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RENOVATION IN AUSTRIA – ANALYSIS OF THE ENERGY PERFORMACE CERTIFICATES BETWEEN THE YEARS 2006 AND 2015 OF THE COUNTY SALZBURG

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Abstract
In Austria funded renovations as well as newly constructed buildings are bound by the issue of an Energy Performance Certificate. Due to that fact, there is a large pool of Energy Performance Certificates which are listed in the ZEUS database for the Austrian county Salzburg
The data basis for this work consists of approximately 40.000 Energy Performance Certificates. The focus of the study is the examination of the renovation’s impact on the buildings energy relevant values. Those buildings for which both an Energy Performance Certificate before renovation and after renovation is available are filtered and statistically analysed. There are several studies which statistical analyse different values from Energy Performance Certificates. The major difference to those studies is that within this study the changes of energetic values in the course of renovation are observed for more than 2000 buildings.
The analysis shows that the heating demand obviously decreased in the context of renovation. There is a difference in the reached heating demand after renovation depending on the year when the reconstruction measurements took place. Besides the insulation measurements, renovation often goes along with changes in the heating system. The data analyses showed a clear trend away from the energy source oil for the production of the thermal energy in residential buildings. In return biomass, natural gas, district heating and electricity for the operation of heat pumps become more important.

Keywords:
Energy Performance Certificate; Renovation; Heating demand; U-value

1 INTRODUCTION

The Energy Performance Certificate (EPC) parameters heating demand and energy performance factor have integrated into everyday life, because these values have to be mentioned in any real estate listing based by law [1]. Every new building and funded renovation is bound by the issue of an EPC in Austria. Based on these facts there is a large pool of EPC. For the county of Salzburg the EPC are listed in the ZEUS database.

The data basis for this work consists of approximately 40.000 EPC. This is the amount of EPC which was uploaded to ZEUS in the period 2006 to June 2015.

The focus of the study is the examination of the renovation’s impact on the buildings energy relevant values. In this context, those buildings for which both an energy performance certificate before and after renovation is available are filtered and statistical analysed. For this study, only the residential buildings where an EPC before and after the renovation exists are considered and compared with the values of the analysis from new buildings.

This work differs from other statistics on EPC, such as [2] and [3] to the effect that the focus here is the comparison of the renovation to inventory. Also the considered population differentiate, in this work the EPC of the province of Salzburg are analysed. Furthermore, this study distinguishes

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from [4] and [5] at the high amount of analyse EPC concerning the existing building stock. The distinction to [6] and [7] is the expanded period under observation and the different research questions.

2 METHODS AND DATA BASIS

In several cases EPC are multiple uploaded into the ZEUS database for different purposes, e.g. for different funding programs. Also, there are EPC which are not plausible in ZEUS. Consequently, it is necessary to make a pre-analysis of the data before starting the actual data analysis. Concerning the plausibility check of the data, a model was developed which restricts the range of values. In this context, it was determined which values are possible and plausible for each variable. For the description and analysis of the data, methods from the field of descriptive statistics are used.

After validating the EPC and considering multiple entries of the same EPC in the database the data basis is reduced to 35,230. This amount includes the EPC for all categories of buildings.

The comparison of inventory and restoration in this work only includes the EPC before renovation (inventory) to the EPC after renovation (restoration completion) of residential buildings. By filtering this data, the data basis for the statistical analysis is reduced to 4,460 EPC (2,230 inventory and 2,230 restoration completion).

The comparison of the renovation with the construction (new building) is carried out with all the latest valid construction completion EPC. In the event that several EPC are available for a construction object, the newer EPC is taken into consideration (= last valid). The number of latest valid new building EPC is 2,146.

3 RESULTS

3.1 Heating demand before and after renovation

A frequently used parameter for the evaluation of the energy performance of buildings is the heating demand. The heating demand can be distinguished between two bases, namely reference climate and location climate. In this work only the heating demand at the location climate is considered. This parameter was chosen for the statistical analysis based on its importance in the context of the zoning law and the residential building subsidies.

