# Case Study:
# U-Value Measurement of a Window using the gO Measurement-System

Each building element has a specific U-value, also called thermal transmittance, that describes its insulation quality: the lower the U-value, the better the insulation. The U-Value of a building element can be measured precisely with the heat flux method[1], using greenTEG's gO Measurement-System (gOMS).

In this case study, the windows of a terraced house from the 1930s have been characterized. The windows are double-glazed and were installed in 2009.

The primary aim of this case study is to show and explain how U-values on windows can be measured using the gO Measurement-System from greenTEG.

**Key Information**

Measured element:
Double glass window, 2009.

Date and location:
May 2019, Zürich, CH.

Method:
Heat flux method. Continuous measurement over 5 days with subsequent analysis using the data visualisation provided by the cloud and EXCEL.

System:
gO Measurement-System.

Measured U-value:
0.87 W/m$^2$K.

## 1. Measurement

Assuming all windows having the same characteristics and hence U-Value, the measurement was done on one window facing north-east. The gOMS[2] was mounted to the window as described in the manual and documented in the photos below. The measurement was started on May 18, 2019. The live results were checked regularly via the cloud access. As the U-Value for the third night deviated by 28% from the value of the two previous nights, the measurement was extended and terminated on May 24, 2019.

Fig. 1: Window with measurement node type 1 (R) and measurement node type 2 (L). View from inside the building.


Fig. 2: Window glass with sensors on both surfaces.

Fig. 3: Terraced house from the 1930s.

[1] *ISO 9869-1, Thermal insulation - Building elements - In-situ measurement of thermal resistance and thermal transmittance; Part 1: Heat flow meter method.* 2014, ISO, Switzerland.
[2] In order to measure the U-Value, one gateway (ID: 355000080035463), one measurement node type 1 (SN: C800019) and one measurement node type 2 (C800011) were used.

## 2. Data analysis

The raw data (ambient temperatures, surface temperatures, heat flux) are shown in the following graphs:

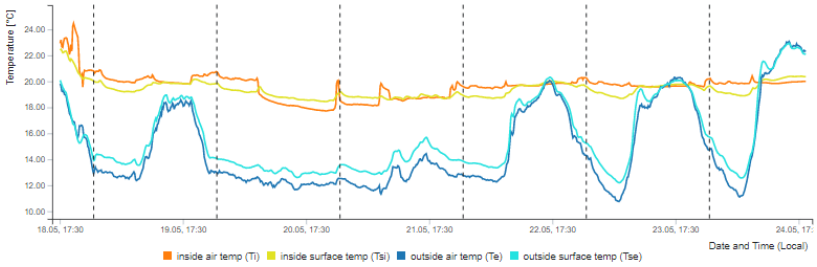


Fig. 4: Measured surface and ambient temperatures

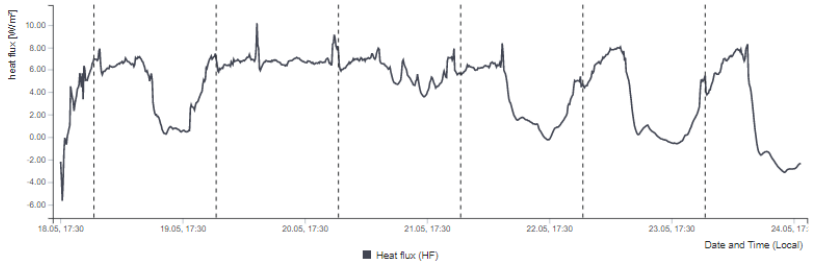


Fig. 5: Measured heat flux

As solar radiation affects the heat flux, only measurement data from the night can be used for analysis. During the measurement period, the nights in Zurich, Switzerland lasted from 21h05 (sun set) to 5h40 (sun rise). In addition, a minimum temperature difference of 5°C is recommended for precise results. Therefore, only measurement data from periods fulfilling these criteria was used for analysis.

There are two methods to analyse the data for selected periods only. The first one uses exclusively the cloud, the second one uses EXCEL. Both methods are described in the appendix and yield the same results:

| | Night 1 | Night 2 | Night 3 | Night 4 | Night 5 | Night 6 | Average |
|---|---|---|---|---|---|---|---|
| **Date** | 18.05. | 19.05. | 20.05. | 21.05. | 22.05. | 23.05. | |
| **Time** | 22:10 – 5:30 | 21:30 – 5:30 | 21:30 – 5:30 | 21:30 – 5:30 | 22:50 – 5:30 | 23:30 – 5:30 | |
| **U [W/m²K]** | **0.88** | **0.88** | **(1.13)** | **0.90** | **0.84** | **0.84** | **0.87** |
| **+/- %** | 1.8% | 0.9% | | 3.6% | -3.4% | -3.4% | |

Table 1: Measured U-Value per night period

The third night yielded a clearly higher U-Value and was therefore excluded[3]. The overall U-value was calculated to be 0.87 W/m²K.

## 3. Conclusion

The measured $U_g$-Value of 0.87 W/m²K is rather low for a double-glass window[4]. It can be deduced that the windows were of good quality at the moment of retrofitting and didn't deteriorate significantly with time.

Double glazing rather than triple glazing was chosen for the retrofit as the house overall is an old house and not well insulated. In order to increase the energy efficiency of the house, it is probably more effective to detect heat bridges and increase the insulation of the walls rather than exchanging the windows.

