3 Are we moving fast enough? The energy renovation rate of the Dutch non-profit housing using the national energy labelling database

Note:
In the previous chapter, the energy efficiency state of the stock was presented. Existing dwellings will dominate the housing stock for at least the next 50 years, based on their life cycle. Moreover, energy renovations in dwellings offer unique opportunities to reduce both energy consumption and greenhouse gas emissions. In this chapter, the renovation rates for the non-profit housing stock of the Netherlands are presented, based on the changes in the energy performance of about 800,000 dwellings for the period of 2010 to 2014. The necessary data are drawn from a monitoring system (SHAERE: "Sociale Huursector Audit en Evaluatie van Resultaten Energiebesparing" – in English: Social Rental Sector Audit and Evaluation of Energy Saving Results) that contains information about the energy performance of approximately 60% of all dwellings in the sector. The method used follows the changes of the dwellings' physical properties and reported energy performance. Thus far, the results show that although many energy improvements have been realized, they result in small changes in the energy efficiency of the dwellings. Deep energy renovation rates are very low. If this pace continues, progress will be too slow to reach national and international policy targets.

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Abstract

The existing housing stock plays a major role in meeting the energy saving targets set in the Netherlands as well as in the EU. Existing buildings account for 38% of the final energy consumption in the European Union (EU), and they are responsible for 36% of the CO_2 emissions. Energy renovations in dwellings offer unique opportunities to reduce both energy consumption and greenhouse gas emissions. In this article, the renovation rates for the non-profit housing stock of the Netherlands are presented, based on the changes in the energy performance of 856,252 dwellings for the period of 2010 to 2014. The data necessary are drawn from a monitoring system that contains information about the energy performance of approximately 60% of all dwellings in the sector. The method used follows the changes of the dwellings' physical properties and reported energy performance. The results show that although many energy improvements have been realized, they result in small changes of the energy efficiency of the dwellings. Deep energy renovation rates are very low. If this pace continues, the progress is too little to reach national and international policy targets. The renovation rates are not high enough and the trends seem difficult to reach.

§ 3.1 Introduction

The energy performance of buildings is generally so inadequate that the levels of energy consumed in them place the sector among the most significant CO2 emission sources in Europe (BPIE 2011). Existing buildings are responsible for 36% of the CO2 emissions in the European Union (EU) (European Commission 2008 and 2014). In the context of all the end-use sectors, buildings represent the largest sector with 38% of the total final energy consumption, followed by transport (European Commission 2016a). A considerable percentage of this energy consumption is attributed to the residential sector, as on average dwellings consume 24.8% of the total energy consumption in the EU (Eurostat 2016). The building sector plays a major role in order to meet the energy saving targets set in the Netherlands and in the EU (SER 2013; Ürge-Vorsatz et al. 2007). This is particularly true for existing buildings, because they will constitute the major part of the housing stock over several decades. The renovation activity will be greater than the construction and demolition activity in the future.

Policy targets and regulations are in force, at an EU level, to ensure the energy efficiency improvement of the building stock. The Energy Performance of Buildings Directive ([EPBD] 2002, recast 2010) is the main legislative and policy tool in EU and focuses on both new and existing buildings. At the same time, the building sector plays a prominent role in the Energy Efficiency Directive ([EED] 2012). Relatedly, in the Netherlands, the foundation of energy efficiency policy has been a number of national cross-cutting measures and EU derived policies that play a large role; like the strengthening of standards for new buildings or dwellings and energy labels for existing ones (EPBD) (ECN 2015). Additional measures target split incentives. In 2013, a revolving fund for savings in buildings was created – 150 million euros from the government and 450 million from market parties (ECN 2015).

The energy savings potential of the existing dwellings is large. In the Netherlands, policy measures have been employed since the last quarter of the 20th century, mainly through building decrees. The energy consumption of new buildings has been regulated since 1975 consisting of limits on transmission losses based on insulation values (Boot, 2009). In 1995 these limits were expanded to include the national "EPC" (Energy Performance Coefficient) which is a figure expressing the energy performance of a building depending on the energy consumed for space heating, hot water, lighting, ventilation, humidification and cooling. The energy performance of the existing housing stock is being regulated through energy labels (A to G – most efficient to least efficient), since 2008, when the EPBD was implemented in the Netherlands. The average energy label in 2015 was C (RVO 2015). As the years pass, more dwellings adopt an energy label and thus far 2.9 million have one. The majority of these dwellings belong to the rental sector.

Despite the regulations and directives, there is a greater focus on newly built dwellings, achieving nearly zero energy standards, than on energy renovations of the building stocks. Nonetheless, energy renovations of dwellings are considered to be more sustainable and cost-effective than demolition and rebuilding (Itard & Klunder 2007), and should be given priority and incentives, especially taking into account the low and declining construction rates in the EU (Pombo et al. 2016; Thomsen & Van der Flier 2002). Energy renovations offer unique opportunities for reducing the energy consumption and greenhouse gas emissions. Energy renovation is instrumental for reaching the EU 2020 goals (Saheb et al. 2015). Moreover, renovations of the existing building stock have implications for growth and jobs, energy and climate, and cohesion policies (European Commission 2014; Saheb et al. 2015). Renovating existing buildings is seen as a 'win-win' option for the EU economy (Saheb et al. 2015). However, there are challenges mainly relating to the financing, market uptake and occupant awareness of energy renovations. Further, although there have been various energy renovation actions of dwellings in Europe (see Section 2), the assessment and monitoring of the pace of these renovations is lacking.

The tenure mix of dwellings bears a significant relevance to the ability to renovate regarding both the energy performance and the impact on the pace of energy renovations. The total amount of dwellings in the Netherlands is 7.5 million. The owner occupied sector comprises 55.8% of the total, whereas the rental sector amounts to 43.5% (BZK 2016b). The ownership type is unknown for the remaining 0.7% (BZK 2016b). The vast majority of the rental sector belongs to housing associations forming the non-profit housing sector. In this paper, we focus on the Dutch non-profit housing because the sector comprises approximately 2.3 million homes, which adds up to 30% of the total housing market (BZK 2016a). This is a unique situation as the Netherlands have the highest percentage of non-profit housing in the EU. The non-profit housing sector can be expected to be a leading example when it comes to energy efficiency goals due to its intrinsic social values.

Although no common definition for the non-profit housing sector is used, three elements are shared across the European non-profit social housing sectors: a mission of general interest, affordable housing for the low-income population and realization of specific targets, defined in terms of socio-economic status or the presence of vulnerabilities (Braga & Palvarini 2013). Non-profit housing is typically owned by the public sector; however, there is an increasing trend towards non-public involvement or the privatization of the non-profit housing sector in Europe, as is the case in Ireland, UK, Austria, France, and Denmark. Since the beginning of the 1990s the Dutch non-profit housing sector deviated from government control and public financing and became an independent sector. In the Netherlands, non-profit housing is almost entirely in the hands of private organisations (Elsinga & Wassenberg 2014; Priemus

2013; BPIE 2011; Kemeny 2002). These organizations can be better described as "hybrid" – they act between government, market and community (Nieboer & Gruis 2016). They have to manage the different and frequently competing interests from each of these three entities (Nieboer & Gruis 2016). The housing organizations have to fulfil several mandatory goals regarding the provision and allocation of homes.