The comparison of the specific heating demand between inventory and restoration is shown in Figure 1 with histograms. The specific heating demand is illustrated by the x-axis, the y-axis shows the frequency of the values. For the purpose of a better illustration, only values of the heating demand in the range 0 - 425 kWh/m².a are shown. These are sporadic higher values, such as the maximum of 745.87 kWh/m².a of the inventory, which are not seen. But these high values are considered by calculation of the median, the mean and the standard deviation.

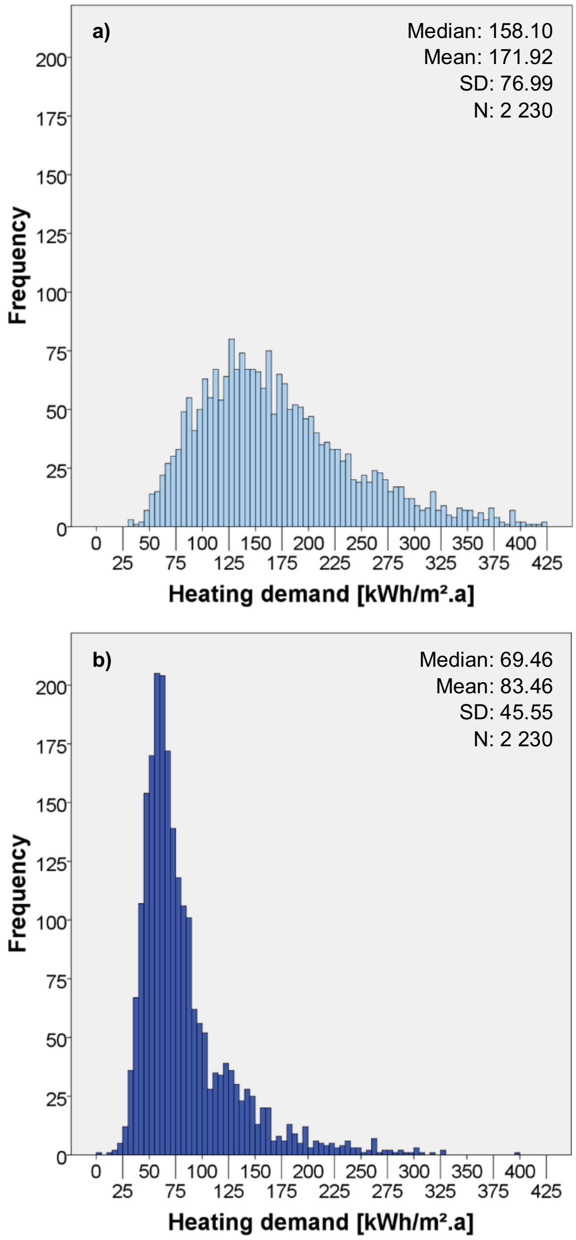

Fig. 1 : Heating demand before renovation (a) and after renovation (b)

The histogram for inventory shows that the heating demand is widely spread, mostly in the ranges between 70 kWh/m².a and 240 kWh/m².a. After renovation the heating demand has obviously been reduced and is located mainly in the field 40 kWh/m².a to 90 kWh/m².a. The median of the heating demand is 158.10 kWh/m².a for inventory and 69.45 kWh/m².a after renovation. In comparison: the median of the heating demand of new buildings is 40.89 kWh/m².a, the average value 42.37 kWh/m².a and standard deviation 16.18 kWh/m².a.

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Figure 2 shows the reached heating demand depending on the year when the renovation was done. The lower whisker at the box plots show the smallest heating demand after renovation. The beginning of the box indicates the lower quartile and therefore the position of the 25% lowest values. The line within the box shows the location of the median and the end of the box the upper quartile. The rings and stars above the upper whisker are outliers. The red line shows the median of the heating demand independent from the year of renovation.

