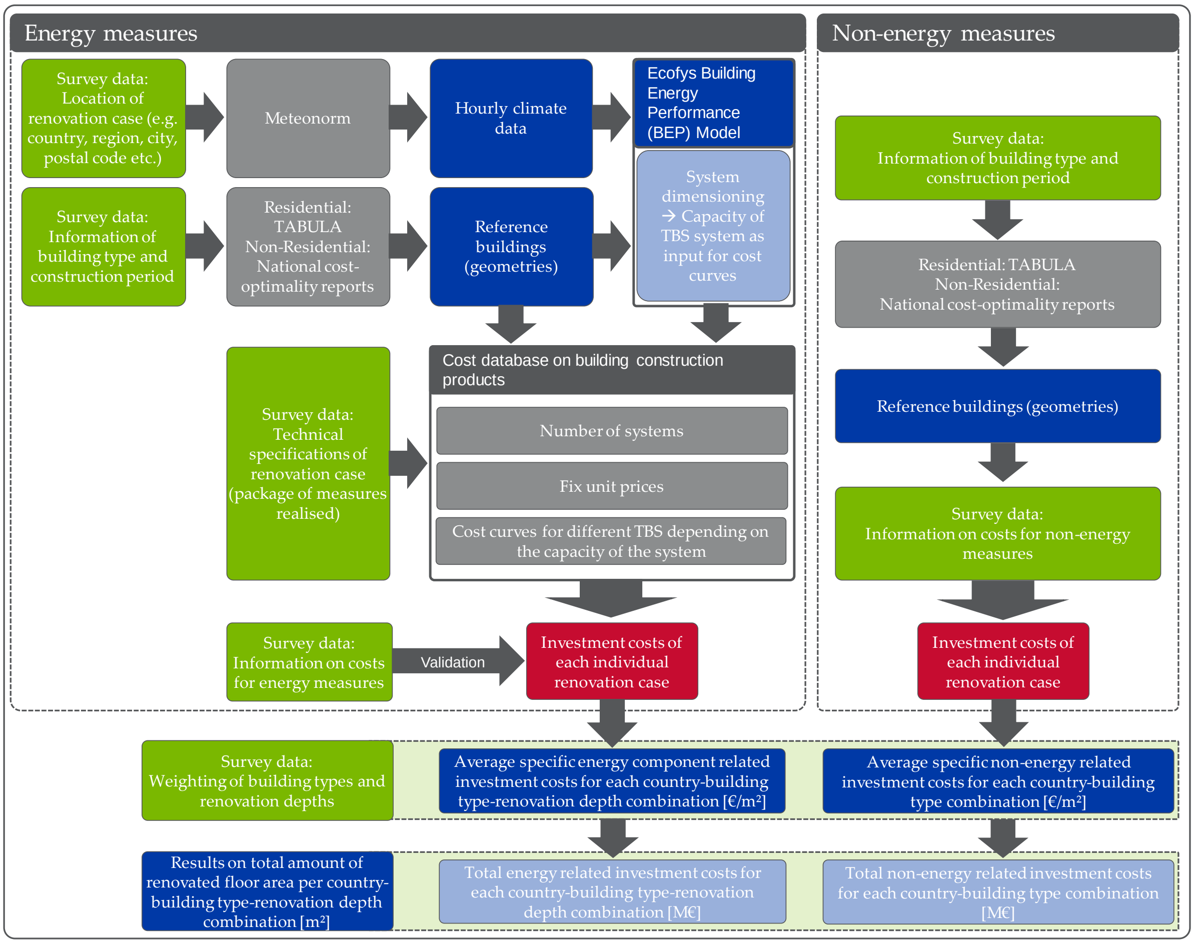
The approach for calculating the investment costs for each renovation case and later for calculating average investment costs for each combination of country, building type and renovation depth is based on two main sources:

1) Investment cost database for building construction products, and
2) Direct cost information obtained from the questionnaires.

For calculating the investments per renovation case, clear information on the renovation measures undertaken is required as well as information to determine the most appropriate reference building to be used for the calculations. For each installed technology, considering the building unit, number of components (e.g. 5 windows per building unit), etc the average investment costs are calculated.

The whole approach is illustrated in Figure 6.

Figure 6: Total approach for calculating investment costs



The following average product costs have been used for the analysis.

Table 4: Envelope measures

	Windows					Doors	Facade		Roof		Attic		Basement		Ground plate	Solar shading
	Single glazing	Double glazing	Double glazing with solar protection	Triple glazing	Triple glazing with solar protection	Average	Fixed costs	Variable costs	Fixed costs	Variable costs	Fixed costs	Variable costs	Fixed costs	Variable costs	Fixed costs	Average costs
	EUR/ m²	EUR/ m²	EUR/m²	EUR/ m²	EUR/m²	EUR/m²	EUR/ m²	EUR/ m²cm	EUR/ m²	EUR/ m²cm	EUR/ m²	EUR/ m²cm	EUR/ m²	EUR/ m²cm	EUR/ m²	EUR/m²
Austria	183	270	294	337	452	1,068	70	1.61	139	1.45	21	1.53	33	1.21	32.98	752
Belgium	212	305	332	376	503	966	63	1.46	126	1.31	19	1.38	30	1.09	29.83	680
Bulgaria	60	117	130	171	241	379	25	0.57	49	0.51	7	0.54	12	0.43	11.70	267
Croatia	88	154	171	214	297	445	29	0.67	58	0.60	9	0.64	14	0.50	13.75	313
Cyprus	117	155	202	243	295	616	40	0.93	80	0.83	12	0.88	19	0.70	19.01	433
Czech Republic	93	158	174	174	301	585	38	0.88	76	0.79	11	0.84	18	0.66	18.06	412
Denmark	217	313	341	385	515	1,380	90	2.08	180	1.87	27	1.98	43	1.56	42.63	972
Estonia	89	153	169	213	294	679	45	1.02	89	0.92	13	0.97	21	0.77	20.98	478
Finland	185	273	298	341	460	1,383	91	2.08	180	1.87	27	1.98	43	1.56	42.70	973
France	195	283	308	350	469	1,087	71	1.64	142	1.47	21	1.56	34	1.23	33.56	765
Germany	181	266	296	332	447	1,333	87	2.01	174	1.81	26	1.91	41	1.51	41.16	938
Greece	107	177	194	238	328	559	37	0.84	73	0.76	11	0.80	17	0.63	17.26	393
Hungary	78	143	158	202	282	488	32	0.73	64	0.66	10	0.70	15	0.55	15.06	343
Ireland	174	257	280	324	436	930	61	1.40	121	1.26	18	1.33	29	1.05	28.73	655
Italy	164	246	268	311	420	696	46	1.05	91	0.94	14	1.00	21	0.79	21.50	490
Latvia	72	133	148	191	268	608	40	0.92	79	0.82	12	0.87	19	0.69	18.79	428
Lithuania	71	133	148	191	267	585	38	0.88	76	0.79	11	0.84	18	0.66	18.06	412
Luxembourg	193	278	303	344	460	1,070	70	1.61	139	1.45	21	1.53	33	1.21	33.05	753
Malta	100	166	184	226	311	658	43	0.99	86	0.89	13	0.94	20	0.74	20.33	463
Netherlands	189	275	300	342	460	1,089	71	1.64	142	1.48	21	1.56	34	1.23	33.63	767
Poland	81	145	160	204	283	521	34	0.78	68	0.71	10	0.75	16	0.59	16.09	367
Portugal	99	167	184	228	315	507	33	0.76	66	0.69	10	0.73	16	0.57	15.65	357
Romania	68	130	144	188	264	357	23	0.54	47	0.48	7	0.51	11	0.40	11.04	252
Slovak Republic	83	146	161	204	284	580	38	0.87	76	0.79	11	0.83	18	0.66	17.91	408
Slovenia	109	178	196	239	327	530	35	0.80	69	0.72	10	0.76	16	0.60	16.38	373
Spain	137	211	231	273	370	675	44	1.02	88	0.91	13	0.97	21	0.76	20.84	475
Sweden	229	327	356	401	536	1,612	106	2.43	210	2.19	32	2.31	50	1.82	49.79	1,135
United Kingdom	140	217	237	280	380	919	60	1.38	120	1.25	18	1.31	28	1.04	28.37	647

Table 5: Technical building systems (1)

	Cooling systems						Photovoltaics			
	Centralised chiller (whole building, replacement)	Centralised chillers (whole building, new installation)	Centralised multi-split system (whole building)	Centralised multi-split system (for appartment)	Mounted single-split/window AC	Movable AC systems	0-10 kWp	10-15 kWp	15-20 kWp	>20 kWp
	EUR	EUR	EUR	EUR	EUR	EUR	EUR	EUR	EUR	EUR
Austria	72,215	541,612	28,591	9,198	1,793	379	2,344	2,374	2,405	2,435
Belgium	73,244	716,299	29,892	9,529	1,754	398	2,362	2,408	2,454	2,501
Bulgaria	60,755	537,560	28,019	8,626	1,221	379	1,904	1,997	2,091	2,184
Croatia	75,472	590,056	35,000	10,759	1,502	474	2,362	2,481	2,601	2,720
Cyprus	61,971	535,040	26,831	8,407	1,372	360	1,972	2,037	2,103	2,168
Czech Republic	66,904	588,641	29,575	9,213	1,437	398	2,119	2,200	2,281	2,362
Denmark	91,027	902,989	35,777	11,536	2,279	474	2,959	2,993	3,027	3,061
Estonia	65,757	513,991	28,269	8,876	1,470	379	2,096	2,162	2,228	2,294
Finland	88,343	839,401	34,394	11,122	2,236	455	2,877	2,904	2,932	2,959
France	72,530	574,329	28,607	9,214	1,809	379	2,356	2,385	2,413	2,442
Germany	73,903	554,270	27,426	9,003	1,968	360	2,430	2,430	2,430	2,430
Greece	74,639	559,794	33,709	10,438	1,551	455	2,351	2,454	2,556	2,659
Hungary	92,866	696,497	37,806	11,625	1,628	512	2,555	2,684	2,812	2,940
Ireland	104,920	786,896	32,633	10,331	1,815	436	2,505	2,568	2,630	2,692
Italy	76,486	573,644	31,053	9,721	1,575	417	2,273	2,350	2,427	2,504
Latvia	76,558	574,185	29,595	9,232	1,457	398	2,134	2,213	2,291	2,370
Lithuania	78,485	588,641	29,575	9,213	1,437	398	2,119	2,200	2,281	2,362
Luxembourg	86,858	651,436	24,438	7,953	1,659	322	2,096	2,107	2,118	2,129
Malta	62,645	469,839	25,481	8,027	1,362	341	1,916	1,971	2,026	2,081
Netherlands	93,863	703,971	29,994	9,631	1,856	398	2,440	2,475	2,510	2,545
Poland	73,226	549,197	32,293	9,991	1,474	436	2,244	2,344	2,443	2,543
Portugal	84,189	631,417	32,281	9,979	1,463	436	2,235	2,336	2,437	2,538
Romania	67,376	505,318	26,616	8,193	1,158	360	1,807	1,896	1,985	2,074
Slovak Republic	90,427	678,203	28,186	8,793	1,388	379	2,032	2,108	2,183	2,258
Slovenia	80,171	601,279	30,915	9,583	1,437	417	2,167	2,259	2,352	2,444
Spain	85,386	640,393	29,650	9,287	1,512	398	2,176	2,249	2,322	2,394
Sweden	121,045	907,836	35,970	11,728	2,472	474	3,107	3,120	3,132	3,145
United Kingdom	67,086	503,148	28,467	9,074	1,669	379	2,248	2,293	2,337	2,381