Energy savings and sustainability are high on the agenda of the non-profit housing sector, especially since 2008 (Aedes 2013). The main energy efficiency policy for the sector is described in the Energy Saving Covenant for the Rental Sector ("Convenant Energiebesparing Huursector", 2012). The current aim of the non-profit housing sector is to achieve an average energy performance indicator, called Energy Index (EI), of 1.25, corresponding to an energy label B, by the end of 2020 (BZK 2014). The Covenant is a voluntary agreement between Aedes – the umbrella organisation of housing associations – the national tenants union, and the national government. The goal of the agreement means a reduction by 33% in energy consumption compared to the 2008 levels (BZK 2014; CECODHAS Housing Europe 2012). This voluntary agreement is a prominent example of policy implementation in organized housing. Agreements like this one could be enforced in communities and other public or private bodies to ensure energy efficiency of housing stocks. However, the application of such agreements is difficult in the owner-occupied housing sector where the owner bears the energy efficiency investment weight alone and is difficult to motivate.

The main aim of the article is to determine the actual renovation rate of the non-profit housing stock in order to conclude if the targets set are reachable and if not, what are the policy instruments needed to increase this rate. The energy renovation rate for the non-profit housing stock of the Netherlands is presented based on the changes in the energy performance of about 856,252 dwellings for the period of end 2010 to the end of 2014. We aim to identify the amount of dwellings in the non-profit housing sector of the Netherlands that showed an improved energy performance during this period. Moreover, we also analyse the energy improvements of the stock per year to get a more detailed view of the trend of the energy renovation rate. Through this study we highlight the importance of monitoring the energy renovations in the housing stock.

A common definition of an energy renovation is lacking. In 2014, the European Commission published the guidelines to finance the energy renovation of buildings. According to these guidelines, there are three types of energy renovations: the implementation of single measures (including the low-hanging fruit), the combination of single measures (which can be termed "standard renovation") and the deep or major energy renovation – referring to renovations that capture the full economic energy efficiency potential of improvements (European Commission, 2014). We define the energy improvement rate as the amount of dwellings that were improved by at least one label step in a specific amount of time (e.g., one year). In addition we also refer to the dwellings that improved towards the highest energy performance (labels A or B). We define the deep renovation pace as the amount of dwellings that improved by at least 3 label categories. We have chosen this minimum of three 'steps', because this improvement in energy efficiency involves the application of a serious package of measures and is in line with several subsidy schemes.

This paper is structured as follows. The second section presents an overview of energy efficiency goals and improvements in several European countries. The third section describes the data and methods of our research. The fourth section presents the results. The fifth section deals with our experiences concerning the database and the longitudinal data analysis. Finally, the sixth section elaborates on policy implications and draws conclusions.

§ 3.2 Energy efficiency regulations, goals and insights in progress

The European Environmental Agency (EEA) reports that the EU is going to achieve its 20-20-20 climate, renewable energy and energy efficiency targets (EEA 2015). The climate targets refer to the Greenhouse Gas (GHG) emissions projected to be 27% lower in 2030 compared to the 1990 levels (based on 2014 data); moreover, the goal for a 20% reduction in 2020 will be met (EEA 2015). The renewable energy targets refer to 20% share of Renewable Energy Sources (RES) in energy consumption. The energy efficiency targets refer to the level of primary and final energy consumption. The energy efficiency target for 2020 is defined as an absolute target. It is set 20% below the level in primary energy consumption of 2005 (EEA, 2015). Apart from the prevailing "20-20-20" goals, when it comes to reducing the primary energy consumption at the EU level, the Energy Efficiency Directive 2012/27/EU (EED) is in place. All Member States have their own national plans to achieve the targets as required by the EED. Since 2005, the levels of energy consumption have been decreasing (EEA 2015); however, the complete implementation and enforcement of the national energy efficiency policies is required to achieve the goals of 2020. The Netherlands, along with seven other Member States (Belgium, Estonia, France, Germany, Malta, Poland and Sweden), have not achieved the required savings (BPIE 2014; EEA 2015). This means that they are only on track towards either the primary or the final energy consumption targets, and not both – despite the fact that the Netherlands reduced both primary and final energy consumption in 2012, as compared to 2005. The 2.0% reduction in primary energy (on average 0.3% per year) is not sufficient to be considered on the right track towards meeting its 2020 target (i.e., an 11.3% reduction in primary energy consumption between 2005 and 2012, or 0.8% per year)[7]. However, the Netherlands made better progress in 2013 in comparison to 2012 reducing the primary energy consumption and the gap towards the projected targets. Some of the reasons that targets are still not reached for the Netherlands, are the very low shares of RES in total (electricity, heating and cooling, transport) and in particular for the heating and cooling sectors relating to buildings. On the other hand, twenty Member States are considered to be on track towards their 2020 energy efficiency targets (EEA 2015). Still, the national targets set by the Member States are not always sufficient compared to the set EU targets (EEA 2015). Thus, all Member States need to enhance the reduction or limitation of their energy consumption by better implementing and further developing their energy efficiency policies.

The 2012 EED and the 2010 EPBD- are the EU's main legislation for the reduction of the energy consumption in buildings. Observing recent trends and policies in Europe, the EED focuses on energy savings in buildings, transport, products, and processes (European Parliament, Council of the European Union 2012). Among other obligations, in article 4 of the EED, Member States are required to establish long-term strategies for mobilising energy renovations in their building stocks (BPIE 2014). A recent evaluation of the EED (BPIE 2014) found that energy renovation plans or guidelines are still lacking in identifying the most effective measures for each climate, country (according to its national energy regulations), type of dwelling, size, age, operation, and maintenance, dwelling envelope, and many more. On top of this, there was no clear definition of the term energy renovation at a European level, thus making the implementation of energy efficiency measures more difficult.

In 2008, the EPBD of the EU was implemented in the Netherlands. Under this directive, all Member States must establish and apply minimum energy performance requirements for new buildings, for the major renovation of buildings and for the replacement or retrofit of building elements (heating and cooling systems, roofs, walls, etc.). They must, also, ensure the certification of the energy performance of existing buildings when they are sold or re-rented. Furthermore, the regular inspection of boilers and air-conditioning systems in buildings is also required. The revised EPBD of 2010 requires Member States to also guarantee that by the end of 2020, all new buildings are 'nearly zero-energy buildings' (Beuken 2012; van Eck 2015). New buildings and major renovations in the Netherlands are required to meet specific standards e.g. thermal resistance (R_c-value) of floors, facades, roofs and thermal

7 Source: Eurostat 2014, reported targets under Article 3 of the EED (Eurostat, 2014)

transmittance (U-value) of windows, as of January 2015 (van Eck 2015). In addition, the term major renovation is used for dwellings where more than 25% of their envelope area is renovated (van Eck 2015) which is in accordance to the 2010 recast of the EPBD (European Parliament and the Council 2010). Only minimum insulation standards are applied for minor renovations or isolated energy efficiency measures, without an energy performance calculation being necessary (van Eck 2015).

