

# Wall-ACE

## Deliverable

### D4.3.: Simplified numerical tools for early-design of the “HONEST” envelopes

<b>WP</b>	4	Demonstration: building validation and tools development
<b>Task</b>	4.3.	Simplified numerical tools for early-design of the “HONEST” envelopes

<b>Dissemination level<sup>1</sup></b>	PU
<b>Nature<sup>2</sup></b>	R

<b>Due delivery date</b>	30/09/2019
<b>Actual delivery date</b>	27/11/2019

<b>Lead beneficiary</b>	POLITO
<b>Contributing beneficiaries</b>	POLITO, CEA, EFFIN'ART, BRE

Document Version	Date	Author	Comments <sup>3</sup>
1	10/07/2019	Valentina Serra, POLITO	Creation
2	27/09/2019	Marco Perino, POLITO	Integration and finalisation
3	25/11/2019	Timea Bejat, CEA	Validation
4	26/11/2019	Tina Oertel, Quick-Mix	Revision and validation
5	26/11/2019	Valentina Serra, POLITO	Internal revision and final version

<sup>1</sup> Dissemination level: **PU** = Public, **PP** = Restricted to other programme participants (including the Commission services), **RE** = Restricted to a group specified by the consortium (including the Commission services), **CO** = Confidential, only for members of the consortium (including the Commission services)

<sup>2</sup> Nature of the deliverable: **R** = Report, Document, **DEM** = Demonstrator, Prototype, pilot, **DEC** = Websites, patent filings, **O** = Other

<sup>3</sup> Creation, modification, final version for evaluation, revised version following evaluation, final

## Deliverable abstract

This deliverable presents the simplified analysis and design tool conceived and developed in Matlab and Simulink environment to aid designers in assessing the energy performance achievable through the use of the different Wall-ACE products which constitutes the HONEST toolbox.

## Deliverable Review

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Answer	Comments	Type*	Answer	Comments	Type*

Is the deliverable in accordance with

the Description of Action?	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		<input type="checkbox"/> M <input type="checkbox"/> m <input type="checkbox"/> a	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		<input type="checkbox"/> M <input type="checkbox"/> m <input type="checkbox"/> a
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that needs further work by the Partners responsible for the deliverable?	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No		<input type="checkbox"/> M <input type="checkbox"/> m <input type="checkbox"/> a	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No		<input type="checkbox"/> M <input type="checkbox"/> m <input type="checkbox"/> a

\* Type of comments: M = Major comment; m = minor comment; a = advice

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## 1. Introduction

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A simplified software was conceived, developed and tested in order to provide a tool to designers (architects/engineers) and final users able to give, in a quick and easy way, general information about the potential benefits that can derive from the use of the various Wall-ACE products that form the HONEST toolbox.

This software was not meant to substitute more sophisticated and accurate tools for the energy simulation of buildings (that are already available, like e.g. Design Builder, E plus, TRNSYS, ...). The idea was to provide a very easy and friendly instrument, shareware and freely distributable that, with few effort and limited technical skills, could nevertheless give a reliable idea of what can be achieved by means of the new materials developed during the Wall-ACE project.

For his reason a 1D model was developed and implemented in the Matlab environment. At the same time a user-friendly Graphic User Interface (GUI) was designed and implemented.

With few information given as input (and the input of data is made easier by integrating a database of materials and of weather conditions) the user can obtain, in a few seconds, a comparison between the thermoenergetic performances of any existing wall and of the same wall retrofitted using one or more of the components of the HONEST Toolbox.

Two versions were developed, one complete with more detailed output and graphs (Wall-ACE) and one simpler providing just the macro numbers (Wall-ACEs), in Figure 1 the splash screen of the software tool is shown.



**Figure 1: Splash screen of the software tool**

## 2. Description of the developed simplified tool

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### 2.1. General overview

Given a wall configuration, the software evaluates the energy savings that can be achieved by means of a refurbishment through addition of an external high-performance insulation render and/or an internal high performance insulating plaster and/or a thermal coating finishing.

