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The energy performance of dwellings of non-profit housing associations in the Netherlands 2017 - 2018

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Abstract. Following regulation of the European Union, objectives were formulated to reduce energy consumption of the built environment in the Netherlands. For the stock of Dutch non-profit housing associations it was agreed to improve the average energy performance to an average energy index of 1.40 in 2020. This research assesses and gives insights in the progress to this objective for over 2.0 million dwellings of over 250 Dutch non-profit housing associations in 2017 and 2018. The assessment consists of an analysis of applied renovation measures, changes of the stock like new construction and demolishing, and clarifying characteristics of housing associations. It is concluded that large urban housing associations with adequate financial positions drive the improvement of the average sectoral energy performance. The improvement happens for a large part within the existing stock, mostly with traditional improvements like improved heating installations and improved insulation. Innovative solutions like: photovoltaic solar systems, combined heat and power systems, biomass systems, heat pumps and external heating, are responsible for a relative small part of the improvement within renovations. New construction and demolishing are also responsible for a relative small part of the annual improvement, but there is potential to improve this.

1. Introduction

The European Union agreed in 2008 on goals to reduce the impact of human activities on the climate by 2020 [1]. In the Netherlands these goals were translated in several sectoral covenants. Non-profit housing associations in the Netherlands have a large impact on the built environment because they manage about one third of the Dutch housing stock, totalling 2.4 million dwellings. For the Dutch non-profit housing sector, agreements were made in 2008 [2] and in 2012 [3], which lead up to the Dutch Energy Agreement in 2013 [4]. Amongst others it was agreed to improve the average energy performance of dwellings of non-profit housing associations to an average energy index (EI) of 1.25 in 2020. The energy index is measured with Dutch legislation on the energy performance [5] which is the Dutch translation of the European Energy Performance of Buildings Directive [6], [7]. In 2015 the determination method of the energy index changed [8] and also the related goal changed to an average EI of 1.40 for housing associations in 2020 [9].

Several sources have discussed the progress of the improvement of the energy performance of the Dutch non-profit housing sector. In the article of Filippidou et al [10] it is concluded that, based on the progress made from 2010 to 2014, the goal of an EI = 1.25 will not be met in 2020. Filippidou et al [11] concluded in another research that housing associations in the period up to 2014 generally did not carry out major renovations, but many smaller investment projects, mostly as part of planned maintenance work. The most frequently applied changes were changes in heating systems, hot water installations and glazing. Other researchers [12], [13] have discussed whether energy performance measures need to be implemented in small steps or whether large-scale renovations are needed, or whether demolition and new construction are better alternatives.

With time progressing, there is a need for more updated insights of the progress of the energy performance of non-profit housing associations towards the goal in 2020. Three elements of the progress are not well understood. First, the effects of changes of the stock, like new construction and demolishing, were not examined in previous researches or papers. Second, the effects of taken renovation measures in the period after the changed determination method in 2015 are unclear. Third, it is not well understood which characteristics of housing associations, for example the size, financial position, or location, can explain the improvement of the average energy performance of the non-profit housing sector.

The following research question was formulated to address this knowledge gap: How does the energy performance of dwellings of non-profit housing associations in The Netherlands improves between 2017 and 2018 and how does this relate to the goal in 2020? Subsidiary questions:

- What is the improvement of the energy index between 2017 and 2018?
- How do changes of the stock and renovation measures taken within the stock explain the improvement of the energy index?
- How do characteristics of housing associations explain the improvement of the energy index?
- How do the insights of the progress of the energy index between 2017 and 2018 relate to the goal of an energy index of 1.40 in 2020?