By looking at the position of the median, it can be seen that the date when the renovation happened has an influence on the heating demand. The reached heating demand in the more recent past is lower as if the renovation measurements took place in the further past. A reason for this result can be the more and more strict regulations by law and the funding guidelines in the field of building. Notable is also that in the former past the standard derivation of the reached heating demand after renovation is decreasing. Besides the stricter regulations another reason for this result can be that the state of the art is changing.

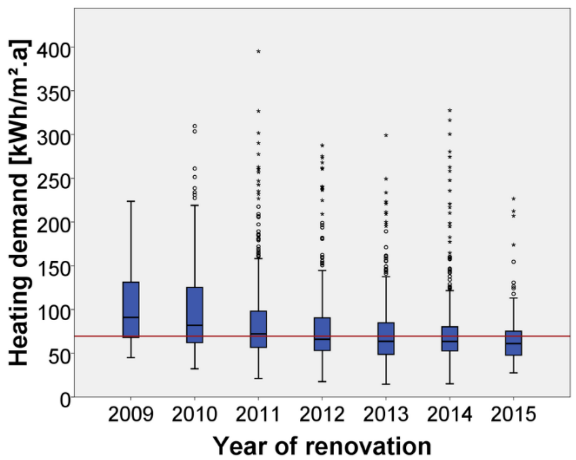

Fig. 2 : Comparison of the heating demand after renovation, depending on the year of renovation

3.2 U-value before and after renovation

During the renovation, the average heat transfer coefficient (U-value) of the residential building has clearly been reduced. The U-value is a relevant parameter for the characterization of the quality of the outer casing and therefore for the construction technology of the buildings.

While the median by inventory is 0.82 W/m².K, it is 0.38 W/m².K after the renovation and so has decreased significantly, in fact it has more than halved. In comparison, the median of the average U-value by construction is 0.25 W/m².K. The distribution of U-values of inventory and restoration can be seen in Figure 3.

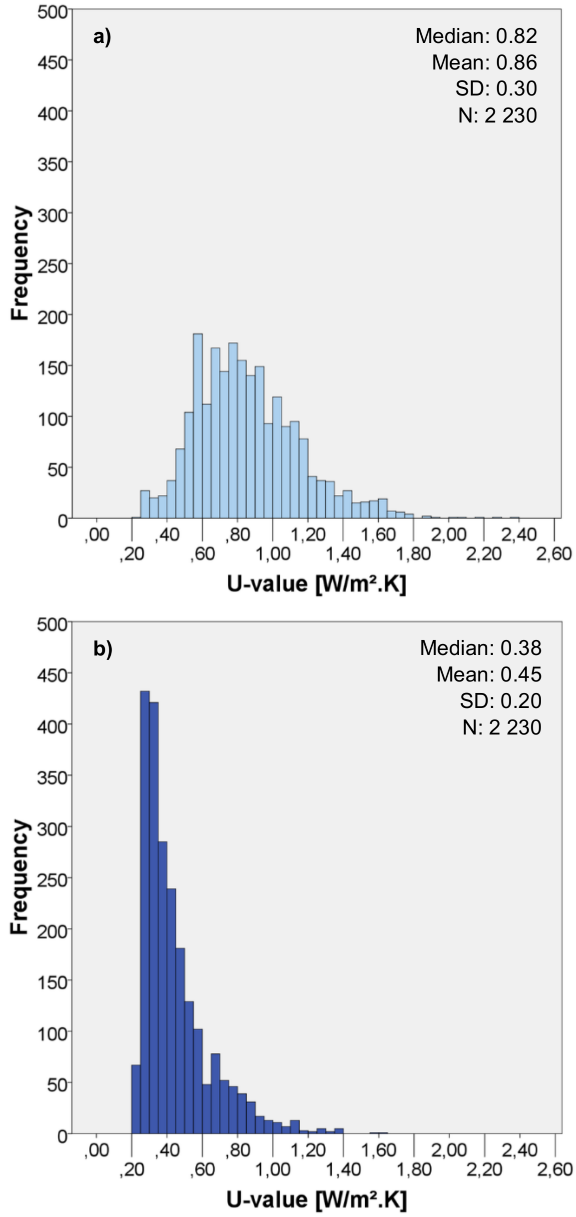

Fig. 3 : U-value before renovation (a) and after renovation (b)