The analysis is performed through a dynamic simulation of the one-dimensional heat transfer within the wall before and after retrofitting, considering outdoor temperature and irradiance profiles on the outer side and a constant air temperature on the internal side. The transient heat conduction equation is solved through the application of the finite difference method with Crank-Nicolson scheme and Gauss-Seidel over relaxation [1, 2]. Uniform time step (15 minutes) and mesh size are considered. Energy losses and energy gains are then evaluated by respectively integrating the negative and positive heat flux densities. Example views of the complete and light versions of software are respectively reported in Figure 2 and Figure 3.

The description of the wall, the boundary conditions and the simulation period need to be defined, together with one or more retrofitting choices. The input data can be saved as .mat files (MATLAB data files) and loaded at any time, whereas the results can be exported in .csv format (comma delimited files).

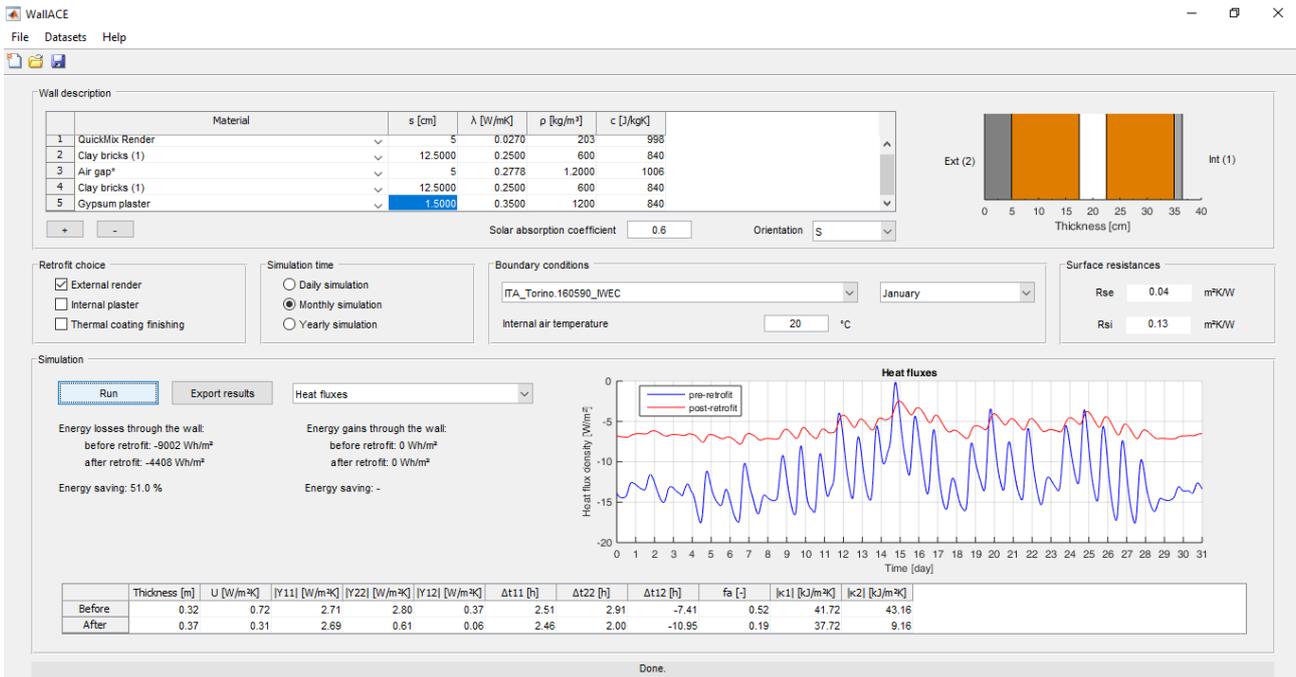


Figure 2: View of the complete version of the software tool (Wall-ACE)

