Dwelling stock that is suitable

How do we renovate 22 million houses towards energy neutral?

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EUROPEAN UNION

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1. Introduction

This report presents an overview of the dwelling stock in the countries participating in INTERREG 5B project INDU-ZERO. The focus of the project is the European North Sea Region (NSR), see

Figure 1. Data from six countries is considered, which are The Netherlands, Belgium, Germany, Sweden, Norway and Scotland. Diverting from the definition of the NSR, the presented data is not regionally differentiated. Instead the report presents data for all of the six participating countries.

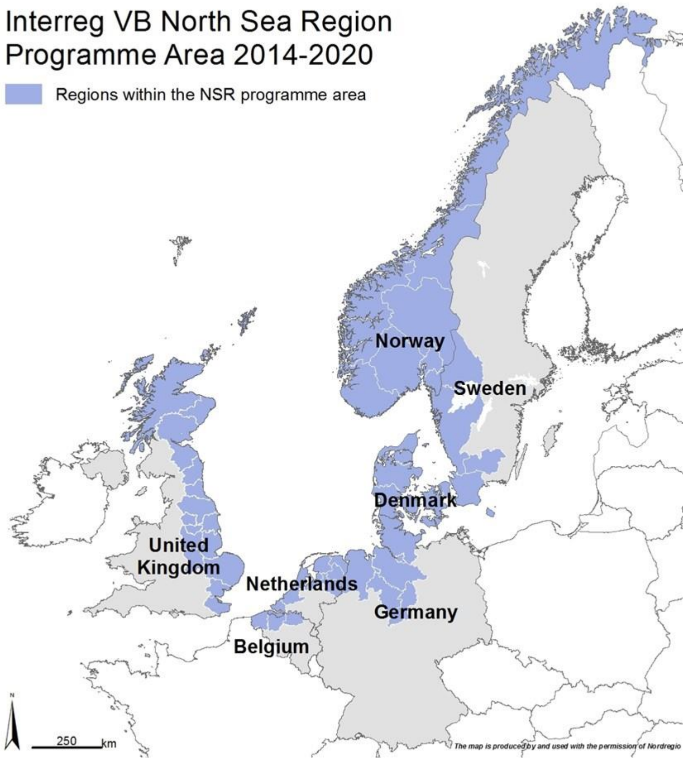

Figure 1: North Sea Region Program area 2014-2020

1.1 INDU-ZERO aims and objectives

The energy transition task for existing residential dwellings of the North Sea Region is extensive, and requires practical solutions urgently. The project partners aim to develop an innovative industrialized way of renovating houses and apartments built between 1950 and 1985 to achieve an energy-neutral energy balance.

By industrializing the energy-neutral renovation of dwellings the project directly contributes to the European climate objectives defined for 2030. During the project 500 houses will be renovated which translates to a CO_2 reduction of 1.800 tonnes/year. INDU ZERO focuses on dwellings built between 1950 and 1985.

Industrialization is necessary to realize energy-neutral renovation at the scale of the NSR quickly, efficiently and cost-effective. In the project a blueprint of an industrialization process will be realized based on the principles of Smart Industry (Industry 4.0) and Circular Economy.

To industrialize the production of renovation packages potential business cases have to address customers how are able to place large orders which allow to financially recuperate the investments in the factory. The customer on which the ideation of the project is based are housing corporations, with hundreds of dwellings in their portfolio. Whilst private house owners are not explicitly excluded the order of one client does not counterbalance the investment. In Europe 30.8% of the population (741.4 mill, 2016) lives in rented dwellings. Assuming an occupancy of 2.5 persons per dwelling, the number of dwellings amounts to 101.5 mill.

1.2 Research questions

To identify the potential or industrialization and to define minimum product specifications for industrially produced renovation packages the present dwelling stock is reviewed and differentiated per country by dwelling type and building period.

Two research questions are answered:

1. Which dwelling type(s) and building period(s) is/are most common in the six countries?
2. Which building type from which building period(s) is / are the most important to renovate until 2050?

2. Methodology

The applied methodology comprises two steps: (1) collection of country specific data and indicative analysis and (2) refined data search, normalization and analysis.

2.1 Step 1: Collection of country specific data and indicative analysis

Data on dwelling types and building periods were contributed by the partnering countries and collected in an Excel table referred to as "INDU-ZERO Research Wall". Based on the Research Wall missing data as well as inconsistencies in the data format were identified.

2.1 Step 2: Refined data search, normalization and analysis

Based on the findings of step 1 a refined desk research was undertaken to identify data to fill gaps, replace reported data on buildings with data on dwellings and to harmonize the reported building periods.

