A SIMPLE USER INTERFACE FOR ENERGY RATING OF BUILDINGS

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ABSTRACT

The Israeli standard 5282 for energy rating of buildings includes, besides a Prescriptive path, a Performance Approach that requires using an hourly energy simulation model to demonstrate compliance.

In this work, we present the development of a Graphical User Interface (GUI), in which most of the expert knowledge needed to run such complex simulation model is embedded in it. The output of the evaluation is a certificate specifying the energy rating of each unit in the building, as well as the energy rating of the whole building. Although IS5282 includes different building types, in this work we will demonstrate the tool using the Residential building type.

One of the advantages of the system is that it suits any stage of the design process and not only the detailed one. In such a way, the user can design buildings being more aware of the energy performance features and their impact on the energy performance of the building. The GUI has been adopted by the Standards Institution of Israel for energy rating of buildings. The paper presents the tool, ENERGYui, and its application demonstrated with a case study.

INTRODUCTION

During the last years, there is an increasing interest and awareness regarding subjects related to sustainable design and green architecture, reducing energy consumption of buildings and pollutant generation, and achieving comfort conditions inside and outside buildings.

Nowadays, there are many different Building Rating Systems required as part of national and regional directives, such as LEED (USGBC, 2009) in North America and the EPBD (EPBD, 2010) in Europe. These directives call for the development of methodologies of calculation procedures for assessing energy performance. The complexity involved in checking code compliance and the particularities of each of them, has resulted in the development of a large array of sophisticated tools. A comprehensive list has been featured by the United States Department of Energy (Crawley, et al., 2005).

Most of the existing detailed hourly energy simulation models demand a high degree of expertise to define the input needed for simulation and understand the output produced by the model on one hand, as well as tedious work of defining all the building parameters and details needed to perform the simulation. Hence, these simulation tools are generally applied at the late design stages, by external expert consultants and not by architects. At this late design stage, it is very expensive and almost impossible to implement major changes in the building should they be required. Using energy simulation tools usually involves a degree of expertise way beyond the professional capabilities of designers. The knowledge required to set the proper conditions of the simulation usually deprives architects from using this kind of tools during the design process. Thus, simulations are performed at the end of the design process only when the building is finished, and by external consultants. As a result, they are unsuitable as practical design aids for architects, since they share the following characteristics:

- Require specialization and expertise,
- Require the definition of multiple parameters related not only to architectural characteristics of the buildings but also to mechanical systems, schedules, etc.
- Produce complex output difficult to translate to design decisions, or answer to the "what to do next" question.

In Israel a new Standard IS5281 "Buildings with Reduced Environmental Impact (Green Buildings") was first approved in November 2005 (SII, 2005), and recently updated (SII, 2011) after a comprehensive revision and is expected to have an important impact in the architectural practice. As in other green standards and systems, the Israeli Standard is divided in chapters dealing with different subjects all related to green design: 1. Energy, 2. Site, 3. Water, 4. Materials, 5. Health & Wellbeing, 6. Waste, 7. Transport, 8. Management and 9. Innovation. Among these topics, energy is the subject with major weight, and its verification and compliance relies on IS5282 "Energy Rating of Buildings".

IS5282 permits to design and demonstrate compliance according to two approaches: 1. the prescriptive-descriptive approach (Shaviv, Yezioro and Capeluto, 2008) which defines different pre-set solutions to achieve energy conservation, and 2. the performance approach that defines the energy performance of the building that should be met. The performance method is based on the comparison of the energy performance of the proposed building with a reference building, which determines the energy budget. For the implementation of this approach, the use of an energy simulation model is required.

The next sections will present the development of ENERGYui, a simple design tool that allows designers to evaluate and rate the energy performance of buildings during all the design stages including the early ones by using sophisticated energy simulation models. The simulation engine of the model is the robust hourly dynamic model EnergyPlus developed by the US Department of Energy (US DOE, 2011). The proposed design tool provides a GUI that includes the knowledge for fulfilling the Israeli 5282 standard for energy rating of buildings. It also includes a materials' library certified by the Standards Institution of Israel. Hence, the user is required only to provide or choose simple data related to architectural characteristics of the project, like location, building type, building geometry (envelope, internal walls, and openings), materials, etc., and rely on pre-set default values, for non-architectural, in order to perform the evaluation of the proposed design alternative. The tool is expected to improve the understanding of the influence of design decisions on the energy performance of the building among designers. This is a simple easy-to-use tool from the user's point of view, but a robust one that creates and simulates a full-detailed model.

