EcoDesigner STAR User Manual

GRAPHISOFT®

GRAPHISOFT®

Visit the GRAPHISOFT website at http://www.graphisoft.com for local distributor and product availability information.

EcoDesigner STAR User Manual

Contents

1. Getting Started With EcoDesigner STAR

1.1 Technical Requirements

EcoDesigner STAR runs with ArchiCAD 17 only.

EcoDesigner STAR is based on ArchiCAD's built-in Energy Evaluation feature, but provides significantly extended capabilities and data settings. You must have an EcoDesigner STAR license key in order to access these extended functions. Apart from inserting this license key, no additional installation or download is necessary.

See the "Product Overview" section below for details on the extended capabilities of EcoDesigner STAR.

Hardware/Software Requirements

The hardware/software requirements for GRAPHISOFT EcoDesigner STAR are identical to those of ArchiCAD 17.

For more details, see "Getting Started with ArchiCAD 17", available from the ArchiCAD Help menu.

File Compatibility

All user-defined settings in ArchiCAD 17's Energy Evaluation function are also used with EcoDesigner STAR. If you have used Energy Evaluation on a project, and later insert a license key to access EcoDesigner STAR, then your Energy Evaluation settings will be read and used without any conflict.

If you use EcoDesigner STAR features on an ArchiCAD project, and then open the project with an ArchiCAD version that does not have STAR functionality, there is no data loss; the extra data are still part of the project, though you cannot access or modify data that are based on STAR-only features and settings.

Localized Contents – the XML Files

Energy Evaluation has its own folder in the Add-Ons folder of ArchiCAD 17 (C:\Program Files\Graphisoft\ArchiCAD 17\Add-Ons\EnergyEvaluation). The version-specific localized content folder or folders (named with three-character nationality codes) are located here. Energy Evaluation automatically loads its data from the folder corresponding to the localized version of ArchiCAD under which it runs. Each localized content folder contains the following.xml files:

DefaultBuildingSystems.xml

DefaultEnergySourceProperties.xml (see *Energy Source Factors*)

DefaultEvaluationReportFormat.xml

DefaultValues.xml

InternalUsages.xml

MaterialCatalog.xml (see U-value (R-value) Override)

OpeningCatalog.xml (see Openings Catalog)

ReportStrings.xml

ShadingCatalog.xml (see Shading Devices)

TemplateOperationProfiles.xml

TemplateThermalProperties.xml

To minimize the numeric user input required, several input parameters are set within EcoDesigner STAR by default or are listed in database catalogs. The .xml files shown above contain these default settings and catalogs. It is possible for users to modify the content of these files by simply text-editing them, in order to tailor the application to their preferences and needs. The best software to use for this purpose is TextPad (available free for download from the internet). Microsoft Word is not suitable for editing .xml file content, as it changes the file format when the modified version is saved. NotePad may be used; however it is inconvenient as it displays the files in one continuous line.

It is strongly advised to save a copy of the original .xml files to a different folder prior to modifying them. Replacing the modified .xml's with the originals allow the users to reset the changed settings and return to EcoDesigner STAR's default state. Users should also back up their own modified files before installing any hotfixes or upgrades to ArchiCAD or EcoDesigner STAR, as the update process may replace customized .xml files. ArchiCAD must be closed and then restarted in order for the modifications to take effect.

Folders Used by EcoDesigner STAR

EcoDesigner STAR manages data using three different folders:

\Add-Ons\EnergyEvaluation: see the section above for information on the XML files stored here.

The locations of the other two folders (Temporary and Cache Folder) are specified individually under **Options > Work Environment > Special Folders** for every user.

Temporary Folder: When ArchiCAD is launched, an EcoDesigner STAR reference result file (.vdt format) is copied into this folder automatically. If an evaluation is carried out in EcoDesigner STAR during the work session, a resultant temporary .vut file (VIP Energy file format that may be opened by the StruSoft VIP-Energy software for detailed analysis) is saved here, as well. Both the .vdt and the .vut files are needed by EcoDesigner STAR to produce the Energy Evaluation Report, because the result file alone is meaningless without the reference data.

The Temporary folder is also used to store the calculation error file (.err file format), which contains information about the cause of failure in case of unsuccessful evaluation.

The climate .xml file currently in use is also copied here from the Cache Folder.

Cache Folder: Climate files coming from the EcoDesigner STAR folder, the online weather database, or any imported standard climate file formats are managed here.

1.2 General ArchiCAD Settings

Units

EcoDesigner STAR uses the calculation units defined by you in ArchiCAD, at **Options > Project Preferences > Calculation Units & Rules**. Thus, Energy Evaluation uses the same units as the ArchiCAD Project to which it is applied.

Additional unit setting options:

- When defining components of Heating and Ventilation systems in the Building Systems dialog box, choose either Celsius or Fahrenheit for the water temperature.

This way, for example, you can set the temperature scale of Hot water generation independently of other units. (This can be useful if your country uses metric dimensions and Fahrenheit temperatures concurrently.)

- On the U-value (R-value) Calculator and the U-value (R-value) Override panels, click the pop-up to alternate between U-value and R-value as needed.

General Modeling Conventions

For best results with Energy Evaluation, follow these conventions of building energy modeling in ArchiCAD:

- Use the Mesh tool to model the building site’s grade level, especially if it is uneven.
- Do not use multiple separate parallel walls (or slabs or roofs) to model composite structures. If such constructions exist in the building model, make sure that only one of the parallel structures is visible in the energy model, and that the adjacent Internal Space Zones touch that structure.
- Use fills consistently within your project: a particular fill should always indicate the same single building material or composite.

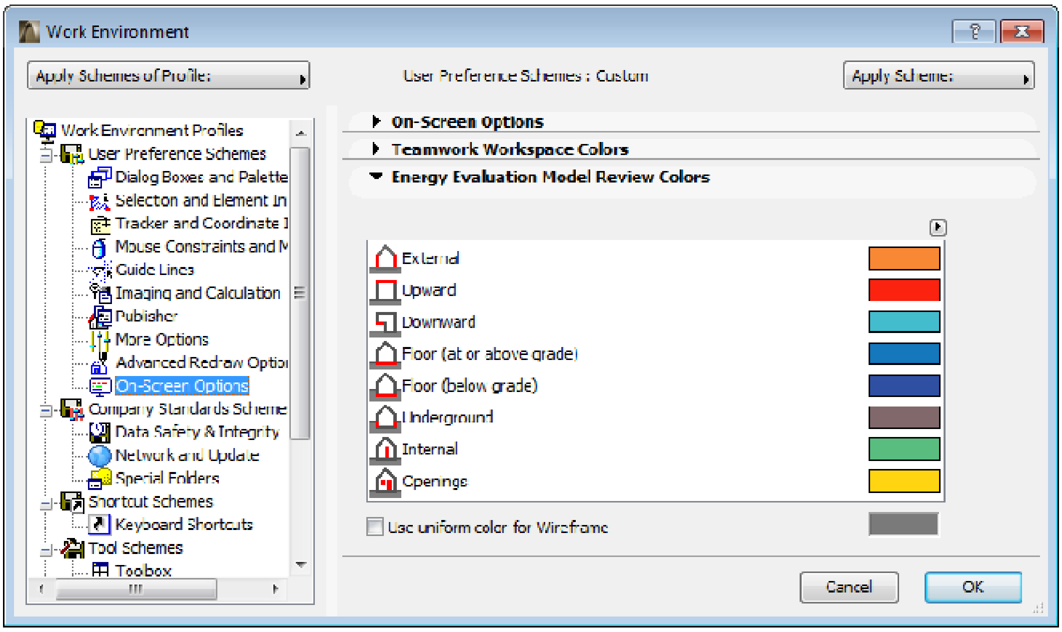
See Direct BIM to BEM for more details on modeling guidelines.

Teamwork Settings

If you are working on a Teamwork project, you must first reserve the Energy Model Review palette using the control light interface on the palette itself, or the dialog boxes that open from it.

Customize Energy Model Review Colors

To define or change the 3D default colors for Structures and Openings listed in the Model Review palette: go to **Options > Work Environment > On-Screen Options**, and use the Energy Evaluation Model Review Colors panel:



A quick way to access these controls is by selecting Customize Model Review Colors from the pop-up to the right of the Show in 3D button, at the top of the Model Review Palette:
Show volumes - Show uncovered areas - Customize Model Review colors

2. Product Overview

ArchiCAD, when equipped with the EcoDesigner STAR add-on, is an energy analysis tool that enables architects to monitor and control all design parameters that influence building energy performance. EcoDesigner STAR places standard-compliant energy analysis at the heart of the architects' familiar BIM work environment.

With EcoDesigner STAR, building systems can be precisely modeled and assigned to the Multiple Thermal Block Building Energy Model, to produce Detailed Output that includes Energy Demand, Energy Consumption, Primary Energy, Carbon Footprint and Building Energy Performance Rating. The software module used for the dynamic energy simulation complies with ANSI/ASHRAE Standard 140-2007 and the performance rating functionality complies with ASHRAE 90.1-2007, so EcoDesigner STAR can be used up to the Construction Documentation phase.

The EcoDesigner STAR add-on for ArchiCAD enables users to utilize the VIP-Core dynamic energy simulation engine in ArchiCAD to its full potential. EcoDesigner STAR expands the Energy Model Review palette of ArchiCAD, making it suitable for providing input for standard compliant building energy analysis. High-end EcoDesigner STAR functions such as thermal bridge simulation and on-site renewable energy system modeling complement ArchiCAD's multiple thermal block building energy modeling capability to provide the most detailed and accurate input for the energy simulation. As a result, the VIP-Core dynamic energy simulation engine produces the Detailed Energy Performance Evaluation Report with certified accuracy. The performance report can be customized to include some or all relevant information regarding the project's energy efficiency.

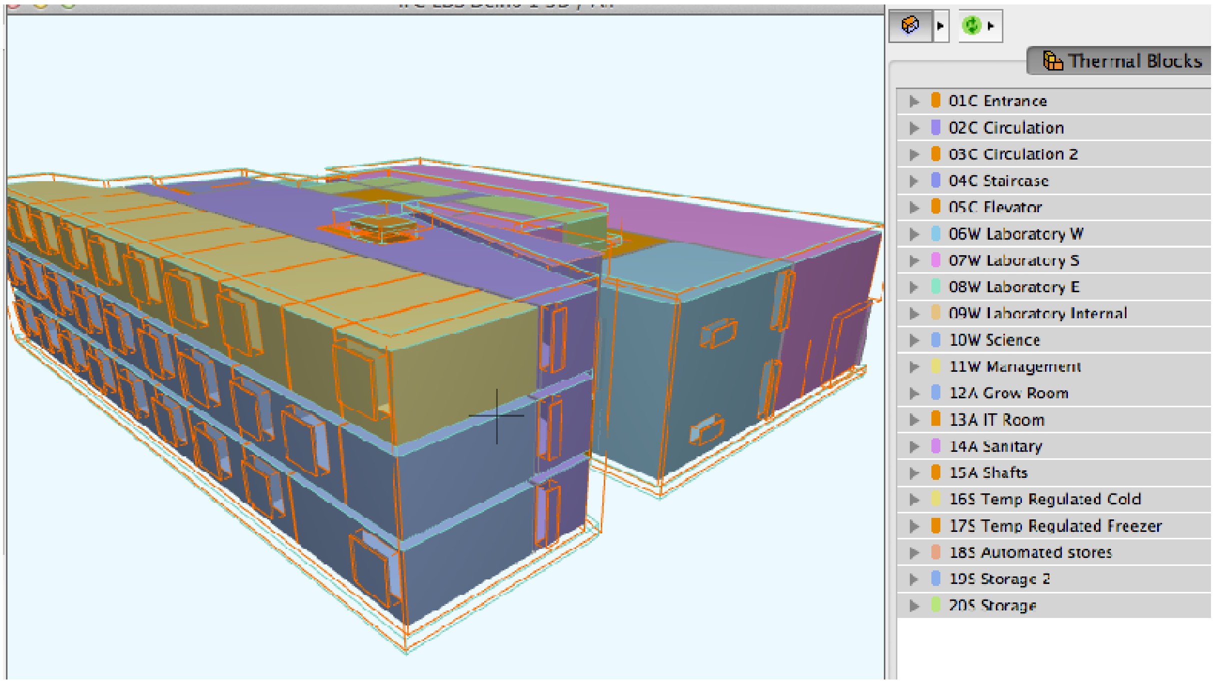
2.1 New Energy Evaluation Features in ArchiCAD 17

ArchiCAD 17 extends ArchiCAD 16's quick and simple energy evaluation workflow with multiple thermal zone support and model-based solar study to enable architects to evaluate the energy performance of their buildings of any size or complexity. Based on EcoDesigner STAR's standard compliant technology, Energy Evaluation in ArchiCAD 17 enables users to check their buildings' energy performance at any stage of the design. However, for full energy performance analysis including advanced HVAC setup, ArchiCAD 17 users must either buy an EcoDesigner STAR license or collaborate with energy experts using 3rd party energy analysis software exporting their BIM through ArchiCAD 17's improved IFC interface.

The following paragraphs briefly introduce the important new features of Energy Evaluation in ArchiCAD 17:

2.1.1 Multiple Thermal Block Building Energy Model

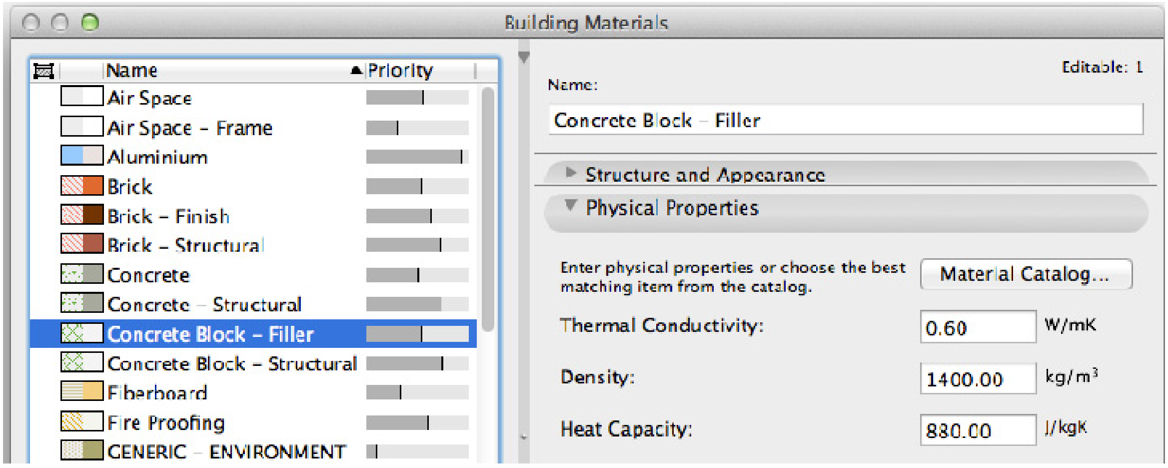
Quickly turns ArchiCAD models into detailed energy models.



- Thermal Blocks tab page on the Energy Model Review palette
- Define thermal blocks by grouping ArchiCAD zones
- Show Unused Zones: this function automatically detects Zones that are not assigned to any Thermal Blocks and highlights them on the 3D building energy model
- Show Uncovered Areas: this function automatically detects space boundaries that are part of the architectural model but are missing from the energy model, and highlights them on the 3D building energy model
- Assign operation profiles and building systems to thermal blocks

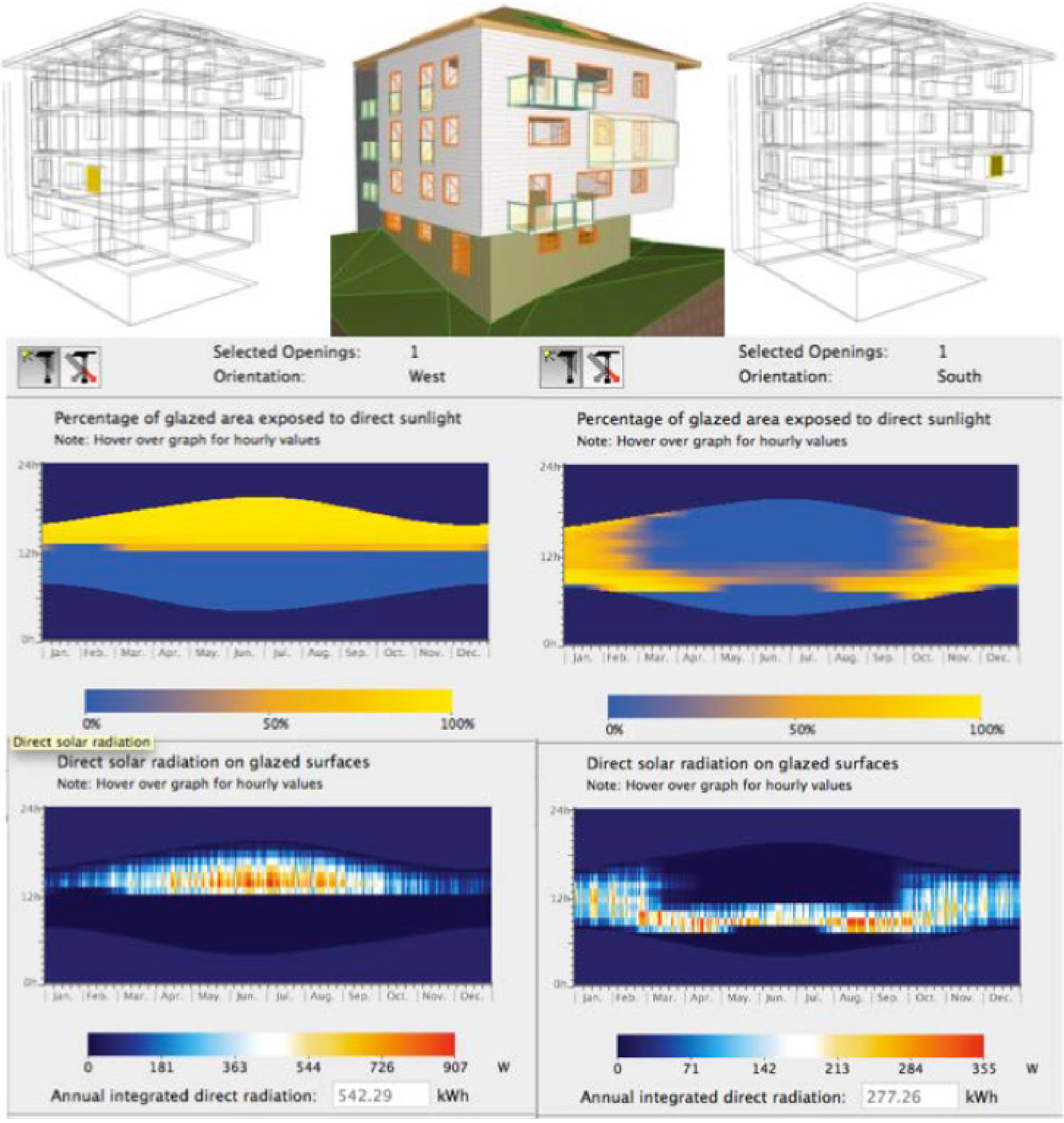
2.1.2 Physical Properties in ArchiCAD 17 Building Materials

Simulation input database integrated in the heart of BIM.



2.1.3 Model –Based Solar Analysis

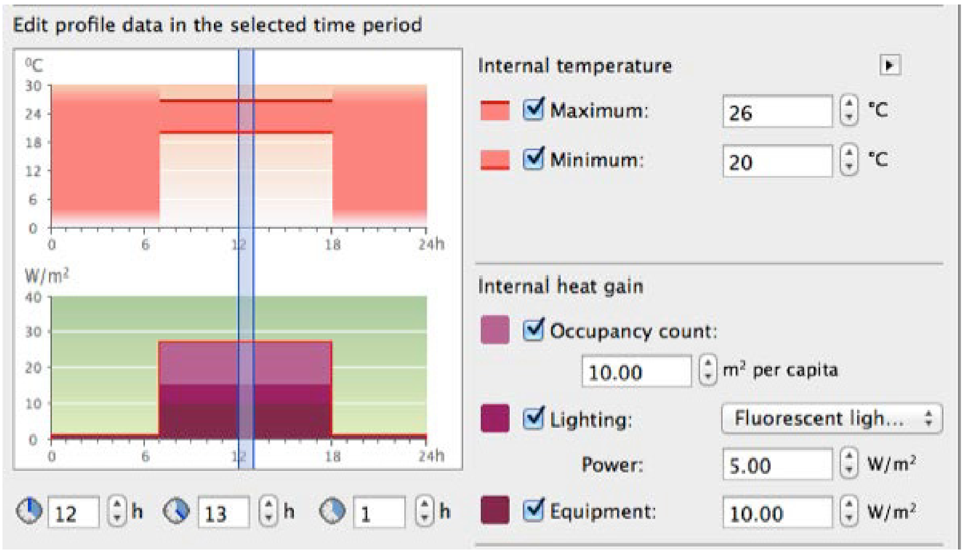
Calculates the solar exposure of each individual external glazed opening, for every hour of the reference year.



- The shadow mask calculation considers the shading effect of the building's geometry as well as external objects (neighboring buildings, trees, etc.).
- Annual crown density schedules associated with deciduous plants (ArchiCAD library objects) represent the seasonal changes in foliage, which is taken into consideration for the shading calculations.

2.1.4 Custom Operation Profiles

Gives users the freedom to input comfort requirements based on local building energy regulations or to model expected real-life occupancy.

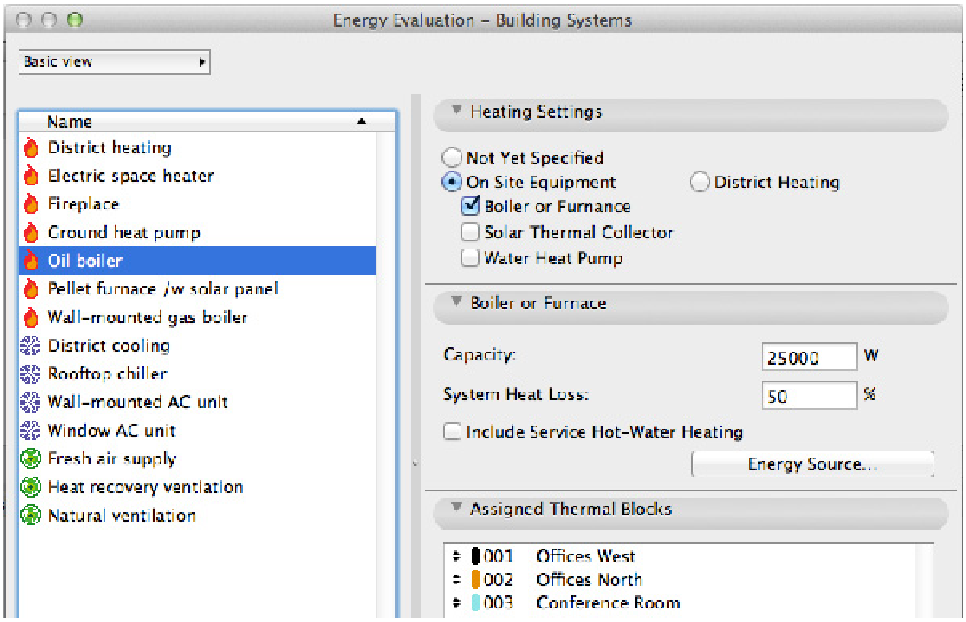


- Operation Profiles are assigned to thermal blocks.

  Note: In previous Energy Evaluation and EcoDesigner versions, only single thermal block energy modeling was supported, therefore operation profiles had to be assigned to the entire project.
- Use the dedicated editor dialog to create operation profiles that contain custom hourly occupancy data and indoor comfort requirements.
- Allows users to tailor the calculation input to suit local regulations or to model real-life building usage patterns to the highest level of detail.

2.1.5 New Building Systems Processing, Dialog and Content

With limited input variables and smart defaults, the Building Systems dialog in "Basic view" makes ArchiCAD's Energy Evaluation easy to use for architects with no engineering skills.

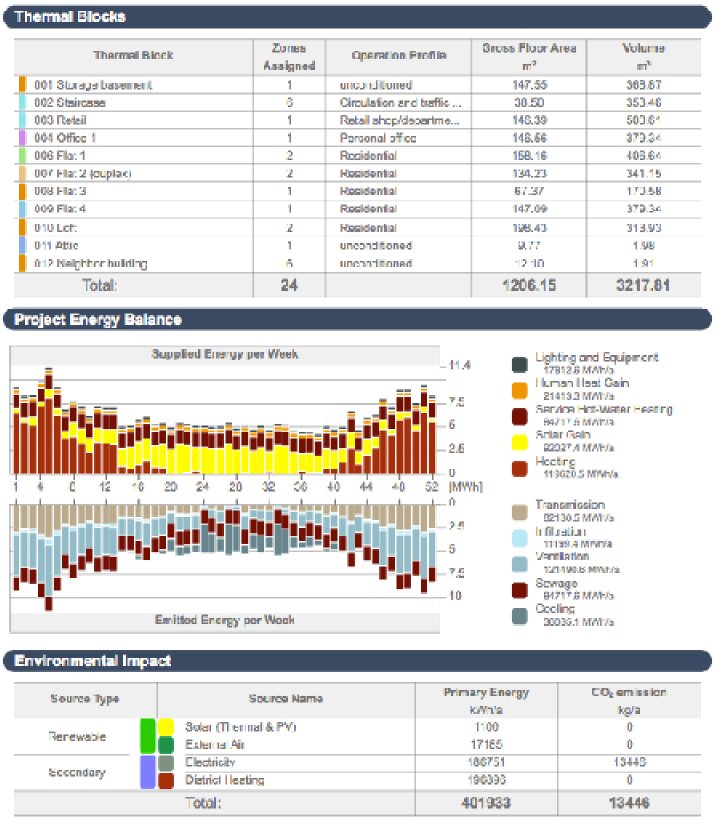


- Building systems are assigned to thermal blocks.
  Note: In previous Energy Evaluation and EcoDesigner versions, only single thermal block energy modeling was supported, therefore systems had to be assigned to the entire project.
- Building systems can be classified as Not Yet Specified for energy demand calculations.

2.1.6 Enriched and Customizable Energy Evaluation Report PDF

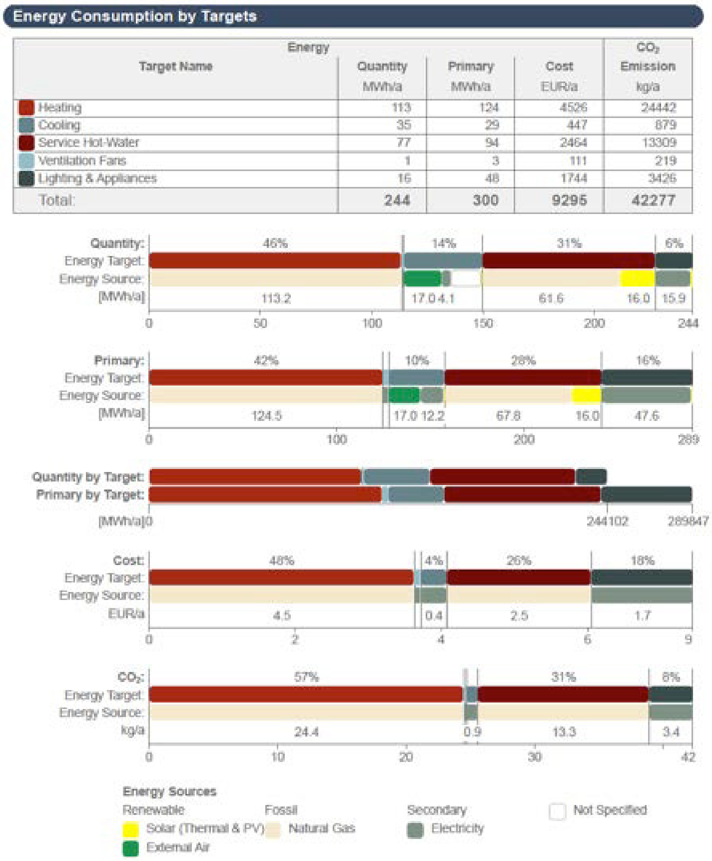
An easy-to-understand yet scientifically precise graphical representation of the building’s energy performance.

- Report format settings



- Thermal Blocks report chapter
- Project Energy Balance in weekly format
- Total annual energy flow display in the Energy Balance chapter

- Environmental Impact report chapter



Energy Consumption by Targets

Target Name	Energy Quantity MWh/a	Energy Primary MWh/a	Cost EUR/a	CO_2 Emission kg/a
Heating	113	124	4526	24442
Cooling	35	29	447	879
Service Hot-Water	77	94	2464	13309
Ventilation Fans	1	3	111	219
Lighting & Appliances	16	48	1744	3426
Total:	244	300	9295	42277

- Bar chart display option of the Energy Consumption by Targets and Energy Consumption by Sources chapters

2.2 Differences between ArchiCAD Energy Evaluation and EcoDesigner STAR

With the introduction of the new BIM Geometry Analysis and Building Systems manager, the Energy Evaluation functionality integrated in every ArchiCAD also supports building energy modeling based on multiple thermal blocks. This green functionality within ArchiCAD provides full BIM to BEM workflow and allows users to evaluate their designs of any size or complexity with standard compliant technology and get accurate overall results.

For those who want greater control over the sustainability features of their design, to participate in the energy certification, and/or create highly efficient buildings that exceed mandatory energy standards (up to the point of net zero energy consumption or even beyond), ArchiCAD extended with EcoDesigner STAR offers support for expert building systems setup and detailed reporting.