2. Availability and categorization of data on dwellings

The collected data varies with respect to dwelling type and building period. For example, data from Germany, Belgium is categorized along other building periods than Sweden, Scotland, The Netherlands and Norway. To allow a fair inter-country comparison, the format has been harmonized. The below paragraphs document the data and data harmonization for Germany and Belgium. The data for Sweden is presented also as only two of four dwelling types are reported. The reference periods adopted are can be found in *Table 1*.

Table 1, Reference building period

Pos.	Period
1	Before 1946
2	1946-1964
3	1965-1974
4	1975-1991
5	1992-2005

Germany

Dwellings reported for Germany [1] are categorized in five distinguishable periods different to the reference periods, see Table 2. To allow a comparison between data from Germany and data from the other countries it is harmonized by associating the reported German dwelling stock per periods to the five reference periods. By doing so the authors accept a limited distortion of the German data set. The German data is shifted backwards about 3 years (1949 to 1946) and the total reporting period is increased about seven years (52 to 59 years).

Table 2: Scheme to associate German data to reference periods

Period (data Germany)		Reference periods
Before 1949	→	Before 1946
1949-1968	→	1946-1964
1969-1978	→	1965-1974
1979-1994	→	1975-1991
1995 -2001	→	1992- 2005

Belgium

Dwellings found in Belgium are categorized using only four distinguishable periods, see Table 3. To allow a comparison between data from Belgium and data from other countries, the Belgium data has been redistributed. Redistributing data across differently defined periods based on averaged distribution profiles is not uncommon and has been used and reported by e.g. [2].

Table 3 : Scheme to associate Belgium data to reference periods

Period (data Belgium)	**Period**
Before 1946	Before 1946
1946-1970	1946-1964
	1965-1974
1971-1990	1975-1991
1991-2007	1992- 2005

To arrive at an suitable distribution profile, data from The Netherlands, Sweden, Norway and Scotland were revisited using the reference periods. The total number of dwellings per building period is calculated. Subsequently, the numbers are averaged for every period. Each period with the corresponding number of dwellings is then summed up. Finally, the contribution is determined in percent for every period.

The resulting scale is relative and based on the percentage of dwellings constructed within the specified period per country multiplied by the percentage of dwellings constructed within the specified period of all countries combined, see . For example, it is clearly visible that the Netherlands contains more dwellings constructed between 1975 – 1991 and therefore contributes more compared to other countries.

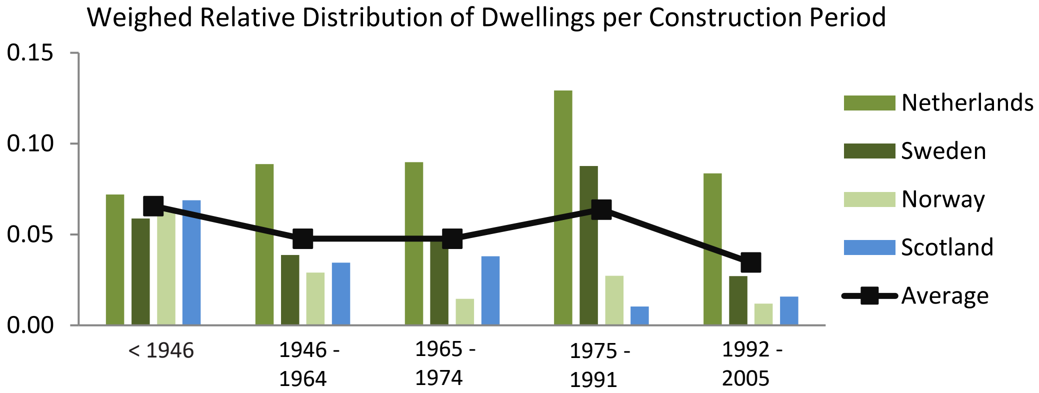

Figure 2 : Weighed relative distributions of all dwelling types per construction period for The Netherlands, Sweden, Norway and Scotland. The black line indicates the average, and represents the distribution used for Belgium and Germany.

This distribution profile is used to determine the distribution of the periods 1946-1970 and 1971-1990 over the periods 1946-1964, 1965-1974 and 1975-1991. The relative distribution of these three periods is adapted and applied on the total amount of dwellings found in 1946-1970 and 1971-1990 combined.
Note that this approximation is slightly distorted as data from Belgium corresponding to 1991 and 2006-2007 is included in building period 1992-2005.

Sweden

Statistics of Sweden are based on registered dwelling. The data source is the national register of Swedish dwellings managed by Lantmäteriet and processed by Statistics Sweden (SCB). Buildings are categorized as follows:

- **One- or two-dwelling buildings**

Buildings consisting of one or two dwellings that include detached, semi-detached or terraced dwellings.