THE SIMPLE TOOL

One of the strengths of the proposed simple tool is that it requires from the user information, he is used to understand and practice, related to architectural features. Among them, variables as project location, building type, building geometry, materials, shading elements etc, are selected or defined by the user. Non-architectural parameters are defined by the tool behind the scenes (see table 1 for a list of architectural and non-architectural parameters). Hence, this avoids confusion for the user regarding the information he is supposed to provide in order for the simulation to be performed on the one side, and avoids errors or manipulation of different simulation settings in order to obtain reliable results on the other In this way the proposed tool adapts to the way architects' work, and allows performing sophisticated simulations without the need of dealing with complex definitions. Moreover, it provides to authorities a way of controlling the correctness of the input data, and reliability of obtained results.

ENERGYui is controlled and organized by a command toolchest that guides and advices the user with respect to the information and input required or missing in order to perform the simulation (see Fig. 1).

Table 1
Information Type

<table>
<tr><th>INFO</th><th colspan="2">PARAMETERS</th><th colspan="3">VARIATION</th></tr>
<tr><td rowspan="12">Architectural (user defined)</td><td colspan="2">Location</td><td colspan="3">Free</td></tr>
<tr><td colspan="2">Build Type</td><td colspan="3">Residential</td></tr>
<tr><td rowspan="8">Geometry</td><td>Opaque</td><td colspan="3">Free (See Figs. 3 and 4)</td></tr>
<tr><td>Windows</td><td colspan="3">Free (See Figs. 3 and 5)</td></tr>
<tr><td rowspan="5">Blinds</td><td></td><td>Shading Coefficient Winter</td><td>Shading Coefficient Summer</td></tr>
<tr><td>No Blinds</td><td>1.0</td><td>1.0</td></tr>
<tr><td>2/3</td><td>0.6</td><td>0.4</td></tr>
<tr><td>1/2</td><td>0.5</td><td>0.4</td></tr>
<tr><td>1/1</td><td>0.8</td><td>0.4</td></tr>
<tr><td>Sunshades</td><td colspan="3">Free (See Fig. 5)</td></tr>
<tr><td colspan="2">Materials</td><td colspan="3">Free (See Figs. 4 and 7)</td></tr>
<tr><td colspan="2">Ventilation</td><td colspan="3">Night Crossed, Comfort</td></tr>
<tr><td rowspan="9">Non Architectural (Tool defined)</td><td rowspan="4">Loads</td><td>People</td><td colspan="3">From 4 to 8 - According to apartment size</td></tr>
<tr><td>Constant</td><td colspan="3">From 1 to 0.5 W/m^2 - According to apartment size</td></tr>
<tr><td>Non constant</td><td colspan="3">From 8 to 4 W/m^2 - According to apartment size</td></tr>
<tr><td>Lighting</td><td colspan="3">5 W/m^2</td></tr>
<tr><td colspan="2">Mechanical system</td><td colspan="3">Ideal system – Heating/Cooling Loads Calculation</td></tr>
<tr><td rowspan="2">Setpoint</td><td>Heating</td><td colspan="3">20 ^{o}C</td></tr>
<tr><td>Cooling</td><td colspan="3">24 ^{o}C</td></tr>
<tr><td colspan="2">Infiltration</td><td colspan="3">1 ach</td></tr>
<tr><td colspan="2">Seasons</td><td colspan="3">According to location climatic zone</td></tr>
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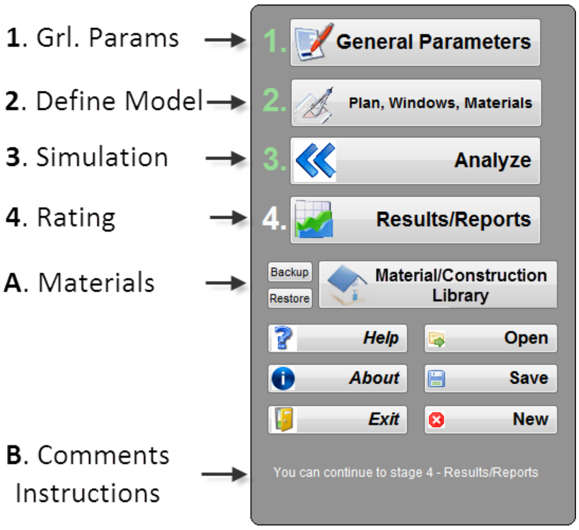