The limitations of Energy Evaluation in ArchiCAD compared to EcoDesigner STAR are the following:

- Thermal Bridge Simulation is not available
- The Building Systems dialog only allows the input of basic system parameters – the expert building system modeling functionality is not available
- On-Site Renewables are not available
- BIM Geometry and Thermal Property Data Export is only possible via IFC
- The basic Energy Performance Evaluation reports do not contain the energy performance of thermal blocks (only the entire projects')
- The Building Energy Performance Rating functionality is not available

ArchiCAD's detailed building energy modeling capabilities may be fully utilized through the EcoDesigner STAR add-on. Using the multiple thermal zone-based BEM & full HVAC parameters input, EcoDesigner STAR offers detailed energy performance calculation and reporting for standard compliant energy certification. It also supports highly energy efficient building design (e.g. net zero energy buildings). Advanced energy performance visualization and BEM export interfaces such as gbXML and PHPP allow full collaboration workflow with 3rd party energy experts.

The essential workflow for EcoDesigner STAR is identical to the intuitive Energy Evaluation workflow that is built into ArchiCAD. In EcoDesigner STAR, you will see the same user-friendly, graphical input and dialog boxes that are familiar from ArchiCAD. Therefore, many chapters of the EcoDesigner STAR User Manual can also be found in the Energy Evaluation section of the Reference Guide for ArchiCAD.

The following are unique additional features of EcoDesigner STAR which are not available in Energy Evaluation, and features which are specially enhanced for EcoDesigner STAR:

- Thermal Bridge Simulation
- Building Systems
- Building Geometry and Material Property Data Export
- Baseline Building
- Report Chapter Settings
- Energy Performance Evaluation – PDF Report
- Energy Performance Evaluation – XLS Reports

2.3 EcoDesigner STAR Only Features

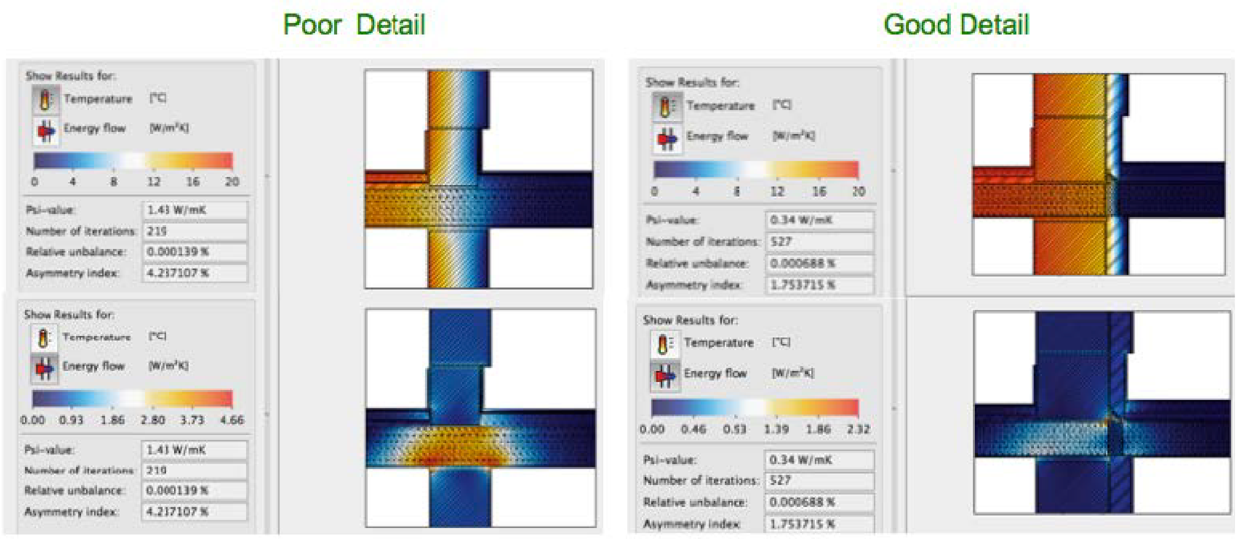
2.3.1 BIM Geometry and Material Property Data Export

EcoDesigner STAR enables ArchiCAD model geometry and material property data export to 3rd party building energy calculation software.

- Direct export to PHPP
- Direct export to iSBEM
- Export via gbXML
- Dedicated “Green” IFC translator

2.3.2 Thermal Bridge Simulation

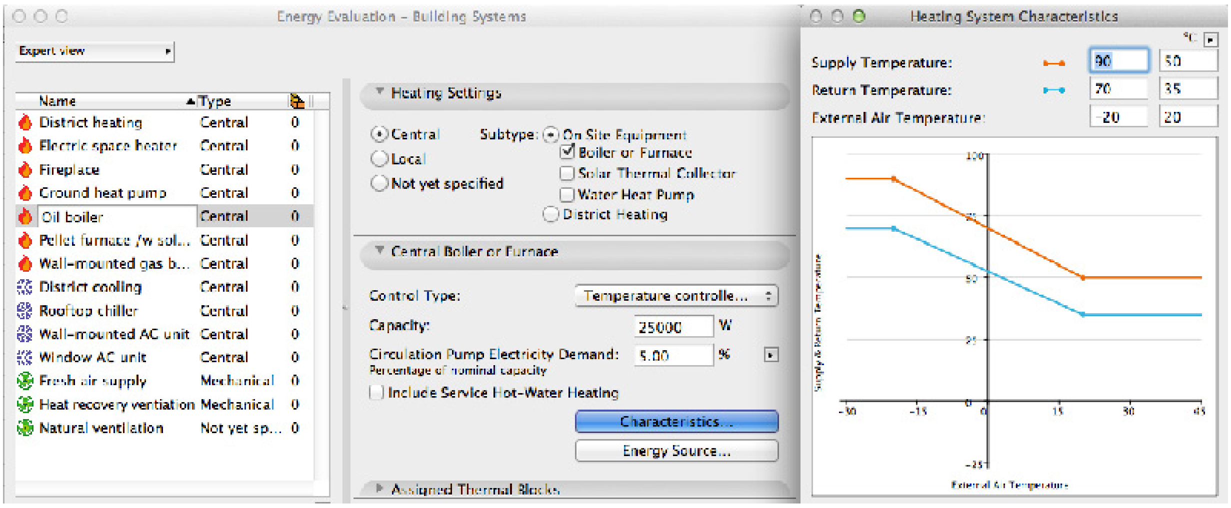
2D heat-flow simulation with mesh adaptation technology on ArchiCAD details, to calculate linear heat loss along the length of thermal bridges.



- Explore results in virtual thermo-vision or energy flow view
- Link thermal bridges to thermal blocks to make their effect count in overall building energy performance
- Place thermal bridge simulation result on ArchiCAD detail, as a drawing

2.3.3 Expert Building Systems Settings

The Building Systems dialog in box Basic View Mode (this is a standard feature of ArchiCAD) only contains the minimum necessary input parameters and is engineered for quick energy evaluations. In Expert View Mode (this is an EcoDesigner STAR-only feature), however, the Building Systems dialog box displays numerous building system setting options to accommodate detailed analysis as prescribed by the relevant building energy simulation standards.

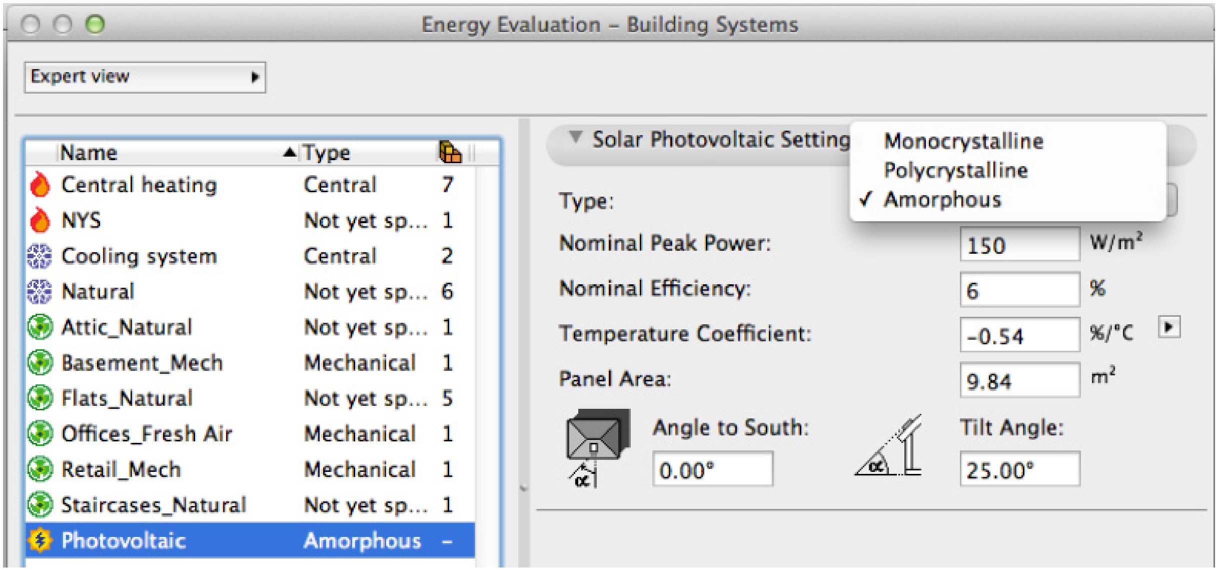


EcoDesignerSTAR's Building System input dialog is truly scaleable and efficient to use, as users can toggle between the Basic and Expert View Modes in case of every building system, independently. This way, input information can be gradually added as the project progresses, while only the relevant parameters are displayed on the user interface at all times.

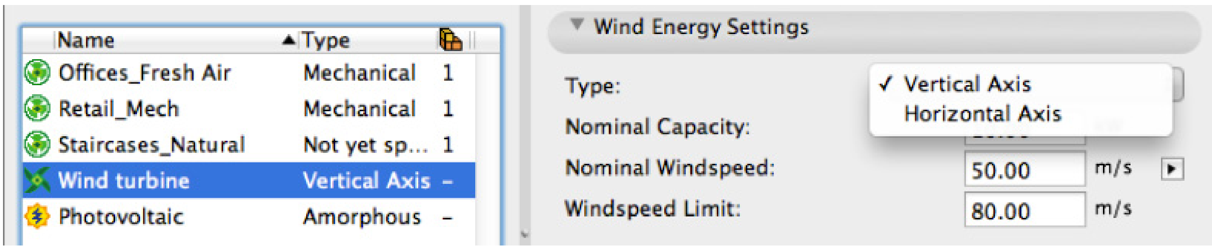
2.3.4 On-Site Renewables

These local, environmentally friendly methods for generating electricity enable excellent energy results or even net zero energy building design.

- Photovoltaic Panels



- On-Site Wind Energy



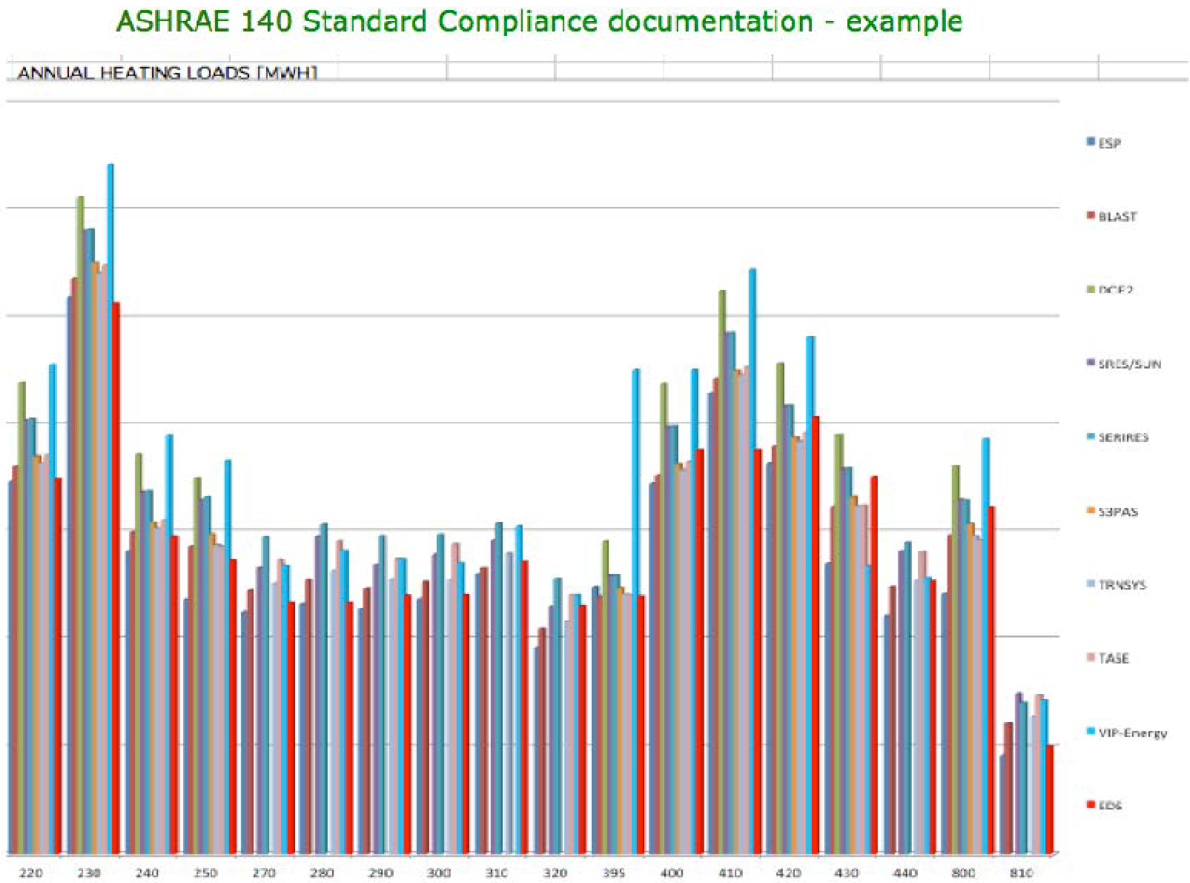
The Renewable Building System Summary chapter of the Energy Evaluation Report helps users to showcase the benefits of on-site renewables and other sustainable solutions applied in the design project.

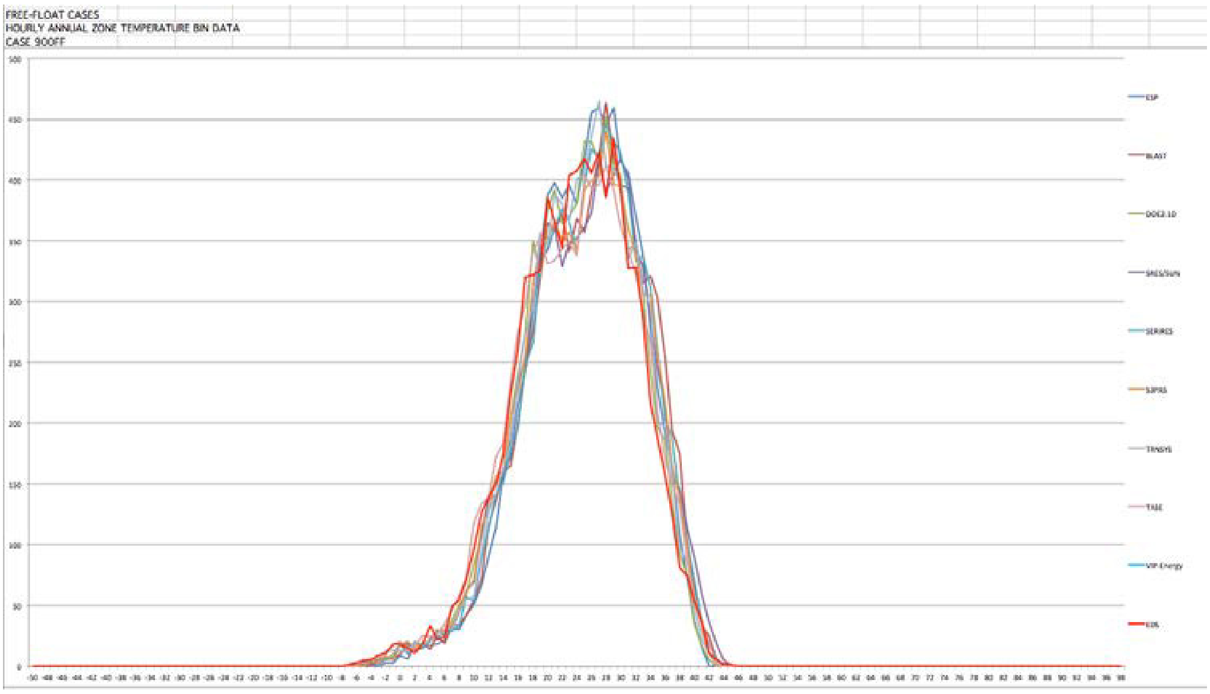
Renewable Building System Summary

Building System	Annual Energy Generated kWh	Renewable Energy Cost EUR
Photovoltaic system	1763	0.0
Solar thermal system	15991	0.0
Total LEED Renewable Energy:	17755	0
Total:	17755	0

2.3.5 Building Energy Simulation using Standard-Compliant Analysis Engine

EcoDesigner STAR's analysis engine complies with ANSI/ASHRAE Standard 140-2007 Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs.





This test method represents the industry standard for the quality assurance of simulation accuracy. It is referenced by most major sustainable building design regulations worldwide, including LEED, Green Star, BREEAM, DGNB and CASBEE, as well as most national standards that endorse dynamic simulation (e.g. ASNRAE 90.1, NatHERS, BCA Section J).

The live test documentation will be available for download from the official product website.

2.3.6 Energy Performance Report of Thermal Blocks

Besides calculation output on the project level (a standard function in ArchiCAD 17’s Energy Evaluation), the detailed Report PDF (an EcoDesigner STAR-only feature) is capable of displaying thermal block level output data. This enables users to not only monitor the entire project’s energy performance but also to control the behavior of spaces (or groups of spaces) independently, in order to truly optimize them for their specific purpose within the building.

HVAC Design Data

EcoDesigner STAR technology enables architects to calculate the energy demand of their buildings effortlessly. Furthermore, only the BIM, its thermal blocks and their usage patterns (Operation Profiles) are needed as input to determine the necessary Building System sizes for any project! This information then can be used to precisely define the Building Energy Model's systems for fuel consumption, primary energy, CO_2 emission and operation cost calculations in a later design phase.

All Thermal Blocks:	**115994**	**88.2** 07:00 Feb. 01	**35274**	**66.3** 16:00 Aug. 14

Number of Used Hours in Year:			Unmet Load Hours in Year:		
Heating:	**6718**	hrs	Heating:	**0**	hrs
Cooling:	**2624**	hrs	Cooling:	**0**	hrs

HVAC Design Data

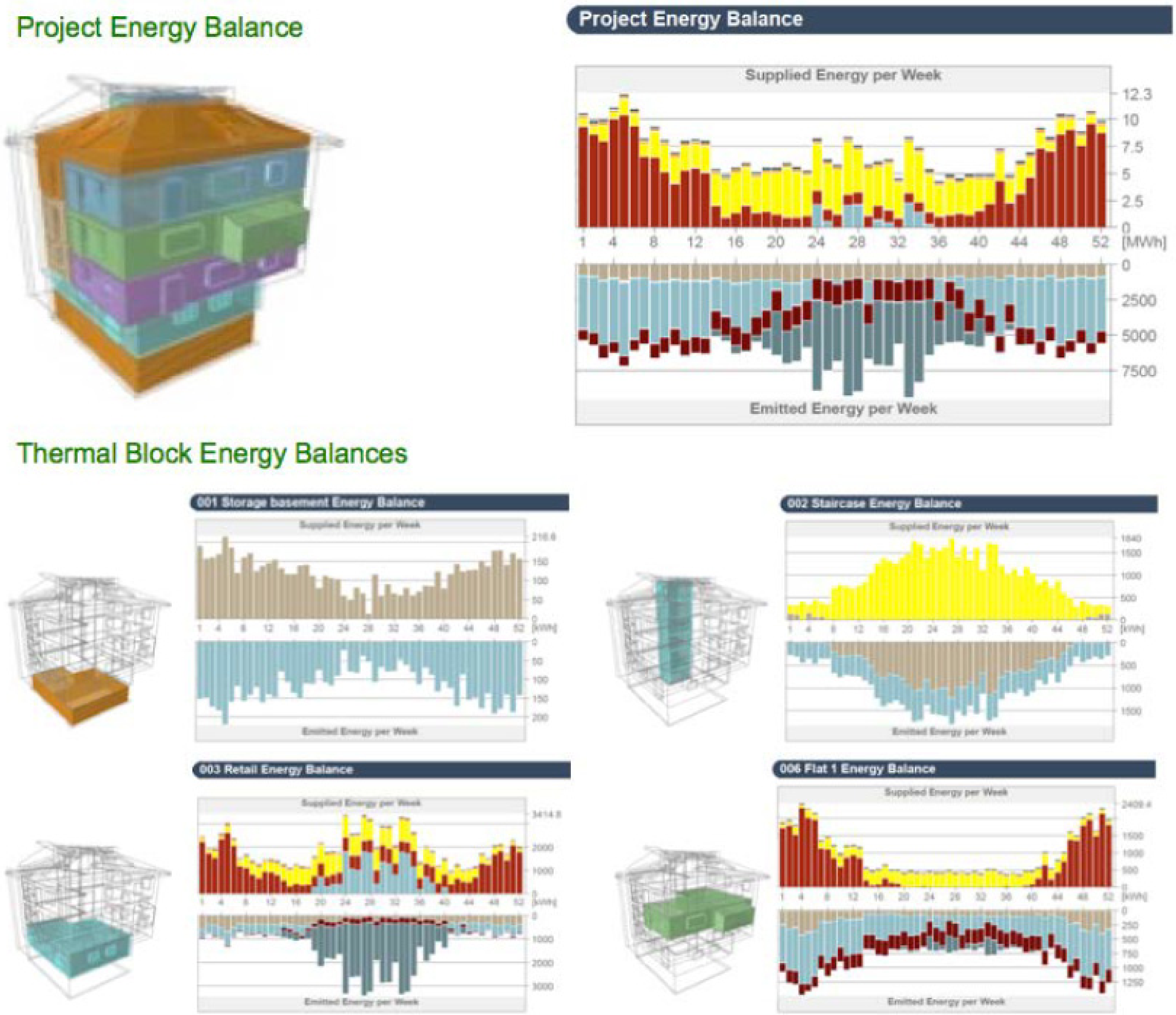
Thermal Block	Heating Demand Yearly [kWh]	Heating Demand Hourly Peak [kW]	Cooling Demand Yearly [kWh]	Cooling Demand Hourly Peak [kW]	Internal Temperature Min. [°C]	Internal Temperature Max. [°C]
001 Storage basement	4618	4.7 06:00 Feb. 01	0	0.0 –	12.0 01:00 Jan. 01	28.1 16:00 Aug. 26
002 Staircase	9051	12.4 06:00 Feb. 01	0	0.0 –	12.0 08:00 Jan. 01	68.3 09:00 Jun. 15
003 Retail	18694	22.4 09:00 Feb. 02	14482	29.7 09:00 Jun. 15	12.0 03:00 Feb. 01	41.1 08:00 Jul. 09
004 Office 1	19913	17.3 09:00 Jan. 01	7161	16.5 15:00 Jul. 09	15.0 06:00 Feb. 01	35.1 15:00 Aug. 26

Thermal Block Key Values

Including: Annual Demands, Peak Demands and Internal temperature extremes with date and hour of occurrence, plus Unmet Load Hours and Degree Days.

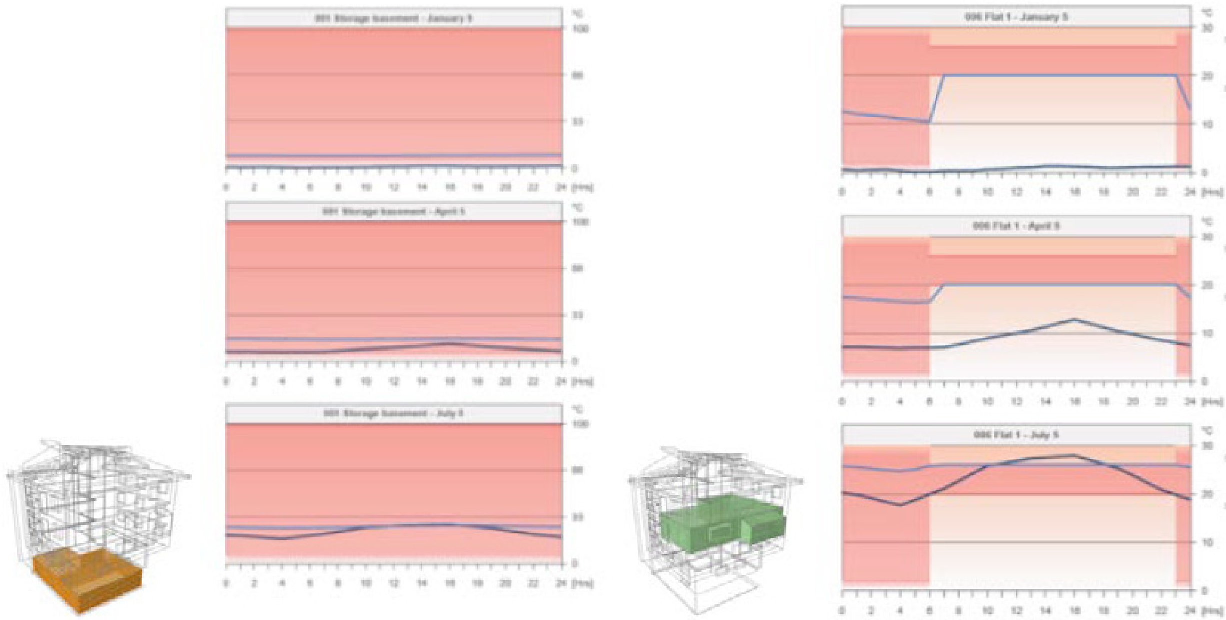
Thermal Block Energy Balance

Control the energy performance of the spaces within the Virtual Building. This option enables users to find the most energy efficient geometry, orientation and zoning.



Daily Temperature Profile

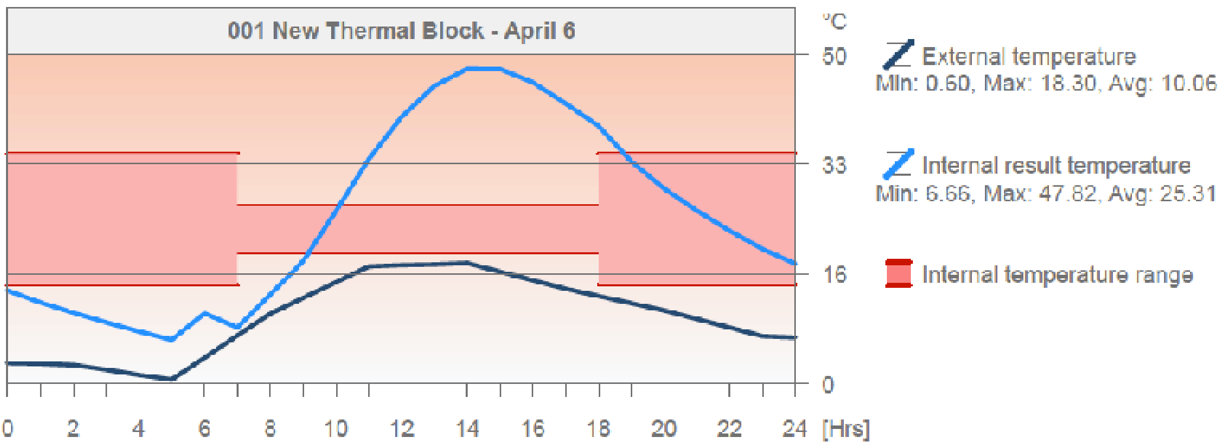
Monitor the hourly temperature inside each thermal block for the entire reference year.



Free Float daily internal temperature curves of the same project:

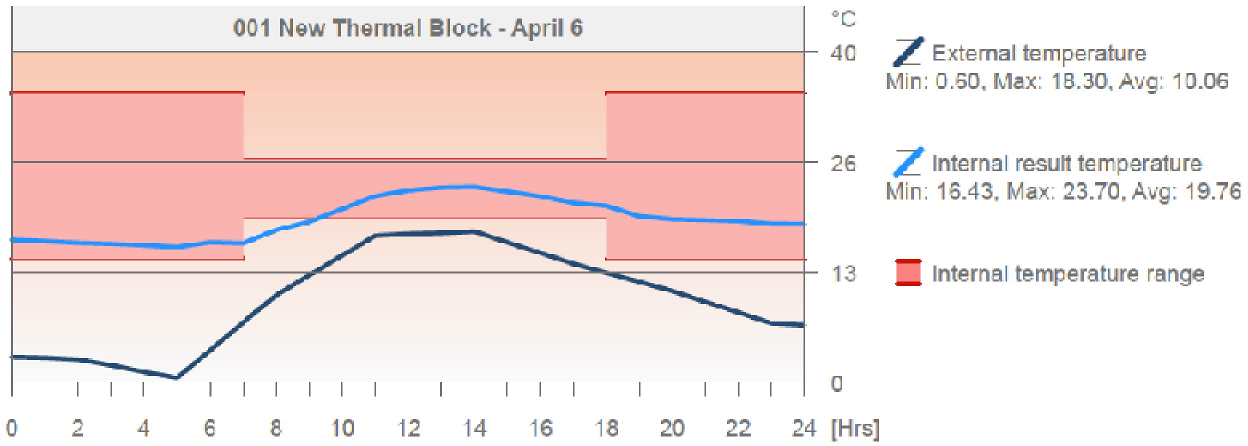
- with Poor Architectural Solutions

internal temperature is rarely within the comfort range



Unmet Load Hours		
Heating:	2602	hrs/a
Cooling:	2662	hrs/a

- with Optimized Architectural Solutions:
  internal temperature is often within the comfort range



Unmet Load Hours		
Heating:	1207	hrs/a
Cooling:	1242	hrs/a

You can simply run simulations using operation profiles that contain no internal temperature limits on design variations of a project. Choose the variation with the least Unmet Heating and Cooling Load Hours in order to find the best architectural solution set (combination of building shape, zoning, orientation, materials etc.) for the specific location and design task.