- **Multi-dwelling buildings**
  Buildings with three or more dwellings i.e. apartments including balcony access housing.
- **Other buildings**
  Buildings not intended for residential purposes e.g. offices, businesses and public buildings.
- **Special housing**
  Dwellings intended for the elderly, disabled, students and other uncommon households.

The data used within the project does not include 'other buildings' and 'special housing'. Therefore, only detached, semi-detached, terraced dwellings and apartments are taken into account. However, no differentiation of detached, semi-detached and terraced dwellings exists as they are regarded as single-family homes [3, 4]. Therefore only two dwelling categories are reported for Sweden: (1) apartments and (2) other dwellings.

3. Dwellings per building type per country

This section of the report is dedicated to the discussion of the number of dwelling per type and country. The aim is to determine which dwelling types have to be targeted for industrialized renovation to achieve a CO_2 emission reduction of 1.800 tonnes/year.

Figure 3 shows the total amount of detached, semi-detached, terraced dwellings and apartments per type for six countries of the NSR. The total numbers of detached, semi-detached, terraced dwellings and apartments are 17.94 million, 5.33 million, 8.61 million and 25.36 million respectively. The highest number of dwellings are of type apartment, followed by detached and terraced dwellings.

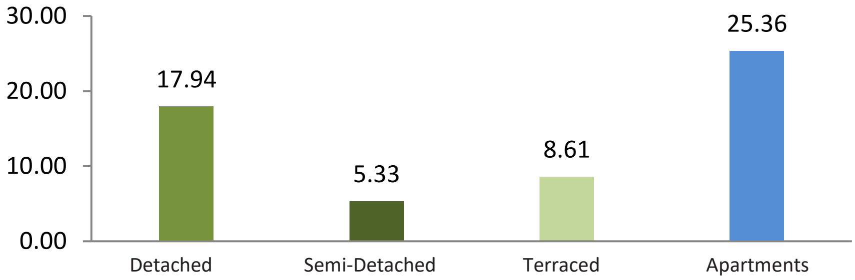

Figure 3: Amount of detached, semi-detached, terraced dwellings and apartments (in millions)

Germany contributes the highest number of apartments (20.56 million), followed by Sweden (1.87 million, mainly due to the 'Miljonprogrammet' between 1965-1974), Belgium (1.15 million), Scotland (0.95 million), The Netherlands (0.55 million) and Norway (0.29 million).

Furthermore, Germany contributes most to the collective amount of detached dwellings (11.41 million), followed by Sweden (2.42 million), Belgium (1.33 million), The Netherlands (1.10 million), Norway (1.09 million) and Scotland (0.6 million).

Only the Netherlands (3.23 million), Belgium (1.16 million) and Germany (3.08 million) significantly contribute to the amount of terraced dwellings. Semi-Detached dwellings do not seem to be common in any individual country (except for Germany relative to the other countries).

Data for Sweden cannot be discussed with respect to detached, semi-detached and terraced dwellings as they are presented in a combined form. See Figures 4-9.

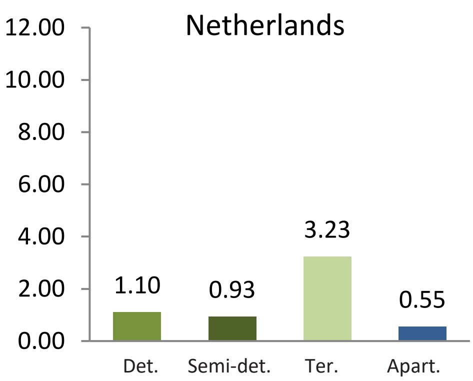

Figure 4: Amount of Dutch dwellings (millions) per building type.

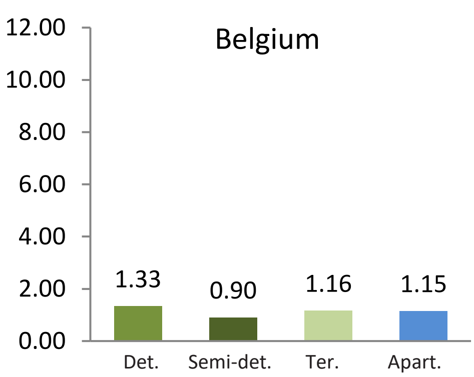

Figure 5: Amount of Belgium dwellings (millions) per building type.

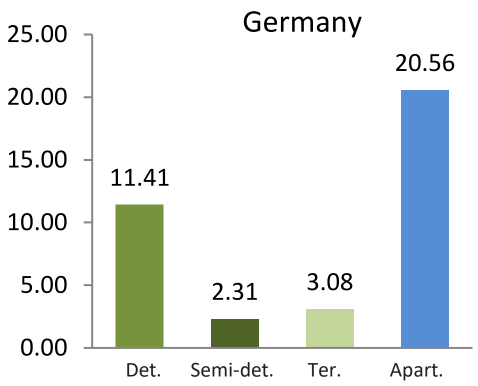

Figure 6 : Amount of German dwellings (millions) per dwelling type.