Table 6: Technical building systems (2)

	Space heaters	Other heat emitters than radiators	Radiators	Ventilation		Domestic hot water systems		Lighting
	Average	Average	Average	Central	Local	Central	Decentral	Average
	EUR	EUR/m²	EUR	EUR/m²	EUR	EUR	EUR	EUR/m²
Austria	15,547	33	497	36	2,058	5,087	857	16
Belgium	9,424	30	349	33	1,191	2,692	12,045	14
Bulgaria	4,232	12	154	13	557	2,206	821	6
Croatia	3,839	14	125	15	1,350	1,537	192	7
Cyprus	4,393	19	202	21	254	1,206	146	9
Czech Republic	5,407	18	134	20	1,774	1,676	404	9
Denmark	13,547	43	749	46	5,083	6,927	1,777	21
Estonia	5,431	21	172	23	2,062	1,428	327	10
Finland	13,172	43	674	47	2,305	6,709	2,110	21
France	9,074	34	392	37	1,989	3,332	1,084	16
Germany	15,024	41	585	45	1,340	3,632	991	20
Greece	4,035	17	200	19	1,695	1,052	267	8
Hungary	5,687	15	101	16	1,480	1,356	12,071	7
Ireland	9,027	29	240	31	203	3,945	558	14
Italy	4,968	22	229	23	288	1,364	165	10
Latvia	4,802	19	171	20	1,846	1,317	297	9
Lithuania	4,460	18	161	20	1,774	1,300	303	9
Luxembourg	8,935	33	386	36	1,958	3,281	1,068	16
Malta	8,935	20	216	22	272	1,290	156	10
Netherlands	9,270	34	352	37	2,770	3,683	1,325	16
Poland	4,709	16	146	18	767	1,290	133	8
Portugal	4,836	16	233	17	1,537	1,393	356	8
Romania	3,688	11	89	12	1,085	913	205	5
Slovak Republic	4,607	18	120	20	1,760	1,482	292	9
Slovenia	4,308	16	217	18	1,609	985	180	8
Spain	5,289	21	137	23	291	1,525	287	10
Sweden	1,7582	50	765	54	3,401	6,425	4,435	24
United Kingdom	8,195	28	142	31	201	2,885	906	14

The investment cost calculation of renovation measures is based on following literature sources:

Renovation measure	Source
Windows	• VHK (2015): Final report, consolidated version of 22 June 2015. LOT 32 / Ecodesign of Window Products. TASK 7 – Policy Options & Scenarios
Doors	• IWU (2015): Kosten energierelevanter Bau- und Anlagenteile bei der energetischen Modernisierung von Altbauten
Insulation	• ifeu (2014): 100 % Wärme aus erneuerbaren Energien? Auf dem Weg zum Niedrigstenergiehaus im Gebäudebestand.
Solar shading	• ift (2015): LOT 32 / Ecodesign of Window Products Task 2 – Market Analysis.
Cooling	• ARMINES (2018): Review of Regulation 206/2012 and 626/2011. Air conditioners and comfort fans Task 2 report. • BMVBS (2012): BMVBS-Online-Publikation, Nr. 08/2012: Ermittlung von spezifischen Kosten energiesparender Bauteil-, Beleuchtungs-, Heizungs- und Klimatechnikausführungen bei Nichtwohngebäuden für die Wirtschaftlichkeitsuntersuchungen zur EnEV 2012.
Heating and Domestic Hot Water Ventilation	• VHK (2019): Space and combination heaters. Review Study. Task 2 Market Analysis.
Lighting	• Navigant (2015): Energieaudit nach DIN EN 16274-2
Photovoltaics	• Schlitzberger (2018): Kurzgutachten zur Aktualisierung und Fortschreibung der vorliegenden Wirtschaftlichkeitsuntersuchung sowie zu Flexibilisierungsoptionen.

In the case of insufficient data on country-specific investment costs, existing data sources were used to close data gaps with the help of Eurostat country specific price level indices. The respective price levels and VAT differences in the EU28 member states were considered. The investment cost calculations are also inflation-adjusted and show end-user costs including VAT and installation costs.

3.4. Uptake of nearly-zero energy buildings

The uptake of nearly-zero energy buildings (NZEB) has been calculated by using mainly three sources:

a) "The architectural professions in Europe 2018. A Sector Study" by the Architect's Council of Europe (ACE) (in the following we are referring to the dataset as "ACE dataset"): The study gives a comprehensive overview of the architecture sector and its practitioners, as well as activities referring to the overall construction sector. It collects and presents statistical data on the market by surveying architects in in various European Countries; overall in 2016 more than 27.000 architects from 27 countries participated and completed the questionnaires. The study has been conducted in two-years intervals.

For our analysis, ACE studies from 2012, 2014 and 2016 has been used to examine the role of nearly-zero energy buildings in the EU and its member states. Among others, the study reveals on country level

- how often architects are being asked to build to nearly-zero energy standards,
- the proportion of work undertaken by building type, i.e. for new and refurbishment projects, and
- the proportion of work undertaken by building sector, i.e. differentiated by residential and non-residential building types.

The results offer valuable input for the analysis and hence the outcomes have been incorporated into the approach to quantify the uptake of nearly-zero energy buildings in the EU and its member states.

b) The architect survey which has been conducted in this assignment (in the following we are referring to the dataset as "survey dataset"): The survey conducted within this assignment represents another source of valuable input to identify the role of nearly-zero energy buildings. Among others, the data shows the share of nearly-zero energy buildings within each of the following groups for the years 2012 and 2016:

- new residential buildings
- new non-residential buildings
- renovated residential buildings
- renovated non-residential buildings

Another important source for the analysis was the statistics on new construction activities in the EU28 and its member states (in the following we are referring to the dataset as "survey dataset").

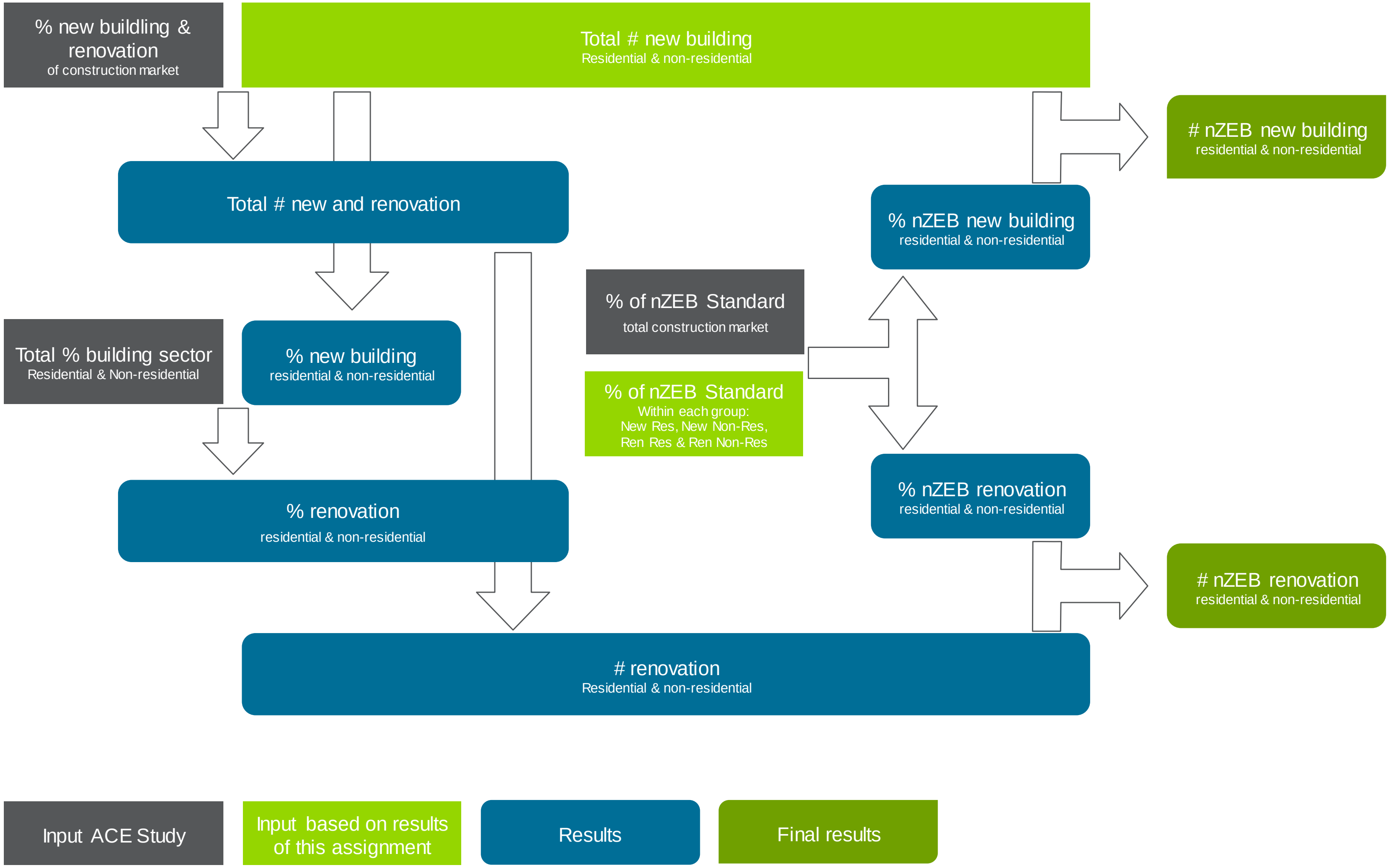
Based on the above-mentioned sources, following approach as has been developed and implemented; the approach has been illustrated in a flow chart (see Figure 7):

- The ACE dataset on "proportion of work undertaken by building type, i.e. for new and refurbishment projects" and the survey dataset "total number of new buildings differentiated by residential and non-residential" has been used to calculate the "total number of renovated and new buildings".
- The "total number of renovated and new buildings" and the survey dataset "total number of new buildings differentiated by residential and non-residential" has

been used to derive the "share of new residential and non-residential buildings of the total construction market".

