Improving the Energy Performance Certificate recommendations’ accuracy for residential building through simple measurements of key inputs

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Abstract. The Energy Performance Certificate (EPC) allows building users to be informed and aware of the quality of the buildings in terms of energy needs. Additionally, the EPC includes a future for existing buildings, which is the incorporation of a Recommendation list of Measures (RLMs) to improve their energy performance in a cost-effective way. Which have risen the question if this tool can provide trustful Cost-effective recommendations due to the use of standardized inputs. This study focuses on estimating the impact of using measured ventilation rate, heating set point and airtightness on the profitability of the recommendations. The study is based on common dwelling in Norway, comparing results obtained with a Building Performance Simulation Software, following the Norwegian standard for energy certification and with the use of measured ventilation rate, airtightness and real heating set points. The results show that the performance gap can be reduced significantly just by adopting these inputs, increasing the confidence on the RLMs and reducing the uncertainty of the investment.

1. Introduction

One of the most important commitment made by the European Commission is to reduce by 20% of the energy by 2020 compared to the projected consumption in that year. Considering that, 40% of the total energy consumption in the EU are due to Buildings (1). Actions to reduce their energy contribution are of great importance. One of the main policies to engage this issue was the introduction of the Energy Performance Certificate (EPC) as an information source of energy performance for both policy makers and building owners. However many aspects around this tool have not been fully studied (2). The EPC quality it is strongly influence by the accuracy of its results, therefore the assessment methodology including their standardised inputs are central to achieved quality information (3). These become critical for existing buildings, which are the ones that most energy inefficient sector. Several studies carried out in EU have reported inferior energy savings than expected in retrofit projects as well differences between assumed indoor temperatures and actually used (4). Despite that the gap between simulation and actual energy saved, the EPC calculation are not comparable with the actual performance due to the use of standardised conditions and a number of loads that are not included in energy performance calculations (4). These might be appropriate for the purposes of comparing buildings energy performance. However, when it comes to set energy efficiency recommendations for renovation purposes, standardised procedure might not be adequate, since the estimation of the energy savings and the accuracy of the measures for the renovation it requires an analysis based on real energy consumption.

Extensive research have been done around EPC and homeowners, however little investigations have been conducted on to support certifiers work. Certifiers have a central role to play in ensuring the credibility of the EPC scheme, most of the issues reported focus on the cost of the EPC, highlighting the
tension between the speed and the cost of the certifier’s services one of the main issues. The quality of the energy recommendations c on the fees of the certifiers works, meaning that the more detailed recommendations more expensive the EPC it will be (5). One of the main aspects that can improve the accuracy of the saving estimation and increase the usability of the list of the recommendation measure, is to review the method of how certificates are developed. Improving both the tools for calculation and the procedure carried out by the certifier.

Several attempts have been done to simplified measurements techniques to assess the building energy performance and many of them can be uses for housing inspections. Airtightness is one of the most important aspect in energy savings, however the blower door test can take a long time and it is very expensive. In Norway a blower door test for a typical wood-frame house can cost up to 1250 Euro, which is hired that the price of an EPC (6). Nevertheless in literature it can be seen several method to estimate the airtightness [13], but the one that suit the most for inspection it is based on the characteristic leakages. Despite that this method could lead to large deviation, this will depended on the quality and number of measurements used for the estimation of each leakage (7). The U-values of the envelope in existing buildings without documentations are very common, the best source of information in that case is the uses of the regulation code of the time. Despite that in many cases that might not exist, it still a wild gest. The uses of Infrared Thermographic Images (IRT) has been used for this purposes and can provided quick, affordable and acceptable level of accuracy (8), as well it can be useful to collect additional information, such as the indoor temperature to determinate heating set point when no thermostat is available. This become more relevant in dwelling since having several indoor set point temperature for different rooms can be a common practice (9).

The aim of this study is to show that valuable data can be taking from field inspections, through simple measurements without increasing the price of EPC, since it will not extended the duration time of the inspection and not highly costly equipment are needed. This data can be used as inputs to improve the recommendation and accuracy of the certificate produced by the certifier.

2. Methodology

As with many existing buildings, technical information on housing is non-existent, the main source commonly accepted for labelling purposes is the use of the building code of the time. To overcome the uses of standardised input and to reduces the uncertainties that these involve in the results and the energy recommendations. It is proposed a set of simple measurements to be undertaken during the one-hour field inspection. To test the usability of the proposed field inspection measurements, the study was divided into three steps. First, an energy model of the dwelling was calibrated in DesignBuilder, the input data used was obtained from both, blower door test and the hourly electric consumption obtained from the smart meter. Secondly a field inspection to the houses was performed as a certifier normally would do, checking measurements plans, maintenance and heating systems of the dwelling. The regular inspection method is complemented with the following activities: a visual inspection with a checklist of typical air leakages and heating set-points, IRT and mechanical ventilation airflow measurements. Lastly, the EPC was calculated separately, using standard and field inspection inputs. Both results were compared with the calibrated model.