Throughout Europe, national approaches to building stock monitoring have evolved separately. Information about the progress of energy performance improvements is not only needed to track the progress of policy implementation (Boermans et. al. 2015) but better information and data are necessary to help develop roadmaps in order to achieve more energy efficient buildings (BPIE 2011). At the time, each country is gathering and analysing data for the development of their building stocks differently. Some collect data through the Energy Performance Certificates (EPCs) databases and others perform housing surveys in representative samples. Another way is to collect information through the investments on energy renovations and calculate the progress. In this paper, we use yearly records gathered centrally and stored in a dynamic database by housing associations through the energy labelling of their stocks. Similarly, every country regards energy renovations in a different way when it comes to the level of performance achieved after one. Concerted guidelines for data collection, energy renovation definitions and implementation of policies are much needed on an EU level.

However, there is a limited amount of data available regarding the pace of the energy renovation of the building stocks in Europe. Detailed knowledge of the renovation rates, achieved in the housing stocks, is of great importance as they help monitor the progress of energy renovation and their impact on the energy performance of the housing stocks. Renovation rates can help predict future energy consumption values of the housing stocks and the overall reduction of energy consumption on a global scale. Apart from helping realize the challenging goals set for the built environment, renovation rates are also important to understand how quickly and what energy performance level can be achieved. They also relate to other issues in the built environment, such as fuel poverty. Ultimately, renovation rates are an indication of the progress of the buildings stocks and a tool for achieving future goals and policies.

Due to the fact that each country has implemented different national plans for the efficiency of the housing stock, the assessment methods and the reported progress are also different. The availability of data is limited to the goals that countries set, the investments that took place for the renovation of the stock or in terms of energy consumption reduction. In Denmark, the final heating energy consumption of residential dwellings in 2014 was 45% lower per square meter in comparison to 1975 data but there is no actual energy renovation rate reported (Danish Government

2014; Wittchen & Kragh 2014). In the UK, the country's 26 million dwellings were responsible for 27% of all UK CO_2 in 2008 (Dowson et al. 2012; Utley & Shorrock 2008). According to the yearly housing survey, in the UK, in 2013-2014 the English housing continued to improve but there is no reported renovation rate (English Government 2014). In Germany, the annual renovation rates reported are based on the m^2 of improved elements of the envelopes of the existing stock. Nearly 1% p.a. of residential buildings built up to 1978 added exterior wall insulation (IWU 2010), and the thermal insulation of top floor ceilings is between 1% and 2% p.a. (IWU 2010). Based on a study by the Institut Wohnen und Umwelt (IWU), with data retrieved form a large survey on thermally renovated dwellings, for the period of 2000-2009 the annual renovation rate was 1% (IWU 2010).

Sandberg et al. (2016) use historical statistical data and a dynamic model to compare the renovation rates of dwellings between countries. They estimate the renovation activity resulting from the natural ageing process of the dwelling stock in each country involved. This definition relates to deep energy renovation happening every 40 or 50 years. The basis of the model is a populations' need to reside. The input parameters are the drivers in the system, the historical population development and the development of the number of persons per dwelling (Sandberg et al. 2016). The model includes, in the form of probability functions, the historic demolition and construction rates of each stock and the share of dwellings that are never demolished (e.g. monuments). The main outputs are the construction, demolition and renovation rates. Most scenario analyses and roadmap reports on energy renovations and savings usually calculate high energy renovation rates, for the near future, of 2.5-3%, in order to achieve the goals (BPIE 2011; European Parliament, Council of the European Union 2012; Sandberg et al. 2016). The results of Sandberg et al. indicate renovation rates between 0.6% (for Serbia) to 1.6% (for Great Britain) over 2015. The rates projected for 2030 and 2050 remain quite stable with no sudden positive developments. For the Netherlands the renovation rate is 1.3% over 2015 and 1.4% over 2030 and 2050.

In the Netherlands, the majority of policy measures aimed to reduce the energy consumption by increasing the energy performance of buildings through the improvement of the energy labels (BZK 2014). The energy performance of an existing building is expressed by the EI, which is the figure relating the modelled annual primary energy consumption, the total heated floor area, the heating losses. The EI typically takes values between 0 (extremely good performance) to 4 (extremely bad performance), and is categorised in energy labels (see Section 3.3).

Although there has been a great deal of research on the energy efficiency and consumption of the housing stock, little has been published on the improvement pace. In a previous publication by the authors the pace of several energy improvement measures is reported – with the majority of dwellings having improved the heating system and the glazing (Filippidou et al. 2016). Even though the energy efficiency policies and initiatives implemented in the Netherlands place it at one of the leading positions of the EU residential sector, there is no evidence of a steady reduction of the gas and electricity consumption compared to the 1990 levels (Majcen et al. 2013a). On the contrary, the total energy consumed (gas and electricity) by households increased by 11% from 1990 to 2008 (Majcen et al. 2013a). According to the energy module of the Dutch National Housing Survey ("Woononderzoek Nederland" – WoON), Laurent et al. (2013) stated that the energy performance has increased since 2006. However, it was also found that the energy performance of the non-profit sector was low in comparison to the rest of the residential stock (Tigchelaar & Leidelmeijer 2013). The non-profit sector has a large potential for improvement.

§ 3.3 Data and methods

This study focuses on the non-profit sector, which forms 30% of the Dutch housing stock and is representative in terms of building typology (Stein et al. 2016; Filippidou & Nieboer 2014). Moreover, the non-profit housing sector is more active than the owner-occupied when it comes to energy renovations. A detailed analysis of the energy renovation rates in the non-profit housing will lead to more extensive knowledge on what type of energy renovations are undertaken. Furthermore, we identify the energy efficiency achieved after the energy renovations and we discuss what can be expected in terms of renovation rates in the future.

In this paper, the Dutch EI will be examined through consecutive years in order to calculate the energy renovation pace based on the energy performance of the dwellings. The EI is the official coefficient for measuring the energy efficiency of an existing dwelling, and is often categorised into an energy label, ranging from A to G (see Table 3.1).

The EI is related to the total theoretical energy consumption of a building or a dwelling: Q_{total}. According to the norm of the calculation of the EI, as shown in Equation 3.1, it is corrected taking into account the floor area of the dwelling and the corresponding heat transmission areas.

