

Baseline data to prioritize building renovation.

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The European “Next Generation” funds are going to provide an opportunity for the rehabilitation of buildings. It invites to reflection on how to prioritize actions. In the scope of the EERAdata project (<https://eeradata-project.eu/>), in which the Malaga College of Architects participates as an expert entity in the construction process and link with the profession, society and public administration, it is under develop a SW application called Decision support Tool (DST). It helps those responsible for managing buildings in making decisions about renovation thanks to the information on the expected impact in different areas (social, economic, environmental, etc.)^[1].

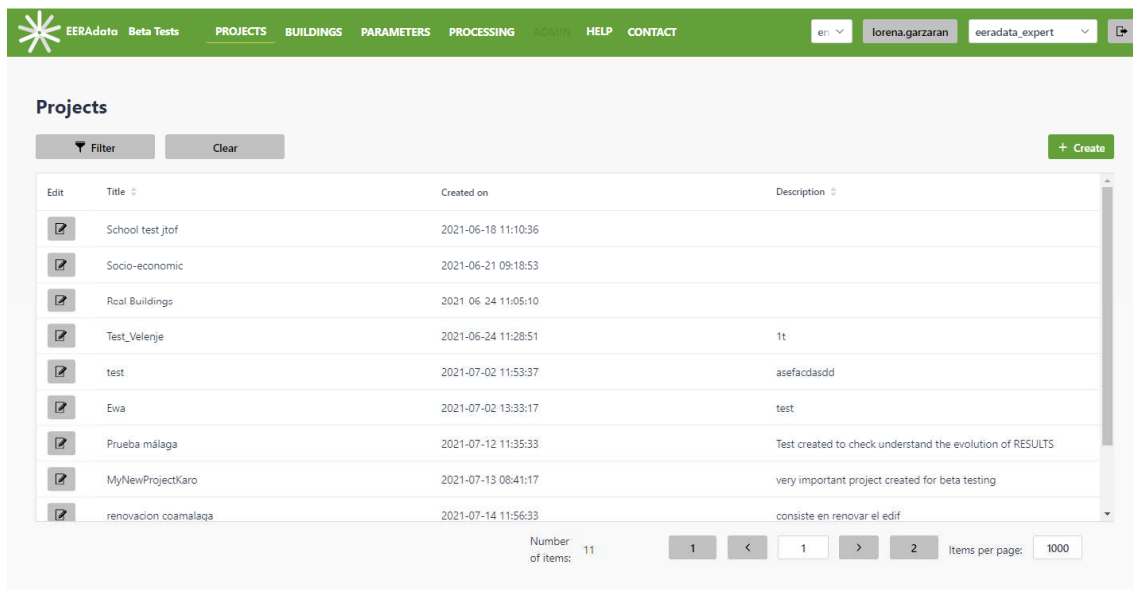


Figure 1: DST Main menu

^[1] This document is based on research carried out in the EU-funded EERAdata project, which has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No. 847101.

The characterization of the sets of buildings to obtain the parameters that must be entered in the SW application can be done in two ways.

In one side, through the specific average parameters that defines each building, for which it will be necessary to have a prior study (energy certification) and a treatment of the data included in the energy certification files. This would be the way in which an expert / technical user would obtain the parameters to be entered in the SW application.

On the other side through default parameters of each building that will depend on the year of construction. This would be the way in which a normal user would use the tool, through default values previously entered in the SW application.

In this article, the first aspect will be developed, that is, the work of data treatment of energy certificates to obtain the specific parameters that feed the SW application in relation to the building envelope. It is important to highlight the following two points:

- a) The SW application does not aim to design the specific rehabilitation of each building, but rather to guide building network managers on the positive impact that the rehabilitation of their network of buildings can have in different areas of interest: environmental impact, economic, embedded carbon, user health, etc.
- b) There are other relevant parameters of the building envelope, which are not developed in this article, such as the permeability of the window, which the SW application takes into account as input data.

Reference elements

Reference elements are understood to be those that act on behalf of the building as a whole. The values of these reference elements are obtained through the analysis of the data in the calculation files of the energy certificates, which are downloaded in Excel sheets and the equations that will be explained below are applied to them. The Andalusia Energy Agency (hereinafter A.E.A) has provided both the energy certificate and the CE3X file for calculating the buildings that are presented below.

Reference Window

The first of the reference elements is the window. It consists of a window with the average values of the different windows in the building. The specific calculations in Excel to obtain the average values that represent the reference window must be adapted to the way in which the data has been entered in each certification file for each building, which is not always the same.