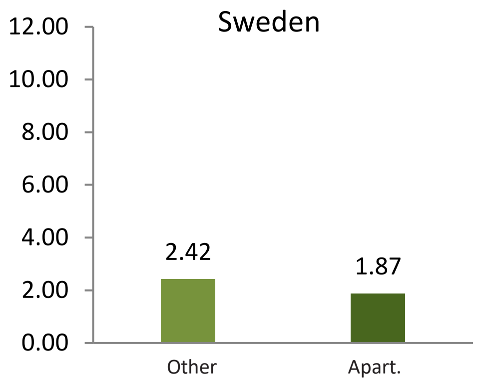

Figure 7: Amount of Swedish dwellings (millions) per dwelling type

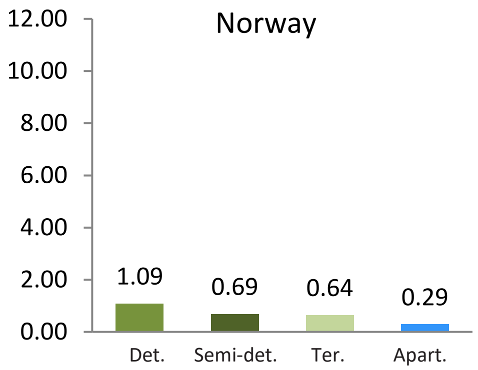

Figure 8: Amount of Norwegian dwellings (millions) per dwelling type.

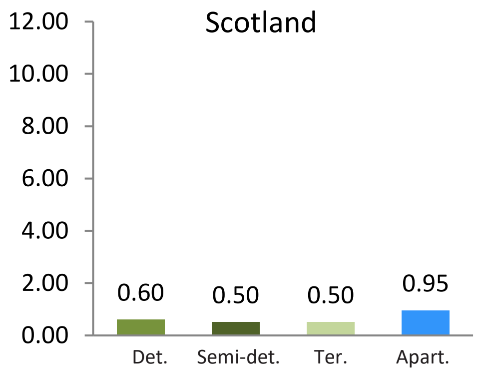

Figure 9: Amount of Scottish dwellings (millions) per dwelling type.

Summary

The aim to achieve a CO_2 emission reduction of 1.800 tonnes/year can be achieved by targeting the most prominent dwelling types for the represented countries. The most prominent dwelling types are apartments in Germany, Scotland and Sweden and terraced dwellings in The Netherlands and Belgium.
As end-of-the-row dwellings are per definition part of a terrace of dwellings (begin & end) with performance characteristics comparable to semi-detached dwellings this type is not being neglected.
As the project focuses on customers with a significant portfolio of dwellings to be renovated, detached buildings are not considered. Because detached dwellings are in many cases owner occupied they are at first excluded from further analysis.

4. Dwellings per building type per period

Section 4 is dedicated to the identification of the building period and thereby the building standard for the buildings to be renovated. All dwellings per building type (collectively of all countries) are summed up. Figure 5a presents the distribution of the amount of dwellings per period (all dwelling types combined). Figures 5b, 5c, 5d, 5e presents the distribution of the amount of dwellings per period per dwelling type in the North Sea Region. In absolute numbers, dwellings built before 1946 are most common (15.03 million) followed by dwellings built between 1946 – 1964 (14.53 million), then by dwellings built between 1975 – 1991 (11.51 million), then by dwellings built between 1965 – 1974 (9.72 million) and then by dwellings built between 1992-2005 (6.45 million).

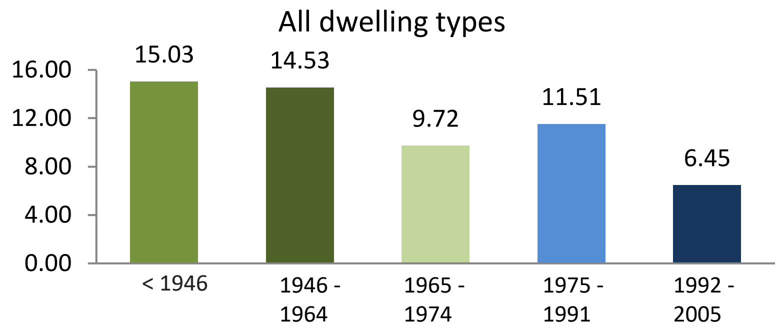

Figure 5a: Amount of dwellings (in millions) in the North Sea Regions categorized by period.