- Based on the ACE dataset "proportion of work undertaken by building sector, i.e. differentiated by residential and non-residential building types" and the previously revealed "share of new residential and non-residential buildings of the total construction market" the difference has been calculated leaving the "share of renovated residential and non-residential of the total construction market" as result
- The calculated "share of renovated residential and non-residential of the total construction market" has then been multiplied with the calculated "total number of renovated and new buildings" resulting in the "total number of renovated buildings differentiated by residential and non-residential".
- In the next step, the ACE dataset on the "share of nearly-zero energy buildings on the total construction market" and the survey dataset on "share of nearly-zero energy buildings within each of the following groups: new residential buildings, new non-residential buildings, renovated residential buildings and renovated non-residential buildings" has been used to calculate the (i) "share of nearly-zero energy buildings for new residential and non-residential buildings" and the (ii) "share of nearly-zero energy buildings for renovated residential and non-residential building"
- Finally, the "share of nearly-zero energy buildings for new residential and non-residential buildings" respectively the "share of nearly-zero energy buildings for renovated residential and non-residential building" has been multiplied with the "total number of new buildings differentiated by residential and non-residential" respectively "total number of renovated buildings differentiated by residential and non-residential" resulting in the "total number of new buildings in NZEB standard" and "total number of renovated buildings in NZEB standard"

Figure 7 : Flowchart of the approach to calculate number of new and renovated buildings in nearly zero energy standard



The following assumptions have been made:

- Since ACE input data are only available for 2012, 2014 and 2016, interpolations have been conducted to identify an appropriate starting point for the analysis for 2013 and 2015.
- The ACE study 2012 does not provide information in same granularity as in the following years for the dataset "how often architects are being asked to build to nearly-zero energy building". Therefore, deviations between the available data for 2012 and 2014 has been calculated and applied to estimate the "share of nearly-zero energy buildings on the total construction market".
- The ACE study 2012 does not provide information on "proportion of work undertaken by building type, i.e. for new and refurbishment projects". After comparing the share of new and refurbished buildings of the year 2014, 2016 and 2018, it can be stated that the numbers are in a comparable range. Based on this finding we estimated the "proportion of work undertaken by building type, i.e. for new and refurbishment projects" by calculating averages based on the years 2014, 2016 and 2018.
- Since the 2016 ACE dataset on "how often architects are being asked to build to nearly-zero energy building" does not contain information for the Germany, interpolations based on available number for 2014 and 2018 has been conducted.
- The survey dataset "share of nearly-zero energy buildings within each of the following groups: new residential buildings, new non-residential buildings, renovated residential buildings and renovated non-residential buildings" showed gaps in few categories and countries. These gaps have been filled by using EU averages for further calculations. The following countries per category are affected:
  - New Residential: Estonia, Slovakia and Finland
  - New Non-Residential: Luxembourg, Slovakia and Malta
  - Renovation Residential: Denmark, Slovakia and Finland
  - Renovation Non-Residential: Cyprus, Slovakia and Ireland
  - In the ACE publications 2012 to 2016, few countries were not included, which resulted in missing data regarding the dataset "how often architects are being asked to build to nearly-zero energy building". For these countries averages have been built based on geographical proximity and considering economical comparability. The following table provides an overview of missing countries in each publication.

Table 7: Overview of countries which are not covered in the ACE publication

Country	ACE publication 2012	ACE publication 2014	ACE publication 2016
Cyprus	x	x	
Estonia	x		
Greece			x
Hungary		x	x
Lithuania	x	x	
Latvia	x		x
Netherlands	x		

Poland	x	x	
Slovakia	x		

3.5. Survey methodology

Three different surveys were conducted to generate primary data on energy renovation activities and NZEB, covering both residential and non-residential buildings both on EU28 and on country level:

- Consumer survey
- Architect survey
- Construction companies survey: main contractors and installers

This section describes the key aspects in the design and the fieldwork of the three survey questionnaires. The table below illustrates the coverage, sample size and complementary objectives of the three surveys. The large-scale online consumer survey covering each Member State of the EU28 gathered project-relevant data related to residential buildings. The two B2B surveys among relevant stakeholders also cover the EU28 but are more limited in terms of scale. The architect survey focuses on the demand side both for residential and non-residential buildings (e.g. offices, schools, hospitals, etc.), while a second B2B survey is tailored towards the supply side targeting both construction companies (main contractors) and suppliers (installers) of construction materials.

Table 8: Overview of the surveys

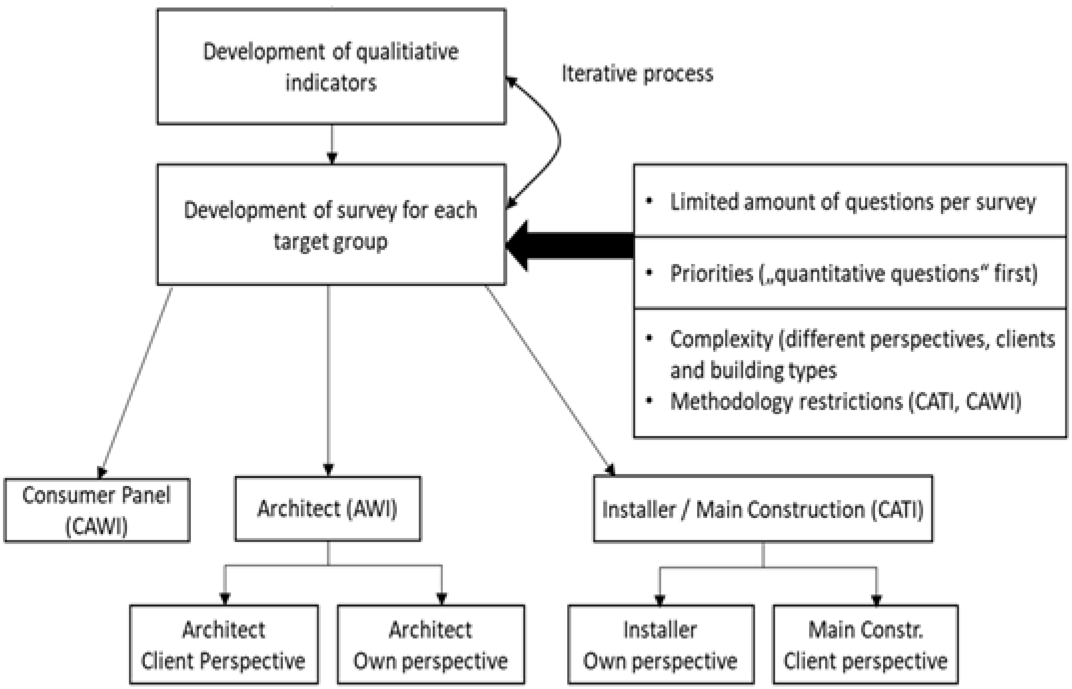
	Consumer survey	Architects survey	Survey of construction companies (main contractors) and suppliers (installers) of construction materials
Coverage		EU28	
Method	CAWI	CAWI	CATI
Target sample size	N =1 6,800	N = 5,000 (best effort, relying on cooperation of ACE's member organizations)	N = 1,990
Achieved sample size	N = 30,118 (all) N = 18,302 (energy renovations)	N = 1,581	N = 2,009
Sampling	A representative sample of national population 18+	Convenience sample	Sample based on Dun & Bradstreet (D&B) company database
Target respondents	Consumers with renovation experience	The European Architects Council's (ACE) member organizations	Construction companies involved in renovation activities + suppliers of construction materials
Objective	Collect data on renovation	Collect data on the demand side both for	Collect data on the supply chain and quality of the

	of residential buildings	residential and non-residential buildings covering renovation and NZEB	works both for residential and non-residential buildings covering renovation and NZEB
Timing fieldwork	16 August – 28 September 2018	27 August 2018 – 15 March 2019	13 August – 6 November 2018

Development of the surveys

Ipsos and Navigant worked closely together in designing the questionnaires to translate the development of indicators into three different yet complementary survey questionnaires. Ipsos has extensive experience in developing the methodology for conducting large-scale multi-country surveys that target consumers, companies and/or other relevant stakeholders in a variety of sectors. Navigant provided the expertise in the project subject-matter as well as in the development of the methodology outlined in the previous sections. As a result, each of the three surveys was conducted based on a questionnaire that has been very specifically tailored to the target group and the data that needs to be obtained with only minimal overlap with the other questionnaires. Figure 8 below illustrates the close interaction.

Figure 8: Approach for survey development



Each questionnaire was developed starting with a discussion of the final methodology and creation of a general outline of the key topics to be covered. The relevant indicators described in the previous sections served as an initial basis for the questionnaire design approach. For each of the selected indicators, the concrete data points identified as those feasible to be gathered via a consumer and/or B2B survey were discussed and defined in detail. In doing so, Ipsos and Navigant carefully considered previous projects and conducted desk research to estimate which data points would fit each target group. At this stage, any potential data collection issues that emerged, e.g. data points which were likely to be difficult for target respondents to recall without aid, data points which target respondents would not feel at ease sharing, etc., was flagged and tackled a priori when designing the survey questions by adjusting the approach as needed.

The final list of data points served as the basic input for the questions' design and as the general structure of the three draft questionnaires. The questionnaires are intended to provide the main methodological instrument for data collection from both the consumer and business stakeholder perspectives within the project.

Consumer survey

The objective of the consumer survey was to collect data that feeds into indicators describing the state of play for residential renovations. The consumer survey was conducted using a computer assisted web interview (CAWI) methodology in all 28 EU Member States. As internet penetration has progressed in all EU Member States, online surveys are seen as a robust way to conduct surveys among the general public. The main fieldwork launched on 16 August 2018 and continued without interruption until 28 September 2018.

Target group, sampling and weighting approach

The target group of the consumer survey is consumers with knowledge/experience with renovation, or energy renovators. Because of the specific nature of this target group, a slightly different approach to questionnaire design and data collection compared to a standard multi-country survey was needed. Concretely, a two-tier approach was used to identify the relevant target group.

The first tier (Part 1) of the survey served as a respondent "recruitment" or "screening" tool, identifying relevant consumers who have experience with energy renovations. As such, it measured the incidence of renovations in each EU Member State. The screener also covered household composition, region, type of renovation done and the overall costs of the renovations, which will allow clustering the results into market segments, based on these indicators.

Using a random sampling approach, a representative sample per country was invited to participate in the survey. All respondents had to fill in the first part of the questionnaire (screener) and were screened based on energy renovations.

The second tier (Part 2) of the survey focused only on consumers who have engaged in energy-related renovation during 2012-2016. This was the main instrument used to gather the relevant data needed for analysis which will segment renovation based on a pre-defined set of criteria (e.g. the depth of renovation, materials used, costs and benefits, drivers and motivation etc.). Only respondents who qualified to take part in this survey based on their answers to questions in Part 1 were allowed to answer Part 2.

Table 9 below summarises the number of interviews achieved per country and compares them with the number of completes including and excluding the screen-outs, as well as the resulting incidence rates. The table shows that a total of 18,302 respondents completed the questionnaire and that the targets have been achieved in all countries.

Table 9: Overview of the achieved sample of the Consumer Survey

Country	# total interviews (incl. screen-outs)	# completed interviews	Incidence rate	Target sample
Austria	974	560	57.5%	500
Belgium	969	560	57.8%	500
Bulgaria	743	621	83.6%	500

Croatia	521	360	69.1%	300
Cyprus	1267	211	16.7%	200
Czech Republic	721	540	74.9%	500
Denmark	1023	546	53.4%	500
Estonia	514	329	64.0%	300
Finland	1153	559	48.5%	500
France	1802	1051	58.3%	1000
Germany	2141	1058	49.4%	1000
Greece	762	564	74.0%	500
Hungary	677	509	75.2%	500
Ireland	562	351	62.5%	300
Italy	1598	1148	71.8%	1000
Latvia	491	348	70.9%	300
Lithuania	535	344	64.3%	300
Luxembourg	269	150	55.8%	100
Malta	268	212	79.1%	200
Netherlands	1899	1022	53.8%	1000
Poland	1319	1008	76.4%	1000
Portugal	1766	1020	57.8%	1000
Romania	1337	1161	86.8%	1000
Slovakia	686	540	78.7%	500
Slovenia	474	379	80.0%	300
Spain	1757	1100	62.6%	1000
Sweden	2236	1015	45.4%	1000
United Kingdom	1654	1036	62.6%	1000
Total	30,118	18,302	60.8%	16,800

The overall sample (Tier 1) was weighted to be representative on household composition. Due to the nature of the survey, household composition is a more relevant indicator compared to gender and age of the overall sample. As such, all Tier 1 respondents were weighted representative on household composition (see Table 10 below) and not age and gender as suggested in the tender. Concretely this means that in Tier 1 of the survey, the household composition of all Tier 1 respondents was measured rather than age and gender. The household composition of the survey respondents was then compared with the target based on Eurostat and a weighting factor was calculated to adjust the reached sample to be equal to this target. For example, in Austria, 3% of the population consists of single adults with children (the ‘target’), while this was the case for 4.8% of the Austrian Tier 1 respondents (the ‘unweighted sample’). A weighting factor is then applied to correct this imbalance and to ‘downweight’ this proportion from 4.8% of the sample to 3% of the sample (the ‘weighted sample’).