Figure 1 Command Toolchest

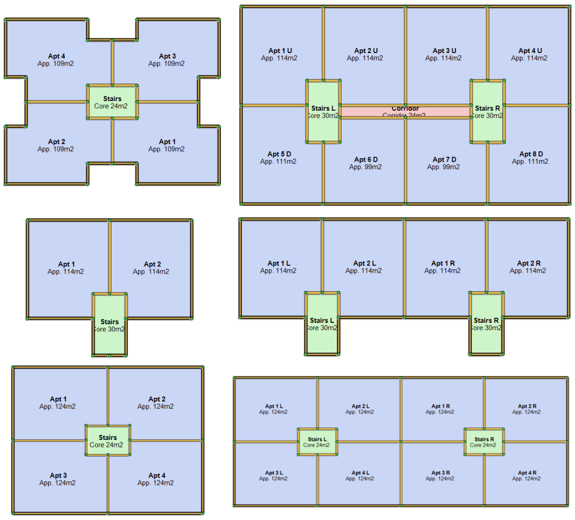

Figure 2 ENERGYui Templates

Stage 1 – General Parameters

The first stage relates to general information of the project in hand, being the most important the definition of the location (i.e. setting weather conditions for the project). Additional information includes designer and developer details and contact, terrain data, etc. After these general parameters are set, the user is allowed to continue to stage 2. If information is missing in stage 1, the toolchest does not allow the user to continue to stage 2 (and so on) guaranteeing in this way the completeness of the data needed to perform the full simulation.

Stage 2 and 3 – Define the Model and Simulate

In stage 2, the user defines the project geometry: plan, external envelope, openings, materials, number of floors, thermal zoning (apartments, cores, corridors, etc). The user can start this stage from scratch or can use one of the templates provided with ENERGYui. The templates define some of the typical building layouts for residential buildings in Israel (see Fig. 2 for some examples).

The user is in charge of providing all the necessary information for the architectural parameters, while all non-architectural are defaulted by ENERGYui. The idea behind this setting is to encourage designers to produce better energy performance buildings based in their architectural characteristics, rather than relying in mechanical solutions. Figure 3 shows the range of information the user needs to provide, besides the geometry itself (walls, windows and thermal zones) (see A in Fig. 3). Each wall needs to be assigned a composite element, which is drawn from a provided library (see Fig. 4) or newly created by the user according to his needs, and can be applied to a selected wall or to all walls in the floor or building. In the same manner, for any window the user needs to choose its frame and glazing material and internal or external shading type (blinds and/or sunshades) (see Fig. 5). While working on this stage, ENERGYui provides feedback on the completeness of included information. For instance, a yellow-mustard color wall or window means that a material definition is missing, while a green one is full defined. Additional information that needs to be defined at this stage relates to north direction, managing floors, managing thermal zones, assigning composite elements for floor, roofs, internal floors, as well as first floor type (on ground, on columns or over an unheated space) (B, C and D in Fig. 3).

Once stage 2 contains all the required information the user is allowed to proceed with stage 3: the simulation itself. ENERGYui automatically creates the full input file used by the simulation engine, i.e. EnergyPlus (US DOE, 2011).