2. Data and method

2.1. Data

In Europe each country has its own data and method to monitor the building stock. In the Netherlands Aedes, the Dutch umbrella organization of housing associations, started a monitoring system of dwellings called *Sociale Huursector Audit en Evaluatie van Resultaten Energiebesparing* (Social Rental Sector Audit and Evaluation of Energy Saving Results) abbreviated SHAERE [10]. The SHAERE database contains the energy performance characteristics of dwellings of non-profit housing associations. After the change of the calculation method in 2015 [8] the structure of the SHAERE database changed. Data collection in this new framework started in 2017. In the database are 2.03 million dwellings of 246 Dutch housing associations for 2017 and 2.07 million dwellings of 253 Dutch housing associations for 2018. Of every dwelling, the energy index under the new calculation method is available, and also 30 clarifying indicators, such as the type and size of the dwelling, types of installations and the degree of insulation of the windows and the envelope. This database is the main source of data for this paper.

Secondly, a dataset of Aedes with descriptive parameters of individual housing associations was used. Of every housing association in the Netherlands the following parameters were available: the size (classification of the number of dwellings), location (province), the financial position (weak, average or above average), the degree of urbanity (rural to urban) and the average energy performance (high, average, low).

2.2. Method

The average energy index of the Dutch non-profit housing sector is calculated as the mean of the available dwellings in the SHAERE database for 2017 and 2018. To explain the improvement of the energy index, two insights are given. First, the improvement of the energy index from 2017 to 2018 is explained by analysing changes of the sample, changes of the stock and changes within the stock. This was done by explaining the relative contribution of changes of the sample, changes of the stock and changes within the stock, to the improvement of the energy index between 2017 and 2018. Second, the improvement of the energy index from 2017 and 2018 is explained with the characteristics of housing associations. This was done by coupling the progress of the average energy performance of each housing association to descriptive parameters of the same housing association as discussed in the previous paragraph. The relative contribution to the improvement of the energy index between 2017 and 2018 of these descriptive parameters was thereafter analysed.

3. Results

The results of the analysis are presented in four paragraphs. First, the progress of the average energy performance is explained. Second, changes of the sample, changes of the stock and changes within the stock are discussed. Third the progress of the energy index of groups of housing associations with the same characteristics are explained. Fourth, the chapter finishes with a paragraph which relates the progress made between 2017 and 2018 to the agreed goal of EI=1.40 in 2020.

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3.1. What is the improvement of the energy index between 2017 and 2018?

Figure 1 shows the progress of the average energy index of dwellings of the non-profit housing sector. Filippidou et al. [10] showed that the progress of the energy index between 2010 and 2015 decreased from 1.80 in 2010 to 1.61 in 2015. A linear extrapolation would exceed the target of EI = 1.25 in 2020. In 2015 the calculation method of the energy index changed. Also, the objective changed to an average energy-index of 1.40 for housing associations in 2020 [9]. Aedes collected data for 2016 in an old database format and data of 2017 and 2018 was collected within this research in a new database structure. A new trend line shows that a linear extrapolation of the average energy index after the change of the calculation method also exceeds the new target of now EI = 1.40 in 2020.

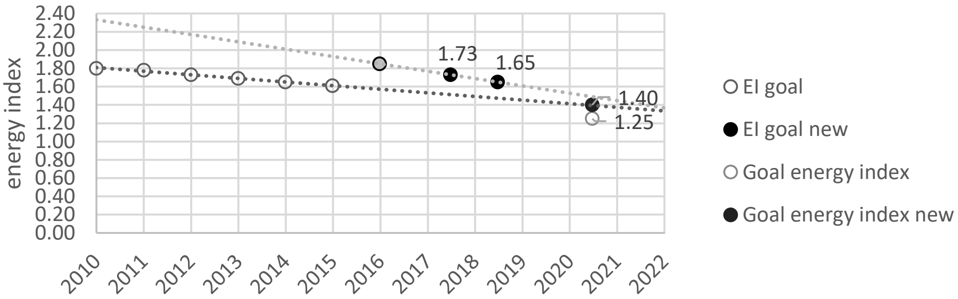

Figure 1: Progress of the average energy index of dwellings of the non-profit housing sector

3.2. How do changes of and in the stock explain the improvement of the energy index?

As shown in Figure 1 the improvement of the energy index between 2017 and 2018 improved from 1.73 to 1.65. The difference of 0.082 can be explained by changes of the sample, changes of the stock and changes within the stock. Table 1 shows that the changes of the sample were found to be responsible for an increase of the average energy index by 2.0%. Changes of the stock were found to be responsible for 14.3 % of the improvement of the energy index and the other 87.7% of the improvement was found to be caused by changes within the stock. This is explained in the following paragraphs.