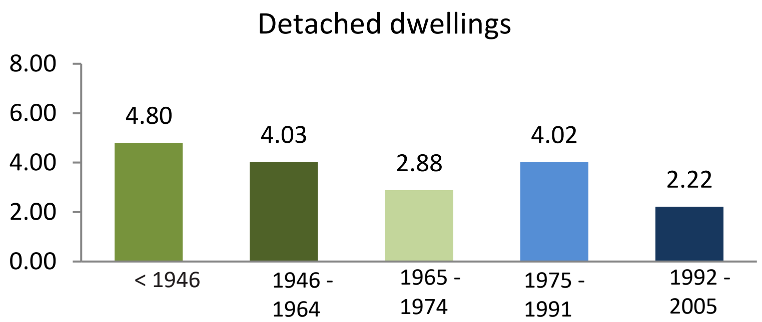

Figure 5b: Amount of detached dwellings (in millions) in the North Sea Regions categorized by period.

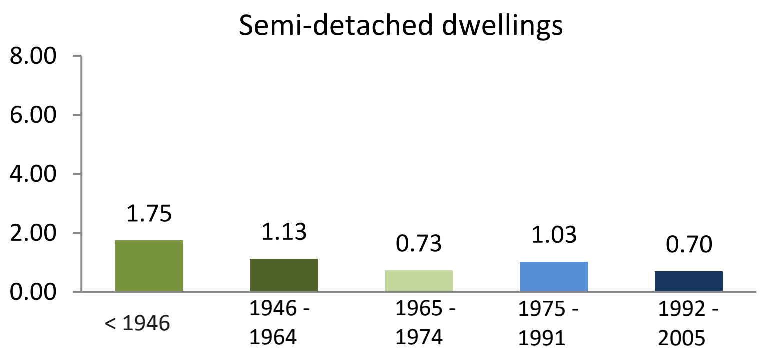

Figure 5c: Amount of semi-detached dwellings (in millions) in the North Sea Regions categorized by period.

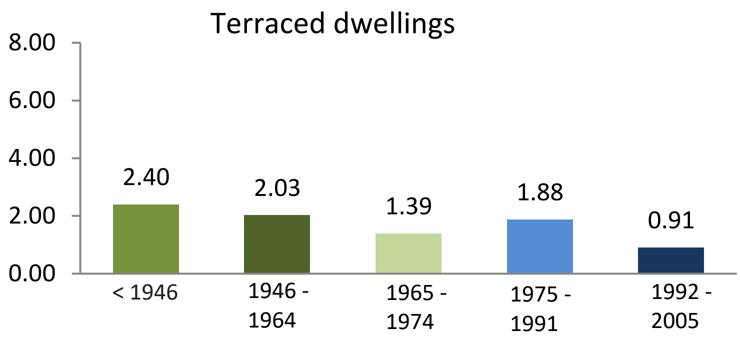

Figure 5d: Amount of terraced dwellings (in millions) in the North Sea Regions categorized by period.

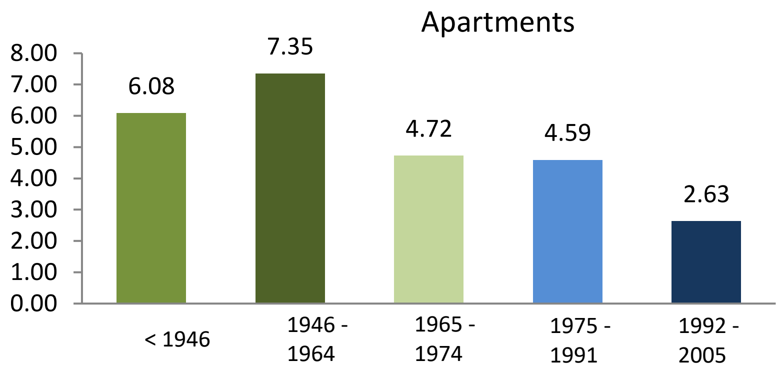

Figure 5e: Amount of apartments (in millions) in the North Sea Regions categorized by period.

The most common building type with corresponding period is an apartment built between 1946 – 1964 (7.35 million dwellings). Dwellings built in that post-war period are due to material scarcity and urgency for living space characterized by a limited floor area and modest construction methods, see appendix 1. Dwellings of that period are in need for an extensive renovation to achieve a similar standard as newly built dwellings. Together with dwellings built before 1946 they may represent economically the most challenging renovation projects. That is why the a representative dwelling for the most common construction period may not be representative for all building types with regards to layout and floor area.

Detached dwellings are also common (especially before 1946 as it is the third most common type overall). However, detached dwellings vary significantly in layout, floor area and design wise. This makes it difficult to design mass produced renovation packages, as each dwelling may differ. Representative dwelling types may be difficult to obtain as well.