A comparison between the U-value of the considered restoration completion and the new building is shown in Figure 4. This visualisation reveals how far the reached standard of renovations differs from new buildings. It should be noted that for the purpose of better illustration, the scale for the average U-value (x-axis) was limited to 1.0 W/m². K.

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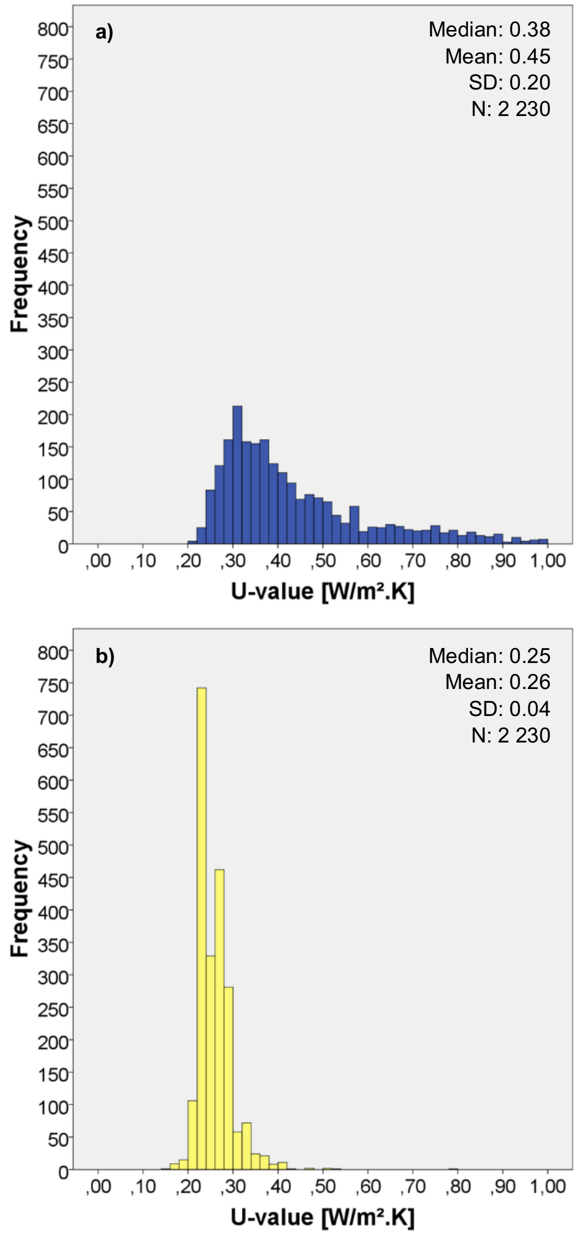

Fig. 4 : U-value after renovation (a) compared to the u-value of new buildings (b)

The comparisons showed clear differences between the standard of buildings before and after renovation as well as for new buildings based on the U-value. Unfortunately, information about the building components are not implemented in the ZEUS database yet. Hence it is not possible to analyse the material changes while renovation and the difference to new buildings. In the near future, a new XML-version of ZEUS will be released. There will be variables implemented for the layers of all the structural components of buildings. So it is a matter of time till it is possible to analyse what construction and insulation materials are used in which thickness and which position in the field of reconstruction and at new buildings.

3.3 Energy sources before and after renovation

During the renovation, the used energy sources have changed by 19 % in residential buildings. In this context it must be mentioned that changes in the heating system are not bound to creating an EPC, even not in the context of residential building subsidies. The most widely used energy source in the considered data is oil, followed by biomass. This applies to both, inventory and after renovation (see Figure 5).