By adopting this weighting approach, the results illustrate the ratio of household compositions that have conducted energy renovations, which is more relevant compared to the renovation rate divided over age and gender (of course, general information on the age and gender of the respondents is available for the Tier 2 sample).

Table 10: Household composition: target sample vs. reached sample (unweighted) vs. reached sample (weighted)

	Single adult with children			Single adult without children			Couple with children			Couple without children			Other type of household with children			Other type of household without children		
	TARGET	REACHED (unweighted)	REACHED (weighted)	TARGET	REACHED (unweighted)	REACHED (weighted)	TARGET	REACHED (unweighted)	REACHED (weighted)	TARGET	REACHED (unweighted)	REACHED (weighted)	TARGET	REACHED (unweighted)	REACHED (weighted)	TARGET	REACHED (unweighted)	REACHED (weighted)
Austria	3.0%	4.8%	3.0%	37.0%	22.5%	37.0%	17.6%	27.2%	17.6%	23.9%	32.0%	23.9%	5.3%	3.7%	5.3%	13.2%	9.8%	13.2%
Belgium	3.9%	10.7%	3.9%	32.0%	23.5%	32.0%	22.1%	34.8%	22.1%	25.6%	25.2%	25.6%	4.7%	1.8%	4.7%	11.7%	4.0%	11.7%
Bulgaria	2.6%	6.1%	2.6%	37.4%	11.4%	37.4%	14.5%	42.3%	14.5%	20.7%	18.2%	20.7%	7.6%	8.6%	7.6%	17.2%	13.5%	17.2%
Croatia	1.9%	7.1%	1.9%	23.3%	12.3%	23.3%	19.1%	43.6%	19.1%	17.8%	16.1%	17.8%	13.0%	10.4%	13.0%	24.9%	10.6%	24.9%
Cyprus	4.3%	3.6%	4.3%	23.5%	19.4%	23.5%	24.9%	53.7%	24.9%	21.9%	16.0%	21.9%	7.6%	4.5%	7.6%	17.9%	2.8%	17.9%
Czech Republic	4.6%	5.8%	4.6%	30.8%	14.6%	30.8%	22.3%	38.0%	22.3%	27.6%	27.3%	27.6%	4.1%	6.2%	4.1%	10.6%	8.0%	10.6%
Denmark	8.6%	9.7%	8.6%	44.4%	25.1%	44.4%	18.7%	30.1%	18.7%	24.1%	28.9%	24.1%	1.7%	2.2%	1.7%	2.4%	4.0%	2.4%
Estonia	6.6%	8.6%	6.6%	39.9%	19.6%	39.9%	20.3%	38.7%	20.3%	20.2%	23.9%	20.2%	3.9%	2.7%	3.9%	9.0%	6.4%	9.0%
Finland	1.8%	7.6%	1.8%	41.3%	29.8%	41.3%	18.2%	26.8%	18.2%	31.8%	28.9%	31.8%	1.9%	1.1%	1.9%	5.0%	5.7%	5.0%
France	6.0%	7.5%	6.0%	35.1%	26.4%	35.1%	21.2%	34.6%	21.2%	26.2%	27.5%	26.2%	3.8%	1.3%	3.8%	7.7%	2.6%	7.7%
Germany	3.6%	4.4%	3.6%	41.2%	28.0%	41.2%	15.7%	25.0%	15.7%	28.4%	33.9%	28.4%	2.9%	2.1%	2.9%	8.1%	6.7%	8.1%
Greece	2.3%	3.5%	2.3%	31.0%	25.2%	31.0%	21.9%	44.4%	21.9%	25.2%	16.0%	25.2%	4.0%	5.8%	4.0%	15.7%	5.1%	15.7%
Hungary	3.8%	8.9%	3.8%	32.5%	18.8%	32.5%	18.4%	28.7%	18.4%	23.0%	16.0%	23.0%	6.7%	10.9%	6.7%	15.6%	16.8%	15.6%
Ireland	6.3%	7.5%	6.3%	24.4%	18.0%	24.4%	27.3%	42.5%	27.3%	20.7%	23.0%	20.7%	6.7%	2.8%	6.7%	14.7%	6.2%	14.7%
Italy	2.8%	6.9%	2.8%	33.1%	19.7%	33.1%	20.9%	46.5%	20.9%	20.7%	19.0%	20.7%	5.9%	4.3%	5.9%	16.5%	3.6%	16.5%

Latvia	6.0%	9.0%	6.0%	35.4%	17.3%	35.4%	15.7%	42.0%	15.7%	18.4%	17.1%	18.4%	8.0%	6.7%	8.0%	16.5%	7.9%	16.5%
Lithuania	7.2%	4.3%	7.2%	42.5%	16.8%	42.5%	14.3%	37.9%	14.3%	16.6%	28.2%	16.6%	6.3%	3.6%	6.3%	13.1%	9.2%	13.1%
Luxembourg	3.7%	5.9%	3.7%	35.3%	14.1%	35.3%	23.7%	49.8%	23.7%	22.6%	22.3%	22.6%	5.6%	2.2%	5.6%	9.1%	5.6%	9.1%
Malta	3.1%	5.6%	3.1%	19.7%	10.4%	19.7%	21.6%	51.1%	21.6%	21.9%	22.8%	31.1%	9.7%	0.4%	0.5%	24.0%	9.7%	24.0%
Netherlands	4.2%	7.1%	4.2%	37.5%	14.6%	37.5%	20.9%	31.1%	20.9%	29.0%	29.3%	29.0%	2.8%	3.4%	2.8%	5.6%	14.5%	5.6%
Poland	3.6%	7.4%	3.6%	23.5%	12.7%	23.5%	24.3%	44.0%	24.3%	23.8%	23.7%	23.8%	9.5%	4.3%	9.5%	15.3%	7.9%	15.3%
Portugal	4.5%	9.6%	4.5%	22.1%	20.6%	22.1%	23.0%	43.4%	23.0%	23.9%	12.2%	23.9%	7.4%	7.6%	7.4%	19.1%	6.6%	19.1%
Romania	2.5%	6.3%	2.5%	27.9%	12.7%	27.9%	20.3%	46.1%	20.3%	20.5%	23.3%	20.5%	12.1%	5.2%	12.1%	16.8%	6.4%	16.8%
Slovakia	2.9%	5.5%	2.9%	22.5%	7.7%	22.5%	21.5%	43.3%	21.5%	22.0%	18.5%	22.0%	12.0%	10.8%	12.0%	19.1%	14.1%	19.1%
Slovenia	3.4%	11.6%	3.4%	32.8%	8.9%	32.8%	22.2%	33.5%	22.2%	21.5%	19.8%	21.5%	5.3%	8.0%	5.3%	14.8%	18.1%	14.8%
Spain	3.4%	5.5%	3.4%	25.6%	17.3%	25.6%	23.1%	47.9%	23.1%	21.8%	20.3%	21.8%	7.2%	4.7%	7.2%	19.0%	4.3%	19.0%
Sweden	6.4%	7.5%	6.4%	51.4%	28.5%	51.3%	18.9%	26.3%	18.9%	19.4%	29.1%	19.4%	1.6%	2.9%	1.6%	2.4%	5.6%	2.4%
United Kingdom	6.6%	11.7%	6.6%	31.1%	23.6%	31.1%	19.6%	30.7%	19.6%	27.0%	27.4%	27.0%	4.4%	2.1%	4.4%	11.3%	4.5%	11.3%

Using the two-tier approach, a screener identified the energy-renovators. The screener collects the most important information needed to select energy renovators and the ratio of energy renovation within a country.

To define consumers as energy renovators and non-(energy) renovators the correct way, question A5[8] was developed. From this question, we were able to identify energy renovators, the type of renovations done and the year the renovation was completed (2012-2016).

Respondents that have done any of the following energy renovations (option 1 – 16) between 2012 and 2016 are considered energy renovators. It needs to be noted, however, that new lighting installations (lamps) (option 16) were only counted as energy-related renovations when combined with other energy-renovations.

Table 11: Types of energy and non-energy renovations included in question A5

Energy renovations	Non-energy renovations
1. Replacement of windows 2. Replacement of the/a building entrance door 3. Installation of thermal insulation on the facade (incl. cavity wall insulation) 4. Installation of thermal insulation of the roof 5. Installation of thermal insulation on the ground plate (floors) 6. Installation of thermal insulation inside basements 7. Installation of thermal insulation on the attic's floor 8. Replacement or first-time installation of a space heat generator 9. Replacement or first-time installation of a water heater (incl. solar thermal collector on the roof)	17. Facade renovation without applying insulation (e.g. just new plaster and/or painting) 18. Roof renovation without applying insulation (e.g. new wood construction, roof tiles or other roof sealing as e.g. bitumen) 19. Building extensions without applying insulation (e.g. extension of the living room or adding a new bedroom or transforming attic into living space) 20. Electric installations (incl. replacement of switches and sockets) 21. Interior wall painting and plastering 22. Interior flooring (incl. baseboards) 23. Renovation of the bathroom or toilet 24. Renovation of the kitchen 25. Wallpapering 26. Grinding & painting doors or window

8 In the timeframe 2012-2016, were one of the following renovations/installations completed for the residential building you rent out or your residence? Please consider all renovations done, including renovations/installations done by yourself, professionals, your landlord, etc. (You can tick multiple renovations).

Always tick the year, in which the renovation/installation was completed (2012 – 2016). Example; you started replacing your windows end of December 2013 and the renovation was completed in January 2014, please only tick 2014.

(The answer options are presented in the table above)

10. Replacement or first-time installation of a radiator 11. Replacement or first-time installation of a floor heating system 12. Replacement or first-time installation of a mechanical ventilation system 13. Replacement or first-time installation of a space cooling system (air-conditioner) 14. Installation of a photovoltaic system (solar modules for electricity generation on the roof) 15. (Automatic) shading system for windows to avoid overheating in summer 16. New lighting installations (lamps)	frames 27. Renovation of stairs 28. Dry-wall or ceiling constructions 29. Renovation or replacement of elevator
30. I built my house recently and don't need to do energy renovations	

The following table shows the proportion of the respondents in Tier 1 (weighted on household composition) that have performed energy renovations, non-energy renovations and no renovations in the period between 2012 and 2016.

The results in Table 12 show that that the incidence rate of energy renovations is relatively high (above 40%) in all countries, with the exception of Cyprus, where only 13.1% of the respondents performed energy renovations. Particularly high incidence rates are noticed in Romania (85.1%) and in Bulgaria (82.3%).

