Appendix A. Software User Manual

I. Building Information Input Page

Figure Appendix- 1 shows the building information page. This is the first page where users need to input their own building information.

"1" is the option users can select if detailed analysis is preferred or fast analysis. For detailed analysis, the program will provide over 90 retrofit measures for selections. Detailed analysis is for advanced user who has good understanding on building energy-efficient retrofit measures. Fast assessment offers about 30 measures for user's consideration, those measures are key building retrofit measures usually been considered in different project. For entry level users, fast assessment is recommended.

"2" asks users to select commercial (public) building type for retrofit. Currently, the software only supports shopping mall and hotel building type. The future release will include more building types.

"3" allows users to select climate regions in China. The user-interface is capable to provide the whole climate regions in China. But current software calculation is implemented based on Shanghai climate. For buildings such as shopping malls, it is proved that their energy use and profile don't change significantly from one climate to another. So, Shanghai's results can be approximately generalized to other cities in China.

"4" is building information input section. In this section, users need to input following parameters:

1) Building owner (optional): owner name, text.
2) Building name: building name, text.
3) Building floor area: total building floor area including unconditioned (such as parking lots) and conditioned floor area (such as lobby, office areas, defined in 4). Input positive number only. Unit is m^2

4) Building conditioned floor area: the floor area which has heating and/or cooling control to condition its room temperature. The conditioned floor area will determine the HVAC energy usage. Input positive number only. Unit is m^2.
5) Window-to-wall ratio (WWR): window-to-wall ratio defines the ratio of building's total exterior window area to the building's total external wall area. The ratio is a unitless number within [0.0, 1.0]. If WWR value is 0, this means the building has no external window, which often refer to a "concrete box". WWR value 1 means that the building has 100% glass façade.
6) Roof U value: the roof U value (or K value) with unit [$W/(m^2 K)$] defines the building roof **before-retrofit** thermal insulation level. In Shanghai climate, the building code required roof U value is 0.7. However, for retrofit case, the before-retrofit insulation level can be worse than the standard value and thus have higher U value number. Depending on building's construction year, the U value before retrofit can be around 2 $W/(m^2 K)$ or even higher. The range for this input is [0.3, 4].
7) Wall U value: the wall U value (or K value), similar with Roof U value, with unit [$W/(m^2 K)$] defines the building wall **before-retrofit** thermal insulation level. In Shanghai climate, the building code required exterior wall U value is 1.0. However, for retrofit case, the before-retrofit insulation level can be worse than the standard value and thus have higher U value number. Depending on building's construction year, the U value before retrofit can be around 2 or 3 $W/(m^2 K)$ or even higher. The range for this input is [0.3, 4].
8) Infiltration rate: the building infiltration rate is measured at **before-retrofit** stage how much outdoor air can infiltrate into one building during certain time period. The number air change per hour (ACH). 1 ACH means that the building's room air can be flushed by outdoor air through infiltration in one hour. Before retrofit, building's air-tightness can be poor, and large infiltration rate (> 1 ACH) is often observed. The range for this input is [0.2, 2].
9) Lighting density: the lighting density input defines the average lighting energy use (W/m^2) at *design level*. It can be calculated by counting the lighting equipments capacity in one building can divided by the building's total floor area. The commercial (public) building code gives lighting density level for shopping mall is 12~19 W/m^2, for hotel

(guest room) is 15 W/m^2. For retrofitting buildings, because of old lighting appliance, the actual lighting density could be higher than those values. The range for this input is [1, 50].

10) Equipment density: the equipment density input defines the average equipment energy use at *design level*. It can be calculated by counting the plug load equipments capacity (such as computers, TVs, and other plug load appliances) in one building can divided by the building's total floor area. The commercial (public) building code gives plug load equipment density level for shopping mall is 13 W/m^2, for hotel (guest room) is 13~20 W/m^2. For retrofitting buildings, because of old appliance, the actual equipment energy density could be higher than those values. The range for this input is [1, 50].
11) Occupant density (**shopping mall only**): occupant density is defined at the peak time one person, on average, occupies how much floor space (m^2/person). The commercial (public) building code gives shopping mall occupant density 3 m^2/person. The range for this input is [2, 20].
12) Operation time (**shopping mall only**): operation time is defined that how many hours the building will operate. Longer operation time means the building will tend to consume more energy. The range for this input is [2, 20], unit hours.
13) Hotel star level (**hotel only**): three-star, four-star and five-star are available to select. The higher the hotel star level is, the more energy it tends to consume.
14) Occupancy rate (**hotel only**): hotel annual average occupancy rate. The rate reflects on average the percentage of guest rooms that are occupied. The higher the occupancy rate is, the more energy the building tends to consume.