1) "Reference" window dimensions:

- Reference window height [m] = (Window height 1 [m] * number of windows of type1 + Height of window2 [m] * number of windows of type 2 + ... + Height of window N [m] * number of windows of type N) / Total number of windows = Total weighted height [m] / Total number of windows.
- Reference window area [m²] = Total window area [m²] / Total number of windows
- Reference window length [m] = Reference window area [m²] / Reference window height [m]

2) Solar gain (g) of the "reference" window: $g \text{ reference window} = (g_1 * \text{window area } 1 [m^2] + g_2 * \text{window area } 2 [m^2] + \dots + g_N * \text{window area } N [m^2]) / (\text{Total window area } [m^2])$

3) U of the reference window glazing, when each U-value of each glazing of EACH individual window is known: $U \text{ reference glazing } [W / m^2 K] = (U_1 * \text{glazed area } 1 [m^2] + U_2 * \text{glazed area } 2 [m^2] + \dots + U_n * \text{glazed area } N [m^2]) / (\text{Total glazed area } [m^2])$

4) U of the reference window frame, having only as initial data the U of each window and the U of the glazing of each window:

- U of weighted frame [W / K] = (U of window type1 [W / m² K] * surface of window 1 [m²]) - (U of frame type1 [W / m² K] * surface of frame 1 [m²]) + (U of window type2 [W / m² K] * area of window 2 [m²]) - (U of frame type2 [W / m² K] * area of frame 2 [m²]) +... + (U of window type N [W / m² K] * window area N [m²]) - (U of frame type N [W / m² K] * frame area N [m²])
- Weighted frame area [m²] = (% of window frame 1 * window area 1 [m²]) + (% of window frame 2 * window area 2 [m²]) +... + (% window frame n * window area n [m²])
- U reference frame [W / m² K] = (U of weighted frame [W / K]) / (Weighted frame area [m²])

5) U of the reference window, when the U value of each window is known: $U \text{ Ref Window } [W / m^2 K] = (U_1 * \text{window area } 1 [m^2] + U_2 * \text{window area } 2 [m^2] + \dots + U_n * \text{window area } n [m^2]) / (\text{Total area of windows})$

6) U of the reference window, having as starting data the U of the frame and the U of the glazing of each window:

- U weighted of the reference glazing [W / K] = Sum (glazing surface N [m²] * U glazing N [W / m² K])

- U weighted frame of reference $[W / K] = \text{Sum}(\text{frame area } N [m^2] * U \text{ frame } N [W / m^2 K])$
- Weighted U of the reference window $[W / K] = U \text{ weighted of the reference glazing } [W / K] + U \text{ weighted of the reference frame } [W / K]$
- U reference window $[W / m^2 K] = U \text{ weighted of the reference window } [W / K] / \text{Total window area } [m^2]$

We present below two examples of data obtained from two CE3X files of two buildings in Andalusia, following the procedure of the previous point 4 (Case1) and the procedure of the previous point 6 (Case 2).

Case 1: Heliópolis building.

The tertiary building under study is a center for the elderly people, managed by the Andalusia administration, located at C/ Padre Mediavilla nº2, Seville. It has 345 windows, grouped into 73 types by size and glazing.



Figure 2: Heliópolis Building

In this case, the U of the individual windows and the U of the glass are known, but the U of the frame is not known. From the treatment of the data exported from the CE3X file, applying the above formulas, the results are obtained in orange in the first table. With these values the reference window is obtained in the second table:

| | Superficie total | Número de ventanas | Altura ponderada | Marco ponderado | U ponderado de la ventana | U ponderado del vidrio | U ponderado del marco | g ponderada del vidrio | Superficie de vidrio |
|--------|-------------------|--------------------|------------------|-------------------|---------------------------|------------------------|-----------------------|------------------------|----------------------|
| Uds | [m ²] | | [m] | [m ²] | [W/ K] | [W/ K] | [W/ K] | [g * m ²] | [m ²] |
| TOTAL: | 1010,01 | 345,00 | 527,05 | 157,41 | 4436,08 | 3538,33 | 897,76 | 660,59 | 852,60 |

| Ventana de referencia | Alto | Superficie | Largo | g | U vidrio | U ventana | U marco |
|-----------------------|-------|-------------------|-------|-------|----------------------|----------------------|----------------------|
| | [m] | [m ²] | [m] | | [W/m ² K] | [W/m ² K] | [W/m ² K] |
| | 1,528 | 2,928 | 1,916 | 0,775 | 4,150 | 4,392 | 5,703 |

Figure 3: Reference Window from Heliópolis building

Case 2: Portugal pavilion.