Table 12: Overview of the incidence for energy renovations, only non-energy renovations and no renovations

	ALL YEARS (2012 – 2016)		
Country	Energy Renovations (2012 - 2016)	Only non-energy Renovations (2012 - 2016)	No renovations (2012 - 2016)
Total	59.8%	19.1%	21.1%
Austria	55.2%	25.1%	19.7%
Belgium	55.3%	20.7%	24.0%
Bulgaria	82.3%	9.8%	7.9%
Croatia	65.4%	20.9%	13.7%
Cyprus	13.1%	36.8%	50.1%
Czech Republic	73.4%	13.4%	13.2%

Denmark	49.7%	24.1%	26.2%
Estonia	64.6%	19.8%	15.6%
Finland	46.6%	23.6%	29.8%
France	55.6%	18.6%	25.8%
Germany	47.1%	23.9%	29.0%
Greece	70.8%	17.3%	11.9%
Hungary	74.2%	14.5%	11.3%
Ireland	60.7%	26.4%	12.9%
Italy	68.1%	16.3%	15.6%
Latvia	67.7%	18.8%	13.5%
Lithuania	61.5%	19.0%	19.5%
Luxembourg	52.9%	24.5%	22.6%
Malta	76.4%	17.4%	6.2%
Netherlands	51.3%	21.5%	27.2%
Poland	74.4%	13.9%	11.7%
Portugal	55.7%	28.9%	15.4%
Romania	85.1%	7.4%	7.5%
Slovakia	75.3%	12.5%	12.2%
Slovenia	77.0%	13.0%	10.0%
Spain	58.4%	18.8%	22.8%
Sweden	42.4%	26.7%	30.9%
United Kingdom	60.7%	18.8%	20.5%

Sample description

As explained above, the target respondent of the consumer survey is those who are energy renovator. The following three large groups of energy renovators are defined:

1. **Owners**
   Tier 2 respondents who own the residence they live in, with no other residential property that is rented out to individuals. Owners will have done the renovations themselves or will have commissioned the renovations.

2. **Tenants**
   Tier 2 respondents who rent the residence they live in, with no other residential property that is rented out to individuals. We identify two types of energy renovations for tenants:

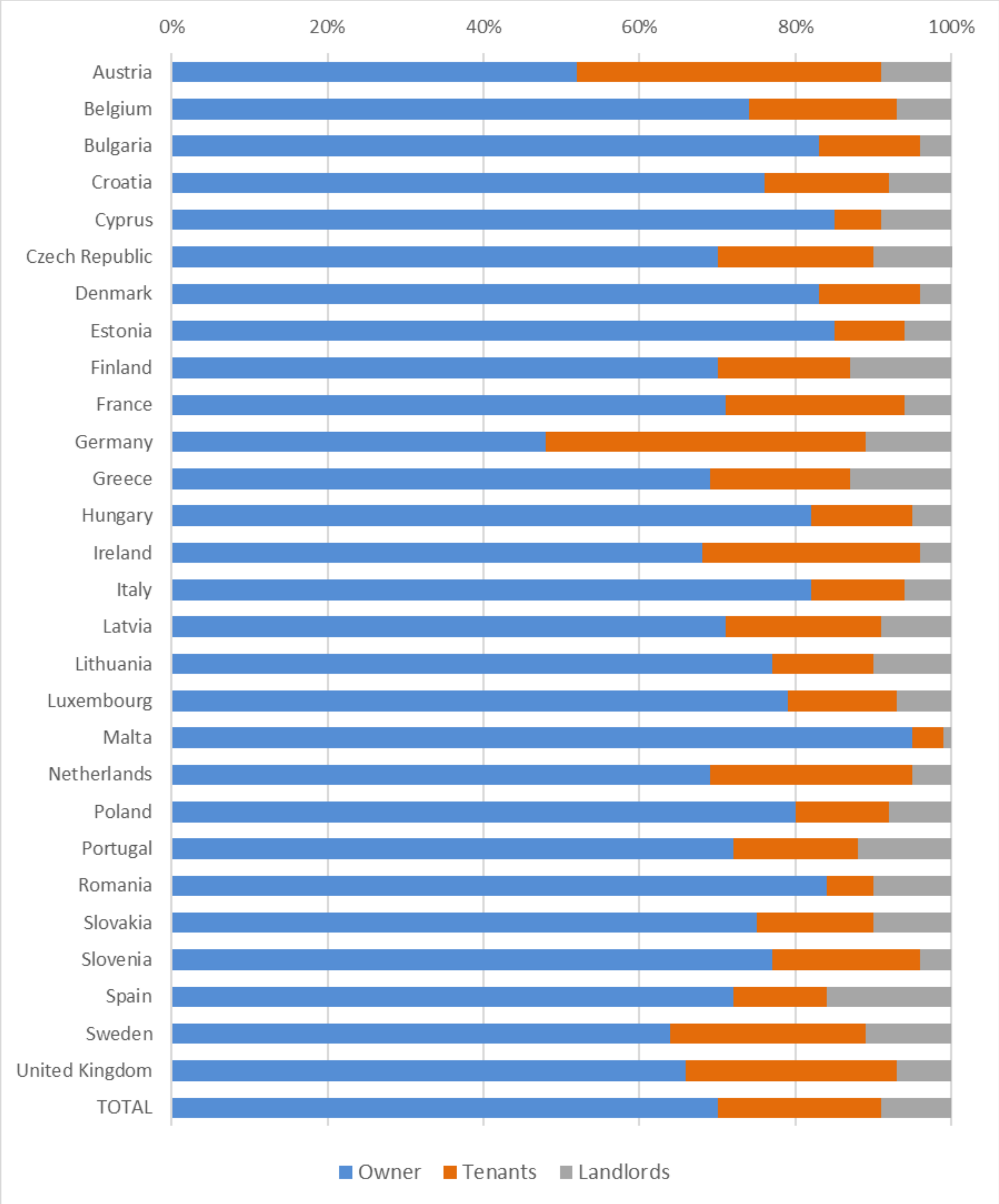
   1. Energy renovations done by or commissioned by the tenants themselves;

   2. Energy renovations done by or commissioned by the landlord.

3. **Landlords**
   Tier 2 respondents who rent out residential dwellings.

The figure below (Figure 9) shows the (weighted) distribution of respondents across owners, tenants and landlords. Most respondents currently own the residence (house, apartment, etc.) they live in, a trend that is consistent across all countries. This is followed by respondents that currently rent their residence. Landlords of a residential building (or units) or dwelling that they rent out to others represent only a relatively small share of the respondents of the consumer survey.

Figure 9: Distribution of sample across owners, tenants and landlords



Apart from the distribution of energy renovators in owners, tenants and landlords, additional questions were included in the questionnaire in order to further break down the Tier 2 data. A description of the sample across these breakdowns is presented for each question in the tables below.

a) Gender

Table 13: Overview of Tier 2 sample by gender

	Male	Female
Total	50%	50%
Austria	54%	46%
Belgium	57%	43%
Bulgaria	50%	50%
Croatia	33%	67%
Cyprus	52%	48%
Czech Republic	52%	48%
Denmark	51%	49%
Estonia	45%	55%
Finland	53%	47%
France	48%	52%
Germany	51%	49%
Greece	52%	48%
Hungary	52%	48%
Ireland	44%	56%
Italy	46%	54%
Latvia	49%	51%
Lithuania	45%	55%
Luxembourg	57%	43%
Malta	55%	45%
Netherlands	56%	44%
Poland	53%	47%
Portugal	47%	53%
Romania	52%	48%
Slovakia	56%	44%
Slovenia	53%	47%

Spain	49%	51%
Sweden	52%	48%
United Kingdom	52%	48%

b) Age

Table 14: Overview of Tier 2 sample by age categories

	18-34 years	35-54 years	55 or older
Total	31.6%	35.6%	32.8%
Austria	32.4%	36.6%	31.0%
Belgium	28.2%	33.5%	38.3%
Bulgaria	30.5%	35.2%	34.3%
Croatia	53.3%	32.7%	13.9%
Cyprus	33.0%	37.0%	30.0%
Czech Republic	23.5%	38.4%	38.1%
Denmark	24.8%	38.5%	36.7%
Estonia	30.2%	31.6%	38.2%
Finland	28.2%	37.4%	34.5%
France	28.0%	33.5%	38.5%
Germany	25.4%	34.7%	39.9%
Greece	35.1%	46.7%	18.2%
Hungary	24.9%	36.9%	38.3%
Ireland	29.2%	42.4%	28.4%
Italy	36.4%	37.7%	25.9%
Latvia	38.2%	30.6%	31.3%
Lithuania	42.6%	27.2%	30.2%
Luxembourg	29.2%	41.7%	29.1%
Malta	39.2%	35.0%	25.8%
Netherlands	24.8%	35.0%	40.1%

Poland	33.9%	35.3%	30.7%
Portugal	38.1%	39.3%	22.6%
Romania	44.7%	37.8%	17.5%
Slovakia	37.3%	41.4%	21.3%
Slovenia	29.8%	44.2%	26.0%
Spain	31.3%	40.0%	28.7%
Sweden	27.6%	34.7%	37.7%
United Kingdom	33.1%	29.7%	37.2%

c) Household composition

Table 15: Overview of Tier 2 sample by household composition

	Single adult with children	Single adult without children	Couple with children	Couple without children	Other type of household with children	Other type of household without children
Total	4.2%	29.7%	23.9%	24.9%	5.7%	11.7%
Austria	2.3%	30.6%	21.4%	25.4%	6.7%	13.6%
Belgium	3.7%	26.1%	26.8%	28.1%	5.0%	10.3%
Bulgaria	2.3%	36.9%	15.3%	20.9%	7.9%	16.7%
Croatia	2.1%	22.3%	22.3%	16.2%	12.9%	24.2%
Cyprus	5.1%	24.8%	39.6%	14.8%	8.1%	7.6%
Czech Republic	4.2%	29.2%	23.7%	29.2%	4.2%	9.5%
Denmark	10.5%	36.6%	24.8%	23.3%	2.2%	2.6%
Estonia	5.3%	39.8%	19.7%	21.1%	5.2%	8.9%
Finland	1.8%	35.8%	23.7%	31.6%	2.2%	4.9%
France	5.0%	30.4%	27.8%	25.2%	4.8%	6.8%
Germany	4.1%	34.5%	19.2%	31.3%	2.5%	8.3%
Greece	2.6%	28.2%	24.9%	27.7%	3.5%	13.1%
Hungary	3.4%	30.7%	19.8%	23.0%	7.1%	16.0%

Ireland	6.4%	26.2%	29.9%	19.5%	5.5%	12.4%
Italy	2.8%	33.8%	23.5%	21.0%	5.4%	13.4%
Latvia	6.4%	33.2%	17.3%	19.4%	8.6%	15.0%
Lithuania	8.6%	38.4%	16.0%	16.8%	7.5%	12.6%
Luxembourg	5.2%	28.1%	25.4%	22.8%	7.1%	11.5%
Malta	3.2%	18.4%	23.5%	30.0%	0.7%	24.2%
Netherlands	4.1%	30.1%	26.5%	31.6%	3.6%	4.1%
Poland	3.7%	20.8%	26.7%	23.0%	10.1%	15.8%
Portugal	4.1%	22.8%	25.9%	20.9%	7.6%	18.8%
Romania	2.5%	26.6%	21.0%	21.2%	12.4%	16.3%
Slovakia	2.9%	18.0%	23.3%	22.8%	14.2%	18.8%
Slovenia	3.9%	30.4%	23.0%	20.5%	5.3%	17.0%
Spain	3.6%	25.9%	27.4%	20.7%	6.1%	16.3%
Sweden	6.0%	43.7%	25.8%	19.4%	2.6%	2.6%
United Kingdom	6.7%	27.4%	23.7%	26.4%	4.7%	11.2%

d) Household income

Table 16: Overview of Tier 2 sample by household income

	Lowest income group	Lower middle income group	Upper middle income group	Highest income group
Total	23.3%	26.8%	28.7%	21.1%
Austria	16.1%	29.0%	29.4%	25.5%
Belgium	15.2%	31.0%	30.1%	23.7%
Bulgaria	48.0%	31.7%	15.1%	5.3%
Croatia	34.0%	33.2%	25.4%	7.5%
Cyprus	12.0%	35.8%	25.4%	26.8%
Czech Republic	30.2%	30.5%	30.8%	8.5%