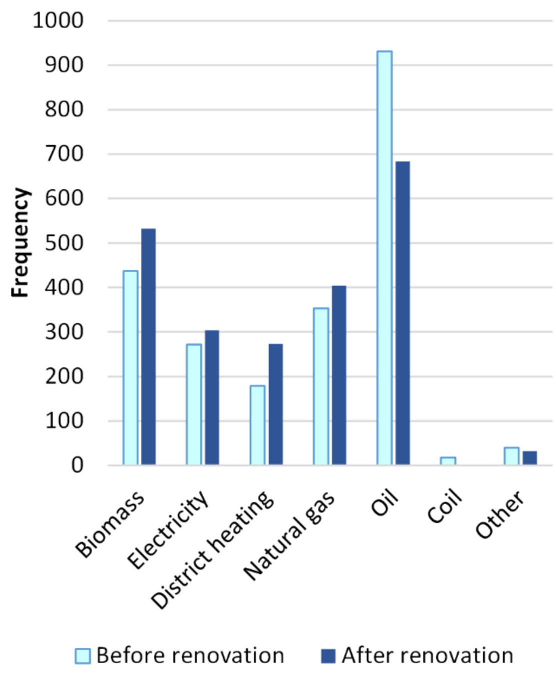

Fig. 5 : Used energy sources before and after renovation

After renovation, often other energy sources are used instead of oil for generating the needed thermal energy. At inventory 42.1 % of the heating systems were operated with fuel oil, after the renovation, the percentage has been reduced to 30.9 %. The share of biomass has increased from 19.8 % to 24.1 %. In addition to biomass, also a significant increase in district heating and natural gas compared to the initial situation are determined. An increase is also reflected in electricity (+ 11.8 %). The change in power is due to the increased use of heat pumps.

Figure 6 shows that exclusively the implementation of heat pumps has led to an additionally use of electricity for heating purposes.

It turns out that the use of heating with heat pumps has increased by approximately 357 % compared to the starting position. The use of direct electricity systems has been reduced by 22.6 % and the use of night storage heaters by 42.9 %.

A main difference between direct a electricity system and night storage heaters is the time

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period when the electricity is consumed to produce heat. Night storage heaters consume electricity at low load periods when the electricity tariff is keen, commonly at night and store the heat for several hours. For night storage heater, a power meter is needed which distinguishes between the electricity consumption at time of normal tariff and low tariff (night tariff). While in former days, there was a big difference between the tariffs night storage heaters were quite popular. Nowadays, the night tariff is not much cheaper than the normal tariff. Furthermore, in this days there are many electricity suppliers which do not even offer a night tariff.

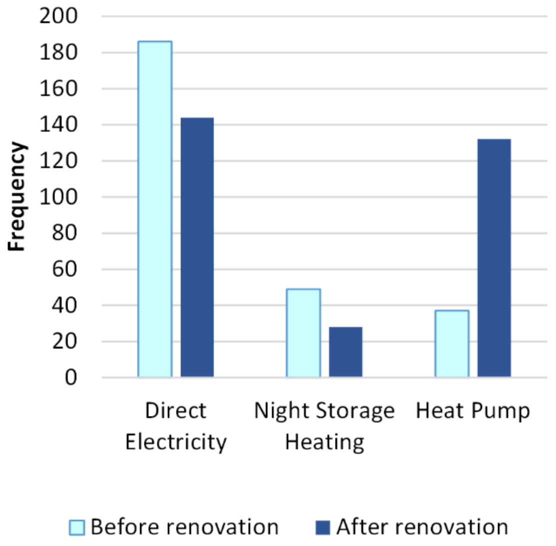

Fig. 6 : Heating systems with energy source electricity

The insert resources by new buildings are not the same. There the most important source of energy is electricity with 29.6 % (for operation of heat pumps) followed by biomass (27.1 %) and district heating (24.1 %). The use of fuel oil to provide the necessary thermal energy has only a proportion of 2.2 % at new buildings in Salzburg.