Stage 4 – Rating Building and Apartments

After completion of the simulation, ENERGYui rates both the whole building and each of the zones or apartments in the building (see Fig. 6). IS5281 requires rating the whole building, while IS5282 requires the rating of both entire building and individual apartments. In this sense, the individual rating can help owners or potential buyers knowing the energy performance of his home. This information can also be used also by planning authorities to stimulate green buildings by providing economic incentives, like low interest rates, or others.

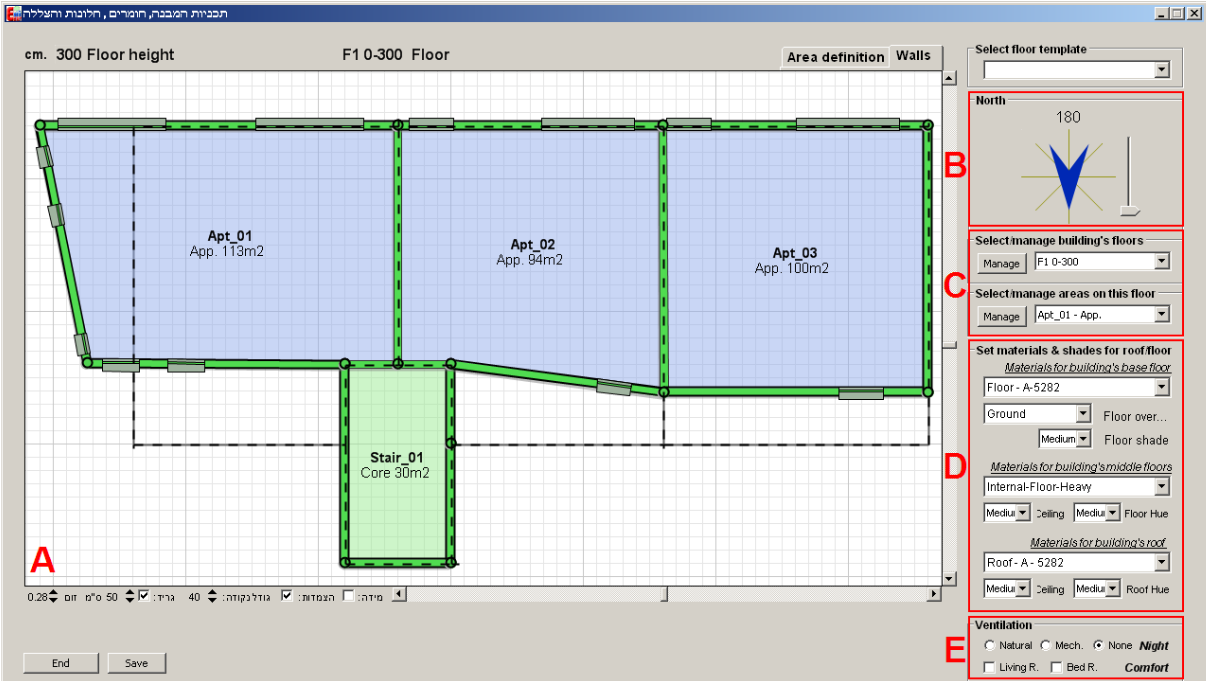

Figure 3 ENERGYui modelling GUI

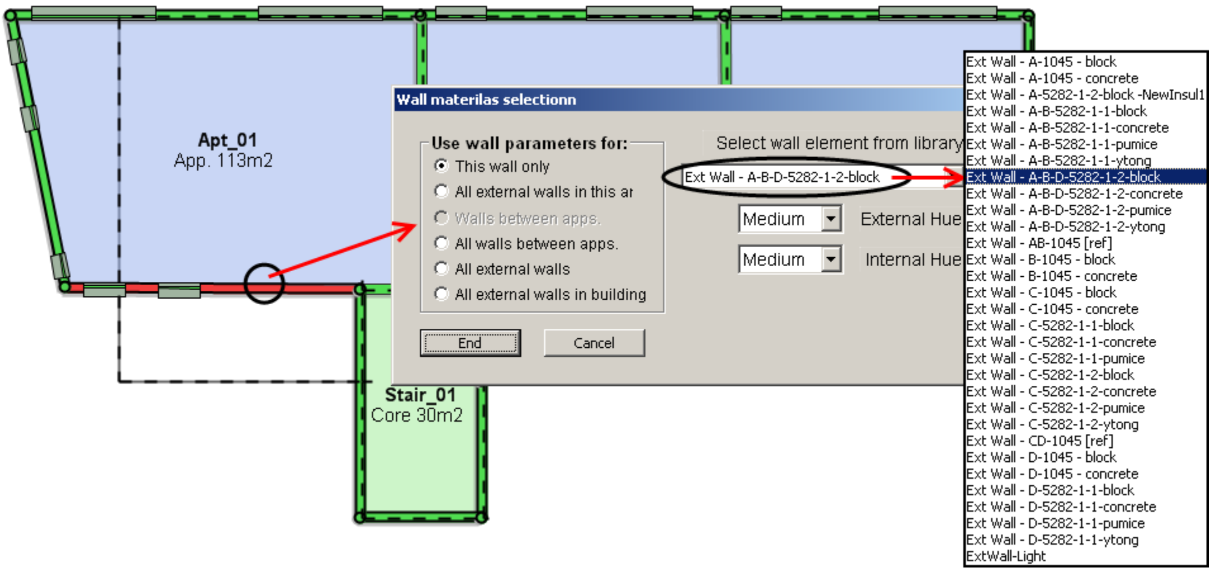

Figure 4 Opaque envelope: Assignment of composite elements

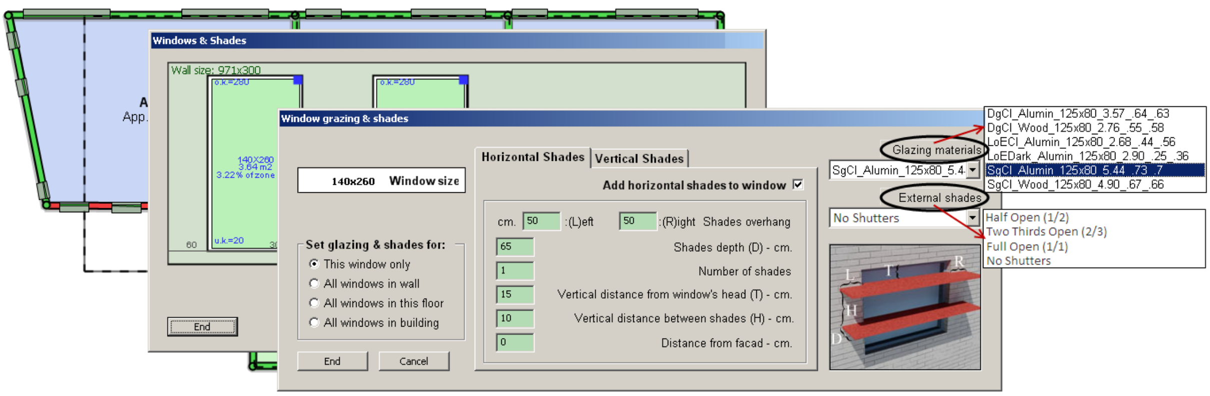

Figure 5 Openings: Assignment of window and shading elements

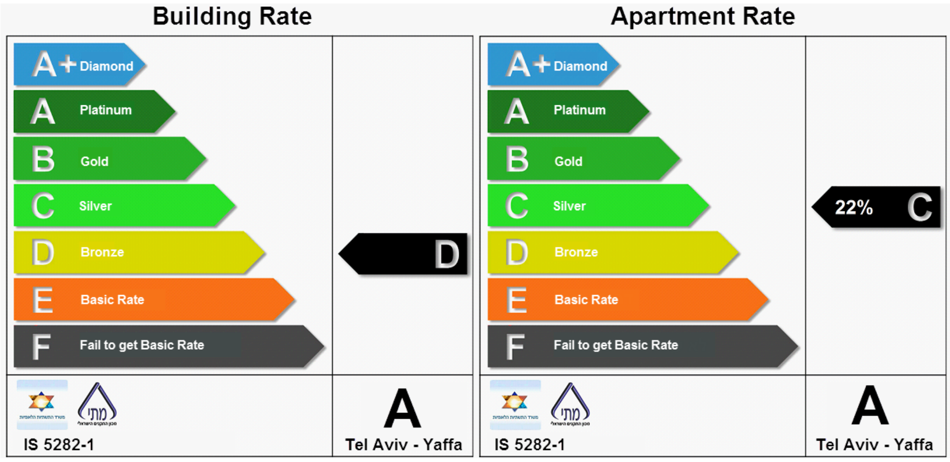

Figure 6 Energy Rating: Building (left) and Apartment (right)