2.3.7 Standard Compliant Building Energy Performance Rating

EcoDesigner STAR's performance rating functionality complies with the standard ASHRAE 90.1_2007 Appendix G: Performance Rating Method as referenced by USGBC LEED – Energy 2007. Furthermore, it can be used to execute Energy Star Primary Energy Consumption and Greenhouse Gas Emission and AIA Sustainable Practice in Architecture 2030 Goal fossil fuel consumption calculations.

Compare your building's energy efficiency with the performance of a baseline version of the same project (specified freely by the User to comply with minimum requirements or to represent the statistical average for similar constructions).

Performance Rating Workflow

- Save the Baseline Building's energy simulation results as Baseline Building reference data file
- Import Baseline Building data
- Use EcoDesigner STAR to automatically rotate, recalculate and document the baseline building three times, as specified in the ASHRAE 90.1 standard (optional)
- View the results of the comparative calculations

Performance Rating Report Chapters

- Baseline Performance

Baseline Performance

Energy Type	Annual Energy & Peak Demand	Baseline Design				
		0°	90°	180°	270°	Average
External Air	Energy Use (kWh)	8578	6452	1862	6301	5798
	Peak Demand (kW)	9	9	3	9	4
Natural Gas	Energy Use (kWh)	5734	6083	6456	5909	6045
	Peak Demand (kW)	3	4	4	3	4
Electricity	Energy Use (kWh)	2655	2737	1872	2547	2453
	Peak Demand (kW)	2	3	1	2	1
Total Energy Use: (kWh/a)		16967	15272	10190	14757	14296

- Baseline Energy Costs

Baseline Energy Costs

Energy Type	Baseline Cost				Baseline Building Performance
	0° EUR/a	90° EUR/a	180° EUR/a	270° EUR/a	EUR/a (average)
Natural Gas	329	349	371	339	347
Electricity	414	427	292	397	382
Sum:	743	776	663	736	729

- Performance Rating Table

Performance Rating Table

Energy Use	Units	Proposed Design Results	BaseLine Building Results	Savings %
Heating	Energy Use (kWh)	76.16	4934.75	98.46
	Peak Demand (kW)	1.66	3.84	56.66
Cooling	Energy Use (kWh)	166.68	4763.31	96.50
	Peak Demand (kW)	0.90	3.64	75.32
Service Hot-Water	Energy Use (kWh)	777.80	1111.15	30.00
	Peak Demand (kW)	0.27	0.39	30.00
Ventilation Fans	Energy Use (kWh)	1.26	315.36	99.60
	Peak Demand (kW)	0.01	0.04	85.69
Lighting	Energy Use (kWh)	68.90	413.42	83.33
	Peak Demand (kW)	0.02	0.14	83.33
Equipment	Energy Use (kWh)	372.08	689.04	46.00
	Peak Demand (kW)	0.13	0.24	46.00
Total Annual Energy Use: (kWh/a)		**1462.88**	**12227.03**	**88.04**
Annual Process Energy: (kWh/a)		**440.99**	**1102.46**	**60.00**

- Energy Consumption and Savings

Energy Consumptions and Savings

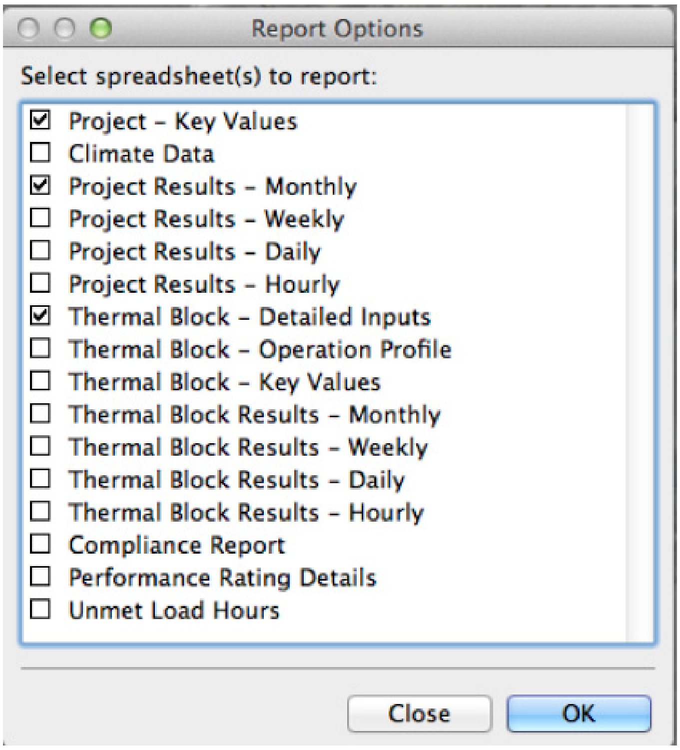
Purchased Energy	Proposed Design Energy Use	Proposed Design Cost EUR/a	Baseline Building Energy Use	Baseline Building Cost EUR/a	Saving Energy Use %	Saving Cost %
Natural Gas (kWh)	0	0	6045	347	100	100
Electricity (kWh)	110	17	2453	382	96	96
Subtotal: (kWh)	110	17	8499	730	99	98

On Site Renewable Energy	Energy Generated kWh/a	Energy Cost EUR/a
Photovoltaic system	389	0
Biofuel-based heating	853	53
Subtotal:	1243	53

	Proposed Design Energy Use kWh/a	Proposed Design Cost EUR/a	Baseline Building Energy Use kWh/a	Baseline Building Cost EUR/a	Saving Energy Use %	Saving Cost %
Total:	1353	17	8499	730	84	98

2.3.8 Customizable XLS Report

Besides the PDF calculation result documentation, EcoDesigner STAR also produces a spreadsheet that can be set up to include any or all calculation inputs as well as energy simulation results (including hourly simulation output) for the purpose of in-depth analysis or post-processing.



2.4 EcoDesigner STAR Workflow

2.4.1 Prepare the Architectural BIM for EcoDesigner STAR

For successful evaluation, the building model must contain at least the enveloping structures and fenestration, as well as all major internal structures that represent significant heat storage mass.

Furthermore, ArchiCAD zones must be placed in every conditioned space of the building, since the model's geometry analysis is based on these ArchiCAD zones.

The Energy Model Review works only on visible elements, so you must define an ArchiCAD view dedicated to the energy model. Use layer visibility to achieve the view you need. Make sure that zones are visible.

> **Note:** Marquee selection does not filter building elements for the purpose of Energy Model Review.

2.4.2 Define Thermal Blocks

Spaces are represented by 3D Zones in the ArchiCAD Building Energy Model. For Energy Evaluation purposes, you will group these Zones together in "thermal blocks", using the Thermal Blocks page of the Energy Model Review palette (**Design > Energy Evaluation > Energy Model Review**).

Thermal blocks are a collection of one or more rooms or spaces in a building that have similar orientation, operation profile and internal temperature requirements (also called thermostat control requirements). Zones need not be contiguous to be combined within a single thermal block.

2.4.3 Automatic Analysis of Geometry and Materials

After the thermal blocks have been defined, the architectural model (BIM) is transformed into a Building Energy Model (BEM) by the automatic model geometry and material property analysis functionality of ArchiCAD. This analysis does the following:

- analyzes the visible structures and openings according to their orientations and positions relative to zones and generates the space boundaries on them. (Space boundaries describe the building's geometry in a format that works for energy simulation input.)
- populates the space boundary lists. Structures and Openings are automatically listed with their properties that are relevant for the energy evaluation.

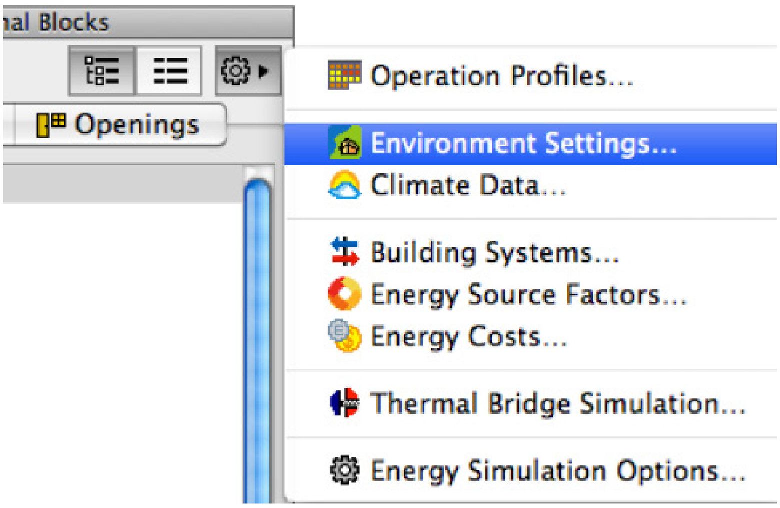
2.4.4 Assign and Input Additional Data to Complete the BEM

The Energy Model Review palette is the main user interface of ArchiCAD's EcoDesigner STAR function. Use the palette to edit the input data for the building energy simulation, as well as to add information:

- Assign Building Systems and Operation Profiles to Thermal Blocks
- Space boundary property settings

  Note: Most space boundary properties are extracted from the architectural model by the automatic model geometry and material property analysis functionality of ArchiCAD. Space boundary property settings allow users to fine-tune this data and add information that does not come directly from the architectural building model.
- Structures property settings: Use the U-value calculator or U-value override functionality and the Infiltration and Surface material settings to define the physical properties of the opaque space boundaries listed on the Structures list.
- Openings property settings: Assign Frame and Glazing performance data to fenestration from the Openings catalog. Select Shading devices from predefined databases to complete the Openings list.

Besides displaying the Structures and Openings list, the user-friendly Energy Model Review palette also contains links to dialogs.



These Additional Data Input dialogs enable quick definition of the following parameters needed to run the EcoDesigner STAR:

- Environment Settings: Provides links to the Project Location, Climate Data and Wind Protection dialogs. Grade level, Soil and Surrounding surface types are also set here.
- Operation Profile: Select the building's function(s) to assign related Internal temperature and heat gain profiles in the Operation Profile dialog. If needed, customize an Operation Profile to fine-tune occupancy according to local regulations or to match actual building usage.

- Building Systems: Provide information essential for the energy calculation, regarding the building's MEP Systems (for heating, cooling, ventilation, hot water generation)
- Finally, in order to enable primary energy, CO2 emission and energy cost calculations, define the Energy Source Factors and Energy Costs, using the dedicated dialogs.

2.4.5 Evaluate Building Energy Performance

Click the Start Energy Simulation button of the Model Review palette to start the Energy Performance Evaluation of your project. The built-in, certified VIP-Core engine executes the dynamic energy simulation that calculates the building's hourly energy balance and outputs a Building Energy Evaluation Report. The report contains information such as the project's energy-related structural performance, yearly energy consumption, energy balance and carbon footprint.

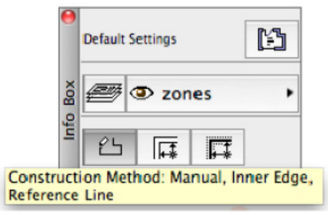
3. Direct BIM to BEM

3.1 The Architectural BIM

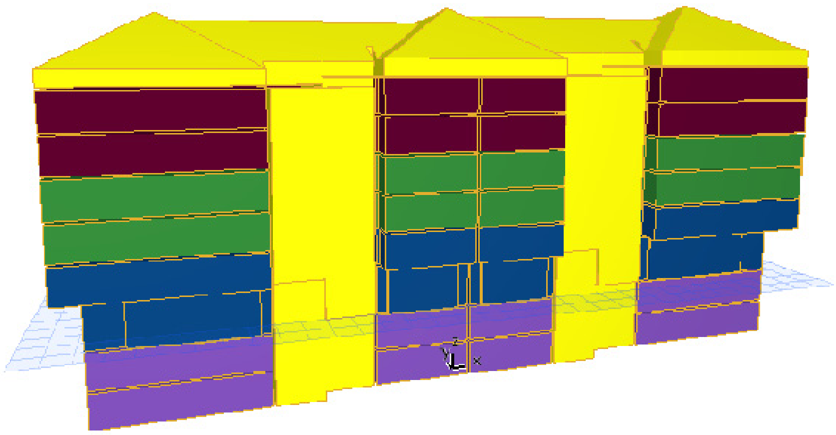
To be able to perform a successful evaluation with EcoDesigner STAR, you must create the virtual building model in ArchiCAD. The more detailed the model, the more accurate the calculation results will be. For successful evaluation, you should model, at minimum, the enveloping building structures and openings as well as the major internal structures that represent significant heat storage mass.

3.2 Internal Space Zones

Create a zone in every conditioned space of the building, using exclusively the Inner Edge zone construction method. EcoDesigner STAR is not compatible with zones created with the Manual construction method. The zones must be directly adjacent to the surrounding elements' surfaces, therefore the Reference Line zone construction method is not applicable for energy modeling either.



Zone construction methods



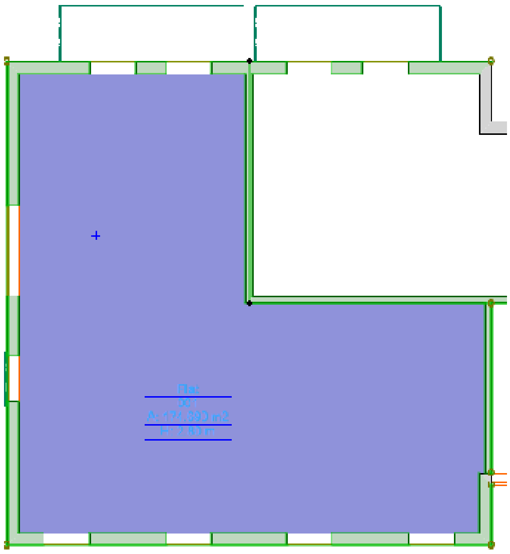
ArchiCAD zones inside the project's internal spaces

3.2.1 3D Zone Boundaries

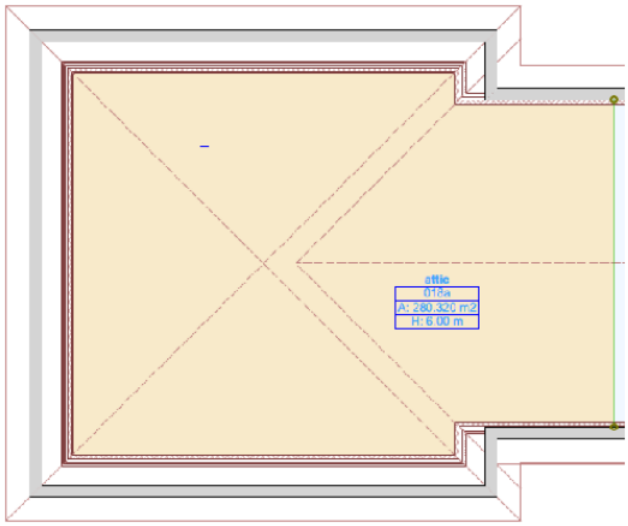
When placing zones on the floor plane, make sure that they are completely enclosed by zone boundaries.

- All ArchiCAD walls (including profiled curtain walls) automatically behave as zone boundaries.
- When using Slabs as bottom or top zone boundaries, make sure that the zone level and/or height are set so that the horizontal zone surface(s) touch the inner edge of the Slab(s).
- If Roofs, Meshes, Shells, Morphs or ArchiCAD library objects are used as zone boundaries, an additional interaction is required besides just creating the zone. In such situations:

- Draw the zone manually, making sure that it extends beyond the Roof, Mesh, Shell zone boundary elements completely.
- Use a command from the **Design > Connect** menu, such as Trim Elements or Solid Element Operations, to shape the zone with the selected zone boundaries and establish the connection between them.



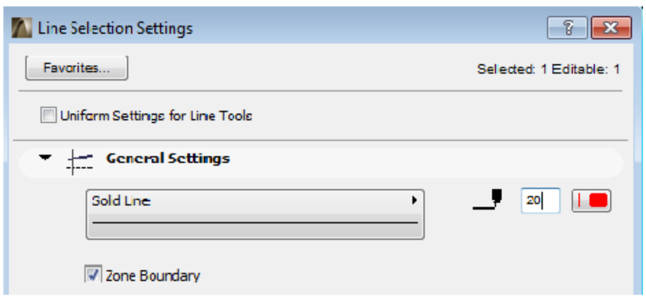
Walls as zone boundaries



Walls and line as zone boundaries

3.2.2 2D Zone Boundaries

It is also possible to define lines on the floor plan as 2D zone boundaries. Select the line(s) you want to behave as zone boundaries and tick the Zone Boundary checkbox on the Line Selection Settings dialog.



Line Selection Settings - Zone Boundary

There are a number of modeling scenarios that make it necessary to define lines as Zone Boundaries. For example:

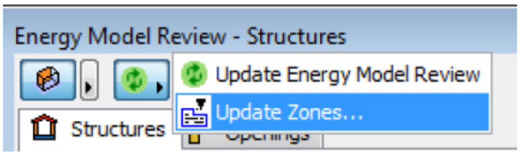
- Modeling perimeter zones in Core and Shell projects
- Atria in buildings

- Spaces that contain several, dramatically different floor and/or roof levels

Attic space with different floor and roof levels

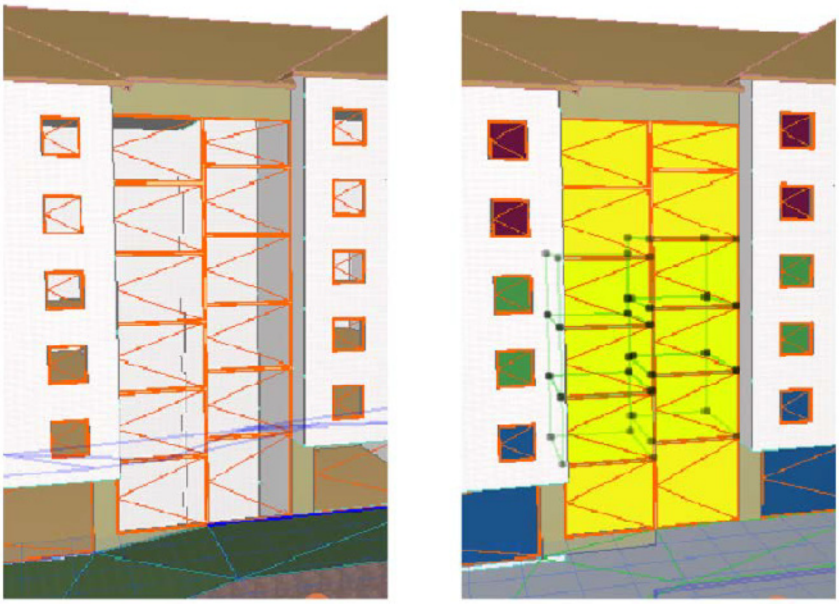
3.2.3 Update Zones

Use the Update Zones command on the left upper corner of the Energy Model Review palette after altering the geometry of zones or zone boundaries. This will ensure that the energy model reflects the up-to-date state of the ArchiCAD model.



3.2.4 Zone Modeling Conventions

- Model multistory internal spaces (e.g. staircase blocks, atria) with separate zones on every ArchiCAD Story.



Staircase – modeling of multistory internal space

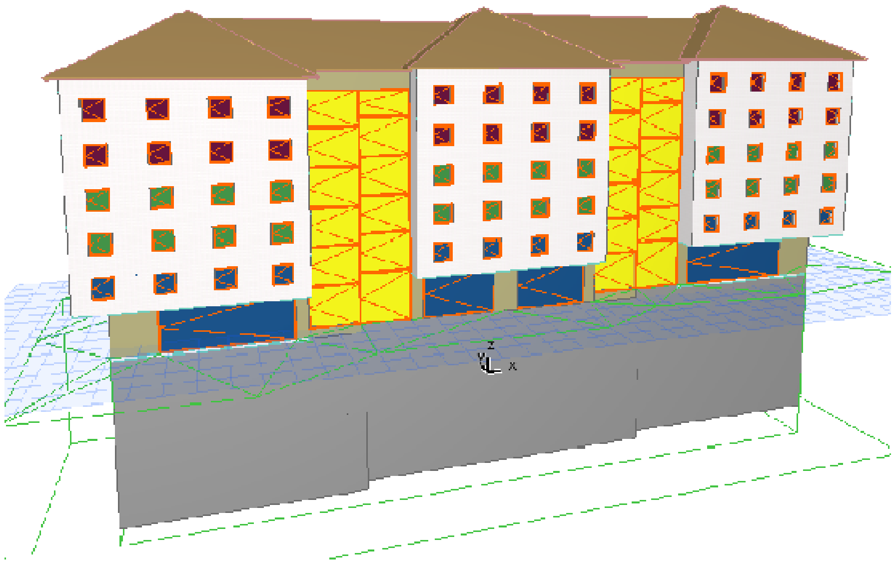
- Adiabatic walls are walls of the building shell that separate heated spaces. They are called adiabatic due to the absence of heat transfer through them. A typical example is a fire wall separating row-houses or other adjacent buildings.

In such situations, model the surfaces of the neighboring building that are adjacent to your building, with thin ArchiCAD zones. Use a separate zone on every story of your project.

3.3 Building Energy Model View

The Energy Model Review only works on visible elements; therefore it is necessary to define an ArchiCAD view dedicated to the energy model. Use layer visibility to achieve the view you need. Make sure that zones are visible.

Note: Marquee selection does not filter building elements for the purpose of Energy Model Review.



Building Energy Model View

The Building energy Model View must display all the parts of the building that you want to include in the energy evaluation (internal space zones, building shell elements, internal structures with significant thermal mass, site mesh) and none that you do not (furniture, zones other than those representing the conditioned spaces of the building, separate parallel ArchiCAD elements representing composites).

3.4 Automatic Model Geometry and Material Property Analysis

3.4.1 Space Boundary Generation

Just select **Design > Energy Evaluation**, and the Automatic model geometry analysis function automatically turns the ArchiCAD building information model (BIM) into input for building energy modeling.

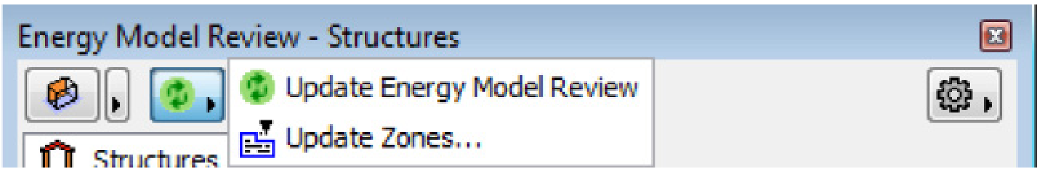
Before the Energy Model Review palette appears, ArchiCAD analyzes the visible structures and openings according to their orientations and positions relative to the zones that represent the internal spaces, then automatically generates the space boundaries. These space boundaries make up the contents of the Structures and Openings lists of the appearing Energy Model Review palette.

> **Note:** When EcoDesigner STAR is selected for the first time on a project, ArchiCAD automatically puts all visible Zones into a default Thermal Block. This represents a single thermal block (simplified) building energy model.

See Create Thermal Blocks for details on how to define a detailed energy model that contains multiple thermal blocks.

3.4.2 Update Energy Model Review

Use the Update Energy Model Review command on the upper left corner of the Energy Model Review palette after redefining Thermal Block data, or after altering the geometry of ArchiCAD Structures or Openings boundaries. This function regenerates the space boundaries, ensuring that the energy mode reflects the up-to-date state of the ArchiCAD model.



4. Building Energy Model Review

The Energy Model review palette is the main user interface of ArchiCAD's EcoDesigner STAR. It contains three tab pages that display input data for the building energy simulation. Use the tab pages to edit as well as to add information to this calculation input data.

General function buttons of the Energy Model Review palette

Besides the three main tab pages, the Energy Model Review palette also contains:

- General function buttons:
- BEM visualization options
- BEM update options
- Tab page view switch
- Links to the Additional Energy Simulation Input dialogs
- Tab-page specific functions: see the following sections for details.

4.1 List and Tree Tab Page View Options

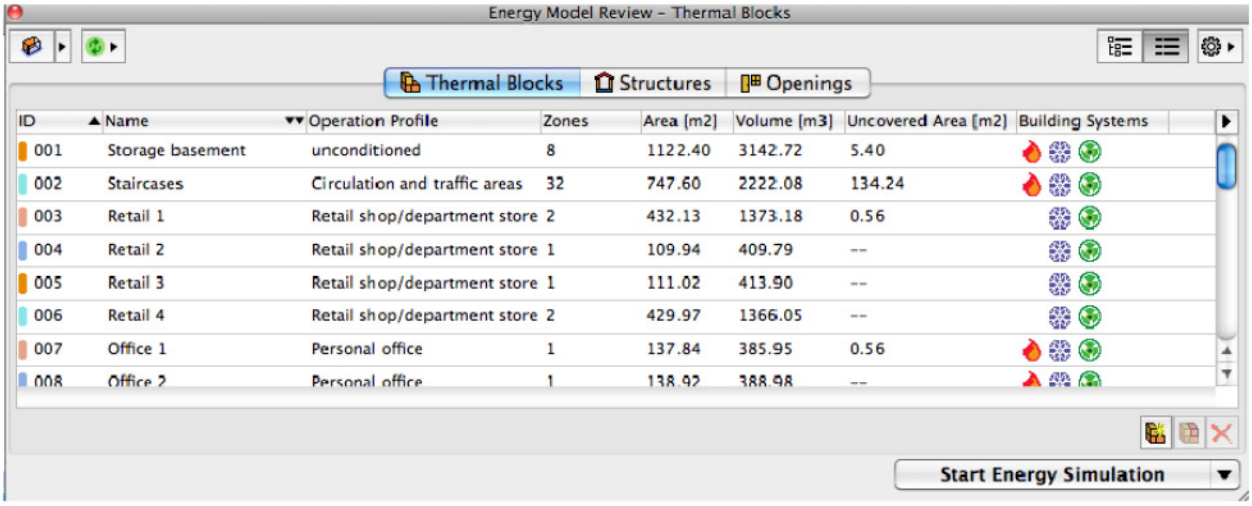
Use the Show Energy Model in list or tree view function buttons of the Energy Model Review palette to toggle between the two available tab page view options.

These view options display the energy simulation input data in two different ways, allowing for a wide variety of user interactions. Most interactions (data assignments, overrides, adjustments etc.) can be performed in both views, while others are view-specific (e.g.: rearranging data according properties is only possible in List View, drag-and-dropping zones into thermal blocks is only possible in Tree View).

4.2 Thermal Blocks Tab Page

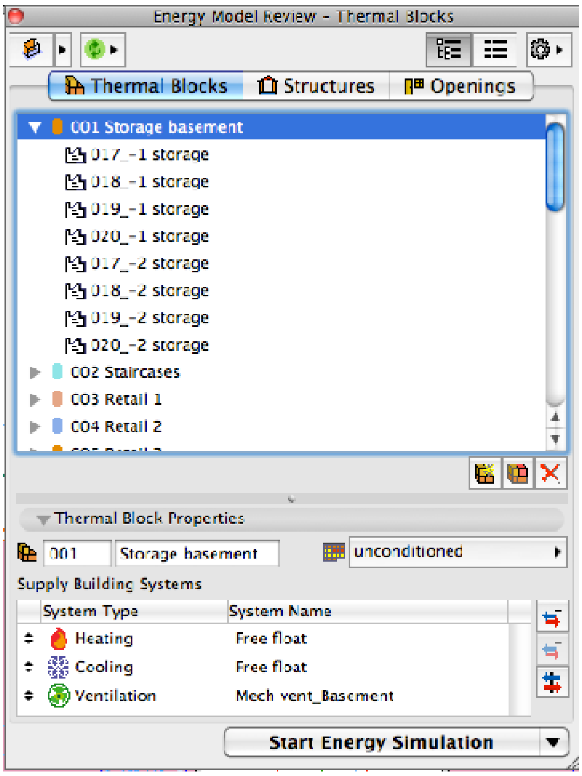
For EcoDesigner STAR purposes, you will group ArchiCAD Zones together in "thermal blocks". Thermal blocks are a collection of one or more rooms or spaces in a building that have similar heating or cooling requirements - also called thermostat control requirements. Thermal blocks are represented by groups of 3D Zones in the ArchiCAD Building Energy Model.

The Thermal Blocks page of the model Review Palette lists thermal blocks with all their relevant properties.



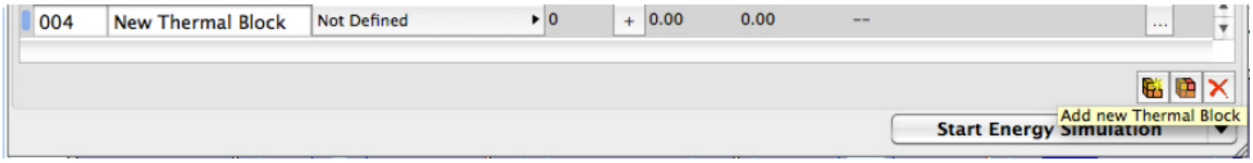
Thermal Blocks Tab Page in List View

In Tree View, users can see the Zones that make up the thermal blocks as well, if they select the dropdown arrow by the thermal block's name. If a thermal block is selected, its properties are displayed on the bottom of the page, in the Thermal Block Properties section.