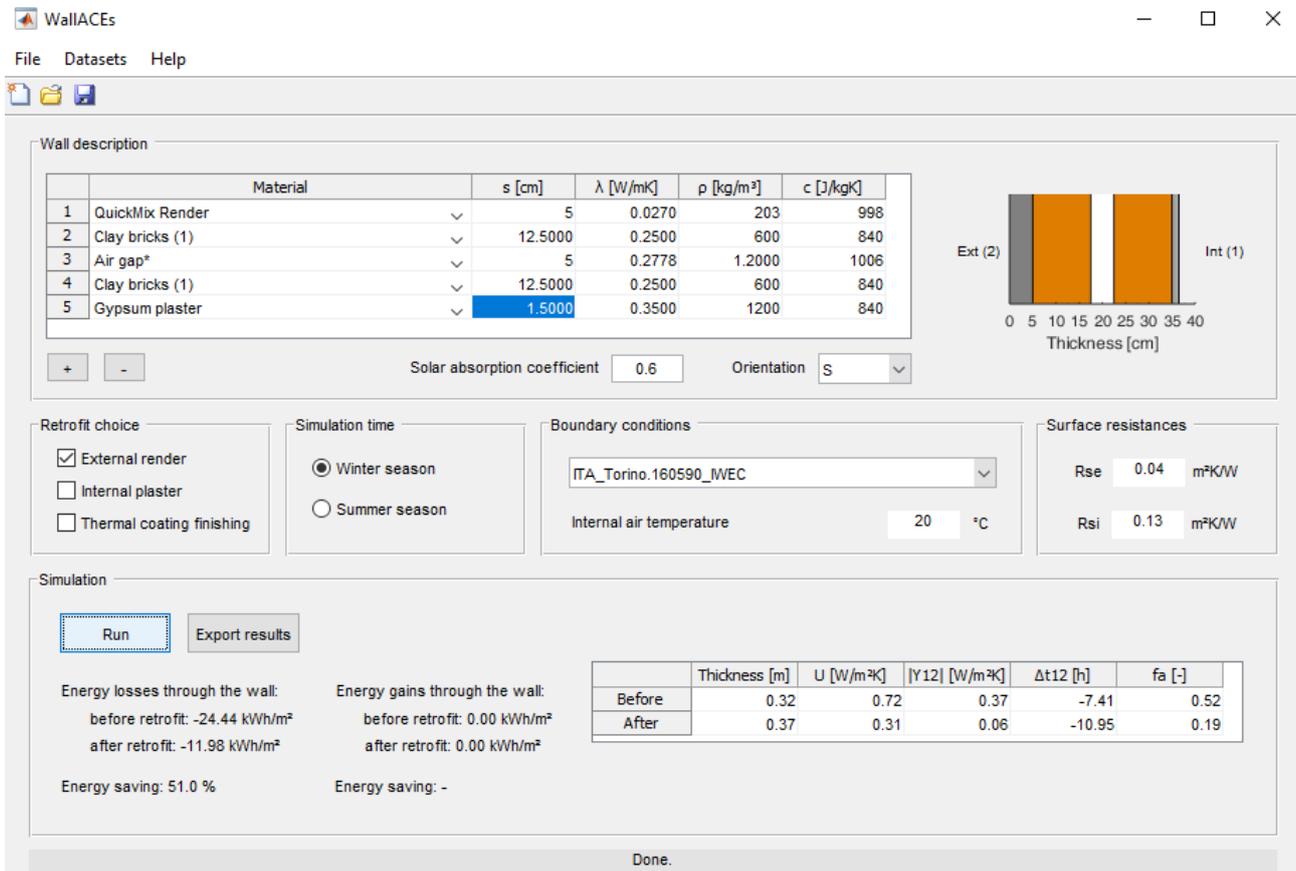


Figure 3: View of the light version of the software tool (Wall-ACE)

## 2.2. Material settings

Information on the wall construction can be entered in table form. A list of predefined materials is available. When a material is selected from the list, the corresponding thermal properties (thermal conductivity, density and specific heat capacity) are automatically loaded. The thickness of the layer is therefore the only value that needs to be manually entered. If necessary, the user can modify the predefined values of the thermal properties. Custom materials can also be added.