[3] The measurement in the 3rd night was affected by a significant heating activity by the heater directly positioned under the window.
[4] EnergieSchweiz: *Merkblatt Fenster. Das Fenster im Energienachweis*. 2009, Bundesamt für Energie BFE, Ittigen, Schweiz.

## Appendix

Analysis via Cloud

1. On the cloud, the data of one night at a time was selected using the slide bar at the bottom of the page:

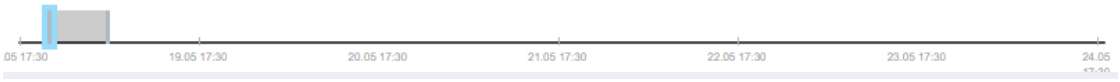


Fig. 6: Selection of the first night

| | |
|---|---|
| Start of selected period | 18.05.2019 21:30 |
| End of selected period | 19.05.2019 05:30 |

Fig. 7: Box on the top right indicates the exact selected time range

The time range might need further adjustment in order to fulfil the requirement of a 5°C minimum temperature difference).

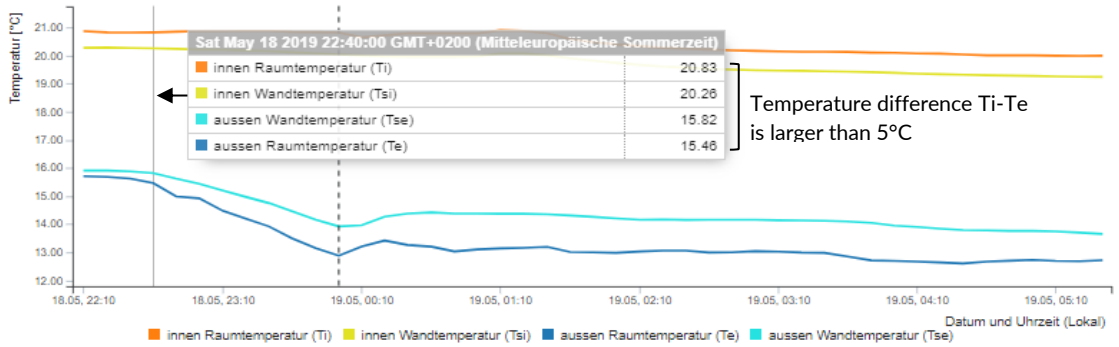


Fig. 8: When moving the mouse over the temperature graph, the exact data is displayed and the temperature difference can be calculated.

2. Read off the U-value for each time range (The U-value equals the last value in the graph “U-value Evolution of Analyzed Period”

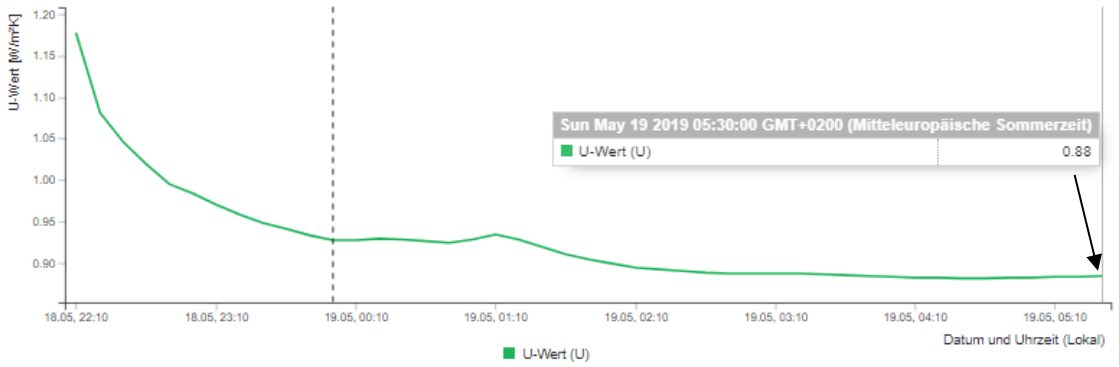


Fig. 8: The U-value for a selected period equals the last value of the graph “U-value Evolution of Analyzed Period”. The exact value is displayed through moving the mouse over this last data point.

3. Compare U-values of the individual time ranges and calculate the mean

Analysis via Excel

1. Export raw data from the cloud:
   -> Select “report”
   -> Select data analysis tool: “raw data export”
   -> select “measurement period”, “Mess-ID” and “Messknoten”
   -> click on “raw to CSV” on the bottom of the page

2. Select the data of one night at a time in Excel[5]. The time range might need further adjustment in order to fulfil the requirement of a 5°C minimum temperature difference.

3. Calculate the U-value for each time range separately, using the formula

$$U - Value = \frac{\sum q_i}{\sum (T_{int.} - T_{ext.})}, with\ q = heat\ flux$$

4. Compare U-values of the individual time ranges and calculate the mean

## Literature

[1] EnergieSchweiz: *Merkblatt Fenster. Das Fenster im Energienachweis.* 2009, Bundesamt für Energie BFE, Ittigen, Schweiz.

[2] *ISO 9869-1, Thermal insulation - Building elements - In-situ measurement of thermal resistance and thermal transmittance; Part 1: Heat flow meter method.* 2014, ISO, Switzerland.

[5] Excel template available for customers from greenTEG.