4.2.1 Create Thermal Blocks

Use the Add new Thermal Block button to create a new thermal block. Its name and ID can then be entered in the list.



To assign Zones to the thermal block:

- Drag and Drop 3D Zones into Thermal Block (in Tree View)
- Use Find and Select to Select Zones and Add Zones to Thermal Block (in List View)

  Note: Zones need not be contiguous to be combined within a single thermal block.

4.2.2 Thermal Blocks Data

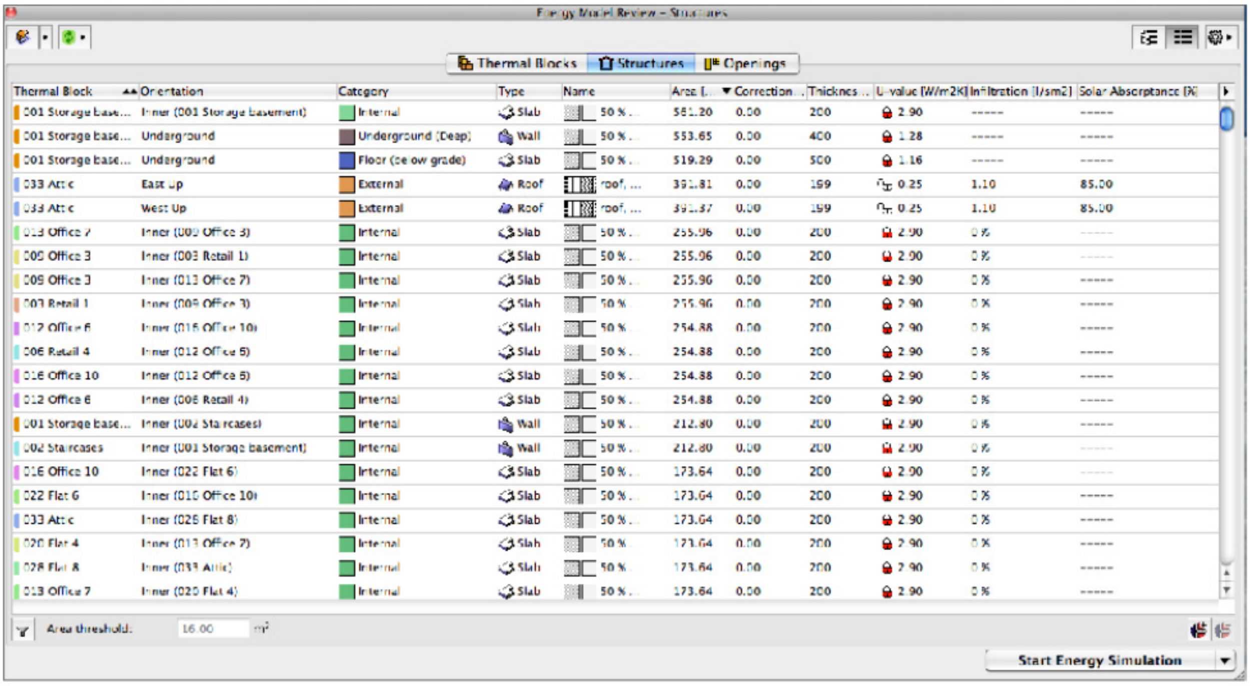
The Thermal Blocks tab page can be viewed in either table or tree form. There are two kinds of data types on this page:

- ArchiCAD model data types (coming directly from the BIM): In case of Thermal Blocks: Number of Zones, Floor Area, Volume, Uncovered Area
- Additional data types (assigned to the Thermal Blocks list entries by the user): Thermal Block ID and Name, Operation Profile, Building Systems

See Thermal Block Property Settings.

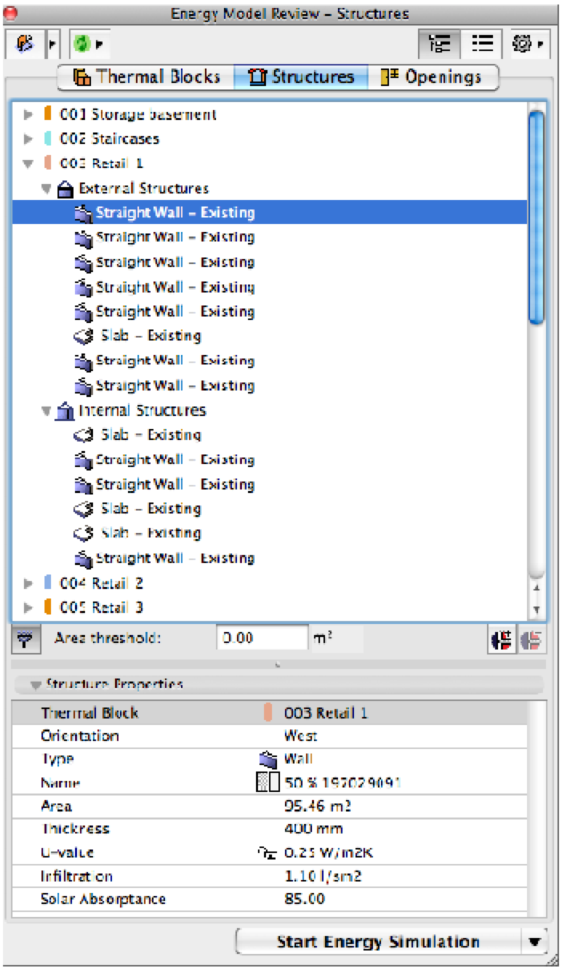
4.3 Structures Tab Page

The Structures tab page of the Energy Model Review palette lists the space boundaries on the building's external and internal structures, with all their physical properties that are relevant for the energy simulation. The opaque panels of curtain walls also appear on the Structures list.



Structures Tab Page in List View

The Tree View of the Structures Page shows exactly which External and Internal Structures belong to which thermal block in an easy to understand, graphic way. If a structure is selected, its properties are displayed on the bottom of the page, in the Structure Properties section.



Structures Tab Page in Tree View

4.3.1 Structures Data

There are two kinds of data types:

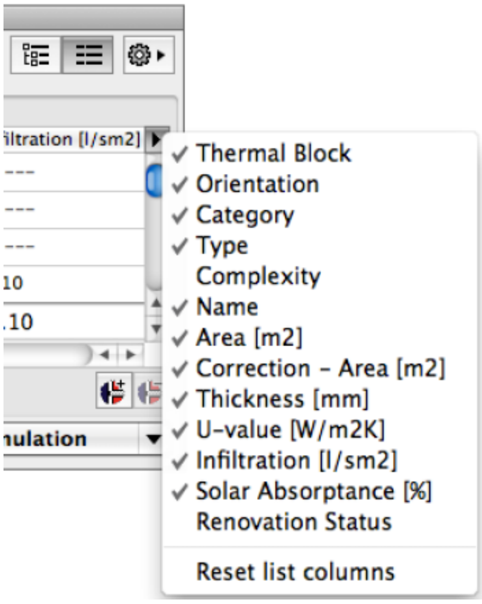
- ArchiCAD model data types (coming directly from the BIM): In case of Structures: Thermal Block assignment, Orientation, Space Boundary Category, ArchiCAD Element Type, Complexity, Name, Area, Thickness, Renovation Status
- Additional data types (assigned to the Structures list entries by the user): U-value/R-value, Infiltration, Solar Absorptance, Correction-area

See Structure Property Settings.

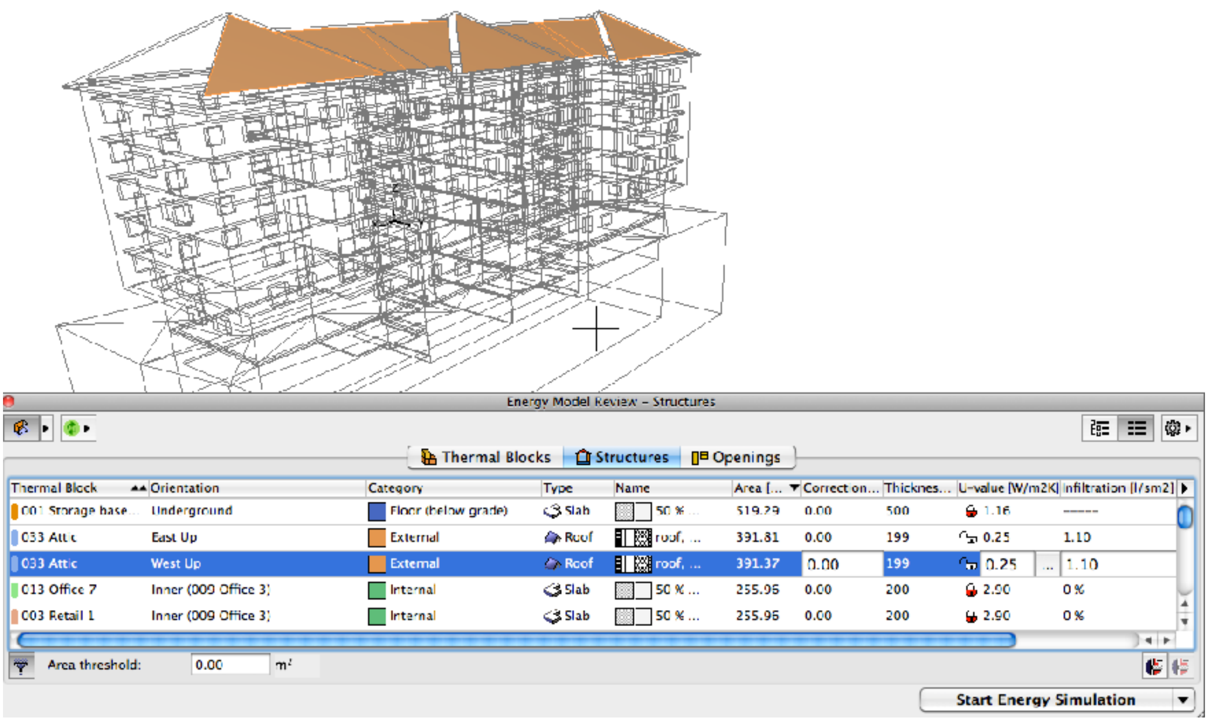
Show or hide any of these data types as needed:

- In tree view: right-click any Structure Properties list item to show or hide the data types

- In list view: Click the arrow pop-up at right to show or hide the table columns



One Structures List entry usually consists of multiple Space boundaries. All Space boundaries that are identical in all their ArchiCAD model data types are aggregated in a single Structures List entry and appear with the sum of their areas on the list.



In list view, you can rearrange the list according to any property by clicking on the property's headline button.

4.3.2 Area Threshold

To filter out structure or opening list entries of negligible area, enter a value in the “Area Threshold” field at the bottom of the Structures list. Entries whose area is smaller than this value will not be listed, and will not be considered by the calculation engine. (If you later lower this area threshold, the filtered-out structures will reappear as applicable.)

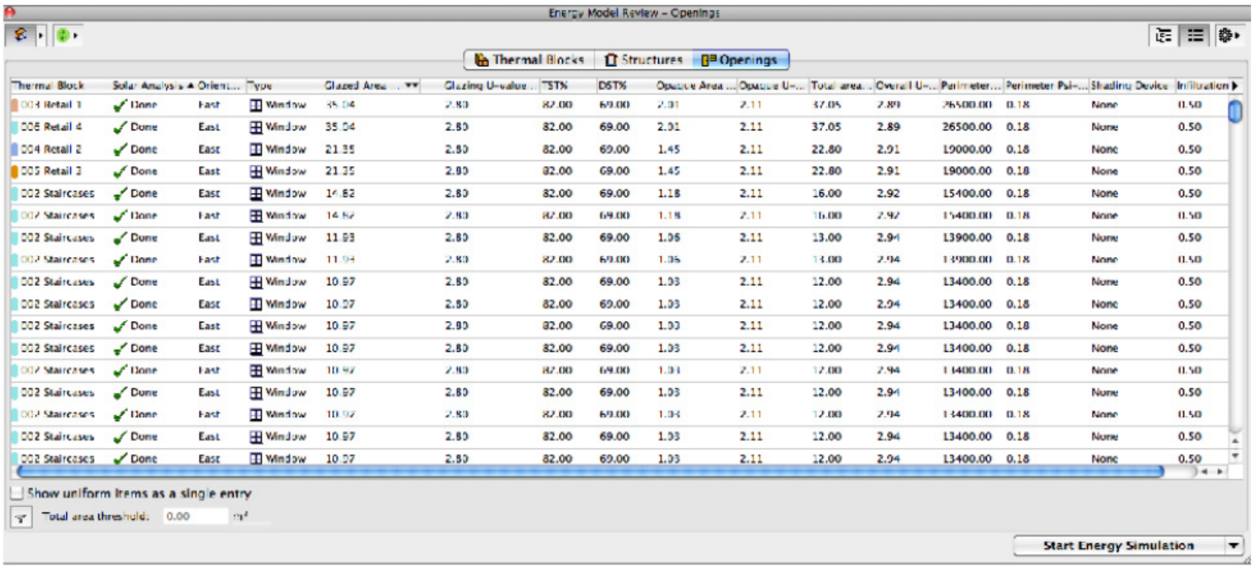
Setting an Area threshold will help you filter out small areas that are insignificant for energy evaluation, resulting in a more manageable Structures list.

4.3.3 Structure Area Correction

The Structures tab page of the Model Review palette has a data type for “Correction-area”. For any listed Structure, you can adjust the area by entering a positive or negative value in this column. The value of this item in the “Area” column will be adjusted accordingly; this corrected Area value (if positive) will be used by the calculation engine.

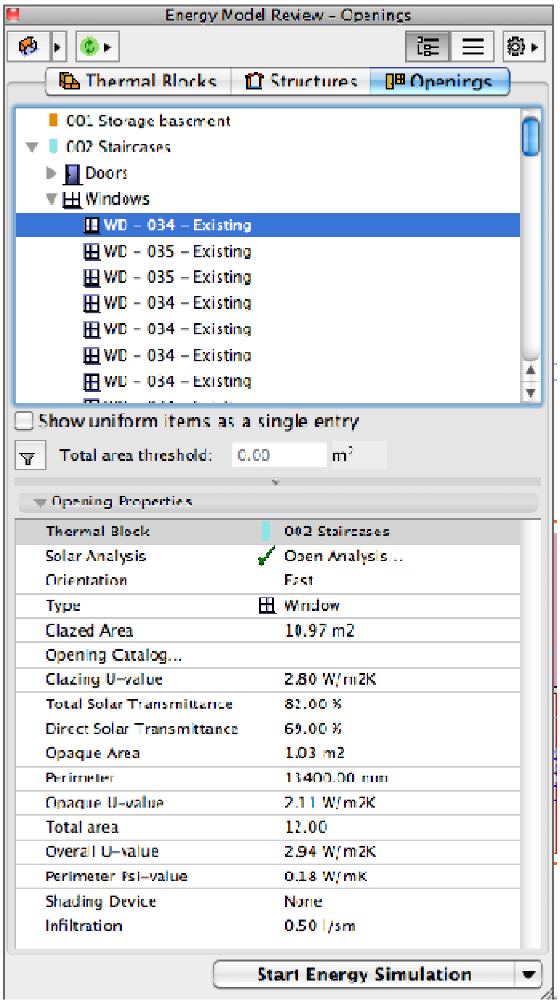
4.4 Openings Tab Page

The Openings tab page of the Energy Model Review palette lists the space boundaries on the building’s external openings, with all their physical properties that are relevant for the energy simulation.



Openings Tab Page in List View

The Tree View of the Openings page shows exactly which Doors, Windows and transparent Curtain Wall panels belong to which thermal block in an easy to understand, graphic way. If an Opening is selected, its properties are displayed on the bottom of the page, in the Opening Properties section.



Openings Tab Page in Tree View

4.4.1 Openings Data

The Openings List can be viewed in either table or tree form; each column represents a data type. There are two kinds of data types:

- ArchiCAD model data types (coming directly from the BIM):

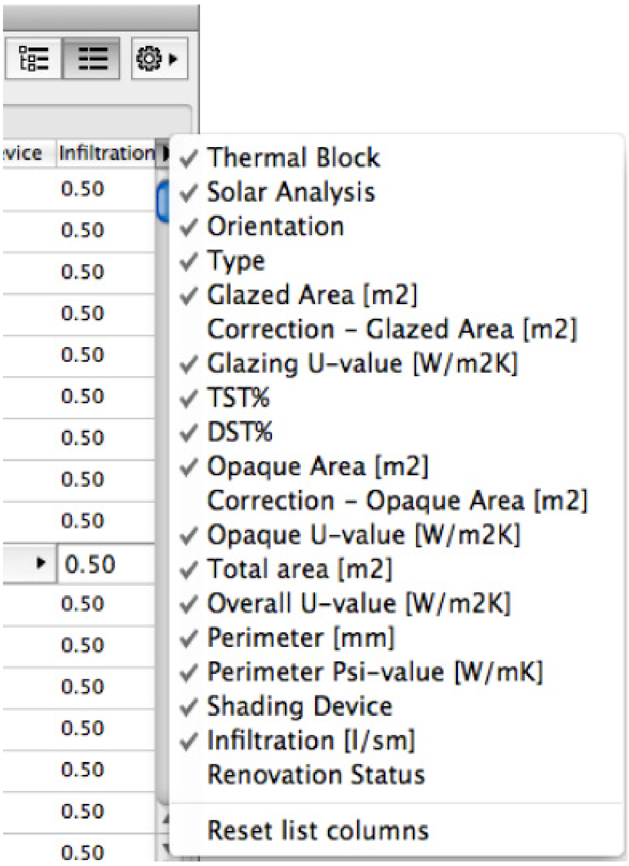
In case of Openings: Thermal Block assignment, Solar Analysis results, Orientation, ArchiCAD opening type, Area (Glazed, Opaque, total), Frame perimeter, Renovation Status.

- Additional data types (assigned to the Openings list entries by the user)

In case of Openings: Total and Direct Solar Transmittance, U-value (for glazing, opaque areas, perimeter and overall), Perimeter Psi value, Shading device, Infiltration.

Show or hide any of these data types as needed:

- In tree view: right-click any Structures Properties list item to show or hide the data types
- In list view: Click the arrow pop-up at right to show or hide the table columns



In list view, you can rearrange the list according to any property by clicking on the property's headline button.

For each Openings list item, the following data are shown in columns:

- Thermal Block Assignment
- Orientation and ArchiCAD opening type
- Solar Analysis result

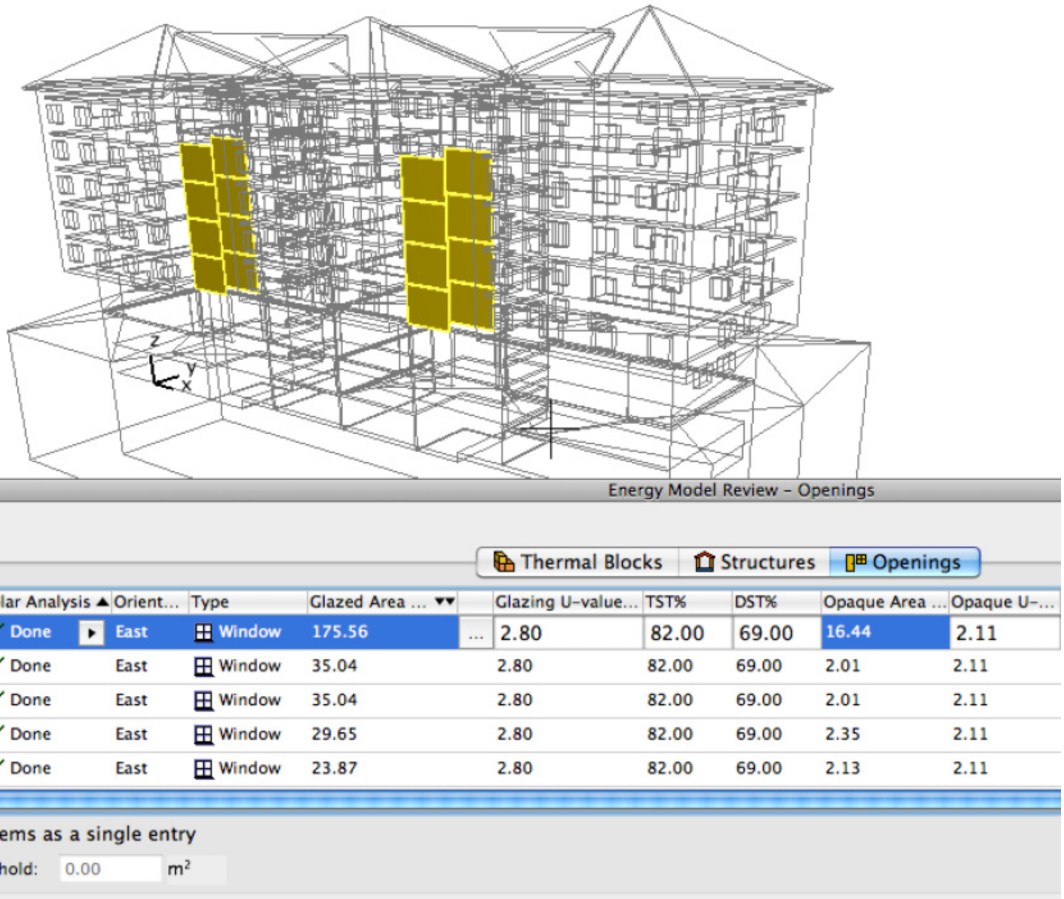
See Solar Analysis.

- Data describing the transparent panels of Openings:
  - Glazed area, frame perimeter
  - Glazing U-value
  - Total solar transmittance (TST): The percentage of incident solar radiation transmitted by an object which includes the Direct Solar Transmission plus the part of the Solar Absorption reradiated inward. TST divided by 100 equals Solar Heat Gain Coefficient (SHGC) or g-value.
  - Direct solar transmittance (DST)

- Data describing the opaque panels and frames of Openings:
  - Opaque area, perimeter, U and Psi-values
  - Infiltration: air permeability of the selected Opening (typically occurs around the perimeter, at the frame to wall connection)
- Shading Device assignments
- Renovation status

4.4.2 Show Uniform Items as a Single Entry

Use this checkbox in the bottom left corner of the Openings page in list view to make every Space boundary which is identical in terms of all ArchiCAD model data types appear in a single Openings List entry, with the sum of their areas on the list.



4.4.3 Total Area Threshold

To filter out opening list entries of negligible area, enter a value in the "Total Area Threshold" field at the bottom of the Openings list. Openings whose total (opaque + glazed) area is smaller than this value will not be listed, and will not be considered by the calculation engine. (If you later lower this area threshold, the filtered-out openings will reappear as applicable.)

Setting a Total Area threshold will help you filter out small areas that are insignificant for energy evaluation, resulting in a more manageable Openings list.

4.4.4 Openings Area Correction

Two columns are available for manually correcting the Opening area: the "Correction - Glazed area" and "Correction - Opaque area." Enter a positive or negative value in this column. The value of this item in the "Area" column will be adjusted accordingly; this corrected Area value (if positive) will be used by the calculation engine.

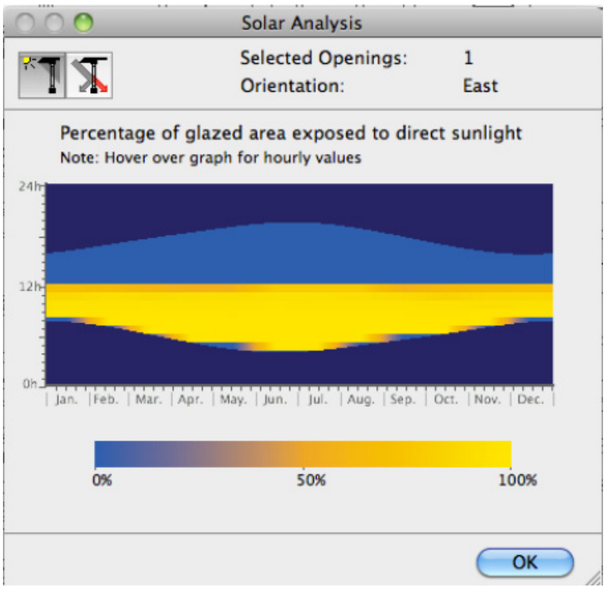
4.4.5 Solar Analysis

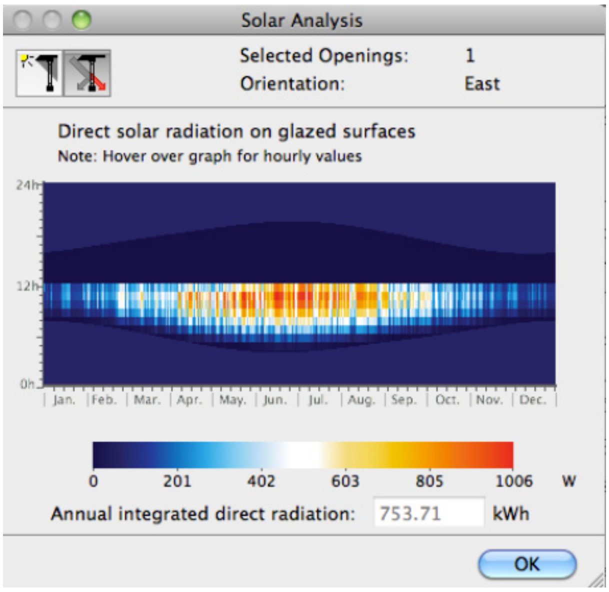
The Openings page of the Model Review Palette allows for the individual analysis (listing, editing and visualization) of every transparent space boundary of the ArchiCAD building model. This is necessary to take advantage of the Model-Based Solar Irradiation Study, with which solar gain through each individual transparent element of the building envelope may be precisely determined. This advanced tool enables architects to strategically determine the place of each individual piece of fenestration with respect to the surroundings and the building's geometry, in order to utilize the benefits yet avoid the unwanted effects of solar gain throughout the year.

The function considers all ArchiCAD objects and elements that are visible in Building Energy Model view, as well as the effect of shading devices, to calculate direct solar irradiation on each glazed opening of the building model. Furthermore, ArchiCAD plant objects act as intelligent shading devices, as their shading capacity is scheduled for the reference year, making it possible to factor in whether the plants used for shading are coniferous or deciduous.

Select any Openings List entry, then click Open Analysis at Solar Analysis to activate the dialog dedicated to model-based solar irradiation study.

The Solar Analysis dialog has two tab pages. Both display diagrams that show each hour of the calculation reference year, with the days of the year along the x axis and the hours of the day along the y axis.





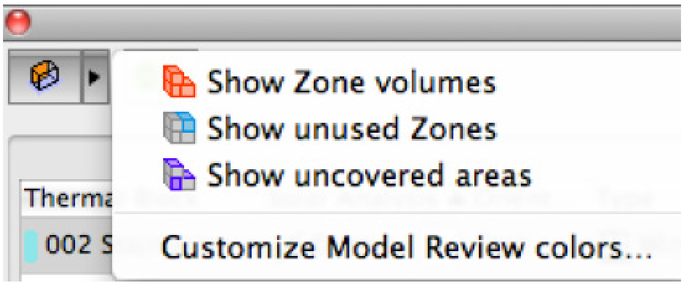
Hover over the “Percentage of glazed area exposed to direct sunlight” diagram to get a precise reading of hourly values, or use the color coding of the diagram to view 100% solar exposure with bright yellow and 0% solar exposure (totally shaded) with blue, while shades of yellow represent times of the year when the Opening in question is only partially irradiated by the sun. This view disregards cloudy days specified in the weather file.

Hover over the “Energy transmission through glazed area” diagram to get a precise reading of hourly energy transmitted through the Opening, or use the color coding of the diagram to view energy transmission intensity: most intense is bright red and 0 is blue, while colors of the gradient between these two extremes represent intermediate energy flow values. This view takes cloudy days specified in the weather file into consideration and displays the resulting “Annual integrated direct radiation value” in kWh.

Note: If multiple entries are selected on the Openings List, or a single entry is selected but the Show uniform items as a single entry option is active, then the Solar Analysis dialog will display data that reflect the solar irradiation on all of the selected Openings items, combined.

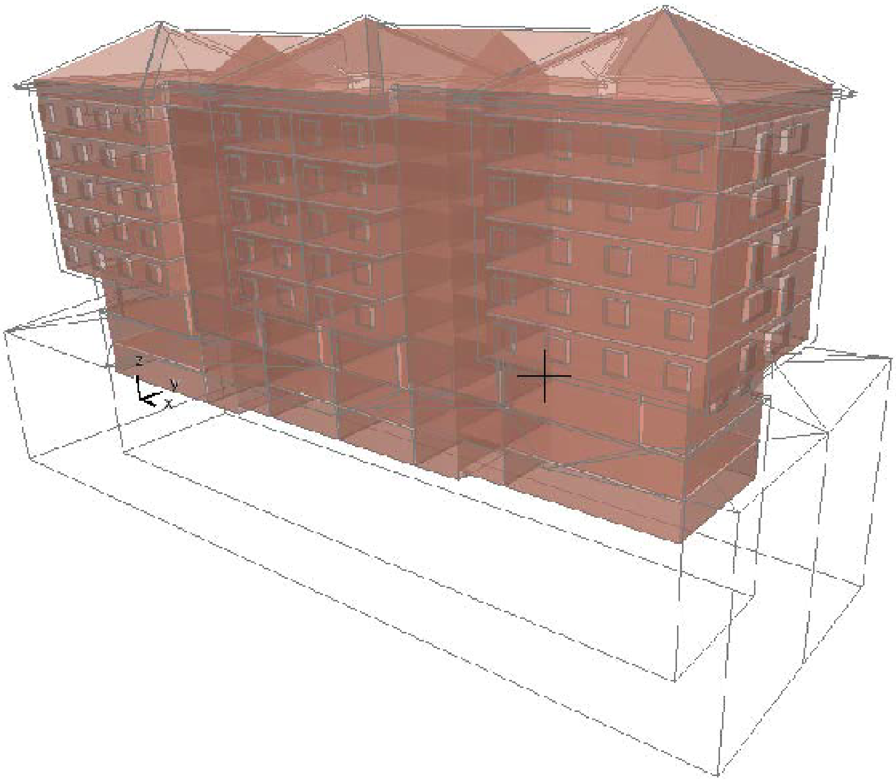
4.5 Building Energy Model Visualization

The Show selected items in 3D button on the upper right corner of the Energy Model Review palette enables you to visualize the energy model of your project in different ways.