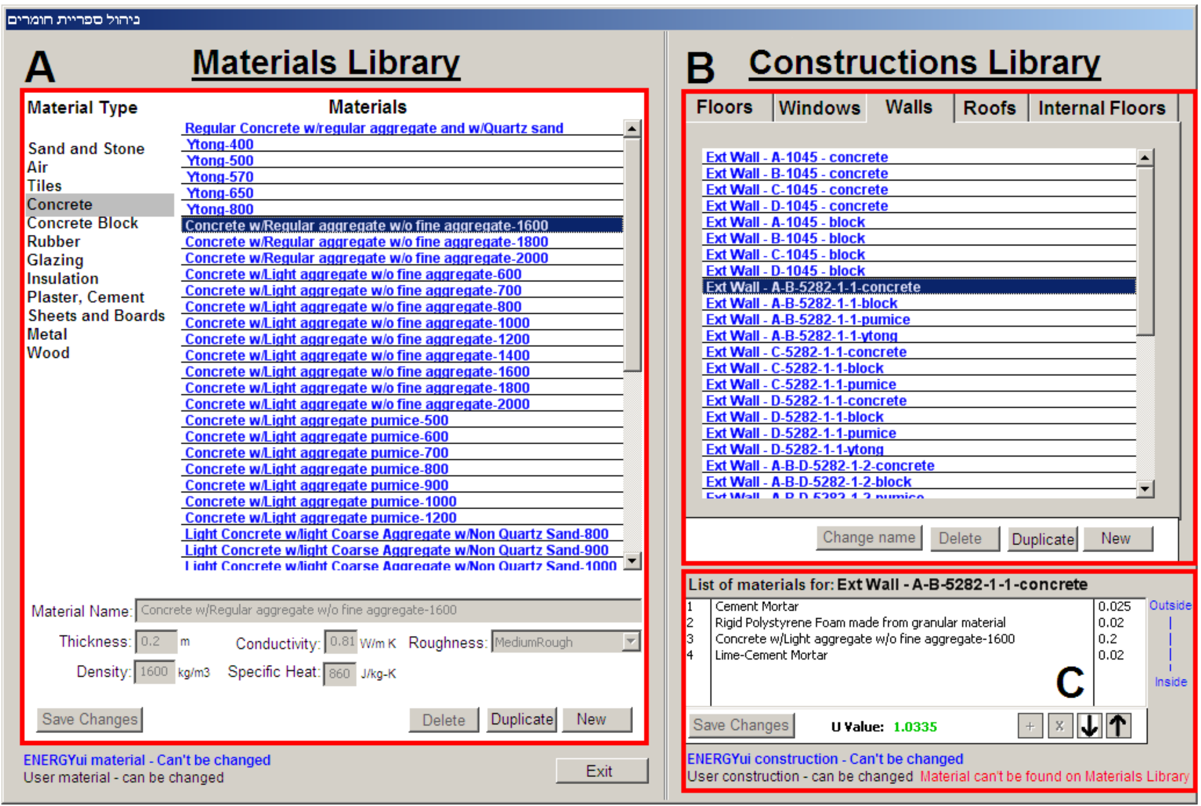

Figure 7 Material/Construction Library. List of materials (left); List of constructions (right)