"5" is before retrofit the building's energy bill input. Input electricity and fuel (natural gas) usage, and the program will automatically calculate the before-retrofit building's energy use intensity level. The inputted energy data will be used by the program to calculate the before-retrofit end use energy and hence the energy savings for retrofit measures. Choose "Use actual energy data" and then type in electricity and fuel energy usage for before-retrofit condition.

Should one is not familiar with before-retrofit the building's energy usage, one can chose "Don't know energy data (use simulation)" option. This option does not require actual energy usage data, but use simulation to predict building energy consumption.

"6" is the economic analysis parameters for the building. The discount rate is the financial discount for the energy saving value. All future saving is discounted to a net present value by using the discount rate. The evaluation period is how long a building will be evaluated. Typically, we evaluate a long period of time (such as 10 years). The evaluation period is used to compare the energy saving benefit (discounted to a net present value) with the retrofit to evaluate cost-effectiveness.

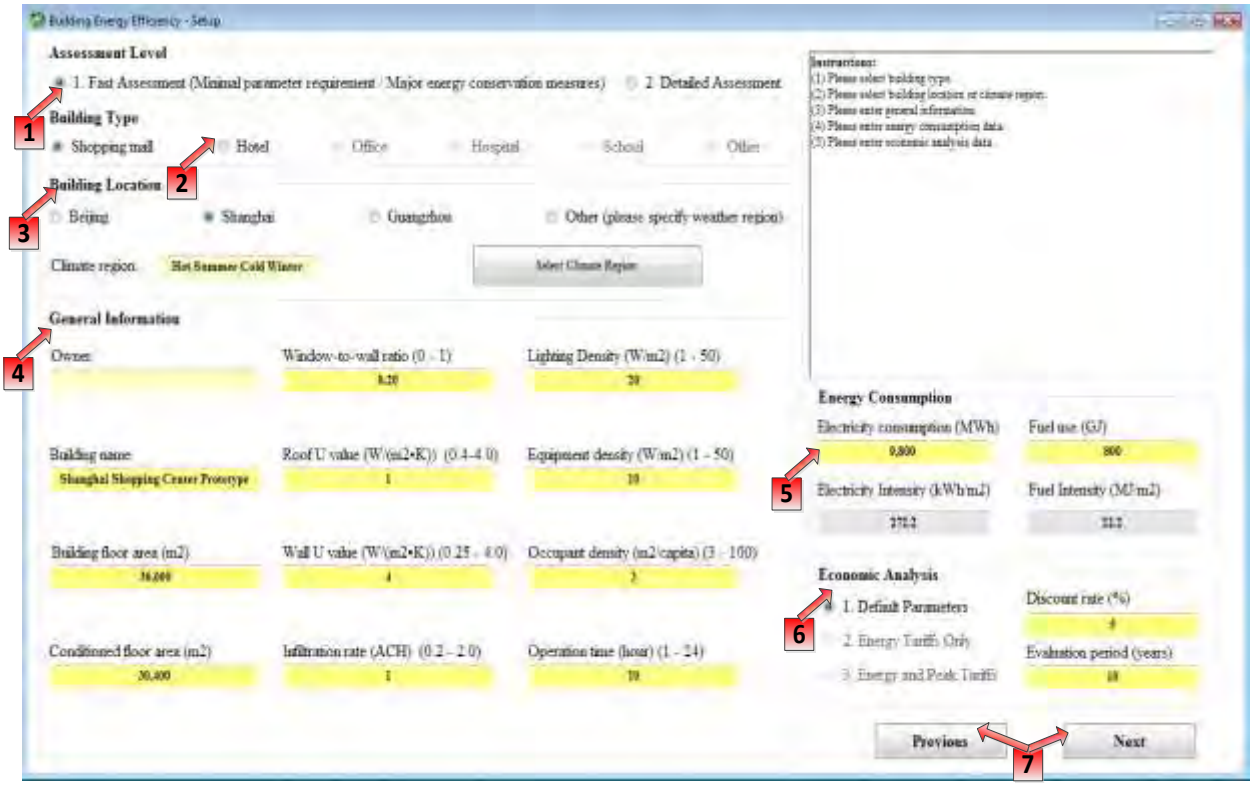

Figure Appendix- 1 Building Information Input Page

II. Retrofit Measure Page

Figure Appendix- 2 shows the page where users can select retrofit measures and define cost.

"1" is the tab where one can select the building system where retrofit can take place. The example show the building envelope system and the retrofit measures in building envelope system are shown in below.