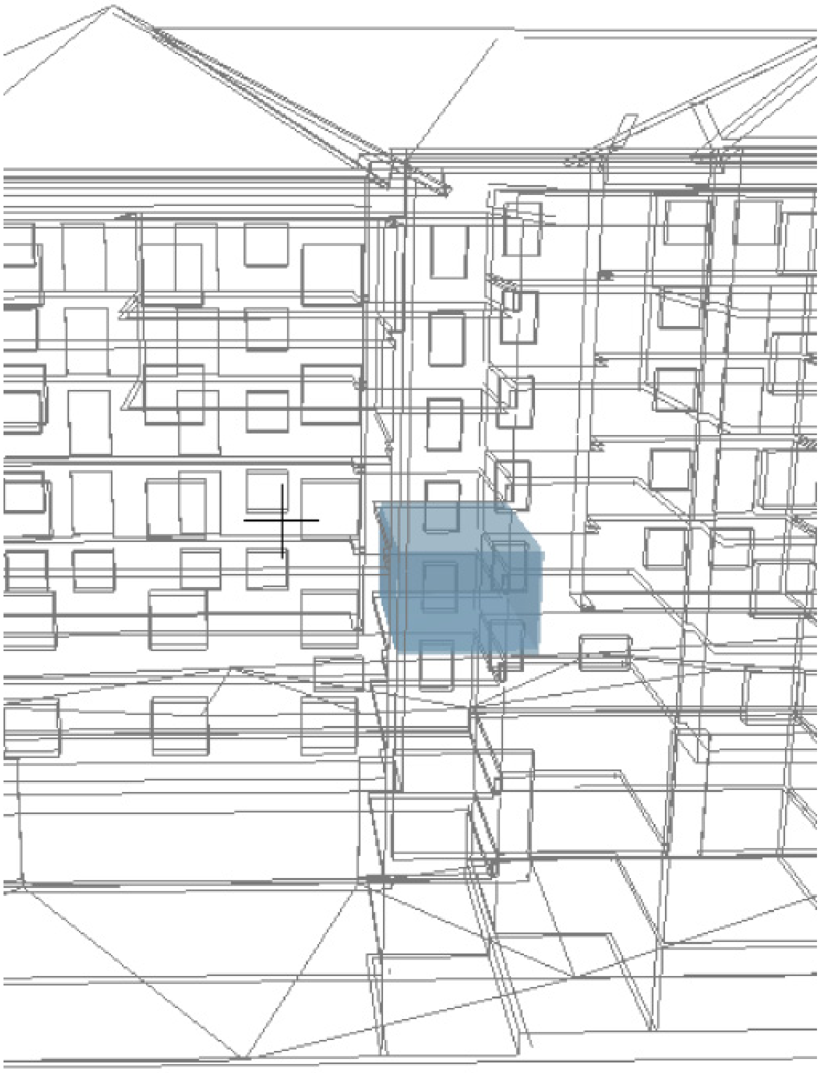
4.5.1 Show Zone Volumes

The Show Zone Volumes function can be used to visualize the internal spaces in 3D.



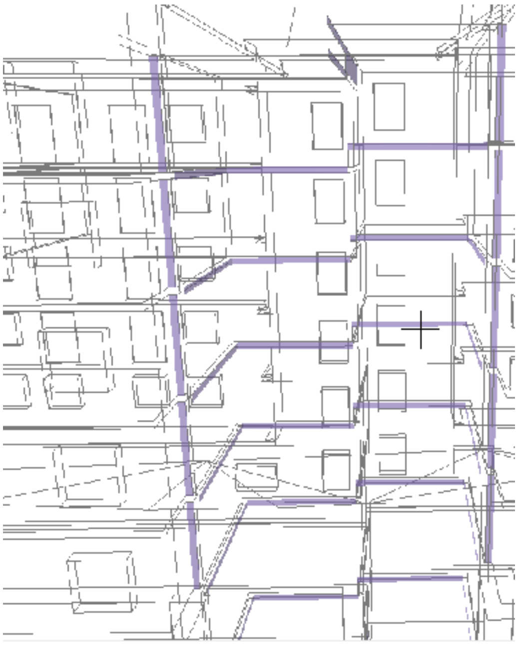
4.5.2 Show Unused Zones

The Show unused Zones function highlights the visible ArchiCAD Zones that do not belong to any Thermal Blocks in the Building Energy Model.



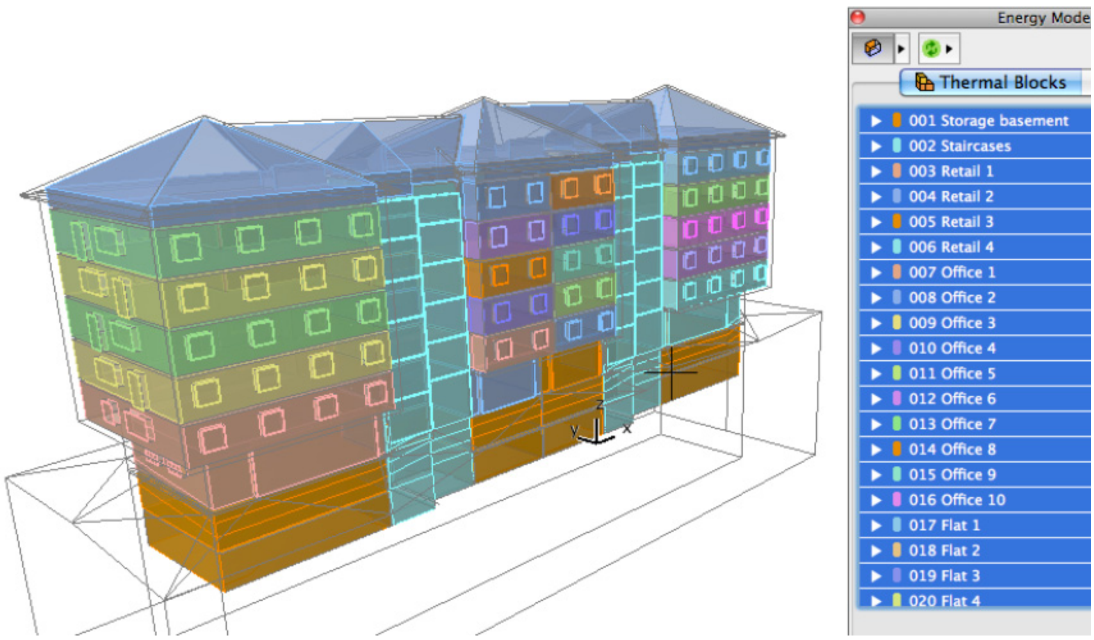
4.5.3 Show Uncovered Areas

The Show Uncovered Areas function highlights the surfaces that do not have space boundaries associated to them. Ideally, all building structure and opening surfaces are covered by space boundaries; so these uncovered areas indicate modeling inaccuracies.

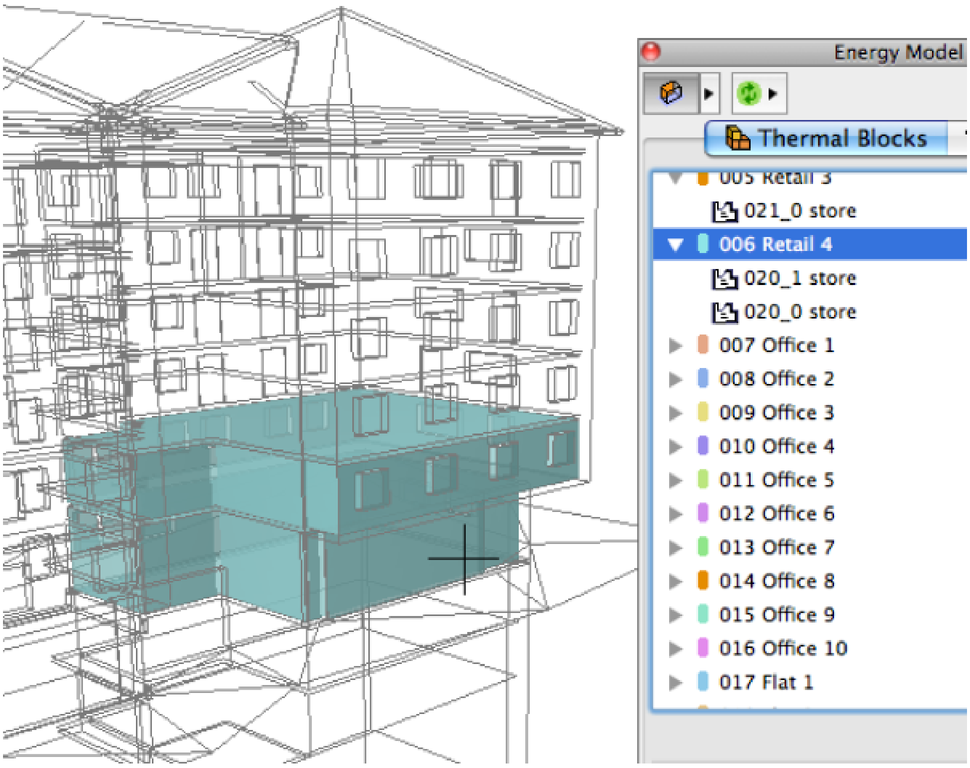


4.5.4 Visualization of Thermal Blocks

In the Energy Model View, the entries that are selected on the Thermal Blocks list are simultaneously highlighted with solid colors on the 3D model.

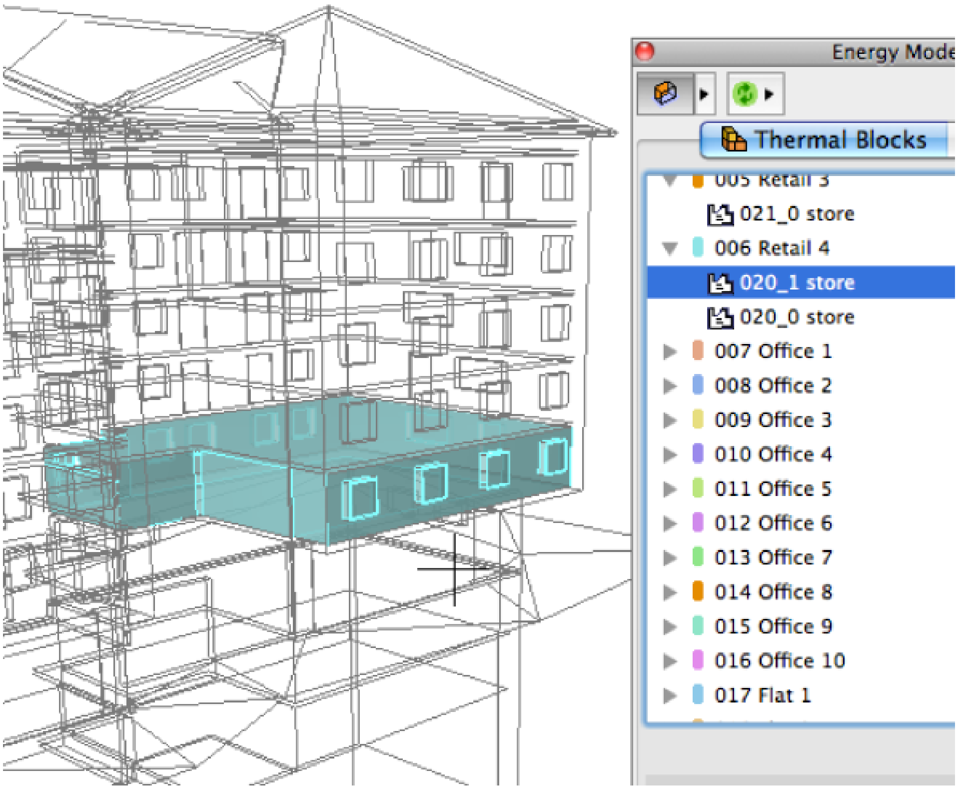


The model elements that are not selected are shown in wireframe while this function is active. In Tree View, it is also possible to select and visualize the zones that make up a thermal block, one by one.



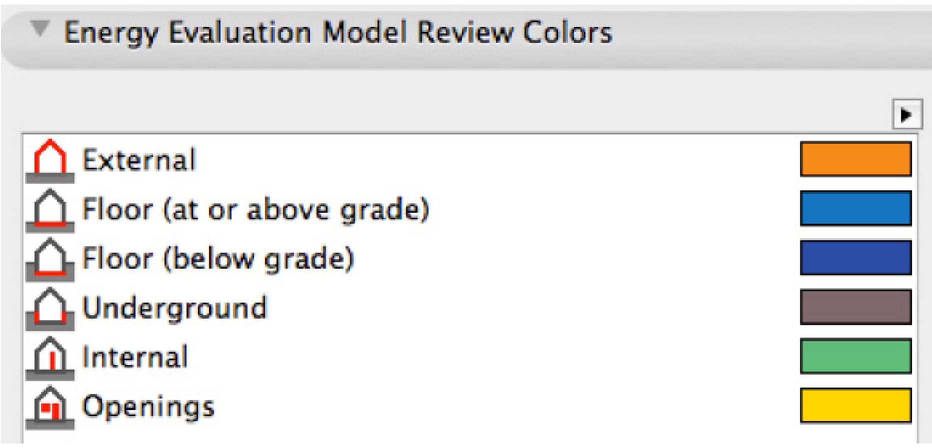
4.5.5 Visualization of Structures

In the Energy Model View, the space boundaries that are selected on the Structures list are displayed on the ArchiCAD building model. Select one or more items from the Structures list, then click Show selected item in 3D (the model elements that are not selected are shown in wireframe while this function is active).

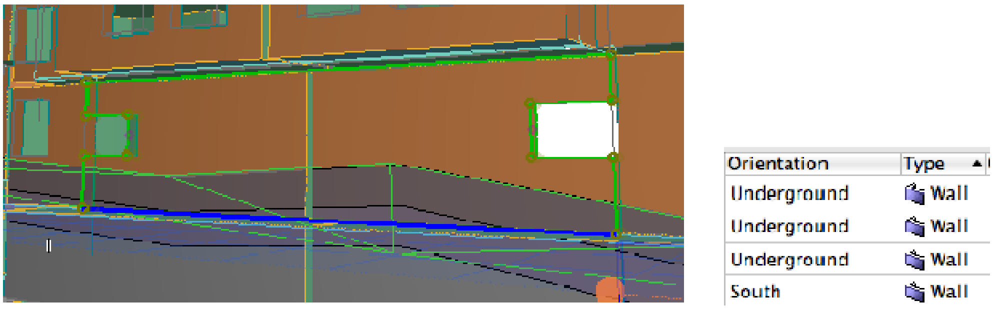


A separate color is assigned to each space boundary category in Energy Model View.

See Customize Energy Model Review Colors.



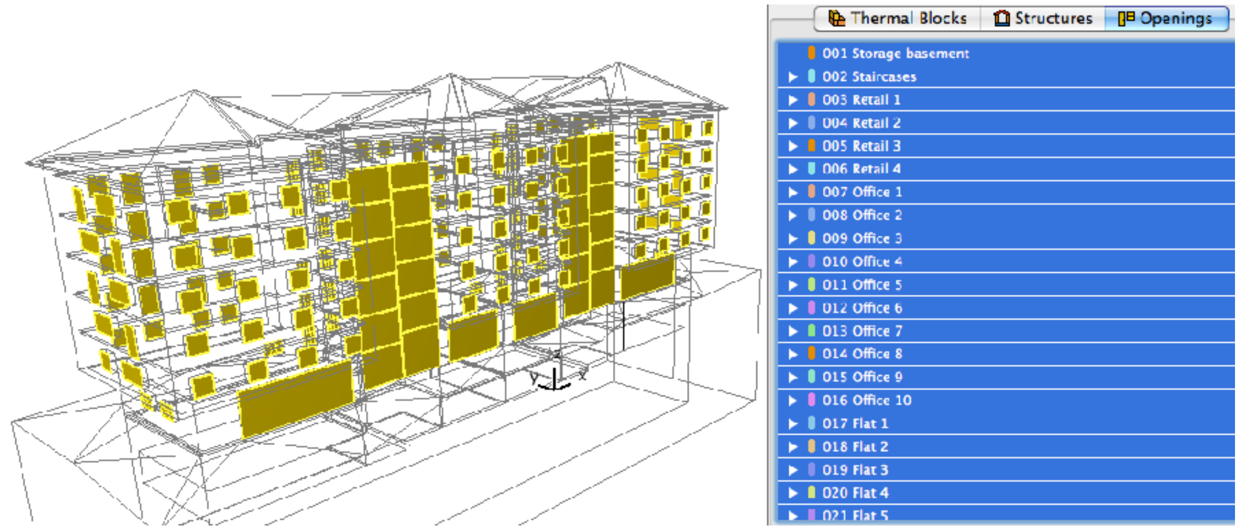
A single ArchiCAD element (e.g. a wall that extends both above- and below-ground) might consist of multiple space boundaries, and therefore might appear as part of several different entries (with different orientations) on the Structures list.



A single ArchiCAD wall element that consists of multiple space boundaries

4.5.6 Visualization of Openings

The Show in 3D button can also be applied to visualize the selected entries of the Openings list.



5. Additional Data Assignment and Input

There are two necessary energy calculation input data types in addition to the information that comes directly from the BIM:

- Space boundary (Structures and Openings) property settings
- Auxiliary data assignment and input

These input data are described in the following sections:

Bring up the Model Review Palette by selecting **Design > Energy Evaluation**. The three tab pages of this palette (Thermal Blocks, Structures and Openings) list data populated by the Automatic model geometry analysis. Additional data beyond the information that comes from the building model must be assigned to the ArchiCAD model data on the Thermal Blocks, Structures, and Openings lists.

Prior to manual editing, the fields of Model Review Palette tab pages that contain additional data are filled with default values. Fine-tune the building energy model by editing this data manually, using the function buttons on the lists.

To modify the editable values for any property, select the property from the list.

In List view, you can edit multiple entries. Select the first entry that needs to be modified. Then add further entries to the selection by moving the pointer with the mouse without releasing the left mouse button, or by clicking on the entries while pressing the CTRL or the SHIFT key. Use the function buttons that appear by the first selected line to modify properties of all selected list entries.

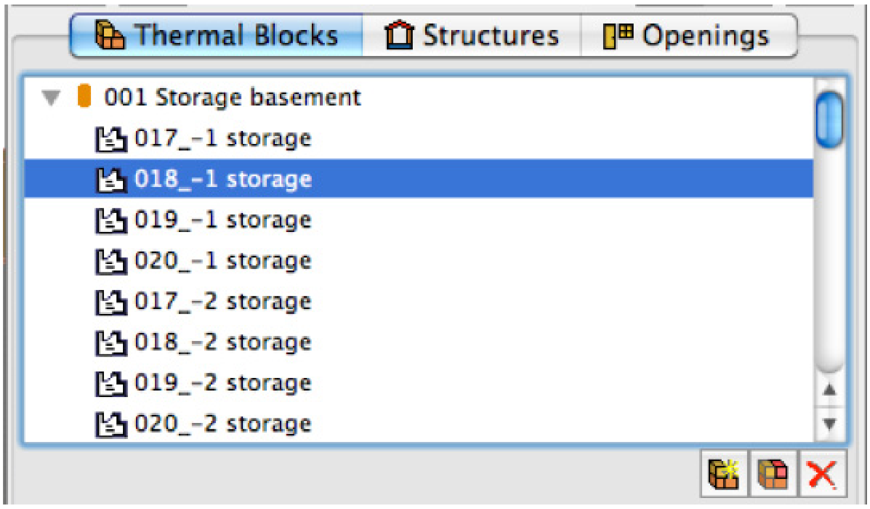
If any of the data on the lists are insufficient for simulation input, the list entry that contains it is automatically highlighted with red, and a warning symbol (exclamation mark in a yellow triangle) appears at the data field in question.

5.1 Thermal Block Property Settings

In order to enable the energy simulation, it is necessary to define three property sets for each thermal block individually. These key thermal block property sets are: Space Zones, Operation Profile and a set of Building Systems.

- Space Zones that make up the thermal block.

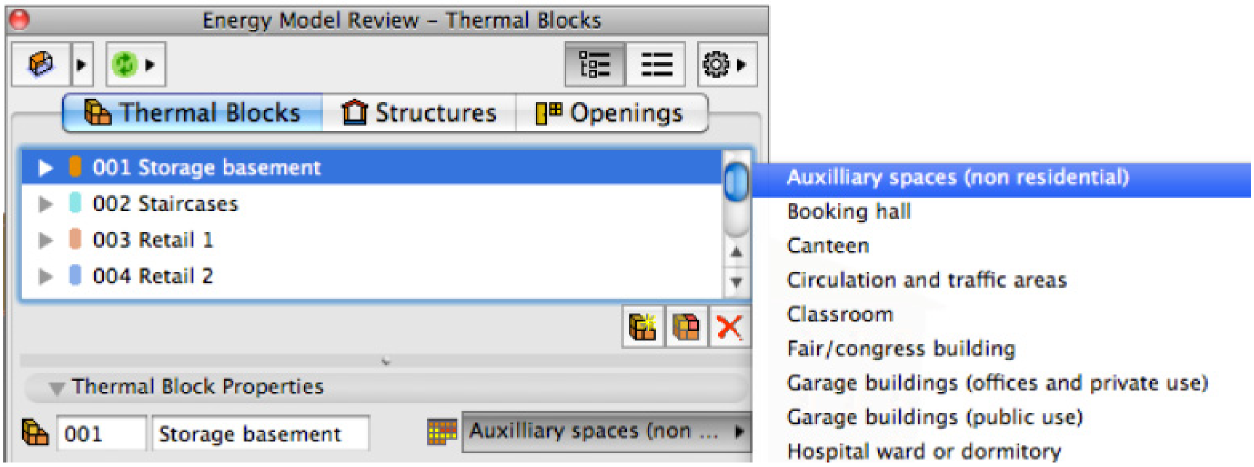
See Create Thermal Blocks.



Use the control buttons below the thermal blocks tree to add or remove ArchiCAD Zones from the selected thermal block, as well as to Create a new thermal block.

- An Operation Profile that describes how the thermal block will be used.

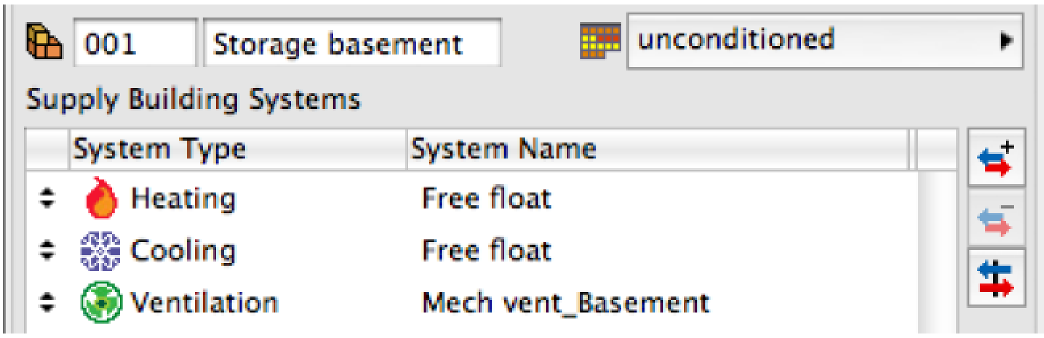
See Operation Profiles.



Click the Assign Operation Profile button to select an operation profile that fits the selected thermal block's function.

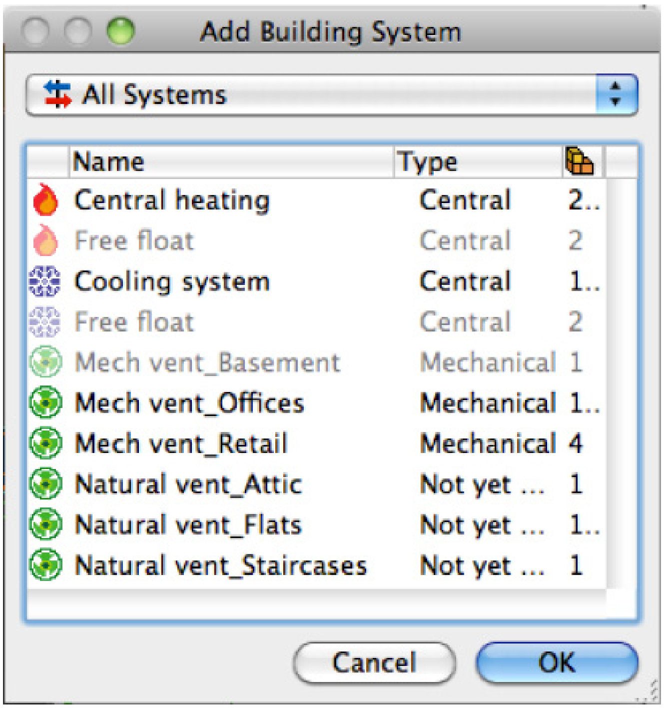
- A set of Building Systems that maintain the comfort requirements defined by the Operation Profile.

See Building Systems.



Use the control buttons next to the list of Supply Building Systems to add or remove systems from the list.

Note: It is also possible to assign systems to thermal blocks via the Building Systems dialog.



Note: One thermal block can only be supplied by one heating system configuration, one cooling system configuration and one ventilation system configuration.

5.2 Structure Property Settings

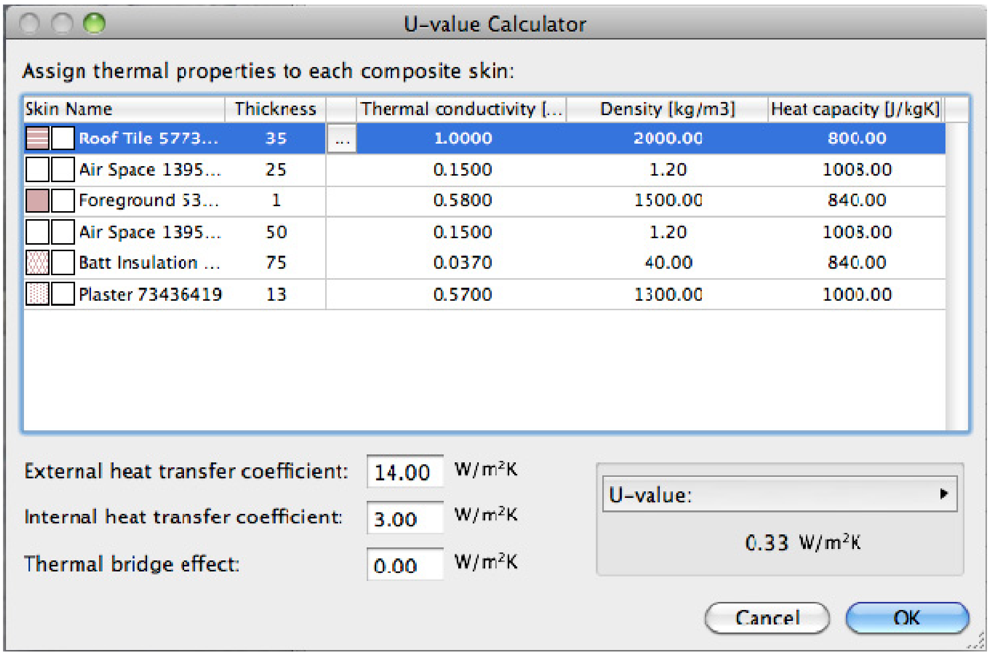
5.2.1 U-Value (R-Value) Calculator

U-value refers to the heat transmission coefficient of the selected structure. Use the U-value Calculator to estimate the thermal physics performance of the structures in your projects, based on the physical properties of the structure's Building Material(s).

Note: For a simpler and faster, but somewhat less accurate method, edit the U-value manually.

See U-value (R-value) Override.

Select any structure in the list. In the U-value column, click the three-dot button - with the lock icon set to closed (red) - to bring up the U-value Calculator dialog.



In the U-value Calculator, the skin(s) that make up the selected structure are listed with their relevant properties (Thickness, Thermal conductivity, Density and Heat capacity), each showing a default value.

Note: These values derive from the Physics Properties panel of ArchiCAD's Building Materials dialog box. You can edit any of these values manually.

Depending on local convention, you may prefer to use the R value (Thermal Resistance Coefficient), which is the inverse of the U value. To list and display R values instead of U values (both here and in the final Evaluation Report), click the U-value pop-up at the bottom right of this dialog box, and choose R-value.

External and Internal heat transfer coefficients, and the Thermal bridge effect related to structural surface area shown at the bottom left of the U-Value (R-Value) Calculator dialog box. These data, in addition to the material properties, are necessary for the calculation.

The Calculated U-value is displayed in the bottom right corner of the panel.

Note: The Calculated U-value shown in this dialog box is based on stationary building component performance data. This kind of data is listed under Key Values/Heat Transfer Coefficients in the Energy Performance Evaluation report. However, EcoDesigner STAR uses a more accurate, dynamic calculation algorithm to calculate hourly heat transmission through the building envelope structures, when simulating the building energy balance for the reference year. The result of this dynamic analysis is the basis of the Energy Consumption, Carbon Footprint and Monthly Energy Balance data displayed on the Energy Evaluation Report.

