

Academic year 2018/2019

Project report



Use of the GreenTEG equipment on the NeighborHub

Sector	Mechanical Engineering – Energy integration
Student	Maxime Esseiva
Responsible professors	Prof. Elena-Lavinia Niederhäuser Prof. Jean-Philippe Bacher
Mandator	GreenTEG AG Technoparkstr. 1 CH – 8005 Zürich
Date	11 January 2019

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1. Introduction

At the Swiss-US Energy Innovation Days 2018 in Geneva, Mr Holger Hendrichs from GreenTEG was able to meet with the NeighborHub team and proposed a partnership.

2. Purpose of the work

2.1 Objectives

The partnership was therefore to test this measurement system on the insulation of the Neighborhub. This allowing to compare the theoretical U-values of the walls with measurements and validate the correct wall insulation.

2.2 Approach

- First contact with GreenTEG
- Selection of the surveyed walls and estimation of their U-value
- Receiving the equipment and carrying out the measures
- Results analysis
- Surrender of the equipment

4. Equipment

GreenTEG provided one gO-Measurement System kit with

- 3 sensors nodes type 1 (Insides nodes, each including 1 combined heat flux/surface temperature sensor and 1 ambient air temperature sensor)
- 3 sensors nodes type 2 (Outsides nodes, each including 1 surface temperature sensor and 1 air temperature sensor)
- 1 sensor node type 3 (one combined humidity/ambient air temperature sensor)

5. Positioning of the sensors and the validation

The walls were selected with Mr. Jean-Philippe Bacher, co-director of the Energy Institute, and then validated by Mr. Claude-Alain Jacot from the Swiss Federal Institute of Technology in Lausanne, technical responsible of the NeighborHub. The latter took care of the installation of the sensors.

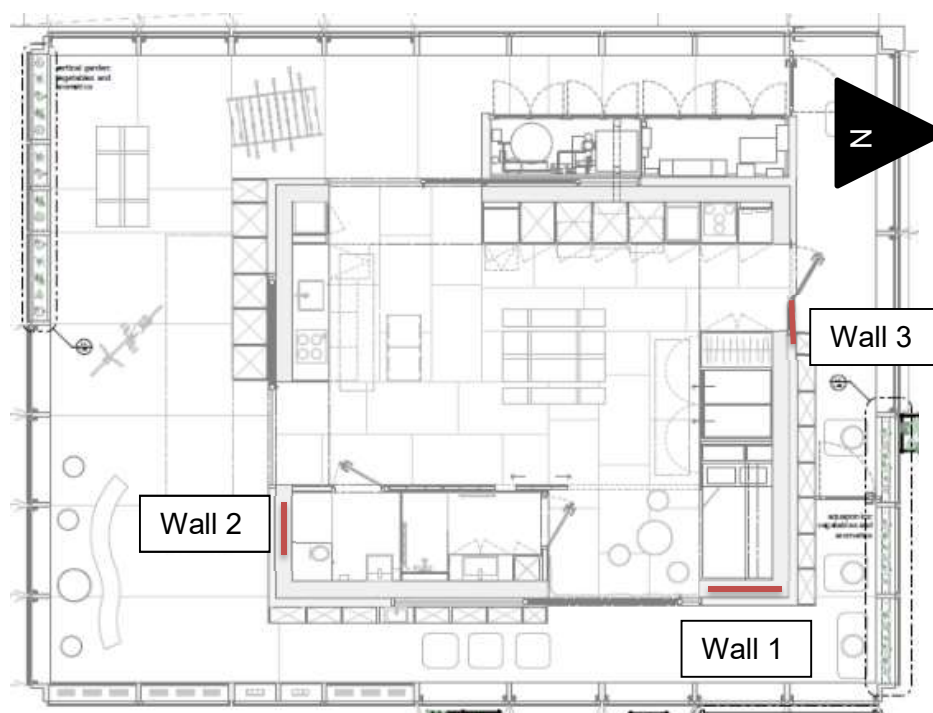


Figure 5-1 : Position des capteurs sur les surfaces en rouge

For the first measurement series, the placement of the sensors was not sufficient. The measurement was affected by an edge effect due to their proximity to the window doors. To validate a new placement for measurements 2 and 3, a short thermal study of the walls using a thermal camera was performed. Further detail are available in the Annex [1].