Table 1. Contribution to the improvement of the energy index 2017-2018 by changes of the sample, changes of the stock and changes within the stock.

Progress EI	Δ EI	%
Changes of the sample	+0.002	+ 2.0 %
Changes of the stock	-0.012	-14.3 %
Changes within the stock	-0.072	-87.7 %
Total change	-0.082	-100.0 %

3.2.1. Changes of the sample. The change of the sample of housing associations in the SHAERE database of 2017 and 2018 has an effect on the average energy index between 2017 and 2018. 11 housing associations did participate in 2017 but not in 2018, and 18 new housing associations delivered data in 2018. The effect on the change in energy index between 2017 and 2018 is EI= 0.002, which is positive. It means that only because of the change of the sample the average EI in 2018 is 0.002 higher than in 2017. This is 2.0% of the total change between 2017 and 2018.

3.2.2. Change of the stock. -14.3% of the improvement of the energy index is explained by changes of the stock. This consists of new built, purchased, sold and demolished dwellings or administrative corrections as shown in Table 2. The percentages do not add up to the total, because of rounding errors.

Table 2. Contribution to the improvement of the energy index 2017-2018 by changes of the stock.

Progress EI	Δ EI	%
New built dwellings	-0.007	-9,1 %
Purchase/administrative	-0.001	-0.7 %
Demolishing/sale/administrative	-0.004	-4.4 %
Total change	-0.012	-14.3 %

New built dwellings are responsible for -9,1% of the improvement of the energy index. The number of dwellings in the sample with a building year in 2017 (8,960) are however lower than expected. According to the supervision organisation of the social housing sector in the Netherlands on average about 15,200 dwellings are built each year [14]. The reason for the lower number in the sample could be that housing association rely on the EPC (obliged for a new built dwelling) rather than on calculating the EI (obliged for existing stock). It can be expected that if all new built dwellings would be present in the sample, a lower average EI would be measured.

When looking at the quality of the new built dwellings it can be seen that the average energy index of a new built dwelling in 2017 or 2018 is 0.70. The main characteristics of new built dwellings are:

- Insulation: floor Rc (m^2K/W) =4.1, envelope Rc=4.5, roof Rc=5.3, windows U (W/m^2K) =1.80
- Heating: HR107 boiler (59%), external heating (28%), heat pumps (11%), electrical heating (2%)
- Ventilation: Balance ventilation system (21%), mechanical exhaust ventilation system (72%)
- Solar: PV systems (58%, in case of single family dwellings 80%), solar heating (1%)

These characteristics can be seen as still quite traditional for Dutch standards. Only solar PV is becoming a standard solution on new built dwellings. To improve the impact of new built dwellings on the sectoral progress, the building quality of new built dwellings should improve further. This means more innovations should be applied in new dwellings. Also if the number of annually new built dwellings increases, the impact on the sectoral improvement of the energy performance could increase.

Besides new construction, dwellings can also be added to the stock by purchase or by administrative corrections. It is not possible to identify which dwellings are purchased or added by administrative corrections, but the impact is relative small. The reason for this is that the energy index of these dwellings is close to the sectoral average. The impact on the improvement of the EI is -0.001 or -0.7%.

Parallel to added dwellings, dwelling can be removed from the stock by demolishing, selling or for administrative reasons. It is not possible to identify how dwellings are removed from the stock, because this information is not given in the database. However, the impact of the dwellings not present in the database of 2018 compared to 2017 can be calculated by measuring the effect as if they would be present in both years. This effect is EI -0.004 and is therefore responsible for -4.4% of the improvement. The removal of dwellings has thus a significant impact on the improvement of the average energy index.