2.1 Study case

A typical Norwegian dwelling was selected to issue an energy performance certificate. The dwellings corresponds to a wooden terraced dwelling located in Oslo. The building was built in 1987 and consists of three levels, a basement and two upper floors. The data gathered from the smart meter and a near weather station weather both in hourly bases and from 2018. Additionally in combination with the blower door test the following input were determinated, the results can be seen in table 1.

| U-value wall (W/m²K) | U-value floor (W/m²K) | U-value ceiling (W/m²K) | U value windows (W/m²K) | Airtightness (ACH) | Ventilation rate (ACH) | Heating set point (°C) | Heating set point (°C) |
|----------------------|-----------------------|-------------------------|-------------------------|-------------------|------------------------|----------------------|----------------------|
| 0,33                 | 0,18                  | 0,17                    | 1,91                    | 6,1               | 0,31                   | 17                   | 15                   |
3. Results

The regular inspection to the house, took 20 minutes, a checklist was used to confirm that all the items were covered. The measurements phase took 45 minutes, which most of the time was used to measure the airflow rate from the exhaust ventilation vent with a Q-trak in each room. The infrared thermal images were taking from inside and outside of the façades, and calibrated in-situ. An air leakages inspection checklist was prepared beforehand to the inspection, were typical weak point were listed and counted while inspecting the dwelling. The whole process took a little more than an hour, which is what one would expect from a certifier to spend on a dwelling. Each of these measurements and their subsequent use in the labelling are detailed below.

3.1 Q-track

The equipment used was the f-500 Q-trak, the location of the measurement were the main exhaust duct of the house, as well the at the extracting point of each room to confirm the total airflow rate. For the main exhaust was, three measurements were done in different points along the duct. While for the room, the ventilation was measure directly at the air extraction point. The result of the total ventilation rate was used to update the building model, the results can be seen in table 2.

| Room 1 | Room 2 | Room 3 | Room 4 | Room 5 | Total |
|--------|--------|--------|--------|--------|-------|
| 35.98  | 20.82  | 11.92  | 20.45  | 9.25   | 98.40 |

3.2 IRT

The IRT camera used was a Flir x-9000, the purpose of using IRT images is to find the corresponding U-values for the wall by applying several formulas designed to determinate the U-values through IRT applications. The camera was also useful to confirm the presence of air leakages and to room temperature. It is worth noticing that the house inspections was performed during winter, which it is the best conditions for IRT measurements, the results can be seen in table 3.

| Method 1(10) | Method 2(11) | Method 3 | Method 4 | Method 5(8) |
|--------------|--------------|----------|----------|-------------|
| W/m²K        | W/m²K        | W/m²K    | W/m²K    | W/m²K       |
| 0.43         | 0.4          | 0.39      | 0.49      | 0.3         |

3.3 Air leakages detection

The checklist was prepared base on literature on typical air leakages in residential buildings, the main characteristics listed were gaps between front/back door and floor, sealing around the window frames, sealing at the access door to the roof cavity, sealing of pipes or duct to the exterior, such as a wooden stove. The impact of the air leakages on the airtightness was based on tables gather from literature. Only evident leakages were considered and the most conservative values for the airtightness were used. The total amount of leakages found was added to the maximum value accepted according to the construction code of the time. The results can be seen at table 4.

| Description                                      | m³/h at 50Pa | Unit |
|-------------------------------------------------|--------------|------|
| Ventilation 100 mm                              | 2.36         | pcs  |
| Unsealed electrical plumbing                     | 0.93         | pcs  |
| Chimney with collar/flashing fastened with mastic| 3.62         | pcs  |
| Door gap 3mm                                     | 0.405        | pcs  |
| Window frame                                     | 0.31         | m    |
3.4 Comparison between standard values and quick measurements

Three rounds of simulation were performed, in each round inputs from standard, field inspection and real values were evaluated. The first round consisted in simulation base on the minimum level of detailed and a Single Zone (SZ), which is the most common procedure for a labelling. The second round used the Multiple Zones (MZ) expect for the standardised procedure where only two zones were defined (heated and unheated). As it can be seen from figures 1 and 2, both simulation have great differences between each other and even more with they are compare against the real values from the calibrated model. However, the simulation with field inspection input have a better fit with the calibrated model, improving the accuracy around 33% for the OZ and 8.5% for the MZ in comparison with the standard model.

![Figure 1. Single Zone](image1)

![Figure 2. Multiple Zones](image2)

The impact of each input in the simulation can be seen in table 5. As the result shows the ventilation rate is the most relevant value, with an impact of 33% in the energy estimation following by the U-values with 5%. It is worth noticing that heating set show a low impact, however that it is because of the airtightness assumed in the standard is very low, by examining the hourly data it is noticed that the indoor temperature almost never reached the 16 degrees during the setback point schedule. Due to this, the impact of the heating setback point are only reflected when the rest of the inputs from the inspection are used.

| Input                        | Standard | Inspection | Impact |
|------------------------------|----------|------------|--------|
| U-Value wall (W/m²K)        | 0.37     | *0.35      | 5.1    |
| Airtightness (ACH)           | 4        | 4.6        | -6%    |
| ventilation rate (m³/h)      | 98       | 0.1        | 33%    |
| Heating set points (T°)      | 21-19    | 21-16      | 3%     |

Table 5. Impact of using standardised inputs compared with simple measurement in the simulation

4. Discussion and conclusion

The study case showed that simple measurement could significantly improve the accuracy of the simulation results for certification purposes, up to 32%. The relevancy of these results is not center on the labelling itself but in the recommendation and the profitability estimation that are included in the EPC. Considering that standard values are about 50% higher than the measured consumption, which can lead to unrealistic energy savings and profitability if recommendations are only based on standardised calculation. The main conclusion of this work, suggest that double inputs should be uses for the certification, one standardised to be able to compare and a supplementary option to represent the real condition of uses of the dwelling. The incorporation of this method should not demand higher cost for the homeowner, since the q-track and IRT with current technology they can be afford by independent certifiers. However much research does need to be done in order to have robust results, especially for the airtightness estimation, since they required a large data based to inform the characteristic air leakage.
by component. As well, the used of IRT to determinate the U-values should be further studied, since did not provided sufficient reliability, but it helped to confirm that U-values are close to the standard and to the heating set points in each room. The ventilation should be considered carefully in dwellings with mechanical ventilation, since infiltration and mechanical ventilation interact with each other.

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