Denmark	28.9%	20.0%	20.4%	30.7%
Estonia	27.4%	37.4%	26.6%	8.6%
Finland	22.6%	24.4%	24.7%	28.3%
France	14.9%	23.6%	31.4%	30.1%
Germany	15.2%	23.1%	32.8%	29.0%
Greece	38.1%	33.4%	21.5%	7.0%
Hungary	49.3%	31.4%	15.8%	3.5%
Ireland	24.1%	24.3%	24.7%	27.0%
Italy	20.3%	29.3%	31.5%	19.0%
Latvia	45.3%	30.9%	18.2%	5.6%
Lithuania	50.4%	30.4%	13.0%	6.2%
Luxembourg	2.8%	7.2%	22.8%	67.1%
Malta	10.2%	24.5%	29.6%	35.7%
Netherlands	18.1%	24.8%	34.4%	22.6%
Poland	23.7%	30.9%	32.4%	13.0%
Portugal	24.5%	35.2%	27.9%	12.5%
Romania	37.6%	32.0%	19.5%	10.9%
Slovakia	21.1%	41.9%	26.7%	10.3%
Slovenia	39.0%	36.2%	16.1%	8.7%
Spain	19.8%	27.3%	30.9%	22.1%
Sweden	30.9%	20.6%	23.7%	24.8%
United Kingdom	27.2%	21.7%	26.3%	24.9%

e) Tenure status

Table 17: Overview of Tier 2 sample by tenure status

	Outright owner	Owner paying mortgage	Tenant or subtenant paying rent at prevailing or market rate	Accommodation is rented at a reduced rate (lower price that the market price)	Accommodation is provided free
Total	52.9%	25.7%	14.3%	5.5%	1.5%
Austria	38.5%	22.2%	25.8%	11.9%	1.6%
Belgium	43.1%	37.9%	12.0%	6.3%	0.8%
Bulgaria	78.3%	8.8%	6.0%	3.8%	3.0%
Croatia	64.8%	19.5%	5.5%	3.7%	6.5%
Cyprus	64.5%	29.4%	0.3%	5.8%	0.0%
Czech Republic	52.4%	28.1%	12.0%	6.3%	1.2%
Denmark	23.6%	44.2%	22.6%	8.1%	1.4%
Estonia	69.7%	21.3%	4.6%	3.4%	1.0%
Finland	42.5%	40.8%	11.8%	3.5%	1.3%
France	46.0%	31.3%	16.4%	4.6%	1.6%
Germany	40.2%	19.1%	28.1%	11.7%	0.9%
Greece	63.5%	18.9%	11.9%	4.2%	1.5%
Hungary	68.7%	18.0%	5.4%	4.5%	3.4%
Ireland	43.6%	28.3%	14.4%	12.6%	1.0%
Italy	68.4%	20.0%	8.3%	2.0%	1.4%
Latvia	68.2%	11.7%	8.5%	6.7%	4.9%
Lithuania	69.2%	17.4%	6.6%	4.0%	2.8%
Luxembourg	44.2%	41.8%	6.0%	3.7%	4.4%
Malta	63.1%	33.0%	1.8%	1.1%	0.9%
Netherlands	19.5%	54.4%	20.0%	5.4%	0.7%
Poland	69.4%	18.4%	6.5%	3.6%	2.2%
Portugal	43.7%	40.8%	10.4%	4.7%	0.4%
Romania	80.4%	13.9%	2.8%	1.2%	1.8%

Slovakia	56.9%	27.7%	8.4%	3.7%	3.2%
Slovenia	71.0%	9.7%	9.7%	6.9%	2.7%
Spain	55.6%	31.9%	8.1%	3.8%	0.5%
Sweden	28.5%	46.4%	19.8%	4.7%	0.6%
United Kingdom	42.9%	29.8%	19.0%	6.6%	1.7%

f) Type of residence

Table 18: Overview of Tier 2 sample by type of residence

	Detached building with 1 or 2 dwellings	Semi - detached building with 1 or 2 dwellings	Attached building (row house) with 1 or 2 dwellings	Apartment building with 3-6 dwelling units	Apartment building with 7 – 12 dwelling units	Apartment building with 13 or more dwelling units
Total	34.8%	11.8%	9.6%	11.8%	11.6%	20.4%
Austria	38.0%	5.2%	6.4%	12.3%	17.3%	20.8%
Belgium	35.7%	22.9%	23.8%	9.0%	3.4%	5.1%
Bulgaria	24.7%	1.7%	0.5%	6.1%	12.4%	54.5%
Croatia	48.1%	6.6%	5.4%	9.4%	10.5%	20.0%
Cyprus	56.5%	15.9%	8.5%	8.3%	6.9%	3.9%
Czech Republic	29.3%	5.9%	6.2%	8.6%	13.7%	36.1%
Denmark	49.9%	9.2%	14.2%	7.6%	6.3%	12.8%
Estonia	31.6%	2.7%	2.5%	6.7%	9.8%	46.7%
Finland	42.3%	5.4%	12.8%	5.4%	6.7%	27.4%
France	50.0%	6.3%	9.4%	8.3%	10.2%	16.0%
Germany	37.1%	11.6%	7.8%	20.8%	13.4%	9.3%
Greece	28.8%	6.1%	4.0%	22.8%	21.0%	17.3%
Hungary	53.6%	3.0%	1.6%	4.8%	9.1%	27.8%
Ireland	43.4%	31.9%	13.6%	5.1%	2.1%	3.8%
Italy	33.1%	8.8%	7.0%	17.0%	16.7%	17.4%

Latvia	29.9%	0.9%	1.5%	7.1%	4.7%	55.9%
Lithuania	27.2%	1.3%	1.0%	3.4%	6.3%	60.8%
Luxembourg	49.5%	15.9%	15.6%	5.9%	7.8%	5.3%
Malta	8.6%	16.9%	42.2%	21.5%	8.7%	2.1%
Netherlands	20.6%	24.3%	33.1%	8.4%	2.8%	10.8%
Poland	36.7%	4.5%	3.4%	6.6%	12.5%	36.2%
Portugal	33.0%	6.4%	5.7%	15.2%	20.7%	19.0%
Romania	35.6%	5.2%	3.3%	4.1%	10.2%	41.6%
Slovakia	38.9%	4.6%	2.7%	7.6%	10.8%	35.3%
Slovenia	60.9%	2.9%	3.1%	3.6%	9.8%	19.7%
Spain	17.1%	5.0%	7.5%	14.3%	19.8%	36.2%
Sweden	46.8%	4.9%	7.6%	8.8%	8.9%	22.9%
United Kingdom	27.9%	35.7%	20.7%	8.7%	2.4%	4.6%

g) Legal status landlord

Table 19: Overview of Tier 2 sample by legal status of the landlord

	Housing association providing low-cost (social) housing	Housing association providing housing at market price	Local authority or government department	Private landlord (including family members)
Total	17.0%	17.5%	11.3%	54.3%
Austria	20.4%	25.0%	9.2%	45.4%
Belgium	21.8%	14.1%	7.1%	57.0%
Bulgaria	2.8%	15.0%	3.4%	78.9%
Croatia	6.1%	8.2%	10.2%	75.5%
Cyprus	12.0%	0.0%	4.6%	83.4%
Czech Republic	10.1%	25.4%	13.7%	50.8%
Denmark	31.2%	42.1%	2.2%	24.4%

Estonia	4.9%	31.6%	15.3%	48.3%
Finland	29.6%	20.7%	4.5%	45.2%
France	20.8%	15.7%	11.7%	51.8%
Germany	12.1%	23.3%	5.3%	59.3%
Greece	0.6%	0.9%	3.5%	95.0%
Hungary	8.8%	6.3%	14.4%	70.5%
Ireland	11.9%	9.3%	11.6%	67.2%
Italy	9.6%	2.4%	12.4%	75.6%
Latvia	14.0%	6.8%	30.5%	48.7%
Lithuania	25.7%	5.4%	0.0%	68.9%
Luxembourg	0.0%	2.4%	0.0%	97.6%
Malta	0.0%	0.0%	5.3%	94.7%
Netherlands	56.4%	21.8%	6.3%	15.5%
Poland	11.8%	23.6%	22.6%	42.0%
Portugal	3.7%	15.9%	3.5%	76.9%
Romania	8.7%	7.9%	7.1%	76.2%
Slovakia	8.0%	27.7%	7.1%	57.2%
Slovenia	17.5%	4.3%	15.9%	62.3%
Spain	5.0%	15.8%	6.9%	72.2%
Sweden	3.1%	18.6%	27.8%	50.5%
United Kingdom	26.3%	12.6%	21.3%	39.8%

Architects survey

The architect survey was also conducted online (CAWI) and focused both on residential and non-residential renovation projects and NZEB, thus complementing the results of the consumer survey.

As an EU-wide panel of architects is not available surveying this target group within other available sources (e.g. consumer panels) would not have been efficient. The survey was therefore carried out via the European Architects Council (ACE) who distributed the questionnaire to its national member organisations.

The ACE was contacted at an early stage by Ipsos and expressed its willingness to fully collaborate in the survey execution. Besides, the ACE shared with Ipsos their last published Sector Study, a biennial survey that collects and analyses statistical, sociological and economic data on the European Architects, the architectural market and the architectural practices. Based on responses from 27.000 Architects in 27 European countries, the 2016 Study is reportedly the most comprehensive on the architectural profession in Europe. The Study allows to draw comparisons between the European countries and helps to better understand the national situations. The ACE also contributed questions to the draft questionnaire.

Based on the number of members in each country and the sample size of past ACE surveys, a sample size of n = 5,000 architects was estimated. The original strategy relied on the participation of the ACE's member organisations as well as the personal willingness of the architects to participate. Therefore, while all reasonable efforts are made to achieve this sample size, the data collection was performed on best effort.

Taking the above into account, as agreed with the European Commission, the following response enhancement measures have been undertaken to maximise the response:

- An official letter of intent was provided to respondents, which clearly outlines the objectives of the study and serves to motivate participation in order to achieve a higher response rate;
- A dedicated email address and mailbox were set up to which respondents could send enquiries or request (technical) support if necessary;
- Reminders were sent out throughout the fieldwork period

The survey was launched on 28 August 2018. On that date, the e-mail invitations and background information were shared with the ACE, which in turn shared it with its member organisations. Throughout the fieldwork period, several additional initiatives were undertaken to further boost the response:

- Based on a discussion with Ipsos, the ACE sent reminder e-mails to its network;
- Ipsos took the initiative to directly contact the ACE (national) network members;
- The survey invitation was further disseminated via social media (LinkedIn and Twitter);
- Through web-scraping and manual desk research, an additional 12,411 unique e-mail addresses were collected based on publicly available information. Ipsos sent out the invitation e-mails to these addresses as well as reminder e-mails at a later stage.
- Ipsos contacted multiple architect associations and related organisations, to aid in promoting the survey.
- Additional data was collected through an external panel and additional contact details were purchased. E-mail invitations were sent out to all these contacts.
- Target group, sampling and weighting approach

The respondents who were reached through the ACE member organisations consist of independent architects (e.g., those who are self-employed) as well as architects working in an architect firm.