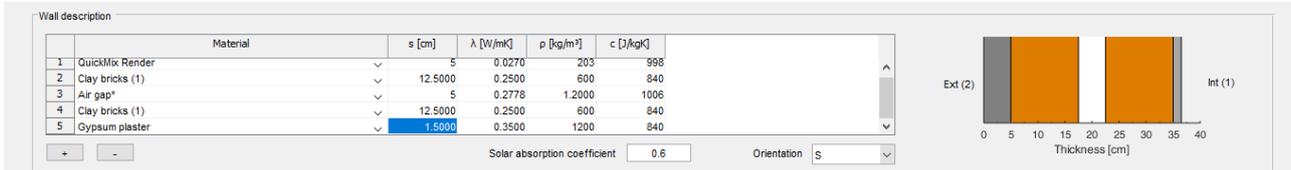


Figure 4: The material and wall setting window

## 2.3. Boundary condition settings

To perform the dynamic thermal simulation, which takes the effect of solar radiation into account, the solar absorption coefficient and the wall orientation also need to be entered.

In the complete version of the software, the simulation period can be either hourly, monthly or yearly. For hourly runs, results refer to a steady-periodic regime. For monthly and yearly runs, initial conditions are evaluated by running a pre-simulation of the previous month. In the light version of the software, the simulation can be launched either for the winter or the summer season. For the winter season, the calculation is run from December to February, and the internal air temperature is set to 20 °C. For the summer season, the calculation is run from June to August, and the internal air temperature is set to 26 °C.

Weather conditions (external air temperature and solar radiation) can be specified by selecting the weather data file of the location under investigation (.stat files for daily simulations and .epw files for monthly and yearly runs).

The solar radiation impinging on the wall is evaluated according to the model reported in the ASHRAE 2009 [4, Ch. 14]. For the daily simulations, the solar position is evaluated on the 21st day of the month.

The standard surface resistances are selected for horizontal heat flux according to EN ISO 6946:2007 [3]. When the thermal coating finishing is selected as retrofitting option, the internal resistance of the refurbished wall is automatically adjusted to take the low-emissivity of the material into account.

The new thermal resistance is evaluated according to EN ISO 6946:2007 [3].



Figure 5: The boundary condition settings

## 2.4. Simulation outputs

For both the pre-retrofit and post-retrofit cases, static and dynamic thermal properties of the wall are evaluated according to the standards EN ISO 6946:2007 [3] and EN ISO 13789:2007 [5], respectively. The complete version of the software reports the full set of properties (i.e. thermal transmittance, modulus and time shift of the internal and external thermal admittance and of the periodic thermal transmittance, decrement factor and modulus of the internal and external areal heat capacity).

The light version only reports thermal transmittance, modulus and time shift of the periodic thermal transmittance, and decrement factor. Moreover, a series of graphics can be visualised in the complete version of the software in order to compare the performance of the pre-retrofit and post-retrofit solutions (plots of internal surface temperature profiles and heat flux densities on the internal side).

A complete report of all the inputs and resulting outputs can be exported in .csv format. In the complete version of the software, detailed tables containing all the interface temperatures between materials and the heat flux densities entering the internal environment for the pre-retrofit and post-retrofit walls are also included.