"2" shows for each measure, one can select the retrofit option. Note that both before retrofit and after retrofit status are needed so the software and identify what retrofit decision has been made. For example, **Figure Appendix- 2** shows we retrofit the building from "Dark" color to "Light" color roof (reflective or cool roof). Note, one can only retrofit a building toward the positive energy saving direction. That is for example, one can only improve the building envelope insulation level rather than decrease it.

"3" is a description text box shows the detailed meaning of one measure. The description contains what does the measure means and what potential energy benefit this measure will bring to the building if selected.

"4" give the retrofit total cost in unit RMB. The cost is calculated as material cost + labor cost + O&M cost (for O&M measures only). Only when before and after retrofit conditions are different, is the cost shown in the text box. The software has its own cost database to define each measure's cost data.

If the default cost does not satisfy users' needs, click "5" can help users define customized cost data.

"6" is shows the measure's special type (in contrast with tradition type such as equipment/material replacement or installation). There are two special types defined in this software, one is "low/no cost" measure (using symbol "L" in the software) which means that the measure will cost very little to achieve. Another type is "control" measure (using symbol "C" in

the software). The "control" measure means install or improve control systems for lighting, HVAC or hot water system in the building.

"7" and "8" is the chart help users to select measure option. "7" shows the saving and cost comparison for all the options available in one measure by comparing every option with the first option. The green bar show the energy saving potential in evaluation years (e.g. in 10 years), and the red bar shows the total cost to implement the measure options. Both the saving and cost is given in currency unit RMB.

After selecting measures in current, users can navigate to next tab or the previous to continue the program. If the current tab is already located at "Renewables & Others", the program will calculate the retrofit saving and economics and show the results in next page.

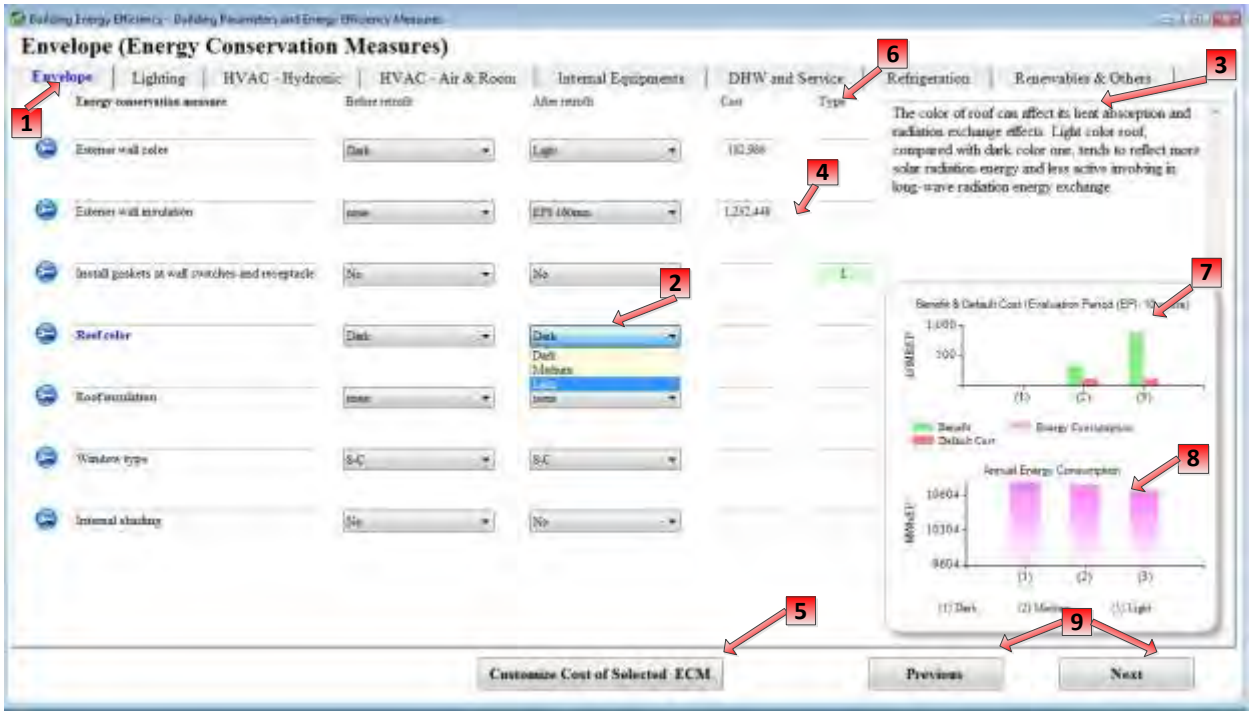

Figure Appendix- 2 Retrofit Measure Page

III. Retrofit results page

Figure Appendix- 3 shows the retrofit calculation results for energy and economics.