When an independent architect is reached, this person was asked to fill in the questionnaire. In case the survey reached an architect firm, the aim was to survey the individual who has the best overview of the types of projects that the company works on, as well as the specific technical measures taken in recent projects. The following types of positions are targeted within architect firms:

- Managing director or top-level manager
- Team manager or top-level project manager
- Project manager of several projects

In addition, the survey aimed to reach architects and architect firms that have performed renovations during the period 2012-2016. These renovations may be performed on residential and/or non-residential buildings. Architects who did not perform any renovations between 2012 and 2016 were screened out. Table 20 below provides an overview of the number of interviews achieved per country.

Table 20: Overview of the achieved sample for the Architects survey

Country	# completed interviews
Austria	8
Belgium	61
Bulgaria	28
Croatia	53
Cyprus	34
Czech Republic	35
Denmark	5
Estonia	13
Finland	2
France	147
Germany	378
Greece	53
Hungary	5
Ireland	17
Italy	210
Latvia	23
Lithuania	16
Luxembourg	2

Malta	12
Netherlands	41
Poland	3
Portugal	19
Romania	82
Slovakia	15
Slovenia	13
Spain	155
Sweden	12
United Kingdom	139
Total	1,581

A large section of the survey consisted of technical questions on a reference project. The reference project is intended as the architect's last project of a particular type in the reference period.

Architects who worked on non-residential buildings provided information on a non-residential reference project (Section A in the questionnaire), whereas architects who worked only on residential buildings, received questions on a residential reference project (Section B). This approach allowed maximizing the information collected on non-residential projects, which is not collected through the consumer survey.

The specific type of building for which the respondent provided information (e.g., office or educational building) was assigned based on a least-filled basis. It implies that the respondents answer questions on their most recent renovation of specific buildings for which the number of responses is the lowest. An overview of the categorisation is provided in Table 21 below.

Table 21: Categorisation of reference project

Non-residential reference project	Residential reference project
If any of the following options were selected, the architect received questions on a non-residential project: Office Educational building Hospital Hotel or restaurant Sports facilities Wholesale or retail buildings Other non-residential buildings	If either of the following residential options were selected (and neither of the non-residential), the architect received questions on a residential project: Single family house Multi-family house (apartment block)

Further filtering was applied in Section F of the questionnaire. In this section, the drivers, barriers and incentives were measured both from the perspective of the respondent (architect's perspective) as well as from the perspective of the respondent's client (client's perspective). The latter implies that the architects estimated which drivers, barriers and incentives played a role in their client's decisions on energy-related renovation. The respondents were randomly assigned to either block of questions, ensuring that 25 percent of the architects received the questions from the architect perspective and 75 percent received questions from the client's perspective.

The overall sample was weighted to be representative of the total building stock on EU28-level. As such, each country was given a weight which represents the proportion of that country in the total EU28 building stock (which includes both residential & non-residential buildings).

As part of the analysis of the architect survey focusses solely on non-residential buildings, a second weighting scheme was constructed which weights the responses to be representative of the total non-residential building stock.

Description of the sample

Table 22 below provides an overview of the sample broken down across three key variables: type of renovation project, type of architect and type of client. Due to the low sample size in several countries, only an overall breakdown is provided.

Table 22: Description of Architects survey sample across three key variables

Type of renovation projects (all respondents)		Type of architect (all respondents)[9]		Type of clients (non-residential renovation only)	
Residential	Non-residential	Independent architect	Part of an architect firm	Mainly private clients	Mainly public clients
24%	76%	69.4%	36.4%	75.7%	24.3%

Construction companies survey

The goal of this third survey was to understand the demand and supply chain as well as the quality of the works related to energy-efficiency and NZEB. The survey was carried out via Computer-Assisted Telephone Interviewing (CATI) in all 28 EU Member States. Similar to the architect survey, this survey also focused on both residential and non-residential renovation projects and NZEB.

Since the survey with construction companies used CATI methodology, it was of particular importance to be able to obtain contact details of companies within the scope of the study. Therefore, the Dun & Bradstreet (D&B) company database was used. The D&B company database provides the highest coverage of companies within the European Union and allowed to obtain information on country, sector and size level. The information on country and sector was used during the fieldwork to pre-target potential respondents.

Before the start of the fieldwork, a live pre-testing of the questionnaire took place to assess the understanding, item response, potential drop-out and length of the telephone interview. This pre-testing took place during the beginning of July 2018 and consisted of 10 interviews with actual respondents. The questionnaire was finalized based on the feedback from this pre-test and focused on revisions to improve the overall user-friendliness of the questionnaire. This included:

- Rephrasing questions and/or answer options to make the questions/answer options better understandable and less complex
- Removing similar and/or overlapping answer options
- Rephrasing instructions interviewers and/or respondents, for questions where the pre-testing showed that respondents were unsure how to answer

Besides these changes, no structural adaptations to the questionnaire were made.

Following the finalization of the survey material, the main fieldwork ran from 13 August 2018 until 6 November 2018. Overall, the fieldwork took longer than originally planned due to a low efficiency of the sample, as it turned out to be much more difficult than initially anticipated to pre-target the subgroups of Installers and Main Contractors. Concretely, this means that a substantial amount of companies that were contacted during the study were not eligible to take part in the survey. As such,

9 Respondents could indicate both answer options

considerably more companies than foreseen had to be contacted to reach the target sample size.

Target group, sampling and weighting approach

As already mentioned above, the survey targeted two main groups of construction companies: installers and main contractors. These subgroups were defined as follows:

1. Installers

Companies that offer installer services for new construction and renovations products, usually focusing on one (or sometimes several) specific trades, such as installing windows or installing heating systems.

2. Main contractors

Companies that offer (either themselves or through subcontractors) or coordinate all required installer services for new construction or renovation projects.

Several screening questions, in addition to the identification of the target group described above, were included in the questionnaire. The purpose of the screening questions was two-fold:

1. Ensuring that the companies that are being contacted are indeed included in the target group of the survey;

2. Identifying the areas in which the enterprise was significantly active between 2012 and 2016, to be able to ask targeted questions to subgroups of respondents (see also the section on the description of the sample below).

To ensure a sound distribution of the subgroups within every country sample, quota targets for the distribution of interviews were defined. This entails that the interviews on country level would aim to be distributed as follows:

Installers – 75% of the country sample
Main contractors – 25% of the country sample

Table 23 below provides a complete overview of the number of completed interviews in each subgroup, as well as the distribution of interviews between the subgroups on country level. The total sample shows a distribution of 74% Installers and 26% Main contractors, which is indeed extremely close to the aimed distribution. On country level, the proportion of Installers in the sample ranges from 77.6% to 65.2% for Installers, and 22.4% and 34.8% for Main contractors (in Bulgaria and Ireland, respectively). In 20 out of the 28 Member States included in the scope of the survey, the deviation from the targeted distribution does not exceed 5%. The sole exception is Cyprus, where the distribution is almost equal between the two target groups (53.8% for Installers and 46.2% for Main contractors). This is mostly due to the extremely low amount of sample available for this country. As such, to maximise the overall response for this country, it was decided to obtain interviews from both target groups on a best-effort approach.

Table 23: Overview of the achieved sample for the Construction companies survey

		Installers		Main contractors	
		Number of interviews	Proportion	Number of interviews	Proportion
Total	Number of interviews	1491	74%	523	26%
Austria	66	47	71.2%	19	28.8%
Belgium	75	56	74.7%	19	25.3%
Bulgaria	98	76	77.6%	22	22.4%
Croatia	32	22	68.8%	10	31.3%
Cyprus	13	7	53.8%	6	46.2%
Czech Republic	64	43	67.2%	21	32.8%
Denmark	76	57	75.0%	19	25.0%
Estonia	56	43	76.8%	13	23.2%
Finland	81	59	72.8%	22	27.2%
France	148	113	76.4%	35	23.6%
Germany	118	90	76.3%	28	23.7%
Greece	88	64	72.7%	24	27.3%
Hungary	101	77	76.2%	24	23.8%
Ireland	23	15	65.2%	8	34.8%
Italy	151	116	76.8%	35	23.2%
Latvia	32	22	68.8%	10	31.3%
Lithuania	34	24	70.6%	10	29.4%
Luxembourg	25	19	76.0%	6	24.0%
Malta	16	11	68.8%	5	31.3%
Netherlands	59	40	67.8%	19	32.2%
Poland	95	73	76.8%	22	23.2%
Portugal	74	56	75.7%	18	24.3%
Romania	77	57	74.0%	20	26.0%

Slovakia	68	46	67.6%	22	32.4%
Slovenia	49	37	75.5%	12	24.5%
Spain	151	116	76.8%	35	23.2%
Sweden	68	49	72.1%	19	27.9%
United Kingdom	76	56	73.7%	20	26.3%

For the Construction companies survey a similar weighting approach as the one adopted in the Architects survey was developed, where the sample is weighted to be representative of the total building stock.

Description of the sample

a) Type of building project

One of the survey questions identified the different areas of projects in which the company was active between 2012 and 2016. As such, the target groups were further broken up into installers or main contractors active in:

- Residential new construction projects;
- Residential renovation projects;
- Non-residential new construction projects;
- Non-residential renovation projects.

The table below (Table 24) provides an overview of respondents per category, spread across the two subgroups, and indicates the proportion of respondents that are active in each category (based on the total sample).

Table 24: Overview of respondents active per type of building project

	Residential new construction	Residential renovation	Non-residential new construction	Non-residential renovation
Total	42.2%	76.3%	36.4%	55.3%
Installers	41.3%	73.1%	34.0%	49.2%
Main contractors	48.6%	100.0%	7.1%	100.0%

b) Type of services offered (installers only)

In order to have a comprehensive overview of the market, several subgroups of construction companies were defined within the two main target groups. Whereas the main contractors include those at least active in non-residential construction project, the subgroup of installers focused on installers offering services for one or more of the following core sectors:

- Performing works on the façade (including insulation works);
- Installing windows;
- Installing heating systems (including solar thermal);
- Installing photovoltaic systems, air-conditioning or electric heating;
- Performing works for the roof;
- Installing mechanical ventilation.

The table below (Table 25) provides an overview of the proportion of respondents active in each of the core sectors included in the scope of the study.

Table 25: Proportion of installers in the sample offering each type of service

Type of service	Proportion of the sample offering this type of service
Performing works on the façade (including insulation works)	29.9%
Installing windows	28.3%
Installing heating systems (including solar thermal)	55.9%
Installing photovoltaic systems, air-conditioning or electric heating;	34.6%
Performing works for the roof;	34.2%
Installing mechanical ventilation.	39.8%

c) Company size

A final breakdown looks at the size of the company of the respondents, which is based on the amount employees.