3.2.3. Changes within the stock. Besides changes of the sample and changes of the stock, the major part of the sectoral improvement of the energy index is due to improvements made within the existing stock. This share is calculated to be -87.7% or EI=-0.072. In this paragraph the relative importance of changes within the existing stock is explained, expressed in the contribution to the improvement of the energy index of applied energy saving measures. Table 3 shows the contribution of changes within the stock. Three groups of changes are responsible for a large part of the sectoral energy index improvement. These are improved insulation, heating systems and improved airtightness. The improved ventilation systems have a negative effect on the average sectoral improvement of the energy index, probably because these are mostly added mechanical systems which use electricity for operation. The effect of adding solar systems is responsible for -8.8%. Cooling and some minor other improvements which are not specified in the database are responsible for another -4.1% of the sectoral improvement.

Table 3. Contribution to the improvement of the energy index 2017-2018 by changes within the stock.

	Δ EI	%
Insulation	*-0.016*	*-19,1%*
Ventilation	*0.002*	*2.0%*
Airtightness	*-0.021*	*-26,5%*
Heating	*-0.021*	*-25,5%*
Hot water	*-0.004*	*-5,5%*
Solar systems	*-0.007*	*-8,8%*
Cooling	*0.000*	*-0.2%*
Minor other	*-0.003*	*-4.1%*
Total change within the stock	*-0.072*	*-87,7%*

Within the changes of the stock a group of measures can be described as more innovative, being innovative heating systems and solar systems. When looking at the impact of the innovative heating solutions (combined heat and power, biomass systems, external heating systems and heat pumps) the effect is respectively -0%, -3% -7% and -6% of the total effect of the changed heating installations. This adds up to -4% of the total sectoral change. Installed solar systems were found to be responsible for -8.8% of the energy index improvement. These innovative solutions used in changes of the stock together are responsible for -13% of the total sectoral energy index improvement.

3.3. How do characteristics of housing associations explain the improvement of the energy index?

3.3.1. Size of the housing association. When looking at the size of housing associations it shows the importance of the order of magnitude. Table 4 shows groups of housing associations with the same size, their average EI of 2017 and 2018, their average EI improvement between 2017 and 2018, the percentage of the non-profit housing stock they own and their absolute contribution to the improvement of the EI between 2017 and 2018. It shows that on average the large housing associations (XL>25000 dwelling) have an energy index of 1.70 in 2018, which is the only group higher than the average energy index of 1.65 of the total non-profit housing sector. However, because of their size they are also responsible for a large part (-0.036) of the total sector improvement (-0.082). To achieve sectoral improvement of the average energy index the large associations have the most potential and the most impact because of the size of the stock they own.

Table 4. Groups of housing associations with the same size, their average EI of 2017 and 2018, their average EI improvement between 2017 and 2018, the percentage of the non-profit housing stock they own and their absolute contribution to the improvement of the EI between 2017 and 2018.

	EI 2017	EI 2018	Av Δ EI	% stock	Abs Δ EI
XL (>25000 dwellings)	1.80	1.70	-0.099	36.12	-0.036
L (10000-25000 dwellings)	1.71	1.64	-0.073	28.69	-0.021
M (5000-10000 dwellings)	1.71	1.63	-0.081	21.77	-0.018
S (2500-5000 dwellings)	1.59	1.54	-0.051	9.25	-0.005
XS (1000-25000 dwellings)	1.59	1.53	-0.063	3.64	-0.002
XXS (<1000 dwellings)	1.62	1.58	-0.040	0.54	0.000
Total sector	1.73	1.65	-0.082	100	-0.082

3.3.2. Location of the housing association. When looking at groups of housing associations sorted by province, it also shows the importance of the order of magnitude. Table 5 shows that 44% of the total non-profit housing stock is located in two provinces (*Noord-Holland and Zuid-Holland*) and in both provinces dwellings have an average EI higher than average in the Netherlands. However, together the dwellings in these two provinces are responsible for 0.045 of the total progress between 2017 and 2018. In some other provinces, housing associations made good progress between 2017 and 2018 (*Zeeland and Limburg*) or good progress has been made in the past (in *Flevoland, Drenthe, Overijssel and Gelderland*), but because of the lower percentage of the total stock the impact of the housing associations in these provinces is overshadowed by the housing associations in *Noord-Holland* and *Zuid-Holland*.

