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# Energy efficiency measures implemented in the Dutch non-profit housing sector

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ABSTRACT

The existing housing stock plays a major role in meeting the energy efficiency targets set in EU member states such as the Netherlands. The non-profit housing sector in this country dominates the housing market as it represents 31% of the total housing stock. The focus of this paper is to examine the energy efficiency measures that are currently applied in this sector and their effects on the energy performance. The information necessary for the research is drawn from a monitoring system that contains data about the physical state and the energy performance of more than 1.5 million dwellings in the sector. The method followed is based on the statistical modeling and data analysis of physical properties regarding energy efficiency, general dwellings' characteristics and energy performance of 757,614 households. The outcomes of this research provide insight in the energy efficiency measures applied to the existing residential stock. Most of the changes regard the heating and domestic hot water (DHW) systems, and the glazing. The rest of the building envelope elements are not improved at the same frequency. The results show that the goals for this sector will be hard to achieve if the same strategy for renovation is followed.


## 1. Introduction

Worldwide, the residential sector consumes an amount of energy that varies between 16% and 50% of the total, depending on the country [17]. Existing buildings account for approximately 40% of the energy consumption in the European Union and are responsible for 30% of the $CO_2$ emissions [13]. The existing housing sector is already playing an important role towards achieving the energy efficiency targets in the European Union (EU) [24,31]. A large part of this energy consumption comes from the residential sector, as dwellings consume 30% of the energy of the total building stock on average in the EU [12]. This study focuses on the existing housing stock in Europe and specifically the Netherlands. Based on 2009 data, households consume 425 PJ annually, in the Netherlands [25].

Existing buildings will dominate the housing stock for the next 50 years based on their life cycle; in the Netherlands the annual rate of newly built buildings is 0.6 of the existing residential building stock in 2014 [18,30,26]. Energy renovations in existing dwellings offer unique opportunities for reducing the energy consumption and greenhouse gas emissions on a national scale in the Netherlands but also on a European and global level. Although there have been initiatives for energy renovations of dwellings in the Netherlands, the assessment and monitoring of these renovations has been lacking. Monitoring the energy improvements of the existing housing stock is necessary and can provide valuable information concerning the technical characteristics and the future potential of the measures applied. This paper investigates what the energy improvement measures in the Dutch non-profit housing sector are over the last years and how they impact the energy performance of the dwellings.

### 1.1. Energy efficiency measures and interpretations of energy renovations

Several measures and energy efficiency policies have been applied both on a European and a national level. In 2008, the Netherlands implemented the EU Energy Performance of Buildings Directive (EPBD). Under this directive, all member states must establish and apply minimum energy performance requirements for new and existing buildings, ensure the certification of building energy performance and require the regular inspection of boilers and air-conditioning systems in buildings [4]. The Dutch energy performance measurement system, based on the 'Decree on Energy Performance of Buildings' (Besluit energieprestatie gebouwen – BEG) and the 'Regulation on Energy Performance of Buildings'

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**Table 1**
Connection of energy index with the energy label in the Dutch context.

| Energy Label | Energy Index | Mean actual primary energy consumption (Kwh/m$^2$/year) [15] |
|---|---|---|
| A (A+, A++) | <1.05 | 138.48 |
| B | 1.06–1.3 | 162.08 |
| C | 1.31–1.6 | 174.27 |
| D | 1.61–2.0 | 195.60 |
| E | 2.01–2.4 | 211.55 |
| F | 2.41–2.9 | 223.83 |
| G | >2.9 | 232.10 |

(Regeling energieprestatie gebouwen – REG), was introduced in 2008. The energy performance of a building is expressed by the Energy Index (EI), which is a figure ranging from ≤0.5 (extremely good performance) to >2.9 (extremely bad performance). The EI is calculated on the basis of the total primary energy demand ($Q_{total}$). The calculation method of the EI is described in NEN 7120 (published by the Dutch Standardisation Institute) and in ISSO publication 82.3-ISSO, The Dutch Building Services Knowledge Centre [9]. Based on the EI an energy label is assigned to the dwellings. The primary goal of the energy labels is to provide occupants and homeowners with information on the thermal quality of their dwellings. In addition, the theoretical energy use of the dwelling is also mentioned on all Dutch labels issued after January 2010, expressed in kWh of electricity, m$^3$ of gas and GJ of heat, for the dwellings with district heating [15].