The wall 3 is a patio door, so a glass pane and as recommended by Michael Chow from GreenTEG, only nocturnal values should be considered for a glass. Fortunately, GreenTEG provides an Excel sheet for this, just download the measurements and insert them into the spreadsheet, with the selection of measure after the sundown to the dawn.

6. Analytic Estimation

To compare, U values were calculated against the construction plan.

Considering two chambers of different temperatures (T_{a1} and T_{a2}) separated by a flat wall of multiple layers. By neglecting the edge effects, a constant and unidimensional heat flux will form from the highest temperature (t_{a1}) to the lowest (t_{a2}).

The flux can be calculated with the following equation (I) :

$$\dot{q} = \frac{\Delta T_a}{R_{th} * A} = \frac{\Delta T_a}{R''_{th}} = U * \Delta T_a \quad (I)$$

R''_{th} is the surface thermal resistance and is the sum of the resistance of each wall and of the convection

$$R''_{th}_{tot} = \sum R''_{th}_i \quad (II)$$

There is two kind of resistance, one of conduction and one of convection:

$$R''_{th}_{conduction} = \frac{L}{\lambda} \quad (III)$$

$$R''_{th}_{convection} = \frac{1}{\alpha} \quad (IV)$$

From the equations (III) and (IV) the resistance of each layer was calculated and summed (II) for finding the total resistance. And with the total resistance, the U-value can be calculated:

$$U = \frac{1}{R''_{th}} \quad (V)$$

In the table 6-1, are written the results for each wall. The detail of the calculations is in the annex [2]

Wall 1	Wall 2	Wall 3
Insulated wall	Insulated wall	Patio door
0.097	0.097	0.751

Table 6-1 : U-values calculated

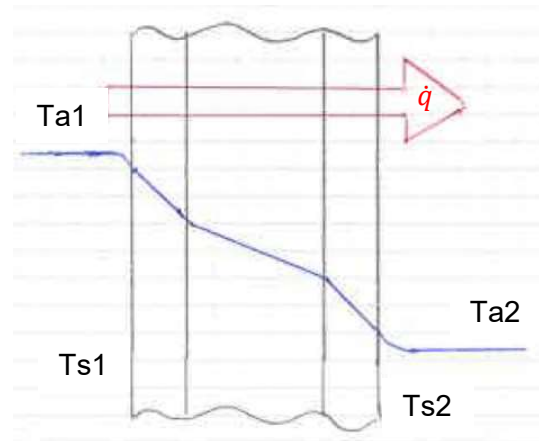


Figure 5-1 : Calculation model

7. Results

The results of the measurements, the graphics provided by the application gOMS of GreenTEG, are available under the annex [3].

A summary of the results can be found in Table 4-2:

U-values [W/(m ² * K)]	Measure 1	Measure 2	Measure 3	Mean	Analytic	Difference	Rel. Error
Wall 1	0.070	0.049	0.081	0.076	0.097	0.022	22.16%
Wall 2	0.086	0.018	0.076	0.081	0.097	0.016	16.49%
Glass	0.729	0.637	1.003	0.790	0.751	0.039	5.15%
Glass nocturn	0.732	0.645	0.995	0.791	0.751	0.040	5.28%

Table 7-1 : Results of measurements and comparison with analytics

During the first measurement, on the wall 1 and 2, an edge effect influenced the results, but they stay coherent.

During the second measurement, a bad fixation of the insides nodes caused the detachment of the wall and seriously impacted the results. They are in red on the table and are not considered for the mean calculation.

The measurement for the patio door are available full measures or only nocturnal measures.