Table 5. Groups of housing associations with the same location, their average EI of 2017 and 2018, their average EI improvement between 2017 and 2018, the percentage of the non-profit housing stock they own and their absolute contribution to the improvement of the EI between 2017 and 2018.

	EI 2017	EI 2018	Av Δ EI	% stock	Abs Δ EI
Flevoland	1.41	1.35	-0.063	1.20	-0.001
Drenthe	1.63	1.55	-0.074	2.33	-0.002
Friesland	1.80	1.72	-0.075	2.53	-0.002
Zeeland	1.68	1.56	-0.119	1.70	-0.002
Groningen	1.71	1.65	-0.052	4.23	-0.002
Overijssel	1.65	1.58	-0.073	5.89	-0.004
Utrecht	1.74	1.67	-0.070	6.85	-0.005
Gelderland	1.56	1.51	-0.050	10.38	-0.005
Limburg	1.84	1.73	-0.112	6.05	-0.007
Noord-Brabant	1.64	1.58	-0.065	14.38	-0.009

Zuid-Holland	1.81	**1.72**	-0.092	**22.83**	**-0.021**
Noord-Holland	1.79	**1.68**	-0.113	**21.63**	**-0.024**
Total	1.73	1.65	-0.082	100	-0.082

3.3.3. Degree of urbanity of the dwellings of the housing association. When looking at the degree of urbanity of the dwellings of housing associations in Table 6, the same pattern arises as with the size and location of housing associations. A large part (almost 70%) of the stock is located in dense cities which is also the part of the stock with the highest energy index. Housing associations operating in suburban areas have a better energy index, but still higher than the average goal of 1.40.

Table 6. Groups of housing associations located in areas with the same degree of urbanity, their average EI of 2017 and 2018, their average EI improvement between 2017 and 2018, the percentage of the non-profit housing stock they own and their absolute contribution to the improvement of the EI between 2017 and 2018.

	EI 2017	EI 2018	Av Δ EI	% stock	Abs Δ EI
Urban	1.83	**1.71**	-0.115	**35.47**	-0.041
Urban-suburban	1.72	**1.65**	-0.068	**33.23**	-0.023
Suburban	1.61	1.55	-0.058	12.36	-0.007
Suburban-rural	1.63	1.57	-0.058	15.83	-0.009
Rural	1.69	1.60	-0.092	3.12	-0.003
Total	1.73	1.65	-0.082	100	-0.082

3.3.4. Financial strength of housing associations. When looking at the financial strength of housing associations in Table 7, it is found that housing associations with a weak financial strength have a higher energy index, but they also make the largest average progress. However, the sector impact of this group of housing associations is modest, because they own a relative small percentage of the total housing stock. Housing associations with a higher financial strength are largely responsible for the progress of the sector.

Table 7. Groups of housing associations with the same categorization of the financial strength, their average EI of 2017 and 2018, their average EI improvement between 2017 and 2018, the percentage of the non-profit housing stock they own and their absolute contribution to the improvement of the EI between 2017 and 2018.

	EI 2017	EI 2018	Av Δ EI	% stock	Abs Δ EI
Above average	1.70	1.61	-0.088	38.78	-0.034
Average to weak	1.74	1.67	-0.067	48.67	-0.033
Weak	1.90	1.73	-0.173	5.21	-0.009
Total	1.73	1.65	-0.082	100	-0.082

3.3.5. State of the energy performance of the housing association. When looking at groups of housing associations with a low, average or high average energy index, it is found that housing associations with an high average energy index, make more progress than the housing associations which already have a low energy index. Table 8 shows that this is both relative and absolute. This can be understood because housing associations in the 1/3 low EI group are already closer to the sector goal of an average EI of 1.40, and secondly, for the 1/3 high EI group it is probably easier to improve the energy index because the dwellings with a lower energetic quality are easier to improve.