"1" shows the building's annual energy consumption summary for before and after retrofit electricity and fuel (natural gas) use.

"2" the saving summary show the annual electricity and fuel saving, energy cost saving, measure total cost, and simple payback period for the selected retrofit measure portfolio.

"3" is the building's annual energy end use consumption breakdown for before-retrofit, after-retrofit, saving defined as ("after" – "before"), and energy saving ratio.

"4" shows the before and after retrofit final energy intensity level change. Energy intensity, in unit [kWh/m2], is defined as building's total final energy divided by building's total floor area. Note that fuel (natural gas) is thermally convert into electricity kWh.

"5" shows the building's retrofit cost-effectiveness. The chart on the left, with unit RMB, compares the building's energy saving benefit (green bar) during user-input evaluation period (10 years in this example), and retrofit measures' total cost. The chart on the right shows the building's retrofit simple payback period (years).

"6" is a summary view of each measure's cost-effectiveness. Click the chart will navigate the users to Figure Appendix- 4. In the measure analysis page, chart "1" shows measures' cost-effective comparison. This is calculated when each measure is calculated alone, its energy saving benefit (in the evaluation period, 10 years in this case) and cost in unit RMB. Chart "2" shows each measure's simple payback period (years) when applied alone. Table "3" is each measure's benefit and cost view which can be sorted by using radio button group "4" on the right hand side. Users can sort the measures' benefit based on benefit (energy saving), net benefit (saving – cost) and payback period.

Figure Appendix- 3 Retrofit Result Page

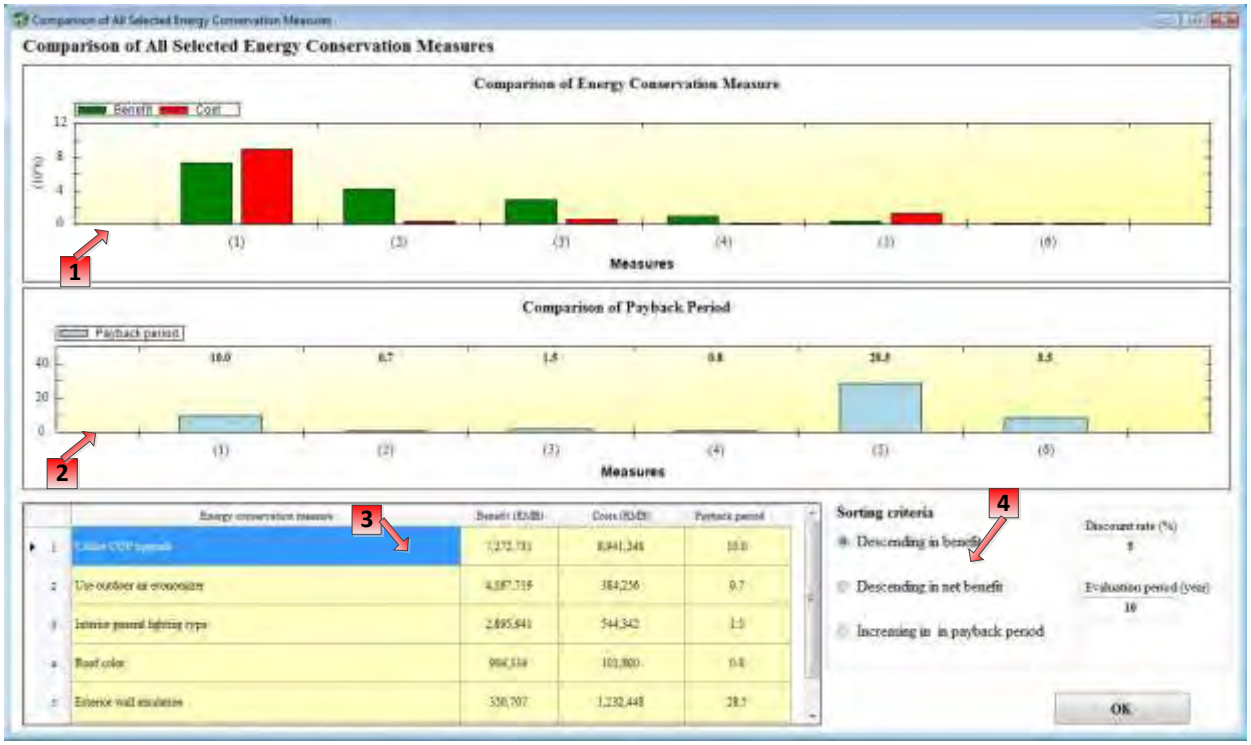

Figure Appendix- 4 Measure Analysis Page