8. Results analysis

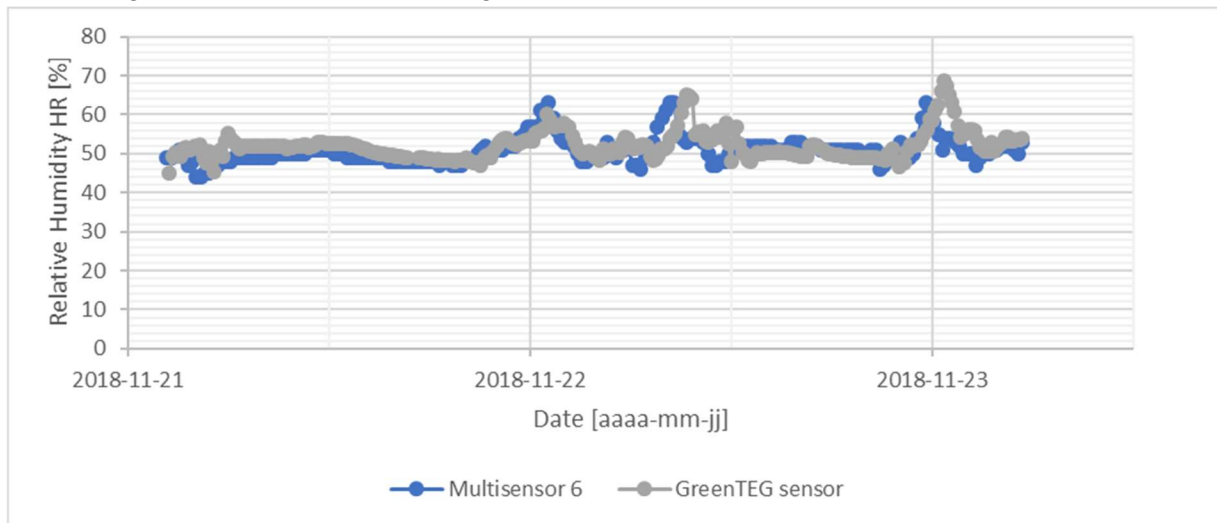
The order of magnitude between measured values and analytical values is respected.

The difference between mean and analytic value decrease with the U value, ($U \approx 0.7 \frac{W}{m^2 * K}$, $\sim 0.04 \frac{W}{m^2 * K}$, $U < 0.1 \frac{W}{m^2 * K}$, $\sim 0.02 \frac{W}{m^2 * K}$). A decrease of factor 2 between the wall and the glass. But the relative error increase by factor 4 (from 5% to 20%).

The difference between glass and nocturnal glass are very low. This can be explained by the position of the patio door which is the north facade and the bad weather during the measurement leading to low sun effect.

8.1 Humidity captor

With the U-value measurement device, a humidity sensor was provided. It was used for confirming the measurements of NeighborHub moisture sensors.



There is some little differences between the two sensors. But the “Multisensor 6” is an all public sensor, not as accurate as the GreenTEG sensor.

9. Conclusion

The equipment from GreenTEG is simple to use with the GOMs platform. It is recommended to use the adhesives of GreenTEG for the installation making it easy. By the experience on the NeighborHub using other adhesives may end at the sensors take-off.

This experiment allowed to validate the good quality of insulation of the walls of the NeighborHub, to know a $U < 0.1 \frac{W}{m^2 * K}$.

A part that can be interesting now for GreenTEG is to know the Ranges of error of the equipment according to the U-value. As said in the chapter 8, the relative error growth by factor 4 with U-value passing from 0.7 to $0.1 \frac{W}{m^2 * K}$. Even if the installation of the sensors on the glass (U=0.7) was clearly better than on the walls (U<0.1). Testing the equipment on multiple times for different U-values can determinate the not-systematic error of the sensors and confirmed the measures on the walls of the NeighborHub is in the range of acceptable error of the measurement system.

10. Annexes

- [1] Thermal photography
- [2] U-values estimations
- [3] Measurement results