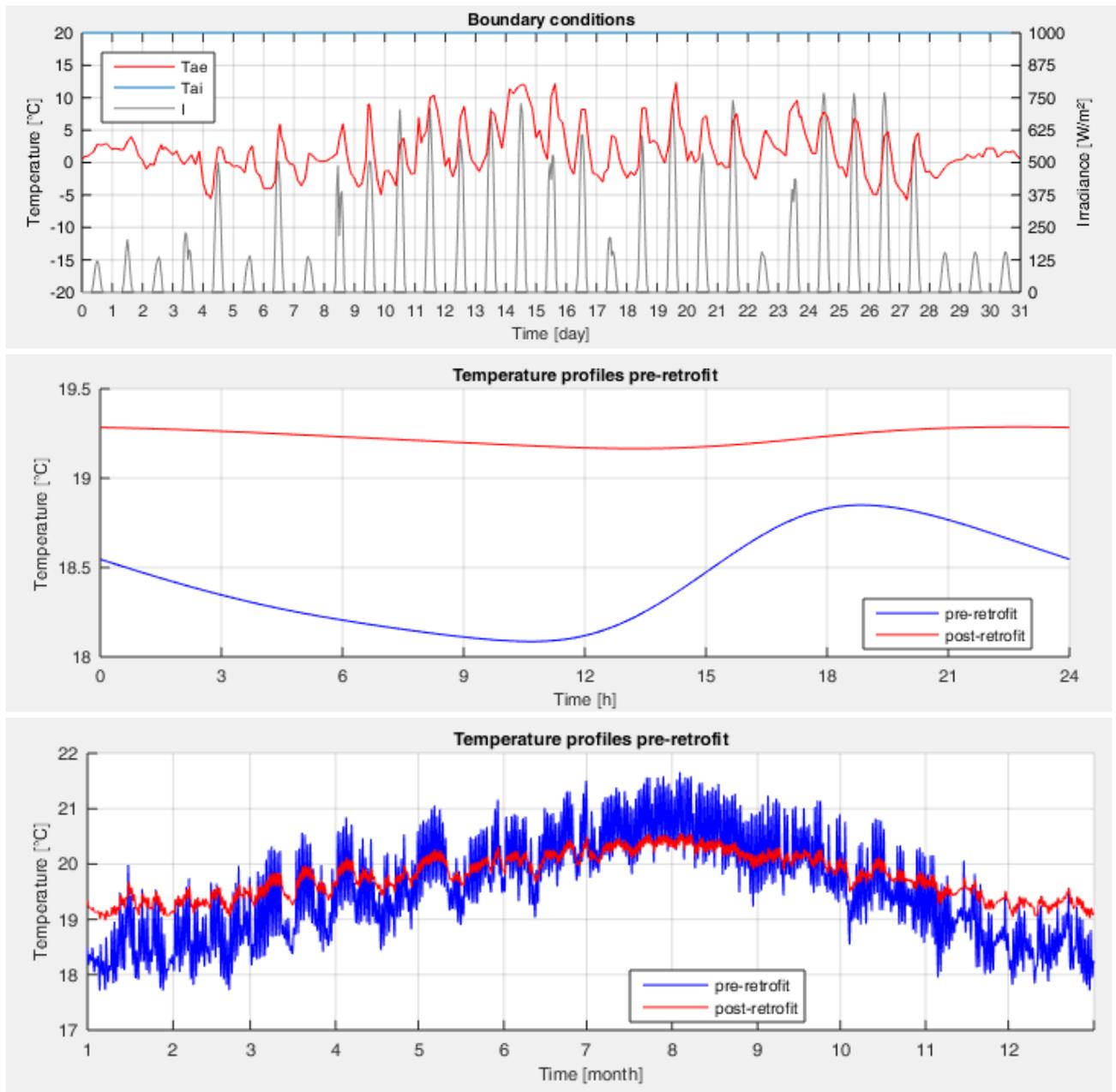


Figure 6: Example of graphical output

## 2.5. Installation notes

The complete version can be installed by download:

- the standard installation (*WallACE\_installers\_mcr.exe*)
- the web version for the online installation (*WallACE\_Installer\_web.exe*)

Wall-ACE performs complete analyses, Wall-ACEs is the simplified version.

Depending on the PC hardware the software starting process may require few or more minutes (this depend on the math lab engine).

It has to be highlighted that is not required a Matlab licence, since what needed is embedded in the installation files.

The software can be freely downloaded at the following link: <http://wall-ace.eu>

## 3. References

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- [1] M. N. Özisik, Heat Conduction, John Wiley & Sons, New York, 1993.
- [2] M. N. Özisik, Finite Difference Methods in Heat Transfer, CRC Press, Boca Raton, 1994.
- [3] EN ISO 6946:2007, Building components and building elements – Thermal resistance and thermal transmittance - Calculation method, International Organization for Standardization, Geneva, Switzerland, 2012.
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- [5] EN ISO 13786:2007, Thermal performance of building components \_ Dynamic thermal characteristics \_ Calculation methods, International Organization for Standardization, Geneva, Switzerland, 2007.