Summary

The layout and construction of buildings build in the periods after 1965 come closest to the currently accepted dwelling standard and are most likely to when renovated generate an economic benefit for housing associations. As the distribution of buildings amongst the building periods does not show outliers or abrupt differences it is suggested to consider the building period 1965-1974 for the definition of reference building type (archetypical buildings).

5. Conclusion

The project INDU-ZERO consortium is formed by six of seven countries of the North Sea Region. Whilst the North Sea Region is made up of regions, this report is based on statistical data for entire countries. Denmark is not considered nor is England.

A method has been derived to redistribute periodical data across five building periods. The resulting distribution when applied to Belgium data provides feasible data. For Sweden only two building types are differentiated. There is no data available for detached, semi-detached and terraced dwellings.

The data analysis indicates that terraced and semi-detached as well as apartments are most suitable for industrial renovation. As detached buildings are in most cases owner-occupied dwellings, they cannot be renovated on large scale.

It is suggested to target the building period from 1965-74 to define archetypical buildings for the definition of renovation packages. That is as that period is characterized by floor areas and construction types that are not anymore influenced by the post-war boom in construction.

6. References

[1] T. Loga, B. Stein, N. Diefenbach, R. Born, Institut Wohnen und Umwelt, Deutsche Wohngebäudetypologie, 2015

[2] L. Itard, F. Meijer, Towards a sustainable Northern European housing stock, 2008

[3] Statistics Sweden (SCB), Bostads- och byggnadsstatistisk årsbok, 2012

[4] Mälardalen University Sweden, Byggnadstypologier Sverige, 2009

Appendix 1: Description of example dwellings

Introduction

Three dwelling types are selected based on similarity of dwellings within the dwelling type. Terraced dwellings, semi-detached dwellings (terraced dwellings on corners) and apartments (one floor) are consistent with respect floor area and overall design. Creating pre-fabricated renovation concepts is more feasible for a certain type of dwelling, as many similar dwellings exist. Detached dwellings, maisonettes and miscellaneous flats are excluded as these types of dwellings are not consistent with respect to floor area and overall design which makes it more tedious to design pre-fabricated renovation concepts. Preferably older dwellings are selected (~ 1950), as these represent worst case scenarios when taking energy consumption into account. It has been concluded previously, that the majority of dwellings in the North Sea Regions is built before 1946. However, this does not imply that a certain dwelling type built in this period, with respect to overall design and floor area, are representative for the entire dwelling type. This report presents an analysis on representative dwellings for the three selected dwelling types.

Example of dwellings are selected from 'Voorbeeldwoningen in Nederland 2011 – existing built environment' provided by the Dutch Ministry of Internal Affairs. Thirty dwelling(type)s are described and are divided in year of construction. The described dwellings are representative for the housing stock in the Netherlands until 2005. Table 1 provides an overview of the listed dwellings and the net floor area per dwelling, categorized per year of construction.

Table 1: Overview of the example dwellings, described by the Dutch Ministry of Internal Affairs.

Floor area per dwelling type per year of construction [m^2]		**≤ 1945**	**1946 – 1964**	**1965 – 1974**	**1975 – 1991**	**1992 – 2005**
Detached		130		144	154	172
Semi-Detached		110		123	123	132
Terraced		102	87	106	106	114
Apartment	Maisonette	88		88	80	84
	Gallery	72		82	68	79
	Shared Entrance	59	66	71	70	74
	Miscellaneous Flat	67		77	70	82

Furthermore, the Dutch Nul Op de Meter guideline (NOM-Keur) is introduced in order to propose a potential standard for renovation of dwellings. NOM-Keur guarantees a net energy usage of zero for dwellings built or renovated according to the guideline.

Terraced dwelling (1965 -1974)

Terraced dwellings from 1946 – 1964 are post-war dwellings and therefore not representative for all terraced dwellings, as method of construction and overall design is influenced by post-war reconstruction. Terraced dwellings from 1965 – 1974 are not influenced by this and have similar floor area to older dwellings. Performance of the façade is 1,54 $W \cdot m^{-2} \cdot K^{-1}$ whereas the performance of the façade of dwellings from before 1964 is 1,61 $W \cdot m^{-2} \cdot K^{-1}$. However, the floor on the ground floor performs significantly worse, 2,33 $W \cdot m^{-2} \cdot K^{-1}$ compared to 1,72 $W \cdot m^{-2} \cdot K^{-1}$. The roof performs significantly better, however, 0,89 $W \cdot m^{-2} \cdot K^{-1}$ compared to 1,54 $W \cdot m^{-2} \cdot K^{-1}$. Floor area for both dwelling types is similar (106 m^2 and 102 m^2). Considering the floor performs worse and the roof performs better, terraced dwellings built between 1965 and 1974 are close to worst case while still being representative for newer terraced dwellings in terms of floor area.

Figure 1: Examples of terraced dwellings built between 1965 and 1974.