The EI is calculated as follows:

$$EI = \frac{Q_{total}}{(155*A_{floor}+106*A_{loss}+9560)}$$

Equation 3.1

Q_{total} refers to the modelled characteristic yearly primary energy use of a dwelling, and includes energy for space heating, domestic hot water, additional energy (auxiliary electric energy needed to operate the heating system, i.e., pumps and funs), lighting of communal areas, energy generation by photovoltaic systems, and energy generation by combined heat and power systems under the assumption of a standard use (Filippidou et al. 2016; Visscher et al. 2012; ISSO 2009). A_{floor} refers to the total heated floor area of the dwelling, whereas A_{loss} refers to the transmission heat loss areas in the dwelling, such as a cellar (Filippidou et al. 2016; Visscher et al., 2012; ISSO, 2009). The numerical values in the denominator are: 155 is the factor for the reference energy consumption per m^2 correction, regarding the useful living area (MJ/m^2); 106 is the correction factor compensating for the transmission losses (MJ/m^2); and 9560 is a standard amount of energy used for existing dwellings (MJ) (NEN, 2012).

TABLE 3.1 Connection of Energy Index with the Energy Label in the Dutch context and the primary energy consumption (ISSO, 2009)

ENERGY LABEL	ENERGY INDEX	MEAN THEORETICAL PRIMARY ENERGY CONSUMPTION (KWH/M2/YEAR) (MAJCEN ET AL., 2013)
A (A+, A++)	<1.05	96.8
B	1.06 – 1.3	132.5
C	1.31 - 1.6	161.6
D	1.61 - 2.0	207.8
E	2.01 - 2.4	265.0
F	2.41 - 2.9	328.0
G	> 2.9	426.9

A complete and detailed assessment of the current efficiency state of the non-profit housing stock in the Netherlands is necessary in order to examine the energy renovation pace. In 2008, after the formulation of the Covenant on energy saving targets, Aedes started a monitoring system of the dwellings called Sociale Huursector Audit en Evaluatie van Resultaten Energiebesparing (Social Rented Sector Audit and Evaluation of Energy Saving Results) abbreviated SHAERE.

This monitor became operational in 2010. Housing associations report their stock to Aedes at the beginning of each calendar year accounting for the previous year (e.g., in January 2014 reporting for 2013) (Aedes 2015). They report the energy status of their whole dwelling stock, every year, using the Vabi Assets software (Tigchelaar 2014), whose basis is the Dutch energy labelling methodology (ISSO 2009). As a result, SHAERE consists of the actual characteristics of all dwellings of the participating housing associations at the end of each calendar year. SHAERE is the first monitoring database of the energy efficiency evolution of the building stock in the Netherlands with microdata information, on a dwelling level. We connect each record to the specific dwelling, it refers to, based on an encrypted identifier variable (dwelling ID) that consists of the dwelling's post code, address, number and possible number addition. It is a time series database including a maximum of five records per dwelling – 2010, 2011, 2012, 2013 and 2014. Table 3.2 shows an example of the structure of the database connecting the dwelling ID with the EI variable. In the same manner all available variables are connected to each dwelling based on the ID.

TABLE 3.2 Example of the structure of SHAERE (variables dwelling ID and EI)

DWELLING ID	EI.2010	EI.2011	EI.2012	EI.2013	EI.2014
#1	1.1	1.1	1.1	1.1	0.9
#2	2.7	2.3	-	2.3	2.3
#3	-	-	3.1	-	3.1
...	...	...	...	...	...

The database includes data from 2010, 2011, 2012, 2013 and 2014, on the performance of the stock in the form of energy certificates. The data comprise of physical characteristics (thermal transmittance [U-value] and resistance [R_c-value] values of the envelope elements, the typology of dwellings, the year of construction, etc.), heating and ventilation installations, theoretical energy consumption, CO_2 emissions, the average EI and more (Filippidou et al. 2016). The variables are categorized per dwelling. A considerable part of the non-profit housing stock is included in SHAERE. However, the number of homes differs per year, as not all dwellings are reported every year (e.g. one can have 2 records whereas another one can have all five). Table 3.3 presents the exact numbers.

TABLE 3.3 Number of dwellings reported in SHAERE per year

YEAR OF REPORTING	AMOUNT OF INDIVIDUAL DWELLINGS REPORTED	PERCENTAGE OF THE TOTAL NON-PROFIT STOCK
2010	1,132,946	47.2%
2011	1,186,067	49.4%
2012	1,438,700	59.9%
2013	1,448,266	60.3%
2014	1,729,966	73.7%

This study focuses on the dwellings that have been reported more than once (i.e. where data have been inputted by the housing associations in repeated years) in order to pinpoint and to study the EI each year. We use longitudinal data to observe the changes of the EI of the same dwellings. We observe whether or not the inputted data have changed from 2010 to 2014 and, in section 4.3, we also analyse the data per year 2010 - 2011, 2011 - 2012, 2012 - 2013 and 2013 - 2014.

At the beginning of every data analysis, extensive data filtering is required. The initial amount of dwellings was 2,151,620. The first step was to exclude the dwellings that were present in the database but bore no information. The second step was to remove potential double cases from the data. When reports with exactly the same address, the same energy index (EI) and reporting year were found, one of the duplicate records was removed. Cases with exactly the same address, the same reporting year, but different EI were also removed, as it is not possible to know which EI was the most recent or correct one. Thus, an amount of 0.25% of the initial records in the database were excluded, this way, from the analysis. Having finished this part of the data filtering, 2,146,014 dwellings with records formed the complete database.

In order to identify and study the energy improvements, we focus on the dwellings that have been reported more than once – meaning that dwellings reported only once had to be removed as their progress cannot be tracked. There were 435,571 unique dwellings with only one report between 2010 and 2014 (20.2% of all records). The amount of 1,716,049 dwellings was analysed.

Essentially, due to the longitudinal nature of the data we have one dataset. In this one, a maximum of 1,716,049 dwellings are present. These dwellings can have two or more reports with a maximum of five (2010, 2011, 2012, 2013 and 2014). In section 4.1, all dwelling records in the period 2010 - 2014 are included because we present the progress of the EI distribution each year. And we assume that, despite not all dwellings being updated each year, the number of dwellings reported each year is high enough to be representative for the non-profit sector. In section 4.2, we only take into account the dwellings that had a record in both 2010 and 2014 to observe the progress in this period (856,252). And in section 4.3, we examine the progress per year – records in both 2010 - 2011 (911,598 dwellings), 2011 - 2012 (868,990 dwellings), 2012 - 2013 (1,132,727 dwellings) and 2013 - 2014 (1,384,831 dwellings).