The EI is calculated as follows:

$$EI = \frac{Qtotal}{(155 \times Afloor + 106 \times Aloss + 9560)} \quad (1)$$

The EI is related to the total theoretical energy consumption of a building or a dwelling $Q_{total}$ (MJ), in the nominator, and corrections applied (based on m$^2$), in the denominator. According to the norm of the calculation, as shown in Eq. (1), the EI is corrected taking into account the floor area of the dwelling and the corresponding heat transmission areas in order not to disadvantage larger dwellings and those that have greater part of envelope areas adjoined to unheated spaces.

$Q_{total}$ is the modelled characteristic yearly primary energy use of a dwelling adding up the energy for space heating, domestic hot water, additional energy (auxiliary electric energy needed to operate the heating system such as pumps and funs), lighting of communal areas and subtracting the energy generation by photovoltaic systems and/or energy generation by combined heat and power systems assuming a standard use as shown in Eq. (2) [9]. It is possible that the photovoltaic systems contribution is greater than the consumption of the rest of the systems and as a result the $Q_{total}$ can be negative [9]. $A_{floor}$ refers to the total heated floor area of the dwelling whereas $A_{loss}$ refers to the areas that are not heated in the dwelling such as a cellar [32,9].

$$Q_{total} = Q_{spaceheating} + Q_{waterheating} + Q_{aux.energy} + Q_{lighting} - Q_{pv} - Q_{cogeneration} \quad (2)$$

The Energy Label is based on the calculation of the EI (see Table 1). Table 1 also depicts the correlation of the EI to the energy label and the mean actual primary energy consumption per label category based on a research performed on 200,000 Dutch dwellings [15], since there is no direct connection of the EI and the theoretical energy consumption. Since January 1 2015 the calculation of the EI has changed in the Netherlands and is based on a point system. However, in this study we use the existing calculation method of the EI. This choice is based on the fact that all available data were collected before January 2015, when the new calculation method was not yet in effect. According to the new method for the EI calculation, the impact on the dwellings based on their typology would be different (distinction between single- and multi-family dwellings) [11]. In a first sample of 27,500 dwellings, 60% of them maintained the same EI and 34% of them acquired a better or worse EI [11]. In addition, the renovation year plays a major role in the new EI and other details that are more precisely calculated. Instead of a number, that is the case with the old method, the dwellings are characterized by a score of points for their energy performance that corresponds to an energy label after the registration to the Netherlands Enterprise Agency (RVO) [11].

**Table 2**
Number of dwellings reported in SHAERE per year.

| Year of reporting | Frequency | 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% |

In the context of improving the energy efficiency of the housing stock, the term 'renovation' is often used. However, there is no clear definition of what an energy renovation is on a global, European or national level. On top of that, there is no definition of the (amount of) improvements that a renovation should include in order to be called like this. For the latter, the European definition refers to either the area that is renovated or the cost of the renovation. A "major renovation" in the EPBD means the renovation of a building where [27]:

(a) the total cost of the renovation relating to the building envelope or the technical building systems is higher than 25% of the value of the building, excluding the value of the land upon which the building is situated; or
(b) more than 25% of the surface of the building envelope undergoes renovation.

This definition does not describe what are the measures that ensure a nearly zero energy consumption of the refurbished dwellings, but rather sets out under what circumstances an energy efficiency renovation should be undertaken. On the national level the situation is similar. Until now, most of the policy measures applied refer to the reduction of the energy consumption and the reduction of specific indicators such as the EI [19], but there are no guidelines or definitions of an energy renovation. According to the national plans for the nearly Zero-Energy Buildings (nZEB) implementation in the Netherlands, the definition of large-scale renovations will be developed in more detail in the Building Decree Regulation.

However, this has not been realized yet [22]. For the aforementioned reasons, in this paper the energy efficiency measures applied on the social housing stock of the Netherlands are going to be identified through individual changes of the dwellings' physical characteristics. We examine every measure individually and then we investigate the number of measures applied in each dwelling. Moreover, we define the energy renovation pace as the amount of dwellings with an upgraded energy performance (at least one energy label step, e.g., from D label to C label) in a specific amount of time (e.g., one year).

### *1.2. Progress in energy efficiency in the non-profit housing sector*

Housing tenures differ across Europe and there is no common definition for the non-profit housing sector. However, three common elements are present across European non-profit housing sectors: a mission of general interest, offering affordable housing for the low-income population and the realization of specific tar-