Table 1: Overview properties of the example terraced dwelling (1965-1974).

	Thermal Transmittance	**Thermal Transmittance**	**Thermal Transmittance**
	m^2	**$m^2 \cdot K^1 \cdot W^{-1}$**	**$W \cdot m^{-2} \cdot K^{-1}$**
Floor	52,0	0,17	2,33
Roof	65,5	0,86	0,89
Façade - front	40,5	0,43	1,45
Glass (single) - front	4,3	-	5,20
Glass (double) - front	21,3	-	2,90
Façade - side	58,3	0,43	1,45
Glass (double) - side	1,8	-	2,90

Semi-detached dwelling (1965 – 1974 or ≤ 1964)

Dwellings built between 1965 – 1974 or dwellings built before 1964 are both representative for all semi-detached dwellings. As can be seen in table 1, dwellings built between 1965 – 1974 are representative for the size of all semi-detached dwellings. However, a semi-detached dwelling may also include the final dwelling in a series of terraced dwellings, see figure 2. Therefore a house built before 1964 is more representative, as the floor area (110 m^2) matches the floor area of the selected terraced dwelling built between 1965 – 1974 (106 m^2).

Facades of dwellings built between 1965 – 1974 perform similar to dwellings built before 1964, 1,45 $W \cdot m^{-2} \cdot K^{-1}$ compared to 1,61 $W \cdot m^{-2} \cdot K^{-1}$. However, the floor on the ground floor performs significantly worse, 2,33 $W \cdot m^{-2} \cdot K^{-1}$ compared to 1,72 $W \cdot m^{-2} \cdot K^{-1}$. The roof performs significantly better, however, 0,89 $W \cdot m^{-2} \cdot K^{-1}$ compared to 1,54 $W \cdot m^{-2} \cdot K^{-1}$. Considering the floor performs worse and the roof performs better, semi-detached built between 1965 and 1974 are close to worst case while still being representative for newer terraced dwellings in terms of floor area.

Figure 2: Examples of semi-detached dwellings built between 1965 and 1974.

Table 2: Overview properties of the example semi-detached dwelling (1965-1974).

	Thermal Transmittance	**Thermal Transmittance**	**Thermal Transmittance**
	m^2	**$m^2 \cdot K^1 \cdot W^{-1}$**	**$W \cdot m^{-2} \cdot K^{-1}$**
Floor	60,0	0,17	2,33
Roof - tilted	65,2	0,86	0,89
Roof - flat	14,0	0,86	0,89
Façade - front	104,7	0,43	1,45
Glass (single) - front	6,7	-	5,20
Glass (double) - front	24,6	-	2,90

Apartment (shared entrance flats) (1965 – 1974)

'Voorbeeldwoningen in Nederland 2011 – existing built environment' distinguishes four types of apartments. However, only one type of apartment is selected. Maisonettes consist of multiple floors and may be similar to a terraced dwelling in some cases. Miscellaneous flats are found to not be consistent in terms of geometry, floor area and such. Gallery flats and shared entrance flats are similar and are both representative. However, gallery flats only make up 6.9 % of the total housing stock in the Netherlands, whereas shared entrance flats make up 12.5 % of the total housing stock. Apartments built between 1965 – 1974 are larger (71 m^2) than apartments built before 1946 (59 m^2) and may be more representative for all apartment types as the average floor area for apartments is 75,1 m^2.

Facades of dwellings built between 1965 – 1974 perform similar to dwellings built between 1946 and 1964, 1,45 $W \cdot m^{-2} \cdot K^{-1}$ compared to 1,61 $W \cdot m^{-2} \cdot K^{-1}$. However, the floor on the ground floor performs significantly worse, 2,33 $W \cdot m^{-2} \cdot K^{-1}$ compared to 1,72 $W \cdot m^{-2} \cdot K^{-1}$. The roof performs significantly better, however, 0,89 $W \cdot m^{-2} \cdot K^{-1}$ compared to 1,54 $W \cdot m^{-2} \cdot K^{-1}$. Considering the floor performs worse and the roof performs better, apartments built between 1965 and 1974 are close to worst case while still being representative for newer terraced dwellings in terms of floor area.

Figure 3: Examples of apartments built between 1965 and 1974.

Table 3: Overview properties of the example apartment (1965-1974).