4 CONCLUSION

In this work the impact of renovation on energetic values was analysed by comparing the EPC before and after reconstruction of more than 2000 buildings. An evaluation of renovation in this way with such a high amount was done in this study the first time.

The study showed that renovation has a significant impact on the energy values of buildings. In line with this, the U-value of the compared residential buildings has been reduced by more than half, related to renovation. Hence there is a significant reduction of the heating demand of the buildings after renovation too. It is notable that the reached heating demand differentiate depending on the year when the renovation took place. Based on the fact that the heating demand is gathered from the EPC, this value matches a requirement and not a consumption.

A look at the used energy sources shows that renovation cannot only be linked to insulation work. During the renovation, the used energy sources changed by 19 % of residential buildings. Before renovation more than 40 % of the analysed residential buildings had implemented an oil heater. After renovation in particular, biomass, district heating, natural gas and electricity for the operation of heat pumps are increasingly used for the production of thermal energy.

When interpreting the results, it should be noted that only those residential buildings were evaluated where an EPC before and after renovation was available in the ZEUS database. Inventory (before renovation) is not necessarily equal to the original state at the time of construction. It is quite conceivable that the existing building has been renovated before. The inventory EPC might be calculated for a funded renovation and compared in this study with the restoration completion EPC (EPC after renovation). In the past there was no obligation to upload each EPC in the ZEUS database. So it has to be assumed that not each EPC exists in ZEUS. However, if there was an application for funding of the renovation, the EPC is available in ZEUS, thus is considered in this data analysis. Last but not least it has to be taken into account that measures such as changing the heating system are not bound by the issue of an EPC.

The amount of EPC in ZEUS will increase steadily. Hence in the future there will be a much higher amount of EPC available for such statistical analysis. To improve the quality of the database and the opportunities to generate insights from the data, the knowledge of this statistical analysis is taken into account by the further development of ZEUS. In the near future a new XML-Version will be released. There will be variables implemented for the layers of all the structural components of buildings, as an example. So in the future it will be possible to monitor a high amount of EPC where building components have changed in the context of renovation.

5 ACKNOWLEDGMENTS

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6 REFERENCES

1. Bundesgesetz über die Pflicht zur Vorlage eines Energieausweises beim Verkauf und bei der In-Bestand-Gabe von Gebäuden und Nutzungsobjekten (Energieausweis-Vorlage-Gesetz 2012 -EAVG 2012),. BGBl. I Nr. 27/2012

2. Brunn M. and Liepert M, Energieausweiszentrale Jahresbericht 2012. 2013, https://www.eawz.at/Daten/Bilder/Infos/EAWZ_Jahresbericht_2012.pdf

3 Dascalaki E. et al., Energy verification of Hellenic buildings: First findings, Energy and Buildings, 2013. Volume 65: p 429-437

4. Dascalaki E. et al., Data collection and analysis of the building stock and its energy performance – An example for Hellenic buildings, Energy and Buildings, 2010.Volume 42, p 1231-1237

5. Loga T. et al: Datamine: Collecting Data from Energy Certification to Monitor Performance Indicators for New and Existing buildings. 2009, https://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/datamine.pdf

6. Prieler M. et al., Sanieren in Salzburg – Analyse der Energieausweise vom Bundesland Salzburg der Jahre 2006 - 2014, in International Conference on high quality retrofit and redensification with timber construction systems. 2015: Graz, Austria

7. Prieler M. et al., Sanierung und Gebäudetechnik - Analyse der Energieausweise vom Bundesland Salzburg der Jahre 2006 – 2015, in e-nova 2015: international congress for sustainable buildings. 2015: Pinkafeld, Austria

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