We determine and examine the energy improvement pace of the social housing stock, observing the whole reported stock for four consecutive years and tracking down the differences in the EI. Due to the fact that the records of existent but also new, to the system, dwellings are added to the database each year, some discrepancies are present. Apart from the double records and missing data that we mentioned above, dwellings with an increasing EI can appear – meaning that the energy performance of a dwelling can deteriorate. In these cases the data are "illogical" since a deterioration is impossible to occur in just one year. Thus, if an increase of the EI was observed over the years, we assume this to be an administrative correction. In these cases, the EI was corrected to the level of the EI before the deterioration occurred, and perceived as no improvement or decrease of the energy performance. As a result, these dwellings are perceived as non-renovated. For 2010 - 2014, about 2.4% of the dwellings analysed presented a decrease of their energy performance. This percentage, when examined for the calculations performed for each year, was shown to be decreasing from 1.9% over 2011 to 0.7% over 2014, as more dwellings were reported. The increase of the EI can be attributed to two main reasons. Firstly, it could be an administrative correction during the process of data input. And secondly, it could be caused by wrong inspection procedures. In both cases, it is very difficult to determine the reason. However, the percentage of dwellings with an increasing EI is very low.

§ 3.4 Results and discussion

This section first presents the energy efficiency status of the non-profit housing sector in the Netherlands, and then goes into the energy renovation pace results between the end of 2010 and the end of 2014.

§ 3.4.1 Energy efficiency state 2010-2014

Figure 3.1 presents the distribution of the energy labels of the non-profit housing stock for four different years (2010 - 2014). In the first column of the graph (A label), the A+ and A++ labels are also include

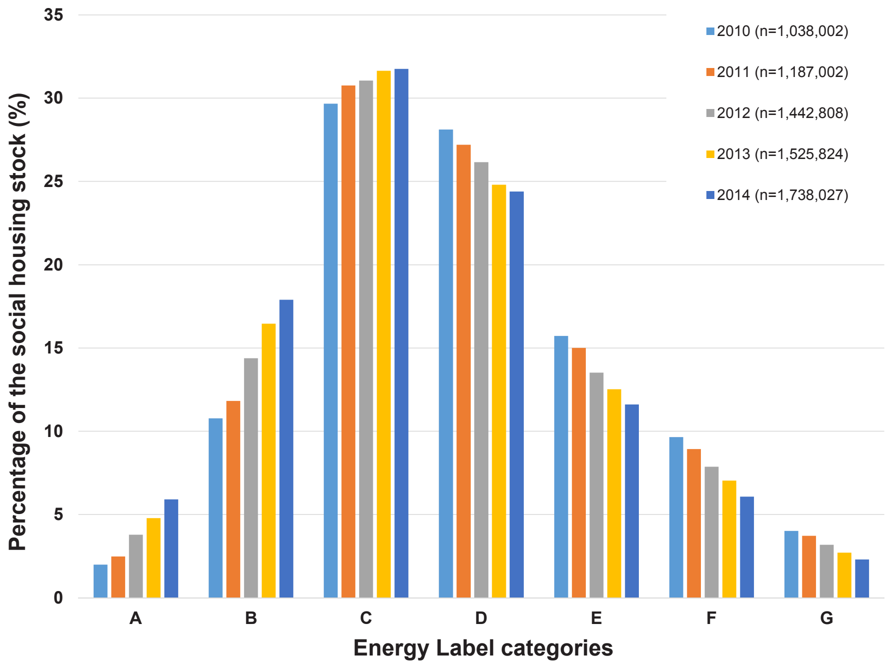

FIGURE 3.1 FDistribution of the energy labels of the non-profit rented housing sector in SHAERE database

It is clear that there is a tendency towards an increasing performance through the years. The labels denoting a relatively inefficient home (D, E, F, and G) show a decline through the years, whereas the 'higher' efficiency labels (A, B, C) show an increase. The same trend in progress is reported, by the Netherlands Enterprise Agency, for the officially registered energy labelled dwellings on a national scale (owner occupied, private rented and non-profit housing) (RVO 2015). The distribution of the labels in SHAERE corresponds to an average EI of 1.71 or an average label D.

In 2010, the average EI was 1.81, in 2011 it was 1.73, in 2012 it was 1.72, in 2013 it was 1.69 and in 2014 it was 1.65 (see Figure 3.2). These averages refer to the non-profit housing stock each year taking into account new construction and demolished dwellings[8]. A linear projection of this decrease reveals that one of the central goals of the national Dutch covenant, namely an average EI of 1.25 in 2020, is not reachable if the improvement rate remains the same. The EI would then be 0.16 too high

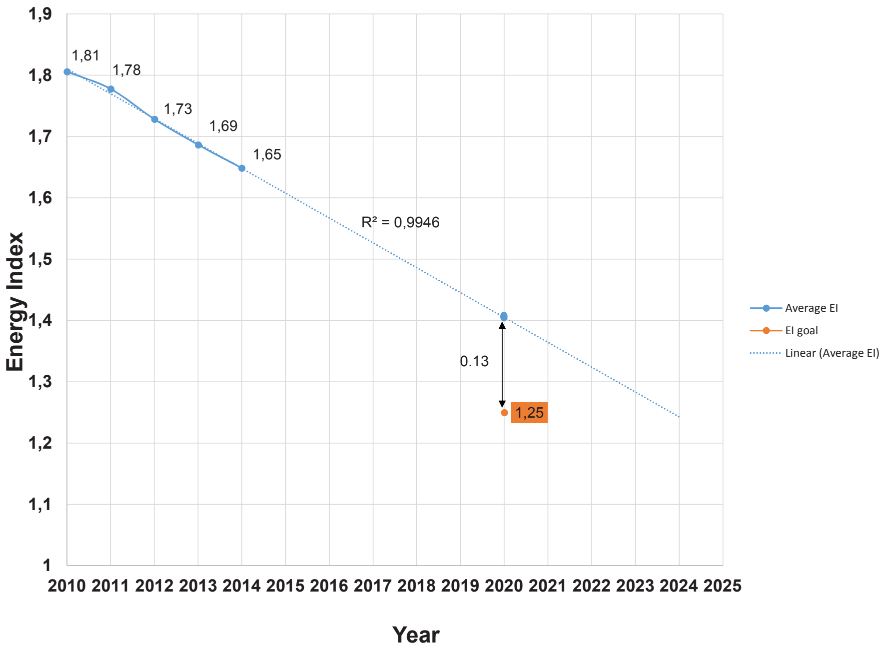

FIGURE 3.2 The Energy Index (EI) development of the non-profit rented housing sector in SHAERE database

§ 3.4.2 Energy improvements 2010 - 2014

This sub-section focuses on the dwellings that were reported both in 2010 and 2014 and highlights the renovated stock. Table 3.4 presents the changes in the energy performance rating between the end of 2010 and the end of 2014. The table is best

8 However, the dwellings reported in the following sub-sections (4.2 and 4.3) are the ones that were reported multiple times – new construction and demolition are not included.

read starting by each column, representing the labels in 2010 and the total amount of dwellings in each label category. For example, the amount of dwellings with an energy label B is 87,682. Below the total number of dwellings, we present the distribution of the energy labels in 2010 (in %). The diagonal line of the table represents the non-renovated dwellings (in italic font). Continuing, reading each row, we show the improvement of dwellings in label steps in the period of 2010 to 2014. For example, starting from the first row, the number of A labelled dwellings is unchanged as they cannot move to a "higher" label category. But from the labelled B dwellings (in 2010), 5,453 had their label improved to A in the period until 2014. In the same manner, 2,541 dwellings had their label upgraded from C, in 2010, to A in the period until 2014. The percentage of improvement, at the bottom of Table 3.4, emphasizes the amount of improved dwellings from a specific label category to another. This percentage is relatively high for the most inefficient dwellings, whereas for label category A, the percentage is 0.