5.2.2 U-value (R-value) Calculation Algorithm

The U-value Calculator calculates the average heat transmission coefficient of Building Materials and composite structures, based on a stationary algorithm that is used by most national standards.

U : Heat transfer coefficient (static value)

$$U = \frac{1}{\frac{1}{h_i} + \Sigma \frac{d}{\lambda} + \frac{1}{h_e}}$$

h_i : internal heat transfer coefficient

h_e : External heat transfer coefficient

d : skin thickness

λ : thermal conductivity

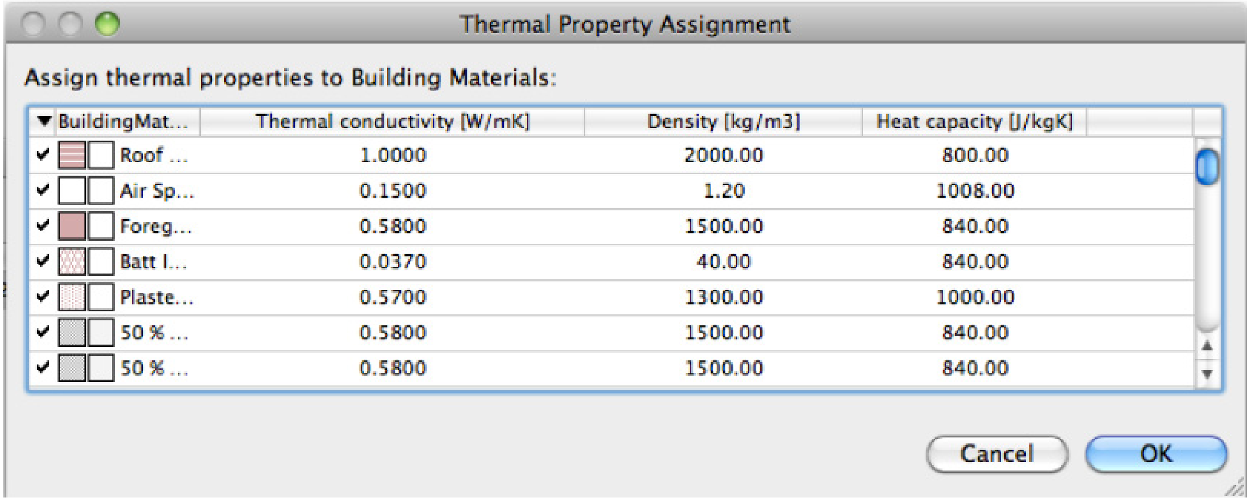
To include the effects of thermal bridges, delta U-values are added to the average U-values of structure group entries. The magnitudes of external and internal heat transfer coefficients and the delta U-value depend on the position of the evaluated structure relative to the thermal current. Default settings are offered within EcoDesigner STAR. However, it is advisable to review and manually override these predefined values if the structural situation demands, or if the standards for the project location are different.

5.2.3 Thermal Property Assignment

View the skins listed in the U-value calculator. While the fill type, name and thickness of each skin is derived from the element’s settings in ArchiCAD, the three properties to the right of the vertical line - Thermal conductivity, Density and Heat capacity - can be modified by you, if the default values here do not correspond to your actual project structures.

To change the Thermal conductivity, Density and/or Heat capacity value of any skin, select it from the list in the U-value Calculator.

Click the button with the three dots to access the Thermal Property Assignment dialog box.



The Thermal Property Assignment dialog box lists all Building Materials defined for this project. Those Building Materials actually used in this project are shown here with a checkmark in the far left column. Each listed fill is shown with the relevant physics properties that are assigned to it.

> **Note:** These values derive from the Physical Properties panel of the Building Materials dialog box (**Options > Element Attributes > Building Materials**).

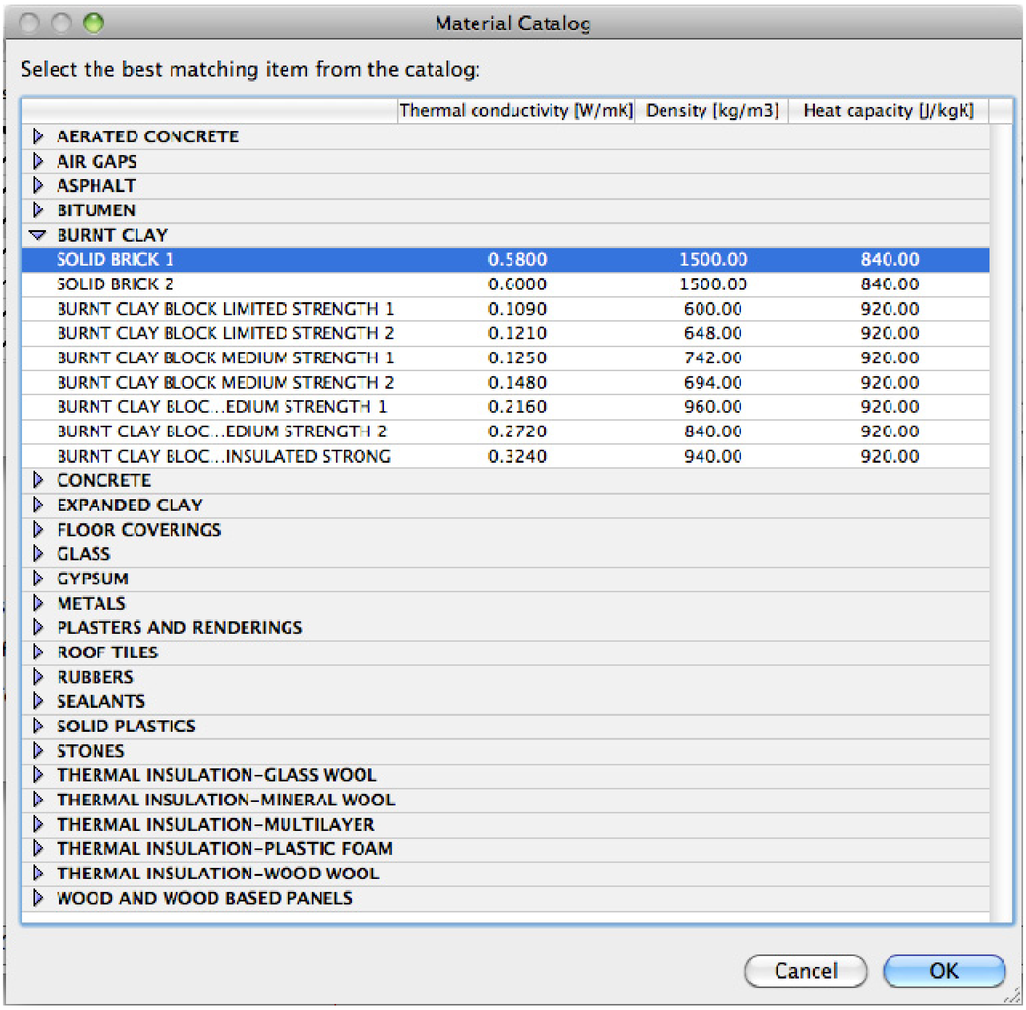
The Building Material you selected in the U-value calculator is highlighted in the list. Here you can edit any value, either directly or by choosing defined values from the Material Catalog.

Any change made here will automatically be reflected in all project elements that include the edited fill.

5.2.4 Material Catalog

Materials in EcoDesigner STAR represent physical properties (thermal conductivity, density and heat capacity). In the Thermal Property Assignment dialog box, highlight a row and click the right-side Catalog button: this brings up the EcoDesigner STAR Material Catalog.

(You can also access the Material Catalog to set thermal properties for Building Materials at **Options > Element Attributes > Building Materials**).



The Material Catalog is an extensive database integrated within EcoDesigner STAR that contains building material information relevant for the energy calculations (Thermal conductivity, Density and Heat capacity). The building materials are grouped in main categories with drop-down detailed lists to enable easy access and quick selection.

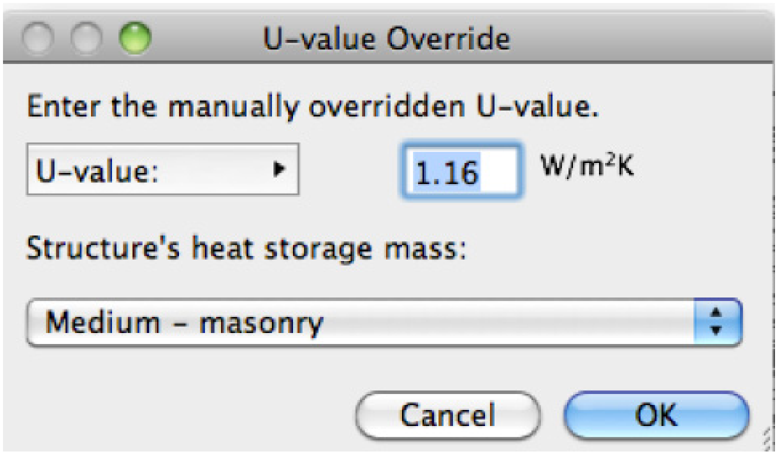
Select a material here whose physical properties correspond to your needs. When you click OK in the Material Catalog, the thermal properties of the selected material are assigned to the Building Material you selected in Thermal Property Assignment.

This way, the calculation engine obtains the physical data required for the thermal evaluation without any numeric input from you.

5.2.5 U-value (R-value) Override

It is possible to enter a U-value (or R-value) manually, instead of using the U-value calculator and Thermal Property Assignment functions. Omitting the Thermal Property Assignment greatly shortens the time needed to evaluate a project, but leads to somewhat less accurate results.

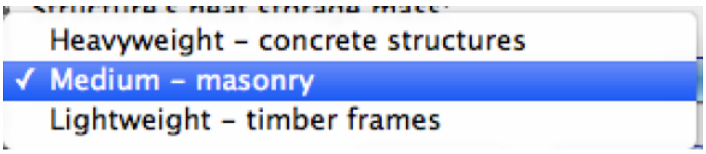
Select any structure in the list. In the U-value column, click the three-dot button - with the lock icon set to open (white) - to bring up the U-value Override dialog.



Click the pop-up to alternate between U-value and R-value as needed. Simply enter the desired value in the editable field.

5.2.6 Structure's Heat Storage Mass

Use this pop-up (also in the U-Value Override dialog box) to select the thermal mass (Lightweight, Medium or Heavyweight) of the selected structure, instead of using the materials coming from the building model directly.



The threshold values for these categories are:

- heavy-weight: > 400 kg/floor area
- medium: 250 – 400 kg/floor area
- light-weight: < 250 kg/floor area

Within EcoDesigner STAR, these predefined settings are linked to mean density values. These density values are multiplied by the total volume of the interior structures, providing the numeric Internal heat storage mass value to the calculation engine.

5.2.7 Infiltration Settings

Modify the default Infiltration (unit: l/s,m2) of the selected Structures List entry to precisely define its air permeability (0.6 l/s,m2 is considered as low, while 1.6 l/s,m2 is considered as high infiltration).

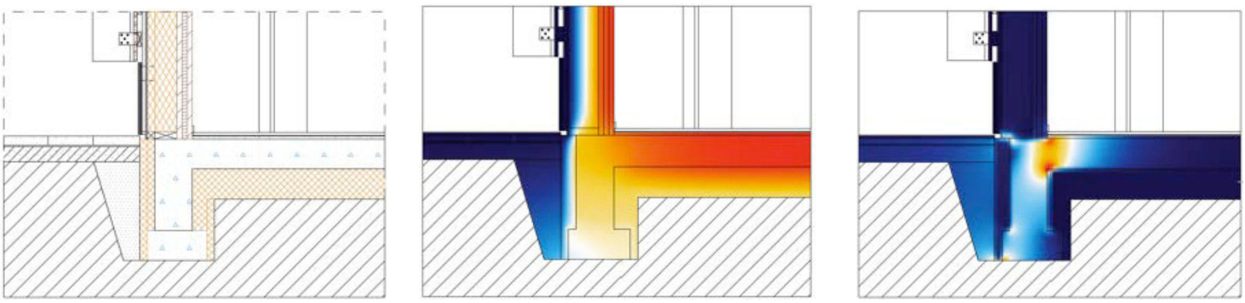
The EcoDesigner STAR function of ArchiCAD not only simulates the effect of infiltration on the hourly energy balance, but also displays the total Air Leakage in ACH (air change per hour), in the Key Values section of the PDF Energy Performance Report.

5.2.8 Solar Absorptance

The Surface material property determines the Solar Absorptance properties of the selected Structure. Click the pop-up arrow in this field to select from a list of surface materials and finishes. Modify the default Solar Absorptance (unit: %) of the selected Structures List entry to precisely define its capacity to absorb solar energy.

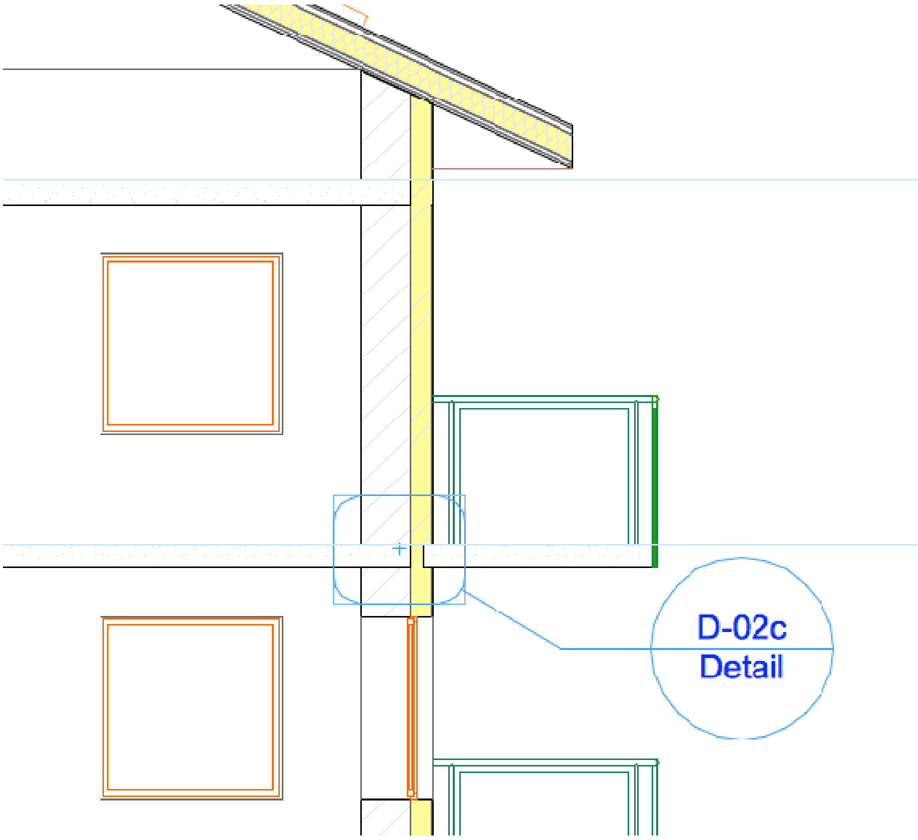
5.3 Thermal Bridge Simulation

Use 2D **Thermal Bridge Simulation** to evaluate the performance of details, then assign the resulting performance values to thermal blocks to factor in their effect on the building's overall energy balance, as a lineal *thermal bridge coefficient* (Psi value). It is also possible to place the graphic results of the thermal bridge simulation (virtual thermal-vision and energy flow diagrams) onto the corresponding ArchiCAD detail, as a drawing.

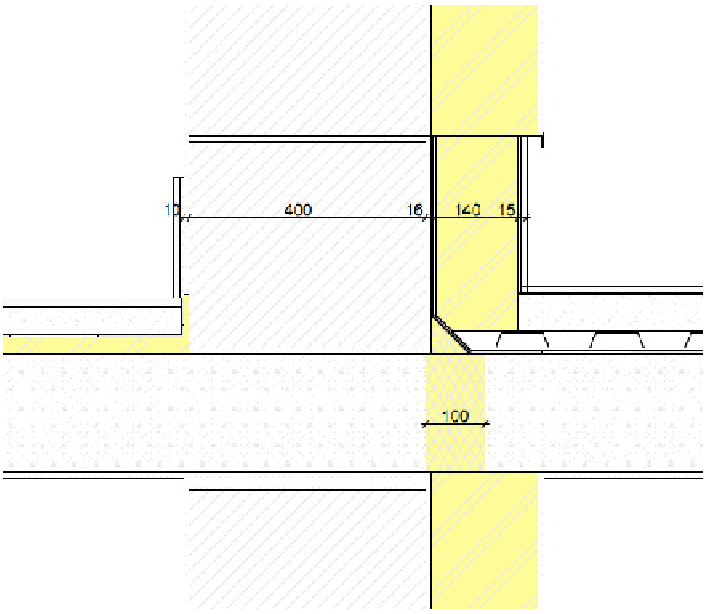


5.3.1 Workflow

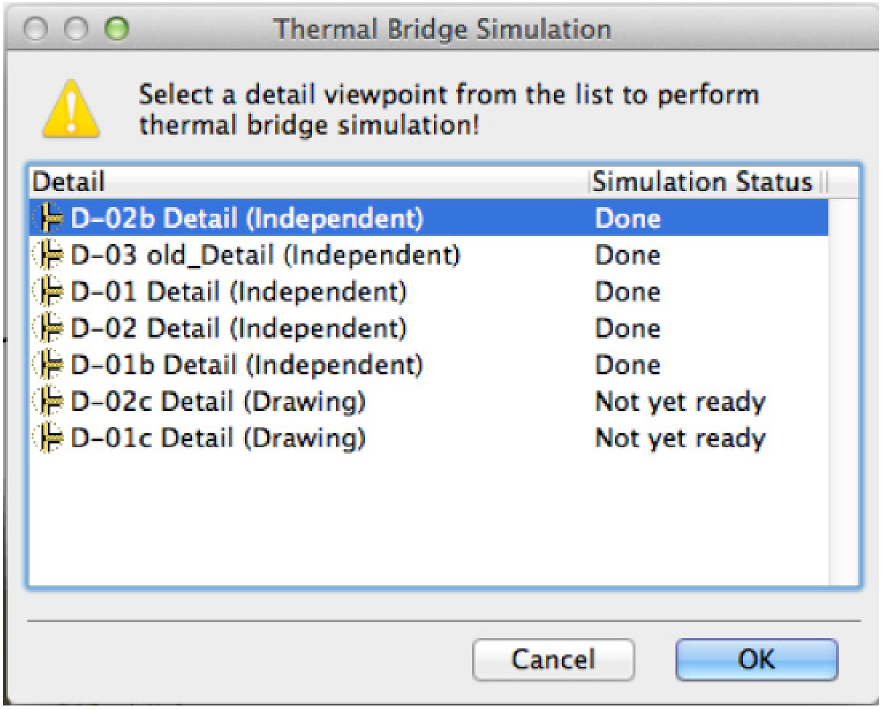
1. Place a detail marker around the area to be analyzed.



2. Use the ArchiCAD detail window to add 2D drawing elements (lines, fills, dimensions etc.) to the detail drawing if necessary.



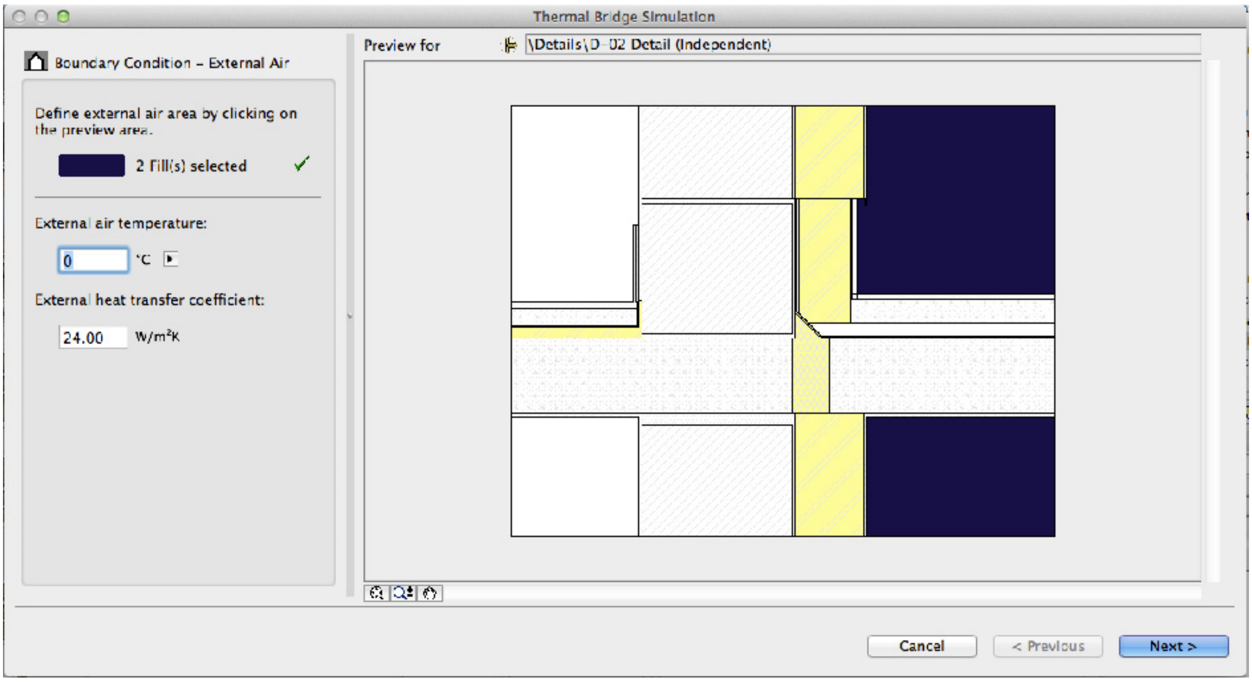
3. Choose **Design > Energy Evaluation > Thermal Bridge Simulation**
   - or the same command from the Model Review Palette's pop-up at the top right
   - or the context menu of the Detail's viewpoint listed in the Navigator.
4. From the appearing dialog box, choose the detail you wish to analyze.



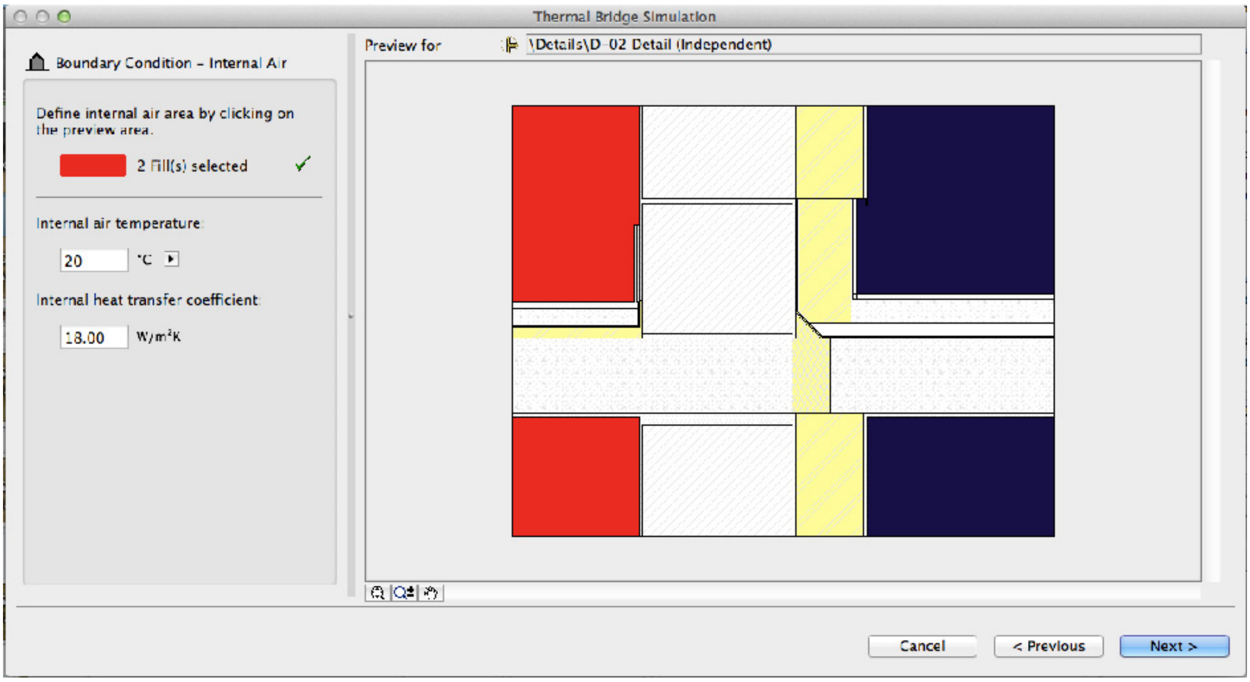
5. Click OK to launch the wizard. From each page of the wizard, click Next to proceed.

   Note: Only fills whose type is "Cut Fill-Building Material" will be taken into account for the Thermal Bridge Simulation, because such fills include physical properties. The detail's Cover/Drafting/Cut type fills are ignored for Thermal Bridge purposes.
6. On the first page (Boundary Condition / External Air)
   - Click on the part of the preview that represents the external air area of the detail. (If several areas represent external air, use Shift+click to select them.)
   - Enter the external air temperature.

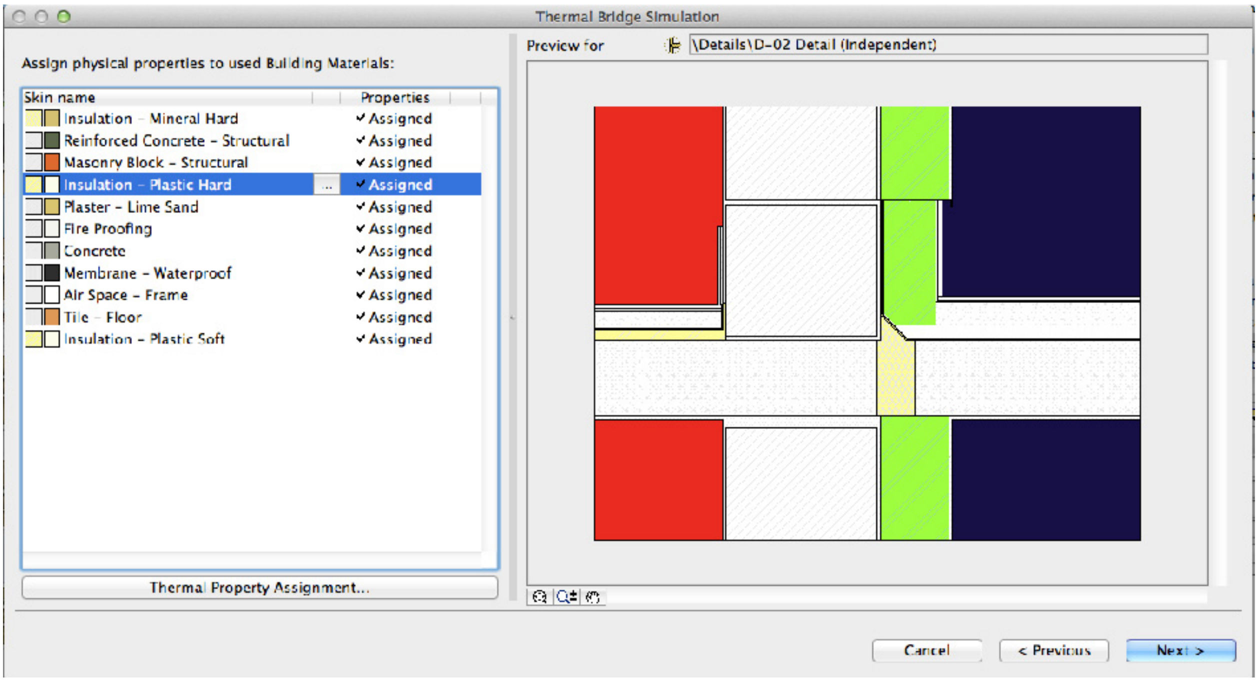
- Enter the external heat transfer coefficient.



7. On the second page (Boundary Condition – Internal Air)
   - Click on the part of the preview that represents the internal air area of the detail. ((If several areas represent internal air, use Shift+click to select them.)
   - Enter the internal air temperature.
   - Enter the internal heat transfer coefficient.