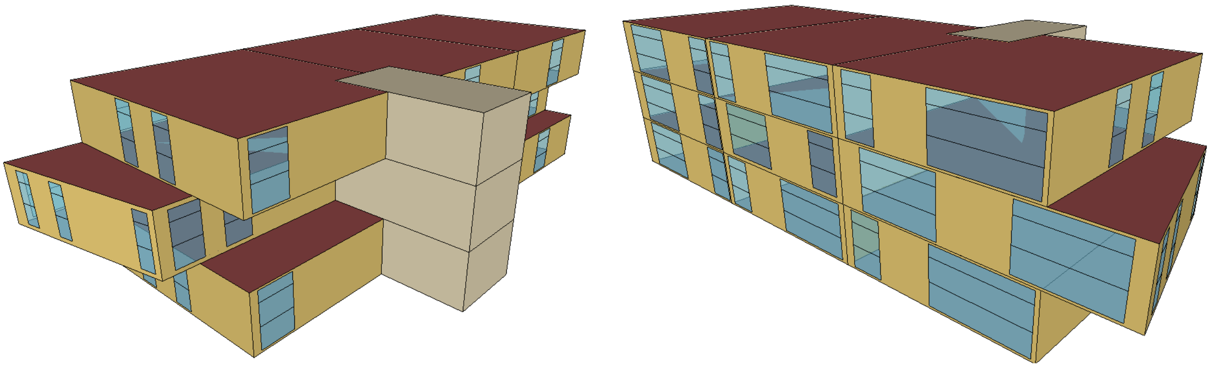

Figure 8 Case study building: View from North-East (left) and South-East (right)

Material/Construction Library

ENERGYui provides a material/composite elements library for the convenience of the user. The materials are categorized according to different types, so the user can quickly find the ones he is looking for (see A in Fig. 7). Individual materials are used for the creation of composite elements for the building envelope. Those assemblies can be assigned to different geometry elements in the building (Floors, Windows, Walls, Roofs, etc) (see B in Fig. 7). Users can choose from predefined composite elements or create new ones as shown in C in Fig. 7. New composite elements can be created based on existing and certified materials included in the library, or based on new materials on the market as defined by the user, In this case, a remark will be included in the final detailed report and the designer will be requested to provide documentation certifying the properties of the new material.

The library manager differentiates supplied materials/composite elements by different colors mainly because the supplied ones cannot be changed by the user.

CASE STUDY

In this section, we demonstrate the use of the tool through the analysis and improvement of a design alternative of a row building, designed in the city of Tel Aviv (32deg.N Latitude, 35deg.E Longitude), in the costal plan zone of Israel. Figures 3 and 8 show the geometry of the studied building.

In this example, due to design and programmatic constraints, there are various fixed variables that cannot be changed during the improvement process, as building geometry and orientation. Therefore, the improvement path focused in variables related to building envelope.

The building was first analysed using basic requirements regarding envelope insulation. Clear single glazing was used for the windows that were designed first without any solar protection. Table 2 presents a summary of the results obtained in the simulations while improving different design variables for Apt_02 (Internal apartment in middle floor) and for the whole building. The basic design alternative is changed according to the following order: improving envelope insulation and installing double-glazing in windows, adding dynamic external shutters that can be totally open and close, and last, implementing night ventilation in summer. As can be seen, the whole building improved its energy rating from a general F level to A, while Apt_02, an internal apartment in a middle floor improved to an A+ level.

CONCLUSION

A simple user interface ENERGYui, to the complex simulation model Energy Plus, for energy rating of buildings was presented. Besides the main purpose of rating buildings, the tool allows the designer to evaluate architectural design alternatives at all design stages, including the schematic ones. Hence, increasing his awareness on energy implications regarding design decisions. The proposed tool demands from the user information related to architectural parameters. The non-architectural ones are provided by the tool itself. ENERGYui is expected to make a great impact among practitioners since it is the recommended tool to be used for checking compliance with IS5282.

Table 2
Design path: improvements of basic design alternative

Description	Apt_02 Middle Floor		Whole Building
	Improv (%)	Level	Level
Basic Insulation Clear Single Glazing No Shading	-2%	F	F
Improved Envelope Insulation IS5282-Level 2 and Clear Double Glazing	8%	E	E
External shutters	25%	B	D
Night Ventilation	38%	A+	A

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