TABLE 3.4 Number of dwellings according to energy label in 2010 and 2014 (n=856,252)

		2010							
		A	B	C	D	E	F	G	Labels in 2014
2014	A	*16977*	5453	2541	2426	1584	1538	384	3.6 %
	B		*82229*	44973	15119	7340	4323	1647	18.2 %
	C			*218506*	54042	14293	6090	2171	34.8 %
	D				*173059*	32504	11638	2326	25.6 %
	E					*72670*	16194	4473	10.9 %
	F						*38186*	5621	5.1 %
	G							*14945*	1.7 %
	Total	16977	87682	266020	247646	128391	77969	31657	856252
	Labels in 2010	2.0 %	10.2 %	31.1 %	28.9 %	15.0 %	9.1 %	3.7 %	100 %
	Improve-ment	0.0 %	0.6 %	5.5 %	8.7 %	6.5 %	4.6 %	1.9 %	28.0 %

Dwellings with an improved label were 28.0% (239,680 of 856,252) in total, while 72.0% (616,572 of 856,252) of the dwelling reports did not change label category (in italic font in Table 3.4).

Figure 3.3 highlights the results of the improved dwellings presented in Table 3.4. The colours in this figure refer to the state at the end of 2010, whereas each of the bars refers to the label at the end of 2014. For example the bar labelled B in 2014 (after renovation), includes 5.2% of G labelled dwellings in 2010 that were updated to label

B until 2014, 5.5% of F labelled, 5.7% of E labelled, 6.1 of D labelled and 16.9% of C labelled dwellings in 2010 that were updated to B until 2014.

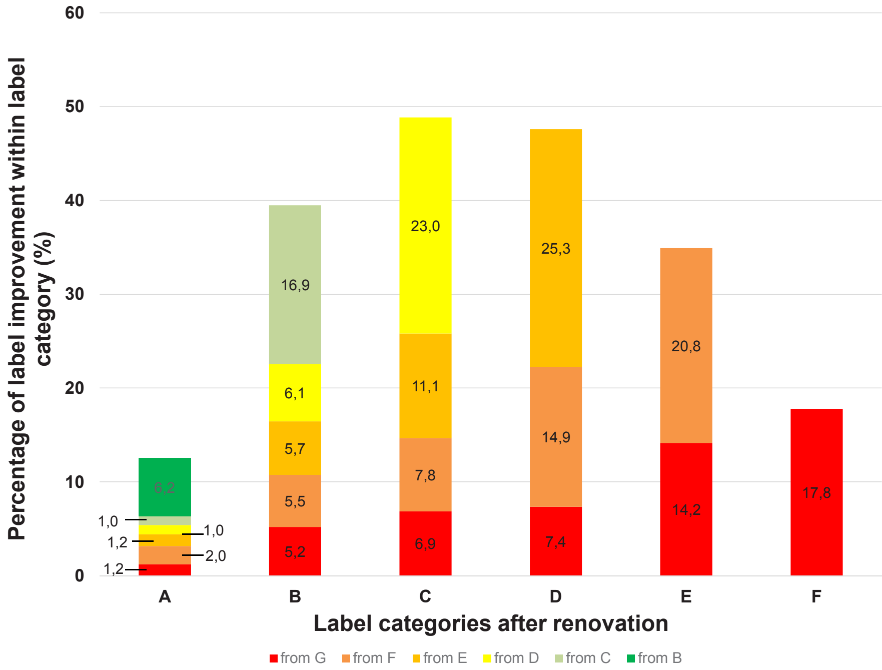

FIGURE 3.3 Improvement of labels of the non-profit rented housing sector from 2010 to 2014

The main message of Figure 3.3 is that most changes are, what we refer to as, 'small label steps'. The majority of dwellings improved by one 'label step' in the period 2010 - 2014. The majority of the dwellings that moved to label A, after renovation, came from a B, C or D label, but not from E, F and G. Similarly, the majority of the E, F and G labels moved to D and E labels. The number of dwellings that improved three or more label categories (e.g., from G to C, F to B, D to A) correspond to, only, 1.4% of the 856,252 dwellings, and form 12.4% of the ones that had their label improved by at least one step (29,829 of the 239,680).

The amount of renovated dwellings – on a national scale – projected to be needed by the Dutch Environmental Assessment Agency in order to reach the EU and national goals of energy efficiency is 170,000 (van den Wijngaart et al. 2014). If we were to allocate 30% – the percentage of non-profit housing of the complete housing stock – of these 170,000 to the non-profit housing stock, the amount of dwellings needed would be 51,000. The 29,829 non-profit renovated dwellings, based on our results, are 58.5% of what would be needed from the non-profit housing sector if the simple 30% analogy was applied. However, non-profit dwellings are expected to be renovated at higher rates due to the social values and the concerted actions of the housing associations. Owner-occupied dwellings (55.8% of the housing stock) are estimated to have lower renovation rates and renovated number of dwellings. The deep energy renovations in the non-profit sector are not enough to support and fulfil the goals set by the government.

§ 3.4.2.1 Energy improvements per year

The same analysis was performed on the available data for a year-by-year overview. Table 3.5 reports the changes in 2011 (in comparison to 2010), while Table 3.6, Table 3.7 and Table 3.8 report the changes in 2012, in 2013 and in 2014 respectively. The numbers in italic denote the dwellings of which the label category did not change in the specific period. The tables should be read in the same manner as Table 3.4.

TABLE 3.5 Number of dwellings according to energy label in 2010 and 2011 (n=911,598)

		2010							
		A	B	C	D	E	F	G	Labels in 2011
2011	A	*17890*	1499	119	211	136	136	43	2.2 %
	B		*95343*	11096	2057	1318	746	255	12.2 %
	C			*258190*	20595	3676	1343	461	31.2 %
	D				*230383*	14112	3518	611	27.3 %
	E					*125627*	8796	1672	14.9 %
	F						*75784*	3411	8.7 %
	G							*32570*	3.6 %
	Total	17890	96842	269405	253246	144869	90323	39023	911598
	Labels in 2010	2.0 %	10.6 %	29.6 %	27.8 %	15.9 %	9.9 %	4.3 %	100 %
	Improvement	0.0 %	0.2 %	1.2 %	2.5 %	2.1 %	1.6 %	0.7 %	8.3 %

In 2011, 8.3% of the dwellings (75,811 of 911,598) had improved their energy performance with one or more label categories (the sum of all dwellings above the diagonal in Table 3.5), whereas 91.7% of the reported dwellings did not change label category (835,787 dwellings, the sum of the diagonal cells in Table 3.5).