	Area	Thermal Transmittance	Thermal Transmittance
	m^2	$m^2 \cdot K^1 \cdot W^{-1}$	$W \cdot m^{-2} \cdot K^{-1}$
Floor	71,0	0,17	2,33
Roof	75,1	0,86	0,89
Façade - front	38,3	0,43	1,45
Glass (single) - front	1,3	-	5,20
Glass (double) - front	16,8	-	2,90
Façade - side	23,2	0,43	1,45
Glass (double) - side	1,4	-	2,90

Nul Op de Meter guidelines (NOM-Keur)

NOM-Keur achieves to maintain a healthy indoor climate in NOM dwellings and to energetically balance NOM dwellings so that energy demand for domestic heating and electricity is equally generated within the dwelling. NOM-Keur is a quality mark awarded by the NOM committee to technical concepts that provide a healthy indoor climate with low energy usage without using natural gas as an energy source. Such a concept includes but is not limited to excellent insulation, mechanical (smart) ventilation and renewable energy generation solutions.

Net energy usage of NOM dwellings is zero (excluding energy usage of appliances), due to energy saving and energy generating systems e.g. additional insulation, solar panels, heat pumps and solar collectors. In 2013, four construction and six housing corporations agreed to renovate 11.000 dwellings according to NOM-Keur. After a successful pilot, another 100.000 dwellings were renovated. The province of Noord-Brabant is currently planning to renovate 800.000 dwellings (73 %) according to NOM-Keur.

Tenants and landlords can agree on an Energy Performance Compensation (EPV). Landlords require a monthly additional fee on top of the monthly rent in order to compensate for the investment of renovation in order to achieve NOM energy performance. Requirements for EPV can be found in section 'NOM-Keur requirements'.

NOM dwellings are for sale/rent without energy systems. These dwellings will not be guaranteed NOM energy performance, but are still amongst the best performing dwellings in the Netherlands based on the Energy

Performance Coefficient (EPC). The energy systems to achieve NOM energy performance are in the order of € 15.000 -20.000 depending on concepts and the size of the dwelling.

NOM-Keur Requirements

Criteria are evaluated on three occasions. (1) 'NOM Keur – Proposition' evaluates the concept based on technical design, quality monitoring plans, performance requirements and resident instructions. (2) 'NOM keur – Application' evaluates the concept as built. The concept should demonstrate that it is executed well in order to match performance criteria. (3) NOM keur is finally awarded when the concept also matches performance criteria after one year of service. The proposed evaluation method is applicable to phase 1 'proposition' and phase 2 'application' and is based on NEN7120:2011. The evaluation method, however, is not mandatory as NEN7120 leaves no room for innovative solutions and systems. Other methods may be used supported by arguments in order for the concept to be awarded the NOM Keur. However, results of the proposed evaluation method should always be included to evaluate deviations. The main criterion of NOM-Keur is a net energy usage of zero, and therefore dwelling(type)s, concepts and corresponding energy systems may vary, however, a few criteria are prescribed. Insulation should have a thermal transmittance of 5 $m^2 \cdot K^1 \cdot W^{-1}$ or higher. Triple glazed windows are standard as well as air tight window and door frames. Solar panels are required to generate electricity where 24-30 m2 is average for Dutch dwellings. Low temperature heating e.g. floor heating is achieved by generating heat through heat pumps. Mechanical ventilation with heat regeneration is recommended. However, there are also requirements with respect to eligibility of EPV.

Energy demand room heating

Maximum net energy demand for room heating per unit area is based on EPC calculations and should be sufficiently low in order to obtain EPV. Maximum net energy demand for room heating is divided by the total area of the dwelling which results in the net energy demand for room heating per area within the dwelling Q_v. Table 1, column 1 presents an overview of three categories; if Q_v exceeds 50 kWh・m^{-2} per year, the dwelling is not eligible for NOM-keur.

Generated thermal energy

Minimum renewable generated energy per area within the dwelling for domestic heating, Q_{th}, should be at least 15 kWh・m^{-2}. The amount of energy should be derived from EPC calculations. Q_{th} should then be divided by the average efficiency of the employed installation. In practice, the indicated amount is low and will most likely be achieved, however if this is not the case the dwelling is not eligible for NOM-keur.

Generated electrical energy

Net electrical energy demand should be renewably generated in, on or around the dwelling. Photovoltaic panels should be employed. In order to evaluate the amount of energy generated, EPC calculations are preferred. However, per concept electrical energy demand and generation may differ due to climate change and user influences and therefore calculations do not necessarily have to be based on EPC calculations.

Table 1: NOM –Keur requirements regarding EPV.

Net heat demand per year – room heating	**Minimum renewable generated heat per year – room heating + water heating**	**Minimum renewable generated energy per year**	**Max EPV**
kWh · m^{-2}	**kWh · m^{-2}**	**kWh · m^{-2}**	**€ · m^{-2} · $month^{-1}$**
$0 < Q_v \leq 30$	$Q_v + 15$	$E_h + 26$	1,4
$30 < Q_v \leq 40$	$Q_v + 15$	$E_h + 26$	1,2
$40 < Q_v \leq 50$	$Q_v + 15$	$E_h + 26$	1,0

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