Table 8. Groups of housing associations with a low, average or high average EI, their average EI of 2017 and 2018, their average EI improvement between 2017 and 2018, the percentage of the non-profit housing stock they own and their absolute contribution to the improvement of the EI between 2017 and 2018.

Progress EI	EI 2017	EI 2018	Av Δ EI	% stock	Abs Δ EI
1/3 low EI	1.48	1.45	-0.037	20.08	-0.008
1/3 average EI	1.64	1.58	-0.054	35.02	-0.019
1/3 high EI	1.90	1.79	**-0.109**	44.90	**-0.050**
Total	1.73	1.65	-0.082	100	-0.082

3.4. How do the insights of the progress of the energy index between 2017 and 2018 relate to the goal of an energy index of 1.40 in 2020?

Figure 1 shows that the annual improvement of the energy index has followed a linear line for several years. With a linear extrapolation of the average energy index in 2017 and 2018, the goal of EI = 1.40 will probably be achieved in 2021. However, this study shows that several factors influence this rate of improvement. First the impact of new built dwellings could be higher in the future if more new built dwellings are reported or more are built in future years. Second the improvement of the average energy index is mostly done with traditional renovations. The effect of innovative solutions on the improvement of the average energy performance is still quite small. It is unclear whether this effect will increase in future years to come. Finally it can be deduced, that given the analysis of the characteristics of housing associations related to the sectoral improvement of the energy performance, the large urban housing associations play a big role in achieving sectoral progress and therefore the sectoral improvement to the goal of 1.40. If the large urban associations fail to improve the energy index as they did between 2017 and 2018, it cannot be expected that smaller housing association are able to compensate this.

4. Discussion

Several remarks can be made about the research method and results of this analysis.

First, this analysis looks at the progress of the energy index of the non-profit housing sector only between 2017 and 2018. This a short time period, but it is aimed to extend this in 2019 and 2020.

Second, this analysis only looks at the progress of dwellings of non-profit housing associations in The Netherlands. It cannot be expected that the described improvements are also applicable to the other two-third of the mostly privately owned dwellings in The Netherlands.

Third, when looking at the data of the dwellings in 2017 and 2018 it can be seen that not all improvements of the energy index are expected to be related to actual improvements of the dwellings. A share of the improvements shown in Table 3 are administrative corrections. This is the case with the improved energy index through improved airtightness. Is it not a measure which is actually measured in the dwelling and therefore could be, to a large extend, a change in the administration of this parameter. It could not be deduced what the actual effect of these administrative corrections are, but they could be considerable.

Fourth, this analysis gives a good insight in the measures taken in the Dutch non-profit housing sector and their effect on the average energy index. Other researchers present measures taken in other countries [15], [16], [17] and [18], but they do not add up to a comparable average energy index. However most of these researches use a theoretical indicator, just like the energy index. Several studies in the Netherlands and in Europe have shown that the results of the forecasting of the actual energy consumption with the energy index can deviate strongly from reality and lead to the systematic overestimation of potential energy savings [19], [20]. According to Filippidou et al. [21], a greater number of renovations at a single dwelling lowers the effectiveness of the individual measures and therefore the realized savings in actual energy consumption are lower than expected. More research is needed to close the knowledge gap on a sectoral level, between the measures taken and the actual energy savings.

5. Conclusion

In this paper, the progress of the improvement of the energy performance of the non-profit housing sector in the Netherlands between 2017 and 2018 is explained. This was done by looking at the relative contribution of sample changes, changes of the stock and changes in the stock to the improvement of the energy index combined with an analysis of characteristics of housing association themselves. Most important conclusions are that large urban housing associations with adequate financial positions drive the improvement of the average sectoral energy performance. The improvement of the average sectoral energy performance happens for a large part within the existing stock, mostly with traditional improvements like heating installations and insulation. Innovative solutions like PV, CHP, biomass, heat pumps and external heating in retrofits, are responsible for only a relative small part of the improvement. New built and demolishing are responsible for another relative small part of the annual improvement, but there is potential to improve this, if the quantity and energetic quality of new built dwelling improves in the future.

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