TABLE 3.6 Number of dwellings according to energy label in 2011 and 2012 (n=868,990)

		2011							
		A	B	C	D	E	F	G	Labels in 2012
2012	A	*20654*	3247	871	590	340	580	204	3.0 %
	B		*99140*	18563	4056	2076	1210	343	14.4 %
	C			*252528*	24885	4795	1400	517	32.7 %
	D				*206733*	15228	4560	664	26.1 %
	E					*104750*	7270	1628	13.1 %
	F						*62750*	2413	7.5 %
	G							*26995*	3.1 %
	Total	20654	102387	271962	236264	127189	77770	32764	868990
	Labels in 2011	2.4 %	11.8 %	31.3 %	27.2 %	14.6 %	8.9 %	3.8 %	100 %
	Improve-ment	0.0 %	0.4 %	2.2 %	3.4 %	2.6 %	1.7 %	0.7 %	11.0 %

In 2012, we compared the report for a certain dwelling in 2012 with the one in 2011. 95,440 dwellings out of the 868,990, for the 2011 - 2012 (Table 3.6) analysis, which corresponds to 11.0% of the sample, had an improved energy efficiency state. 89.0% (773,550) of the dwellings did not change label category.

TABLE 3.7 Number of dwellings according to energy label in 2012 and 2013 (n=1,132,727)

		2012							
		A	B	C	D	E	F	G	Labels in 2013
2013	A	*41238*	2383	915	908	331	160	59	4.1 %
	B		*162606*	13666	4268	1844	1324	339	16.2 %
	C			*346107*	17511	4294	1392	341	32.6 %
	D				*272051*	10298	3288	504	25.3 %
	E					*132570*	4739	1258	12.2 %
	F						*76465*	1614	6.9 %
	G							*30254*	2.7 %
	Total	41238	164989	360688	294738	149337	87368	34369	1132727
	Labels in 2012	3.6 %	14.6 %	31.8 %	26.0 %	13.2 %	7.7 %	3.0 %	100 %
	Improve-ment	0.0 %	0.2 %	1.3 %	2.0 %	1.5 %	1.0 %	0.4 %	6.3 %

In 2013, 6.3% of the dwellings (71,436 of 1,132,727) improved to a 'higher' label category, whereas 93.7% of the dwelling reports did not change a label category.

TABLE 3.8 Number of dwellings according to energy label in 2013 and 2014 (n=1,384,831)

		2013							
		A	B	C	D	E	F	G	Labels in 2014
2013	A	*67069*	2671	1226	1513	616	417	168	5.3 %
	B		*223356*	16835	4921	2261	1336	369	18.0 %
	C			*428732*	16598	3252	1419	325	32.5 %
	D				*323942*	10090	3107	571	24.4 %
	E					*153562*	5285	1572	11.6 %
	F						*81439*	1820	6.0 %
	G							*30359*	2.2 %
	Total	67069	226027	446793	346974	169781	93003	35184	1384831
	Labels in 2013	4.8 %	16.3 %	32.3 %	25.1 %	12.3 %	6.7 %	2.5 %	100 %
	Improvement	0.0 %	0.2 %	1.3 %	1.7 %	1.2 %	0.8 %	0.3 %	5.5 %

In 2014, 5.5% of the dwellings (76,372 of 1,384,831) improved by at least one label category, whereas 94.5% of the dwelling reports did not change a label category.

Figure 3.4 depicts the energy renovation rates of the non-profit housing stock when different levels of energy improvements are taken into account. The 'one label step improvement' rates (blue bar) range from 3.8% (2014) to 8.2% (2012). The 'two label step improvement' rates are significantly lower ranging from 1.02% (2014) to 1.83% (2012). The deep energy renovation rates (interpreted here as 'at least 3 label steps improvement') are considerably low ranging from 0.6% (2011) to 0.9% (2012) being the highest rate. The rate of improved dwellings to A or B labels ranges from 1.9% (2011) to 3.7% (2012). The 'A or B label improvement' is an overlapping category whereas the rest are distinct categories (when summed up they describe the total improved rate). Once more, it is evident that the majority of energy improvements in the non-profit housing sector refer to one label step change. The polynomial trend lines show an increased activity in all types of renovation in 2012 and a slight decrease in 2013 and 2014.

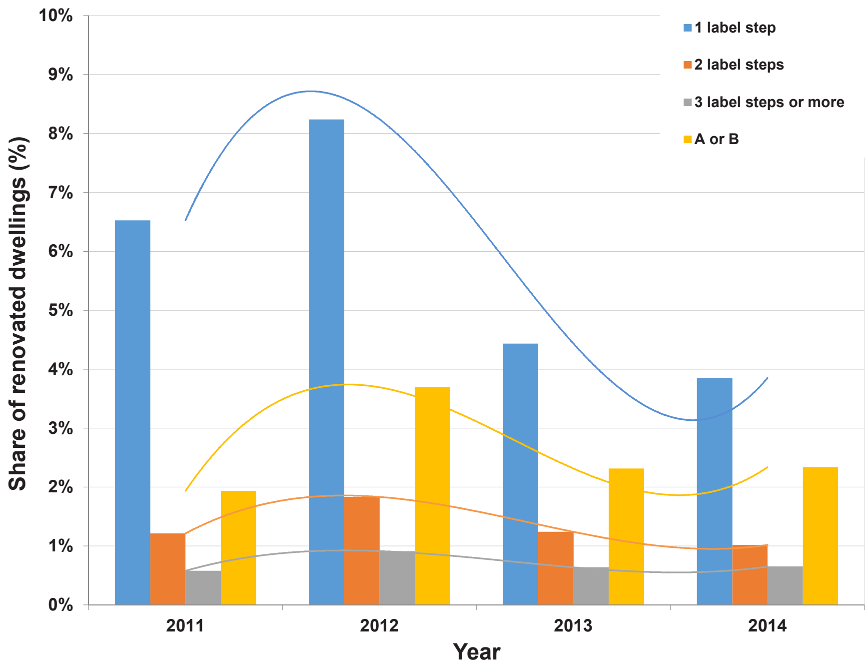

FIGURE 3.4 Energy renovation rates of the non-profit rented housing sector from 2011 to 2014

The data allows us to calculate the deep energy renovation rates (at least three or more label steps) per year. In 2011 the rate was 0.6%, in 2012 it was 0.9%, in 2013 0.6% and in 2014 the rate was 0.6%. The overall deep energy renovation rate for the period 2010 – 2014 was 3.5%. The rates are very low and relatively stable, since 2010, revealing that most of the energy renovations of the social housing stock refer to single improvements or minor renovation works. At the same time, in the Netherlands, the national average annual rate of newly built buildings was 0.6% of the existing residential building stock in 2014 and it has been quite stable since 2010 (Statistics Netherlands 2015; Yücel 2013; Meijer et al. 2009). The demolition rate was 0.15% in 2014 and is also quite stable since 2000 (Statistics Netherlands 2015). These facts highlight the importance of energy renovations and the leading role as an activity in the construction industry in the future.