Table 26: Overview of respondents per company size

	Company size				
	1 (one-man business)	2 – 9 employees	10 – 49 employees	50 – 249 employees	>249 employees
Total	21.9%	48.7%	22.8%	4.7%	1.8%
Installers	22.5%	49.9%	22.1%	3.8%	1.6%
Main contractors	17.7%	39.5%	28.4%	11.2%	3.2%

3.6. Limitations

An enormous effort in activating architects to participate in the survey still resulted in a small sample size of architects (1,581), which does not enable a reliable split of the renovation of non-residential buildings into different building types such as educational buildings and wholesale/retail buildings. During the detailed analysis of the survey results, a significant deviation of the SFH/MFH shares in the samples from the real distribution in the stock has been identified. Because of this uncertainty, the renovation of residential buildings was not split into different building types such as single-family homes and multi-family homes. Note that consumers were asked to report investments between 2012 and 2016 in a survey that took place in summer 2018. It must be expected that not all respondents may have been able to accurately reproduce activities during that period. Therefore, sometimes the average for the whole period from 2012-2016 may be closer to reality than findings for individual years. Many findings are derived from purchased market data, which have been checked thoroughly by data providers and aligned to the needs of this project but could not be further verified within this project. Finally, altogether considerably less data for non-residential buildings was available than for residential buildings. For some sources the level of uncertainty is unclear. Therefore, all results should be understood as best estimates, in the case of non-residential buildings rather as an indication.

4. EU28 building stock inventory

For calculating the renovation rates, it is necessary to first develop a EU28 building stock inventory in a level of detail that is needed to allow results for each considered building type to be presented separately. According to the developed methodology and scope of the project, the following building types according to EPBD Annex I had to be covered:

- Single family houses;
- Multi-family houses;
- Offices;
- Educational buildings;
- Hospitals;
- Hotels and restaurants;
- Sports facilities;
- Wholesale and retail trade services buildings;
- Other types of energy-consuming buildings.

As the renovation rates should be calculated based on building floor area and buildings, the inventory needs to contain both types of information for the years 2012-2016. The initial idea was to directly use the data that is collected in the new EU BSO project (ENER/C3/2014-543), however this information was not available early enough to be usable for this task. In consequence, an own approach had to be developed, which is presented below.

4.1. Approach residential buildings

Basis for the residential building stock inventory is the EU-SILC 2012 Module on Housing Conditions. It contains detailed information on the number of households per dwelling type (detached house, semi-detached and terraced house, apartment or flat in a building w/ less than 10 dwellings, apartment or flat in a building w/ more than 10 dwellings) and for each type the average floor area per country. This information has been used to calculate the 2012 baseline.

Using the Navigant's GLObal BUilding Stock Model GLOBUS and considering the analysed new constructions as described above, the building stock development until 2016 has been projected ex-post.

To convert these floor area numbers into number of buildings, two main sources have been used:

- For single family houses: The 2011 Census database
- For multi-family houses: Entrance average number of dwellings per building (http://www.entranze.enerdata.eu/#/average-number-of-dwellings-per-building.html) combined with EU-SILC, own modelling plausibility checks and assumptions to close gaps

4.2. Approach non-residential buildings

The development of a non-residential building stock inventory builds upon the conducted work within the impact assessment (IA) of the EPBD. The following sources have been used during the IA to compile an overview of the 2012 EU non-residential building stock in terms of gross floor area (m²) per country:

Table 27: Sources – approach to non-residential building stock

Country	Source building stock base year
Austria	Statistik Austria - Mikrozensus
Belgium	BPIE 2011
Bulgaria	BPIE 2011
Croatia	ENTRANZE
Cyprus	(Schimschar, 2015)
Czech Republic	ENTRANZE
Denmark	Statistics Denmark
Estonia	ENTRANZE
Finland	Statistics Finland
France	Objectifs Bâtiments 2012 - 2020, Hubert Despretz – Ademe/DBU
Germany	Statistisches Bundesamt / Fraunhofer [BMWi, 2015]
Greece	BPIE 2011
Hungary	Panorama of the European non-residential construction sector
Ireland	(Schimschar, 2015)
Italy	Statistics Italy (CENSUS)
Latvia	BPIE 2011
Lithuania	BPIE 2011
Luxembourg	BPIE 2011
Malta	BPIE 2011
Netherlands	ENTRANZE
Poland	BPIE 2011
Portugal	BPIE 2011
Romania	BPIE 2011
Slovakia	ENTRANZE
Slovenia	BPIE 2011
Spain	Panorama of the European non-residential construction sector
Sweden	Statistics Sweden (SCB) / Energimyndigheten
United Kingdom	ENTRANZE

These sources have been updated considering the published Long-Term Renovation Strategies of the EU MS and other updated national sources. Missing data and also to calculate the development of the building stock over time, the Navigant Globus model has been used.

To convert these floor area numbers into number of buildings, building stock numbers of the H2020 project "Hotmaps Toolbox" has been used[10]. Accordingly, it was possible to calculate average building sizes per non-residential sub-category, see the following table.

Used non-residential reference buildings for converting floor area into number of buildings

	Floor area [m²]					
	Office	Education	Health and social work	Hotels and restaurants	Wholesale and retail trade	Other
Austria	744	996	200	624	674	1,371
Belgium	914	1,550	416	846	1,339	853
Bulgaria	823	1,292	1,618	1,011	1,328	1,025
Croatia	276	598	140	200	200	909
Cyprus	185	1,201	1,337	107	112	200
Czech Republic	715	998	574	329	428	1,286
Denmark	890	1,170	703	100	984	767
Estonia	3,481	15,813	14,460	2,892	815	10,075
Finland	216	1,263	830	281	954	5,931
France	664	1,209	929	389	432	369
Germany	1,850	2,422	1,460	1,725	656	1,329
Greece	6,673	4,233	284	709	200	283
Hungary	1,063	1,131	1,267	7,539	863	1,524
Ireland	4,635	1,392	304	597	1,147	296
Italy	1,171	1,256	690	217	108	9,530
Latvia	701	1,684	2,212	238	275	719
Lithuania	233	1,292	2,170	723	126	867
Luxembourg	297	1,310	560	870	870	890
Malta	141	3,573	839	454	115	213
Netherlands	553	502	375	1,059	1,963	4,130
Poland	139	2,141	512	1,704	355	21,400
Portugal	347	1,325	561	585	200	711
Romania	158	218	227	101	217	1,681
Slovakia	2,954	1,986	6,190	5,131	25,915	1,091
Slovenia	1,213	2,264	1,611	557	106	496
Spain	398	820	380	250	200	421
Sweden	110	2,316	1,510	710	249	24,308
United Kingdom	641	1,174	1,349	393	789	234

10 https://gitlab.com/hotmaps/building-stock/tree/master

5. New construction activities in the EU28

Similar to the information needed on the total amount of buildings and floor area in the stock for being able to calculate the renovation rate, also the total amount of newly constructed buildings and floor area is needed to calculate the share of NZEB buildings on all new constructions. EUROCONSTRUCT and EECFA provide the number of completed dwellings for many EU countries divided by 1+2 family dwellings as well as flats. For the non-residential sector, the new built surface (in m²) is provided, however not for all countries. The following table provides an overview of the provided information from EUROCONSTRUCT and EECFA.

Country	Information on new dwellings	Infomation on newly constructed non-residential floor area partly in line with required data
Austria	x	
Belgium	x	
Bulgaria	x	
Croatia	x	x
Cyprus		
Czech Republic	x	x
Denmark	x	x
Estonia		
Finland	x	x
France	x	x
Germany	x	x
Greece		
Hungary	x	
Ireland	x	
Italy	x	x
Latvia		
Lithuania		
Luxembourg		
Malta		
Netherlands	x	x
Poland	x	x
Portugal	x	x
Romania	x	
Slovak Republic	x	x
Slovenia	x	x
Spain	x	x
Sweden	x	x
United Kingdom	x	
EU28	21/28	14/28

5.1. Approach for calculating the newly constructed floor area and buildings in the residential sector

For those countries EUROCONSTRUCT and EECFA do not provide the number of new dwellings (Cyprus, Estonia, Greece, Latvia, Lithuania, Luxembourg, Malta), a set of three other sources has been used to calculate these numbers:

1) The State of Housing in the EU 2017, Housing Europe (European Federation of Public, Cooperative and Social Housing),
2) Housing Statistics in the European Union 2010, Ministry of the Interior and Kingdom Relations,
3) EUROSTAT Building permits - annual data [sts_cobp_a].

In the next step, the number of dwellings has been combined with the average size of new dwellings in square metres. Where possible, this information was collected from the ZEBRA2020 data tool[11], EECFA and Housing Statistics in the European Union 2010. Missing data for some years was linearly interpolated. At this stage, the EU BSO (ENER/C3/2014-543) could not provide other useful data.

In the next step, the resulting floor area has been converted into number of newly constructed buildings by using average building sizes of single and multi-family houses. For this purpose, data has been extracted from TABULA/EPISCOPE considering the newest construction period covered per country. The resulting average building sizes per EU MS are presented in Table 28.

5.2. Approach for calculating the newly constructed floor area and buildings in the non-residential sector

As already described above, the main source for new non-residential construction data is EUROCONSTRUCT and EECFA. However, as data is not available for all EU member states, some other sources and assumptions had to be applied.

The ZEBRA2020 data tool and BSO for instance provide some non-residential construction numbers. Other potential sources are EUROSTAT's "Building permits - annual data" (sts_cobp_a), "Annual detailed enterprise statistics for construction" (sbs_na_con_r2) or "Purchasing power parities (PPPs), price level indices and real expenditures for ESA 2010 aggregates" (prc_ppp_ind). Gaps can also be filled with a research on national level. For countries where no information was available, the amount of new non-residential constructions has been calculated with the Navigant Global Building Stock (GLOBUS) model.

For the conversion of the floor area into number of newly constructed buildings, the reference buildings from the national cost-optimality reports according to article 4 EPBD have been used. The cost-optimality reports provide information for more than 50% of the MS in a sufficient level of detail to calculate the size of an average non-residential reference building to be used for converting floor area into number of buildings. For countries, where this information was not available, an average building size of the other countries has been applied. The resulting average building sizes per EU MS are presented in Table 28.

5.3. Used reference building sizes of new constructions

Table 28: Reference building sizes of new constructions

2012	Newly constructed SFH	Newly constructed MFH	Average new residential building (2012-2016)	Newly constructed non-residential building
	m²/building	m²/building	m²/building	m²/building
Austria	174	448	237	3,602
Belgium	224	2,556	344	3,602
Bulgaria	229	1,091	448	3,602
Cyprus	193	1,350	246	5,792
Czech Republic	196	2,396	251	2,250
Germany	236	1,977	345	1,773

11 http://www.zebra-monitoring.enerdata.eu/overall-building-activities/share-of-new-dwellings-in-residential-stock.html#average-size-of-new-dwellings.html

Denmark	162	6,988	307	3,283
Estonia	235	5,853	867	5,820
Greece	308	808	406	3,602
Spain	140	3,449	357	5,544
Finland	120	1,207	241	4,880
France	109	1,096	169	5,023
Croatia	235	1,091	438	2,100
Hungary	136	816	178	1,777
Ireland	198	3,804	214	1,887
Italy	171	1,261	325	3,602
Lithuania	236	5,853	582	804
Luxembourg	187	3,100	332	3,766
Latvia	233	5,853	478	2,677
Malta	208	638	252	3,432
Netherlands	180	3,100	244	3,602
Poland	249	5,853	338	3,602
Portugal	136	3,449	183	3,602
Romania	215	1,091	261	3,602
Sweden	108	1,207	264	3,602
Slovenia	278	3,256	320	1,290
Slovakia	152	2,396	201	3,602
United Kingdom	191	2,011	230	4,500

The calculated floor areas in square metres [m²] have been divided by the respective building size (e.g. 1000m²/per building) to get the number of new buildings.

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