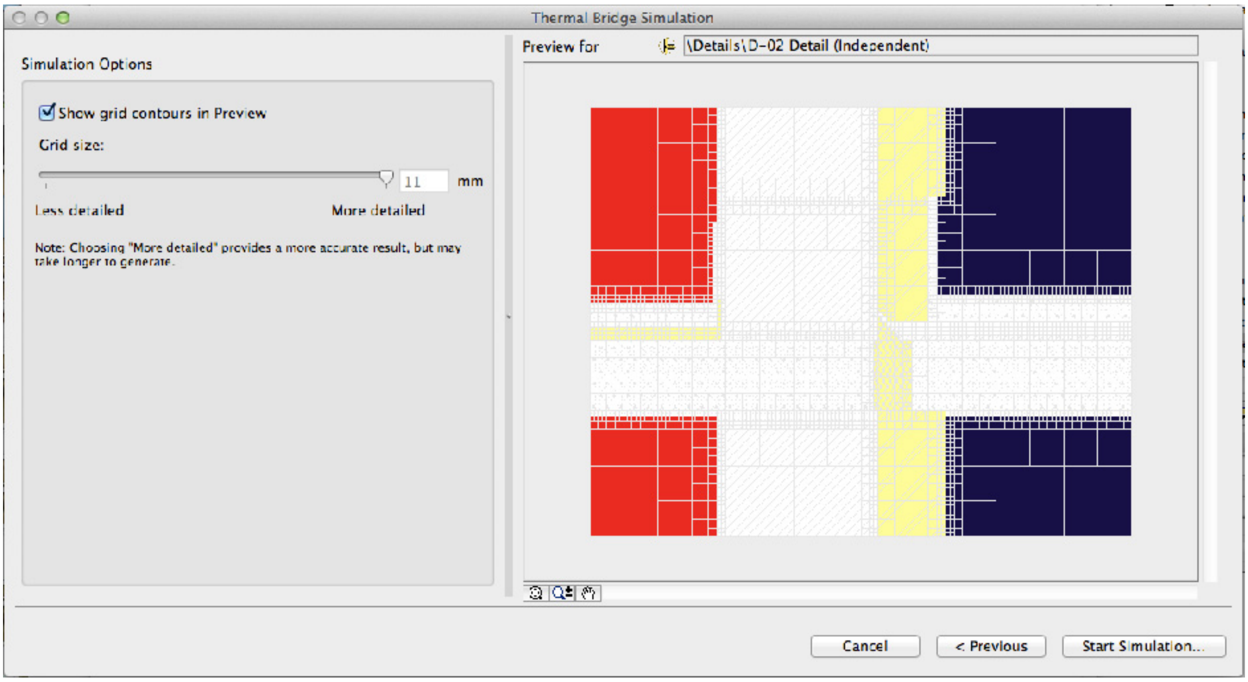


8. On the third page (Boundary Condition – Soil)
   - Click on the part of the preview that represents the soil area of the detail. If there is no soil area in this detail, you can skip this page.
   - Soil type: this value is derived from Environment Settings. Click Change to access Environmental Settings and choose a different Soil type, with its associated thermal properties (shown below)
9. The next page shows you a summary of the materials used in the selected detail. (You can also assign thermal property assignments to any structures that still need it.)



10. On the final page, choose preferred options for the Thermal Bridge Simulation:

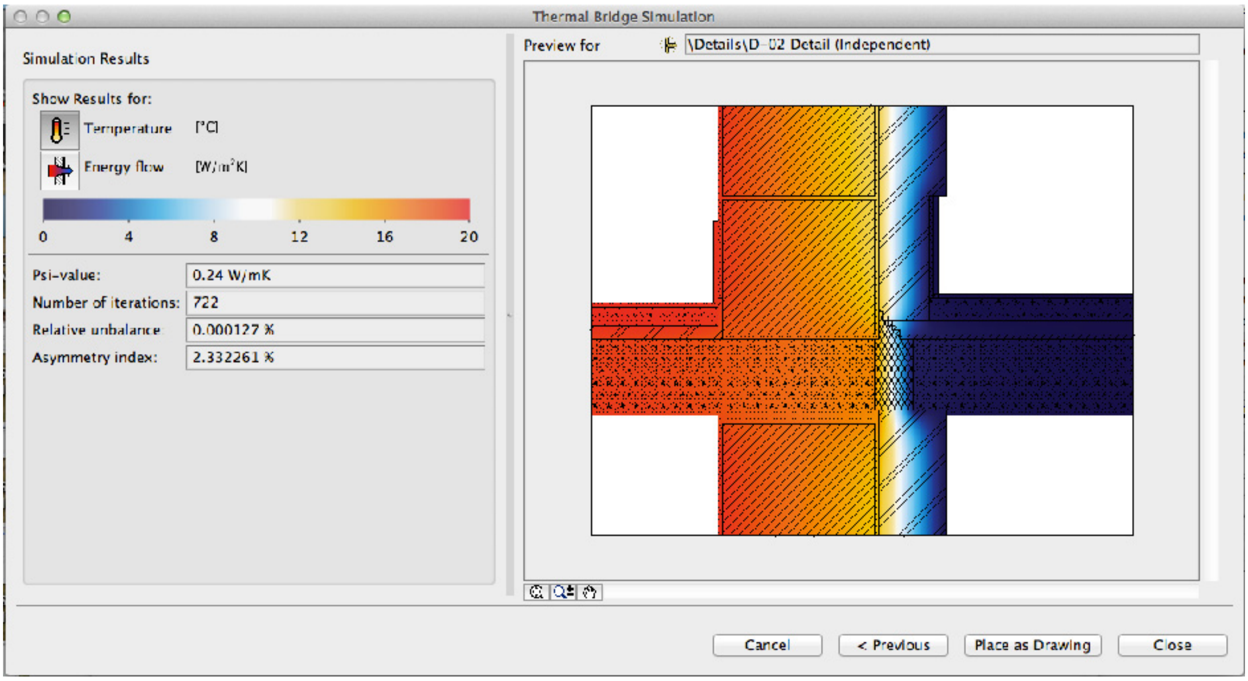
- The Grid size influences the accuracy of the simulation. “More detailed” creates a more accurate simulation, but takes longer to generate.

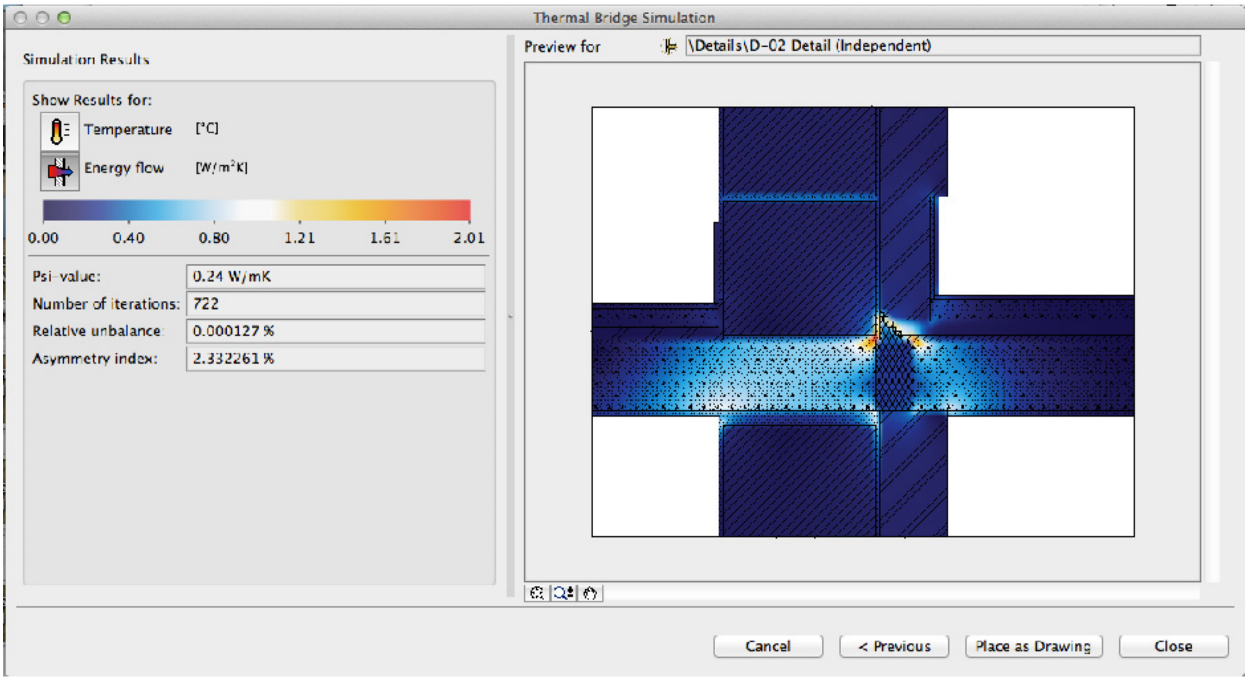


- Click “Start Simulation”.

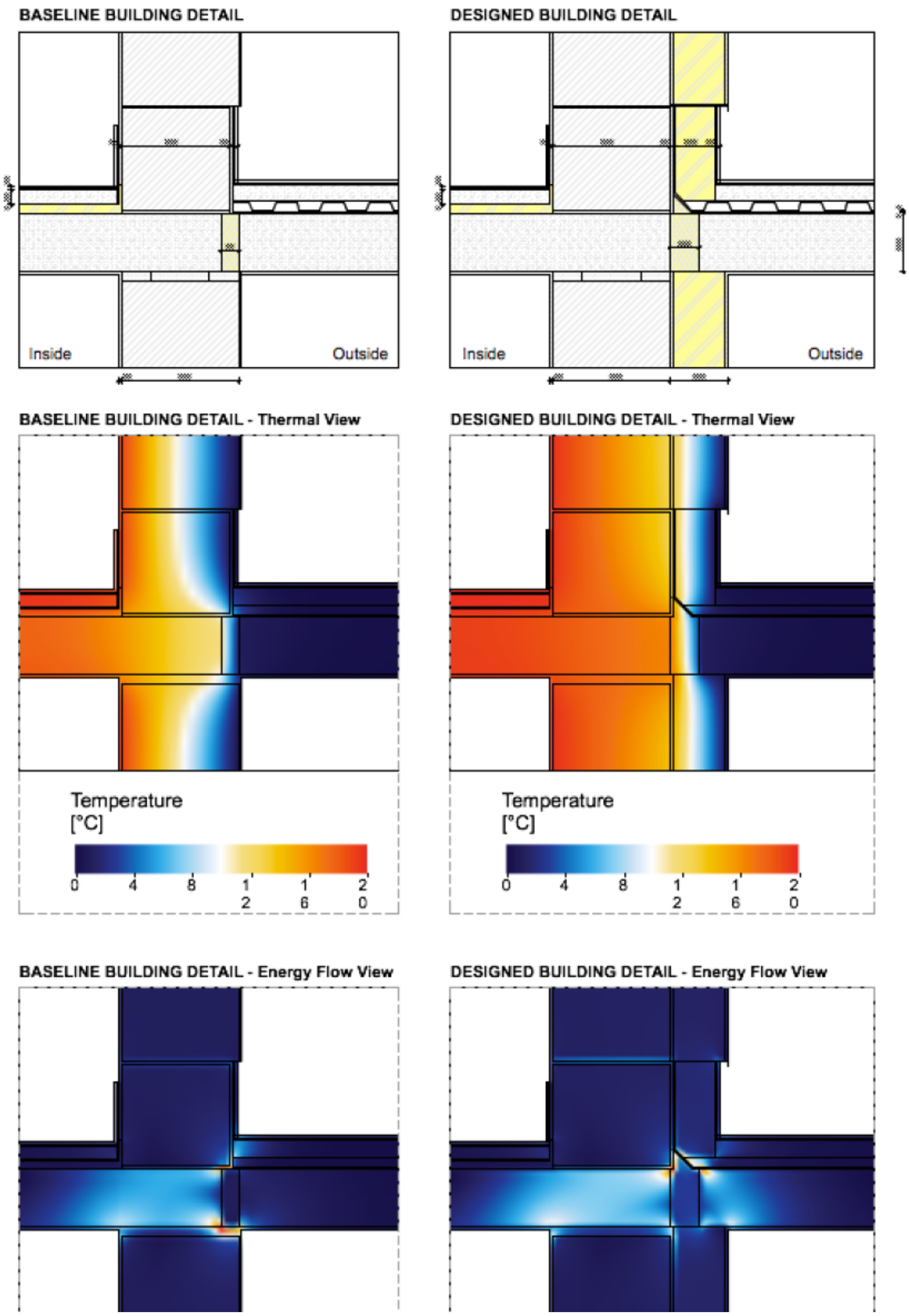
11. Thermal bridge simulation results are available in both graphical and numeric form (Psi-value).

- Click on the “Temperature” or the “Energy Flow” buttons to toggle between these two types of results.



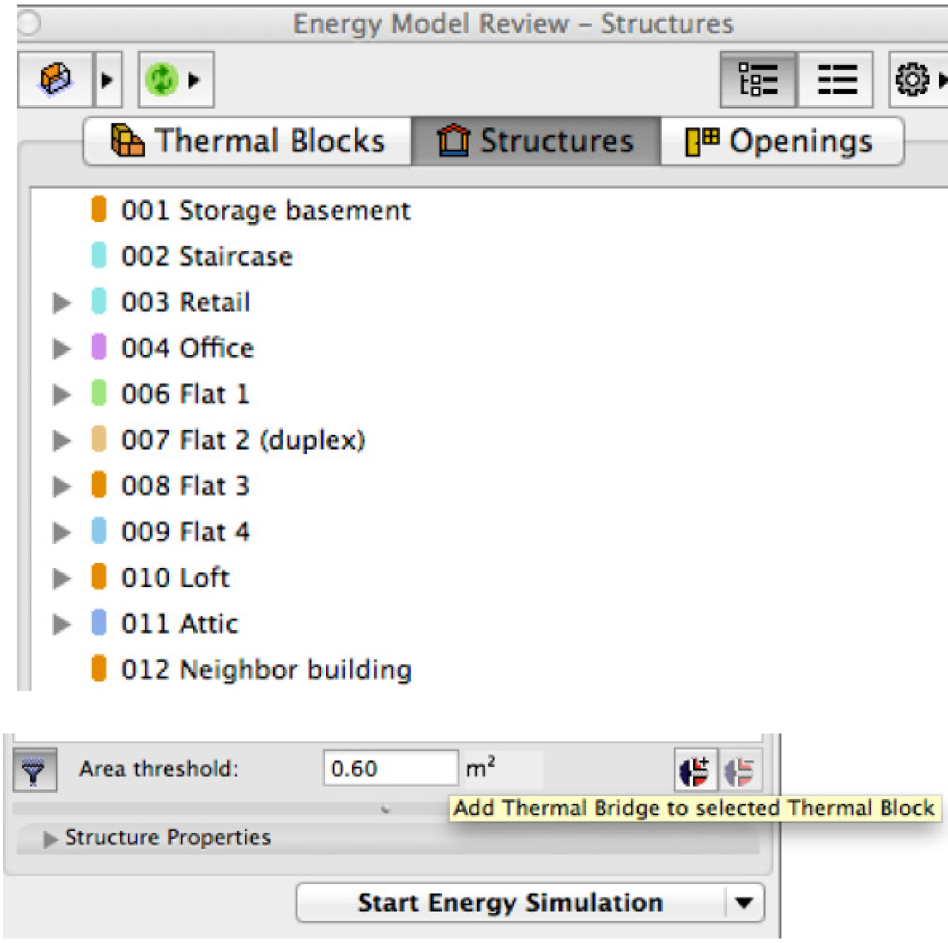


12. Optionally, you can place this graphic as a Drawing onto the detail, so it becomes part of the project documentation. (Note that this placed drawing contained both Temp and Energy Flow information via Drawing layers).



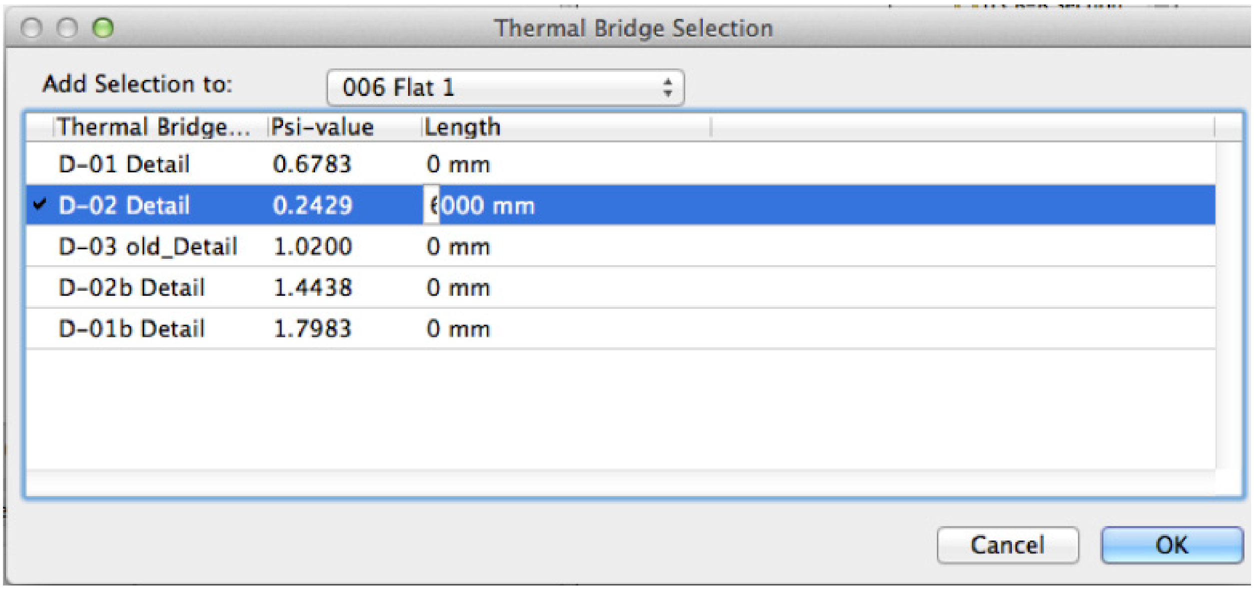
13. If you want the hourly building energy simulation to take your thermal bridge calculation(s) into account, you must add the thermal bridges to the list of Structures in the Model Review Palette:

- On the Structures tab page, click the Add Thermal Bridge icon.

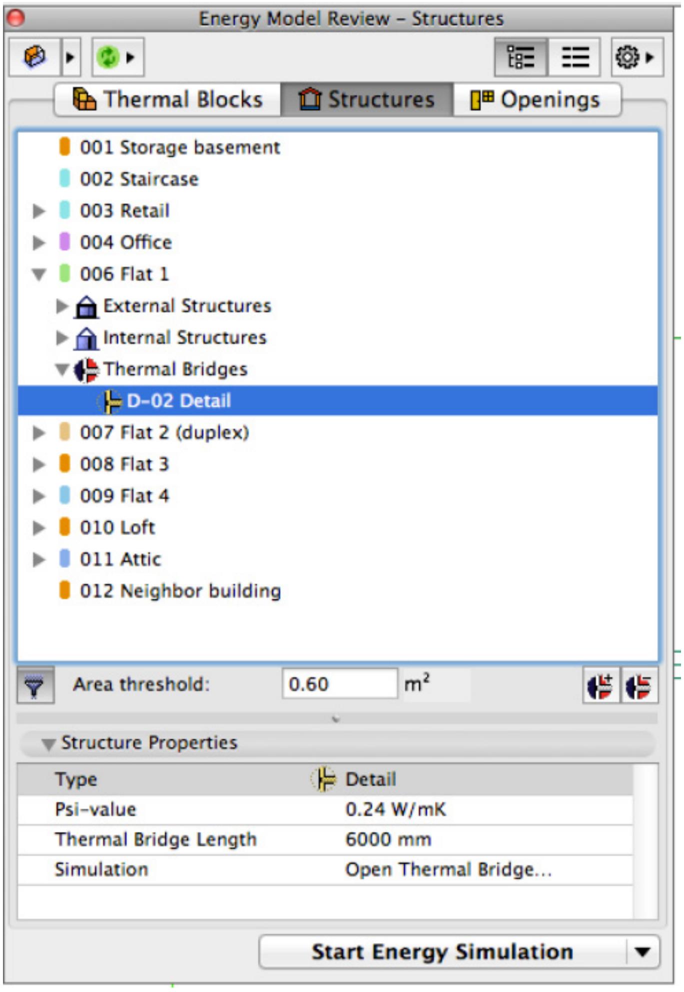


- In the appearing dialog box
  - choose the target Thermal Block from the drop-down menu
  - choose the Thermal Bridge name

- enter a length



- Click OK. The selected Thermal Bridge is now added to the selected Thermal Block.



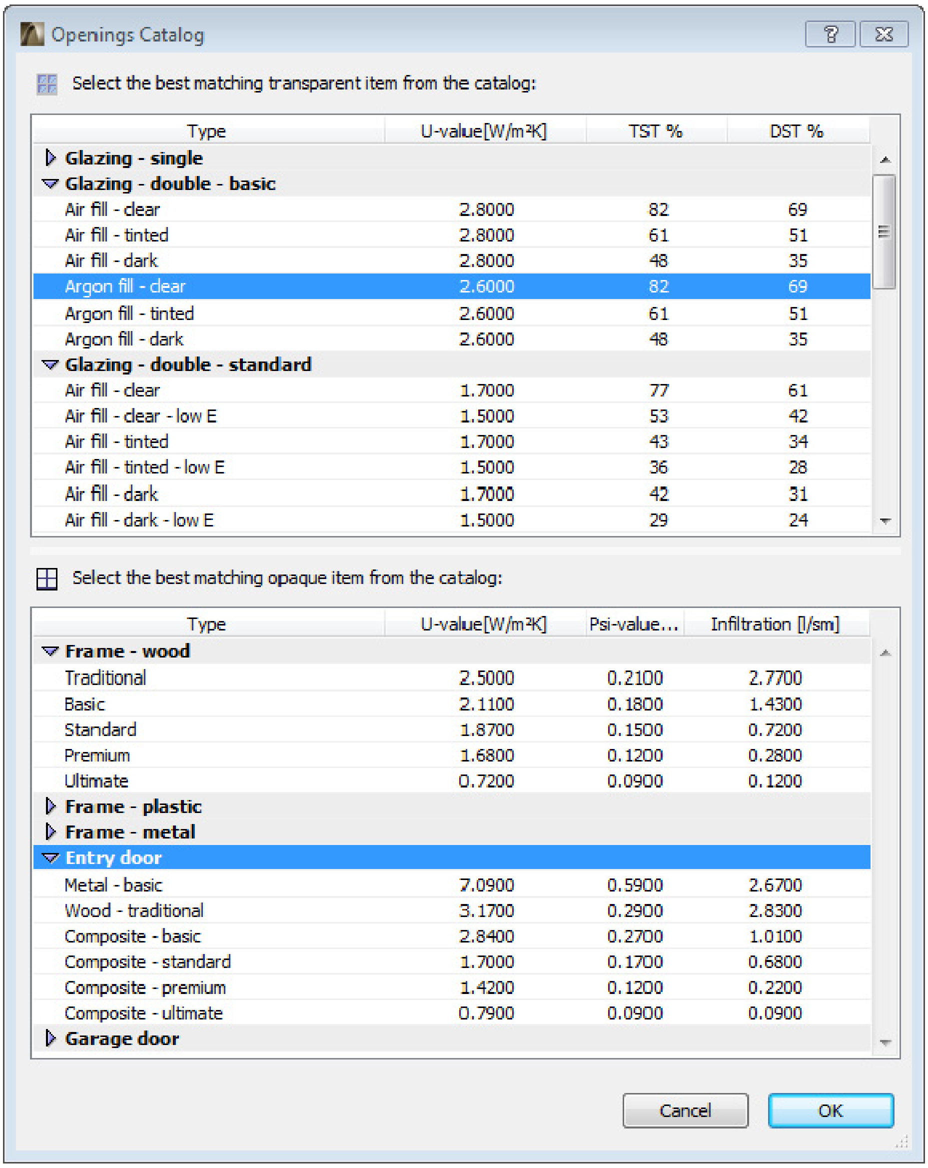
5.4 Opening Property Settings

The Openings tab page of the Model Review dialog box lists data for all of the Openings on the building shell and on internal thermal block boundaries.

To change the physical properties of the selected Openings List item, either edit the values manually, or use the predefined value sets from the Openings Catalog.

5.4.1 Openings Catalog

To access the Openings catalog, select an item on the Openings tab page and right-click to bring up the context menu:

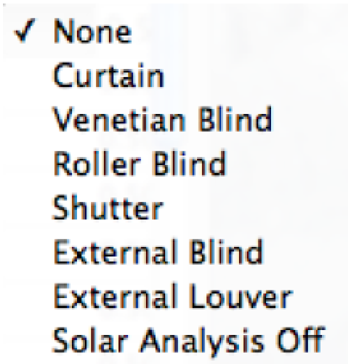


The Openings Catalog is an extensive database of building physics information relevant for the energy calculations. Transparent and opaque components of Openings are listed separately:

- Transparent items are listed with their U-values, Total Solar Transmissions and Direct Solar Transmissions;
- Opaque items are listed with their U-values, Psi-values (the linear thermal transmittance coefficient in W/m,K that are used to factor in the effect of the thermal bridges that occur at the frame-to-wall joint around Openings) and linear Infiltration properties.

5.4.2 Shading Devices

Click the arrow on the Shading Device item to apply a shading device, with its predefined physical properties, to the selected entry.

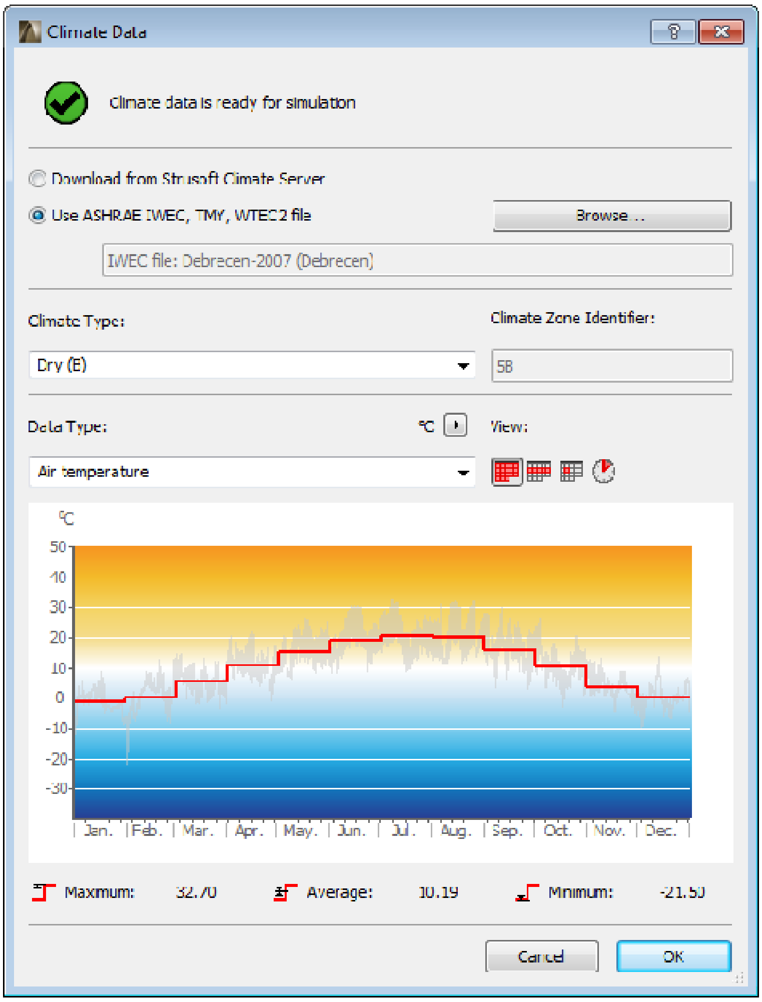


There are two types of Shading Devices on the list:

- Devices whose shading effect is additional to the effect of the model-based Solar Analysis (None, Curtain, Venetian Blind, Roller Blind, Shutter, External Blind, External Louver);
- Devices that disable the effect of model-based Solar Analysis (Canopy, Canopy And Side-Fins, Solar Analysis Off). These settings are mostly used for analytic (scientific) software functionality tests. Users are advised to use Shading Devices from the previous group on architectural projects.

5.5 Climate Data

Open this dialog box from the Model Review Palette's pop-up at the top right; or from **Design > Energy Evaluation > Climate Data**; or from the Environment Settings dialog box.



5.5.1 Climate Data Source

Choose an option for the source of the climate data to be used for EcoDesigner STAR.

- Download from StruSoft Climate Server: With this option, climate data are obtained from the StruSoft climate website, at *http://climate.vipenergy.se*.
  All StruSoft climate data are created from NCEP Reanalysis data provided by the NOAA-CIRES Climate Diagnostics Center, Boulder, Colorado, USA, from their website at *http://www.cdc.noaa.gov/*.

- Use ASHRAE IWEC, TMY, WTEC2 file: Click Browse to select and import data from analytic weather files obtained from an external source (from open source e.g. http://apps1.eere.energy.gov/buildings/energyplus/cfm/weather_data.cfm, or purchased)

  Note: Use analytic ("ideal year") weather data whenever possible, as it usually represents a given location's climate better than climate data recorded in any particular year.

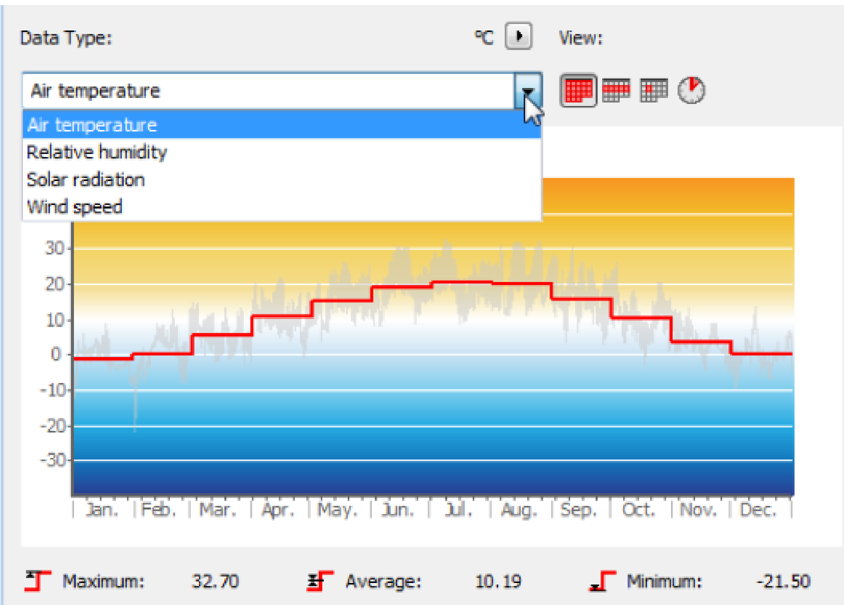
Once the weather data are assigned to a certain project, they are stored in the ArchiCAD Cache Library, so the data remain available when opening another ArchiCAD project later, even if the computer is not online.