§ 3.5 Reflection on the SHAERE monitoring system

Big data are used for research in all disciplines the last years. When it comes to research for energy renovations in the built environment, dynamic databases using time series data prove to be extremely useful. Longitudinal data are very important to follow the actual energy performance of housing stocks. Datasets and monitoring systems with detailed information, like SHAERE or EPC databases, prove to be extremely useful to evaluate policies, project future renovation rates and conclude on best practices for different housing stocks.

As highlighted, one of the strengths of SHAERE is the very large amount of data (2,146,014 dwellings reported at least once from 2010 to 2014), which is more than half of the dwellings of the non-profit housing sector in the Netherlands. The large sample is important since the study aimed at calculating the energy improvement pace of the sector. In this sense, the monitoring system can set an example for the rest of the housing sectors.

SHAERE has proven to be a rich database on the energy performance of the non-profit sector. This research was based on the dwellings' physical properties and the reported EI, in order to examine the improvements. Concerning the quality of the data used and the impact on the results of this study, two points should be mentioned. First, we cannot be completely confident about the quality of the inspections taking place in the sector. As a result, concerns have been raised about accuracy of the input data for the calculation of the EI in SHAERE. Although there has not yet been a study regarding the quality of SHAERE, a series of studies carried out by the Inspection Service of Public Housing, for the official energy labels database of the Netherlands, reported that in a sample of 120 labels issued in 2009, 60.8% of the inspected labelled dwellings had an EI that deviated more than 8% (Majcen et al. 2013a; VROM-Inspectie 2009). In 2010, only 26.7% had a different EI (VROM-Inspectie 2010) and in 2011, 16.7% of labels deviated more than 8% in their EI (VROM-Inspectie 2011). In 2013, the inspection was carried out only for office buildings. Hence, there seems to be a trend of improvement, although the studied samples are small (Majcen et al., 2013a). Further research is required to determine the amount of wrongly reported EI values of dwellings. We recommend that input methods be tested and validated in future monitoring systems.

In SHAERE, data with regard to a new reference date are 'simply' added as new records to the existing dataset, meaning that the database must first be restructured to connect the information about a dwelling with regard to several reference dates (Stein et al. 2016; Filippidou & Nieboer 2014). This is a time-consuming yearly procedure. The situation is exacerbated by the fact that, until 2014, individual dwellings did not have an own ID, by which data regarding several reference dates could be coupled (Stein et al., 2016 Filippidou & Nieboer 2014). Until then this was done by creating an encrypted ID variable based on address information (postal codes, street numbers and possible extensions), but although the Dutch postal codes are very refined (on sub-street level), this method is still less reliable than an individual ID. As a result, in future monitoring systems we recommend the use of an ID for the dwellings from the beginning of the system.

The monitor could be further improved if it contained data on a possible renovation: is the dwelling renovated and, if so, in which year. Until the 1990s, renovations in the non-profit housing sector were subsidised by the national government. Because of this, and because this type of interventions is relevant for today's asset management, there is good chance that housing associations still have this data available (Stein et al., 2016). A pilot would have to be carried out to check this and its applicability.

§ 3.6 Conclusions and policy implications

The main objective of this study was to determine the energy renovation pace in the Dutch non-profit housing sector over the years 2010 - 2014. We presented an analysis of the trends of the energy improvement pace between these years, for both the whole period and also per year. The data used derived from SHAERE, the official tool for monitoring progress in the field of energy saving measures for the non-profit housing sector in the Netherlands. The study consisted of longitudinal data analysis using variables from the monitoring system.

The results have shown that although a number of energy improvements have been realized, they only resulted in small changes of the energy efficiency of the dwellings. Even though 28.0% of the dwellings have improved (towards a 'higher' energy label category), only 3.5% had a major renovation (at least three label steps). This percentage depicts the major energy improvement pace of the non-profit housing sector in the Netherlands for a period of four years. In the sector, if the goal of an average label B is to be reached by 2020, the energy efficiency measures should be decided as packages of measures, rather than single measures because deeper renovations are needed. The pace in the period under investigation is too low to fulfil the ambitious goals of the national Covenant agreed in 2012 or reach the EU goals for energy efficiency. If the linear extrapolation of the EI, as shown in Figure 2, is followed, then the EI in 2020 will be 1.41. Several stakeholders argue that the renovation pace will increase, as there are several policies in effect. However, the results point out that there is a very limited movement towards the A (A+, A++ included) labels, which may indicate that the decrease of the EI will slow down, simply because most of the low hanging fruit (e.g., easy to implement single energy improvement measures such as double glazing windows) has already been picked.

When energy improvements are difficult to implement in non-profit housing, then the implementation will be even more difficult for the privately owned or rented dwellings. The structure of ownership and the buildings are more dispersed and fragmented than in the non-profit housing sector. As a result, in order to motivate private owners to renovate the residential stock, more concerted policies and market uptake plans are required from the central authorities, though strict and tailored implementation from the national governments will also play a major role.

Based on the results, we do not expect future improvements when it comes to the energy renovation pace if the same policies are followed. At the same time, there is also a change in the policies regarding the energy labelling of dwellings and the calculation of the EI in the Netherlands. A change in the methodology of the calculation of the EI is in force since June 2015. From now on, the re-calculation of the matching EI-Energy label is important. Another change in the energy label certificates was already implemented at the start of 2015. A new, easy to acquire and cheaper energy label is in force, based on a different calculation method without an inspection taking place. These changes are affecting the realization of several co-existing policies, and will also have implications with the implementation of energy improvement measures in the existing housing stock, especially in the non-profit housing sector, where specific targets regarding the EI have been agreed.

Further research is recommended on the specific measures that have taken place since 2010, and their subsequent impact on the actual energy consumption. As previous research has shown (Guerra Santin et al. 2009; Majcen et al. 2013a, 2013b) it is crucial to study the impact of the energy improvements of the housing stock on the actual energy consumption of the households in the dwellings. Predictions of the energy savings that can be achieved from the renovation of the stock should be based on the actual and not the theoretical consumption of energy. That way, more information about which combinations of renovation measures are more efficient for different typologies of buildings can also be used. Future research has to take into account the relationship between measures, packages of measures, major renovations on the one hand and the actual energy consumption on the other.

Lastly, the use of dynamic monitoring systems consisting of time series big data, like SHAERE, are very effective and suitable for research performed on the topic of energy renovations. They can be used to evaluate existing policies and improve future plans. They can also be coupled with other databases, for example actual energy consumption databases, to study the impact of renovations and if the energy consumption decreases.

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