The building under study is an office building, managed by the Andalusia Energy Agency (AEA), located at EXPO92, Seville. It has 78 windows grouped into 21 different categories (21 different holes).



Figure 4: Portugal Pavilion

In this case, for each window, the U of the frame and the glazing are known, but not that of the window.

From the treatment of the data exported from the CE3X file, applying the above formulas, the first results are obtained in orange in the first table. With these values the reference window is obtained in the second table.

| | Altura | Número de ventanas | Altura ponderada | Superficie de ventana | U ponderada del acristalamiento | Superficie de marco | U ponderada del marco | U ponderada de la ventana |
|--------------|-------------|--------------------|------------------|-----------------------|---------------------------------|---------------------|-----------------------|---------------------------|
| Uds | [m] | | [m] | [m ²] | [W/K] | [m ²] | [W/K] | [W/K] |
| TOTAL | 43,2 | 78,0 | 135,9 | 275,0 | 732,0 | 55,0 | 313,4 | 1045,4 |

| Ventana de referencia | Acristalamiento Uref | | Marco Uref | | Ventana Uref | | Altura ventana ref | Superficie ventana ref | Ancho ventana ref |
|-----------------------|----------------------|--|----------------------|--|----------------------|--|--------------------|------------------------|-------------------|
| | [W/m ² K] | | [W/m ² K] | | [W/m ² K] | | [m] | [m ²] | [m] |
| | 3,33 | | 5,70 | | 3,80 | | 1,74 | 3,53 | 2,02 |

Figure 5: Reference Window from Portugal Pavilion

Reference facade and roof

The second of the reference elements presented in this article are the facade and roof.

The reference U-value, when each U-value of each part is known, is calculated as follows:

U reference facade = U of the weighted facade [m²] * [W / m² K] / Total area of the facade [m²] = (U₁ [W / m² K] * area of facade 1 [m²] + U₂ [W / m² K] * facade area 2 [m²] +... + U_n [W / m² K] * facade area n [m²]) / (Total facade area [m²])

U reference roof = U of the weighted roof [m²] * [W / m² K] / Total roof area [m²] = (U₁ [W / m² K] * covered area 1 [m²] + U₂ [W / m² K] * covered area 2 [m²] +... + U_n [W / m² K] * covered area n [m²]) / (Total roof area [m²])

In the case of slab in contact with the ground, the ground value will be constant, and if it varies, the previous calculation will be applied.

Case 3: Malaga government delegation.

The Government Delegation in Malaga is an administrative building from the year 1920 that is located in the center of the city on Calle Alameda Principal, nº 18.



Figure 6: Regional Government delegation in Málaga

From the treatment of the data exported from the CE3X file, applying the above formulas, the following results are obtained:

| Fachada de referencia | Superficie total fachada | U ponderada de fachada | U fachada referencia | Superficie total cubierta | U ponderada de cubierta | U cubierta de referencia |
|-----------------------|--------------------------|------------------------|----------------------|---------------------------|-------------------------|--------------------------|
| | [m ²] | [W/ K] | [W/m ² K] | [m ²] | [W/ K] | [W/m ² K] |
| | 1191,68 | 1623,54 | 1,3624 | 506,82 | 1368,12 | 2,6994 |

Figure 7: Reference facade of the Regional Government delegation in Málaga

Conclusions.

In this article, the work of data treatment of energy certificates has been developed to obtain the specific parameters regarding the building envelope.

These parameters can be used in the ERRAdata tool by experts / technicians to define buildings specifically. They can also be used to study a set of buildings by historical periods and obtain the average values of each parameter, with which studying a sufficient number of buildings could characterize a large building park.

In addition, for managers of public or private buildings, it may be useful to order the equivalent buildings in the same climatic zone in a ranking according to the parameter chosen as the ordering criterion. Thus, criteria can be established to prioritize renovations (in addition to those that can be established by the energy rating itself). These criteria may be due to the availability of grants for specific parts of the building (window, facade, etc.).

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Figures:

Figure 1. DST Main menu (source: sw developed by ITTI, as EERAdata project partner)

Figure 2. Heliópolis Building (source:Google street view)

Figure 3. Reference Window from Heliópolis building (source: own elaboration)

Figure 4. Portugal Pavilion (source:Google street view)

Figure 5. Reference Window from Portugal Pavilion (source: own elaboration)

Figure 6. Regional Government delegation in Málaga (source:Google street view)

Figure 7. Reference facade of the Regional Government delegation in Málaga (source: own elaboration)