5.5.2 Climate Type

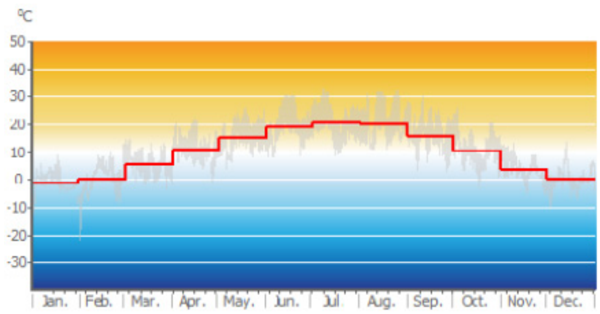
It is possible to assign a Climate Type that best describes that of the building location: Moist, Dry or Marine. This classification is necessary for compliance with certain North American Building Energy Efficiency Calculation Standards, but it has no effect on the calculation result.

5.5.3 View Climate Data

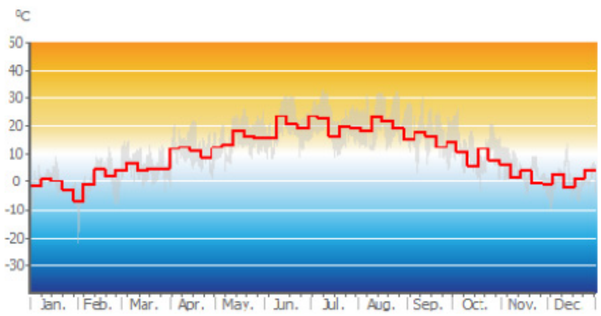
The chart below graphically illustrates climate fluctuation over the course of one year. Choose the climate data type that you want to see in the chart: either Air Temperature, Relative humidity, Solar radiation or Wind speed.



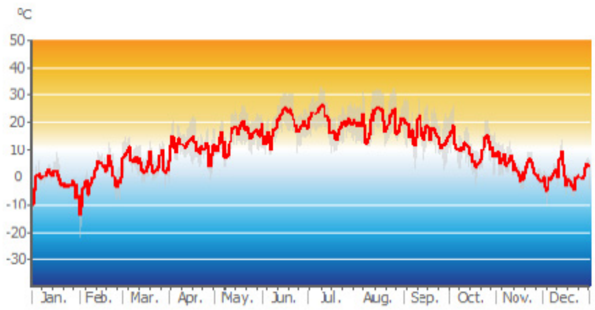
Use the four icons at right to choose the level of detail you want to view: by month, day, week or hour.



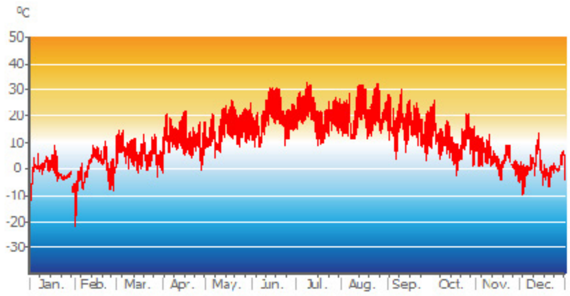
Air Temp monthly



Air Temp weekly



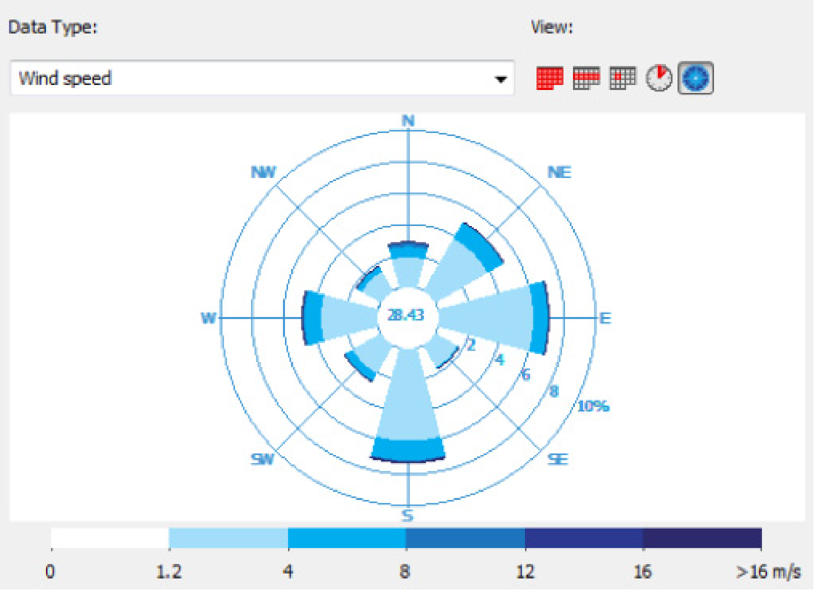
Air Temp daily



Air Temp hourly

Below the graph, the maximum, average and minimum values for the chosen climate data type are listed.

If Wind speed is selected as visualized climate data type, an additional icon is also available, which displays the wind data in wind-rose form.



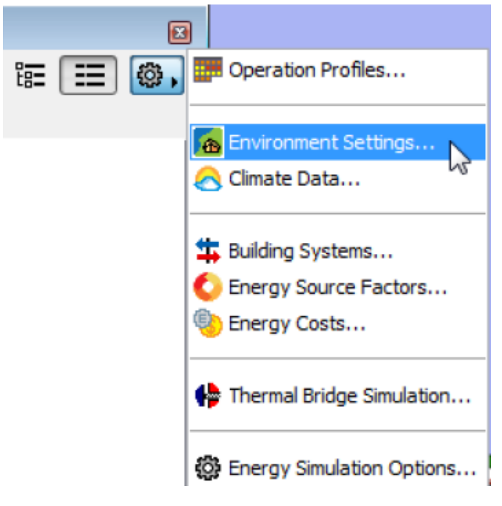
The polar diagram represents the 8 main directions. The length of each segment represents how often (as a percentage, over the course of a year) the wind blows from the given direction.

Each color within a segment represents a wind speed range (as a percentage of the total wind from that direction), in accordance with the color scheme below.

The value at the center of the wind-rose (the white area) represents the percentage of time that the wind is nonexistent or negligible.

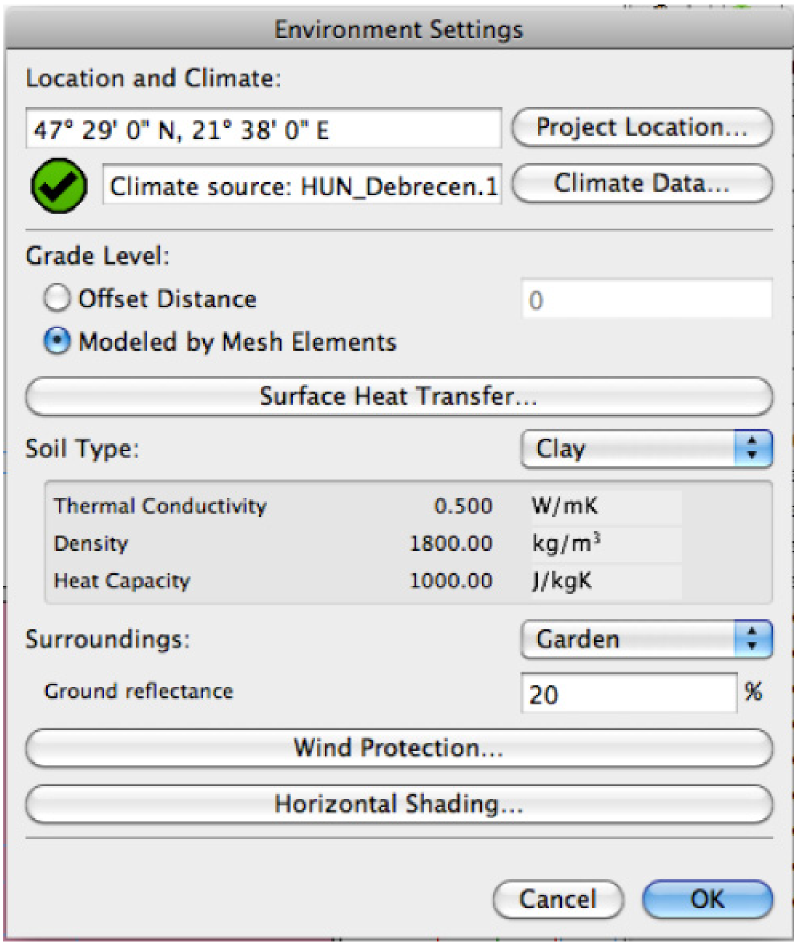
5.6 Environment Settings

Open this dialog box from the Model Review Palette's pop-up at the top right; or from **Design > Energy Evaluation > Environment Settings**.



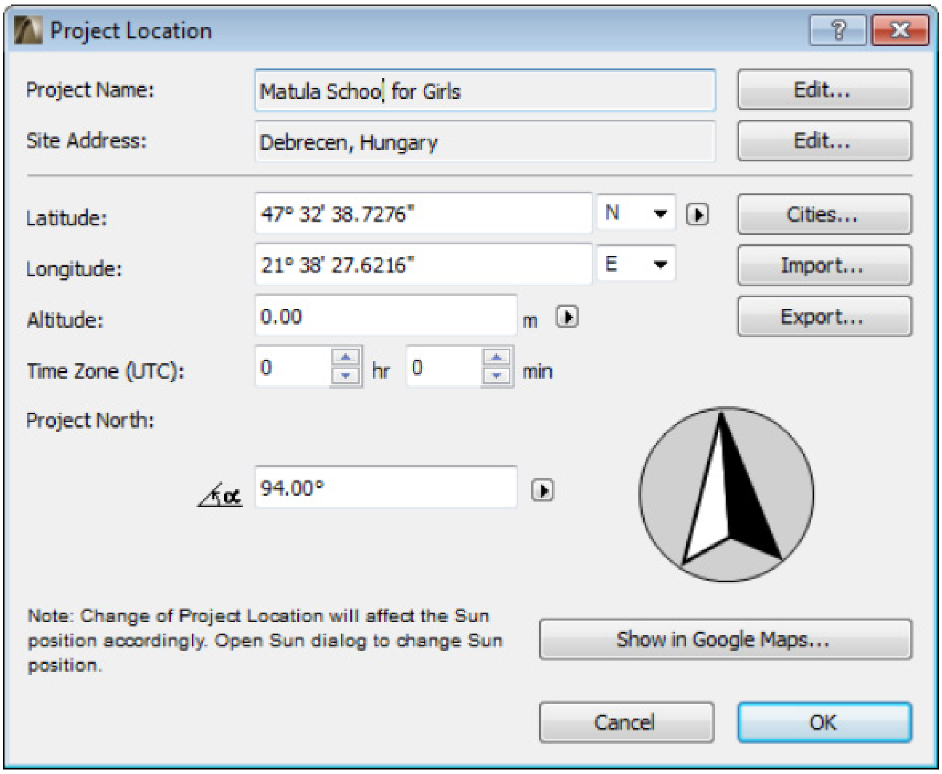
The Environment Settings dialog contains:

- Settings: Location and Climate, Grade Level, Soil Type, Surroundings
- Links to other dialogs: Project Location, Climate Data, Surface Heat Transfer, Wind Protection, Horizontal Shading



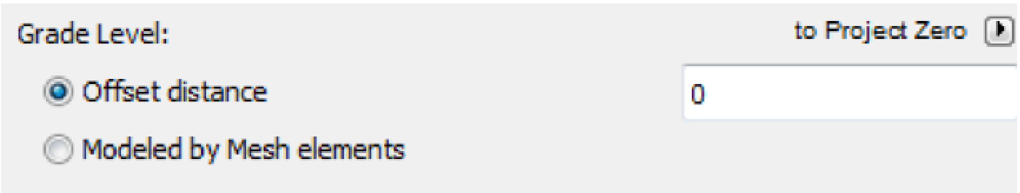
5.6.1 Project Location

EcoDesigner STAR considers the geographic location of your building when obtaining Climate Data from the StruSoft Climate Server. Use the Project Location button on the Environment Settings panel to access the Project Location dialog of ArchiCAD.



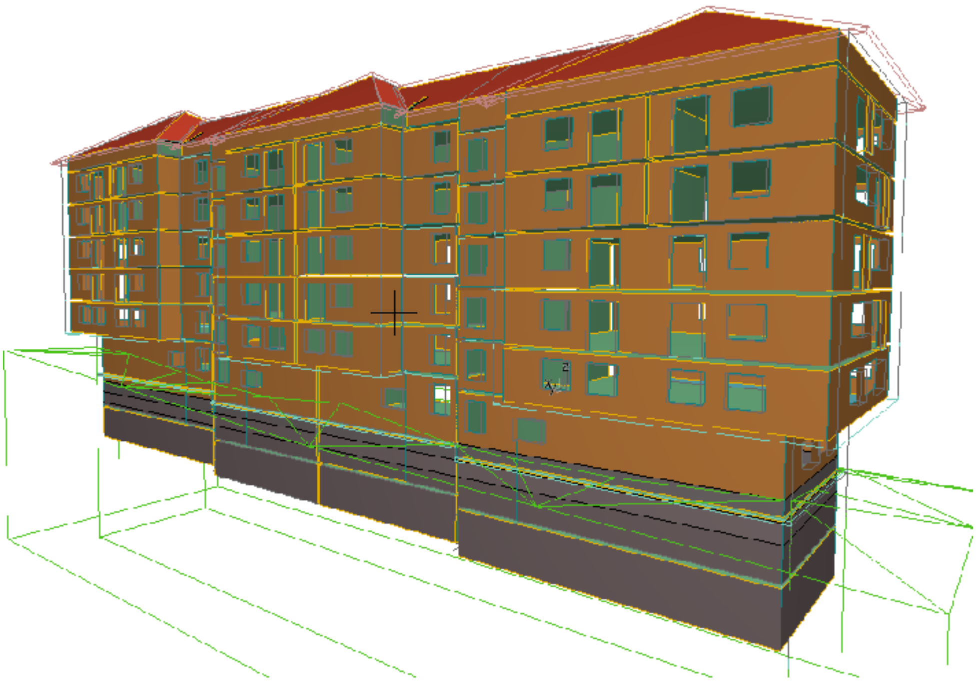
5.6.2 Grade Level

This control is in the Environment Settings dialog box.

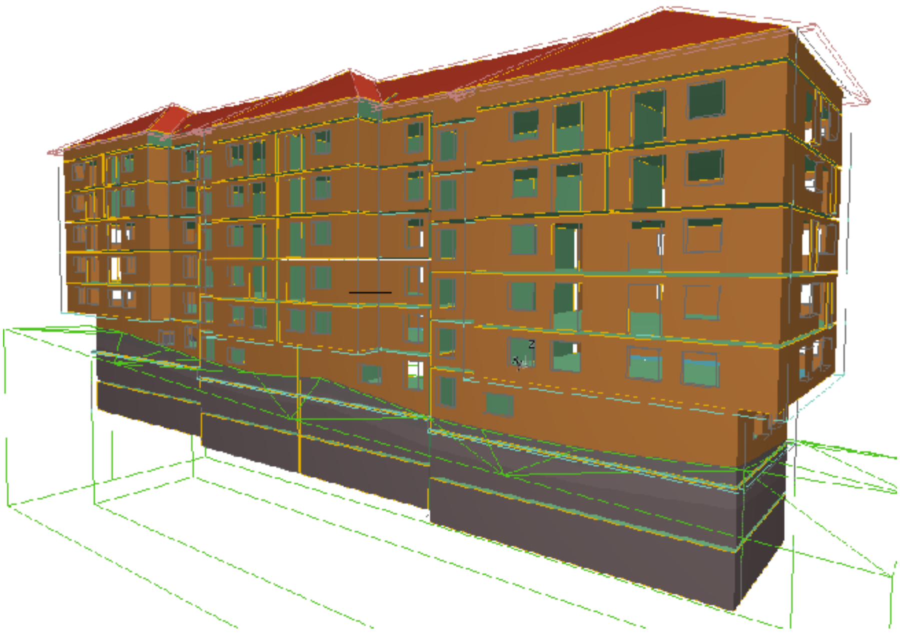


The connection of the ground with the building can be modeled in two ways in ArchiCAD for EcoDesigner STAR:

- Offset distance: the distance by which the pavement is offset from either Project Zero or a predefined Reference level.



- Modeled by Mesh elements: use the Mesh tool to model the site around the building, if it is not completely level, for better energy modeling accuracy of structures in contact with the ground.



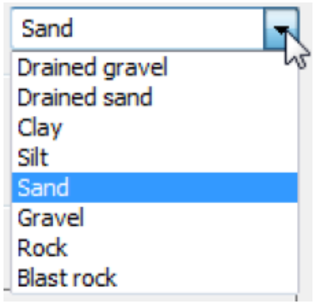
5.6.3 Surface Heat Transfer

This dialog is used to define Internal and External combined heat transfer coefficients for all opaque structures in the project. While the surface coefficients entered on the U-Value Calculator influence only the stationary thermal performance calculations on the level of individual structures, the global settings on the Surface Heat Transfer panel are used for the dynamic energy balance simulation.

Users are advised to change the default global surface coefficient values only if local standards specifically require the use of other values.

5.6.4 Soil Type

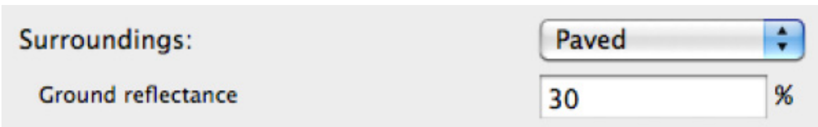
From the pop-up, choose the option that most closely describes the soil type of the building location. This setting serves as the basis for calculating heat flow through structures in contact with the ground.



The applicable Thermal Conductivity, Density and Heat Capacity values are then displayed below your chosen soil type.

5.6.5 Surroundings

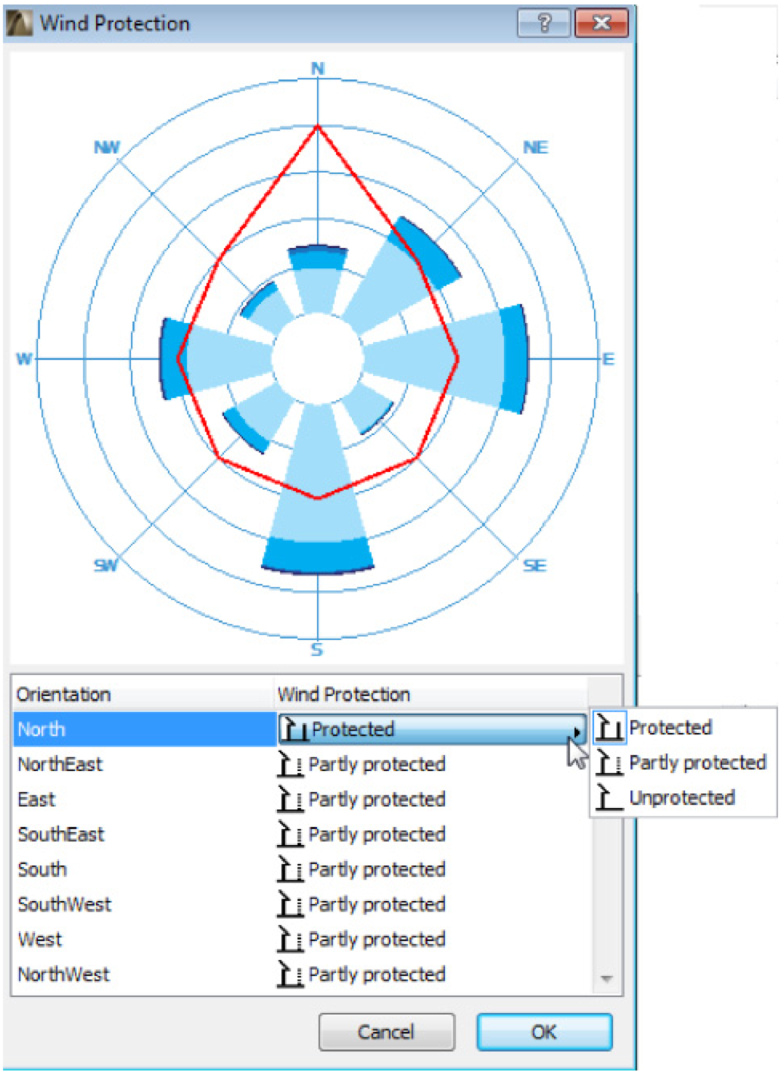
Choose the Surroundings option that best describes the environment of your building: Waterfront, Garden, Paved or Custom.



This setting is used when calculating the effect of indirect solar irradiation.

5.6.6 Wind Protection

From the Environment Settings dialog box, click Wind Protection to open the dialog box of the same name.



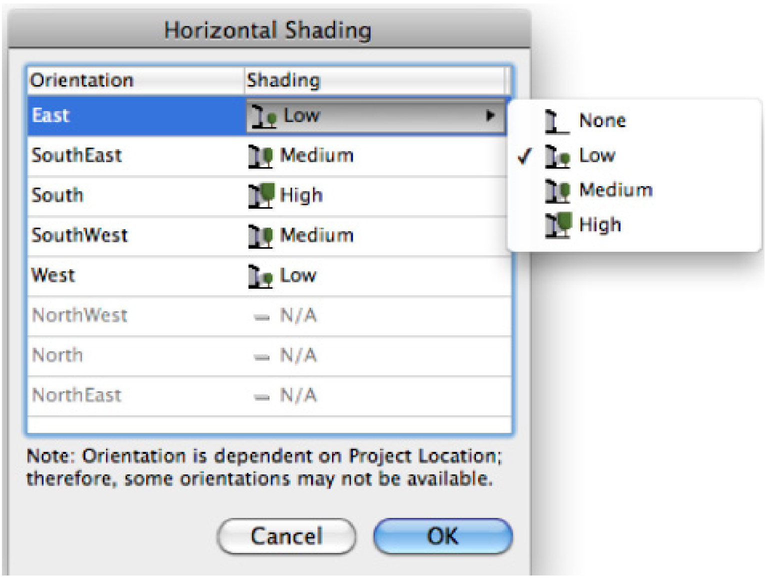
The polar diagram represents the 8 main directions. The length of each segment represents how often (as a percentage, over the course of a year) the wind blows from the given direction, and how fast.

Here, for each orientation of the building, choose the appropriate Wind Protection level: Protected, Partly Protected or Unprotected. For each orientation, a point is placed on the graph representing wind protection (the further out the point, the higher the protection factor), and the points are connected by a red line.

5.6.7 External Shading

The model-based Solar Analysis function of EcoDesigner STAR in ArchiCAD only works on the transparent elements of the building shell. However, it does not automatically determine the extent to which shadows are cast by external objects on the opaque elements of the building envelope.

Use the External Shadings button to activate a separate dialog with a list of those sides of the building that receive the sunlight (the list of Orientations can vary depending on project location).



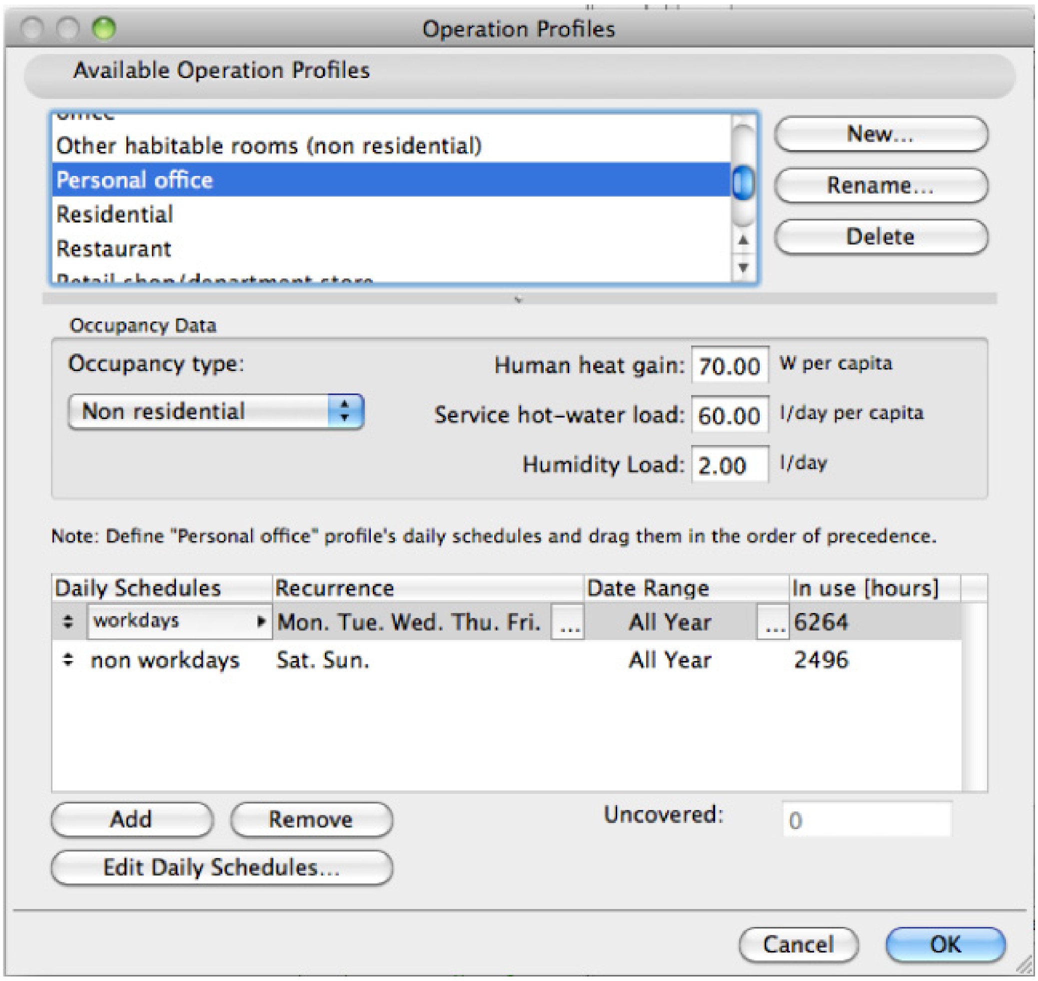
For each orientation, choose the options that best describe the amount of shading resulting from external objects (select an option - Not shaded, Slightly shaded, Shaded or Very shaded).

> **Note:** The effect of shadows cast on each elevation of the building, by the building itself, can be set via the Vertical and Horizontal Shading settings of the Openings List.

It is possible to edit multiple entries of the Façade Shadings list: select an entry that needs to be modified, and then add further entries to the selection by moving the pointer with the mouse without releasing the left mouse button, or by clicking on the entries while pressing the CTRL or the SHIFT key. Finally, use the function buttons that appear by the first selected line to define Façade shading properties for the selected orientations.

5.7 Operation Profiles

Open this dialog box from the Model Review Palette's pop-up at the top right, from **Design > Energy Evaluation > Operation Profile**, or with the **Options > Element Attributes > Operation Profiles** command.



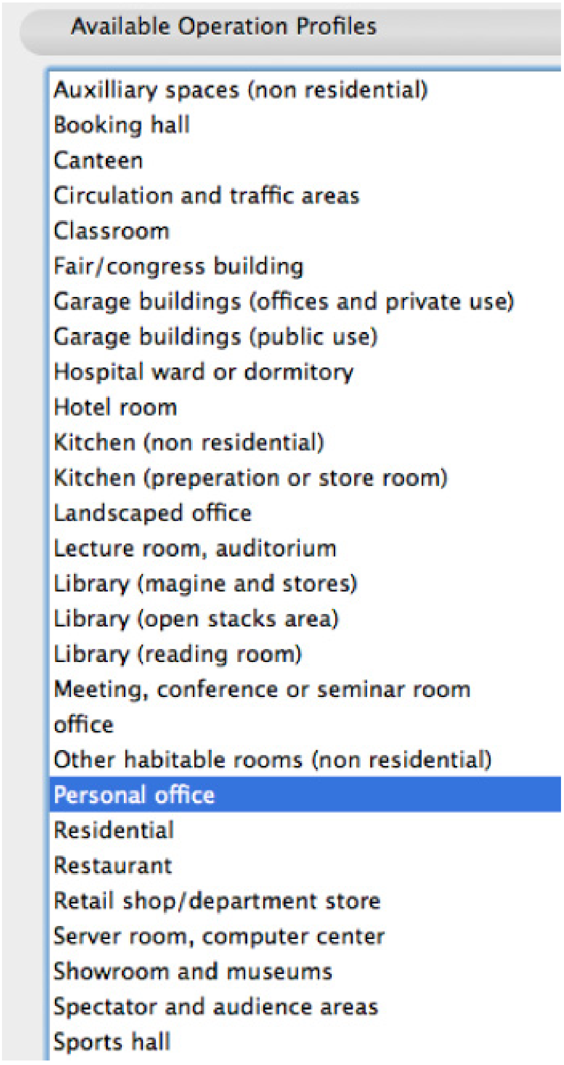
The Operation Profile is an ArchiCAD attribute. A separate Operation Profile can be assigned to each Thermal Block.

Each Operation Profile is associated with a daily schedule comprising the following data, by hour, for a full year (8760 hours total):

- Required Internal temperature range
- Human heat gain
- Hot water needs
- Humidity loads

5.7.1 Available Operation Profiles

Pick the operation profile that best fits the selected thermal block's function from the list of available defaults. These default values reflect the Operation Profile specifications of the DIN 18599 Standard - Energy Efficiency of Buildings.



It is also possible to create custom Operation Profiles with the EcoDesigner STAR function within ArchiCAD, and to add them to the list of Available Operation Profiles. You can also edit them as needed, by changing the values in the daily schedule list item they reference.

5.7.2 Occupancy Data

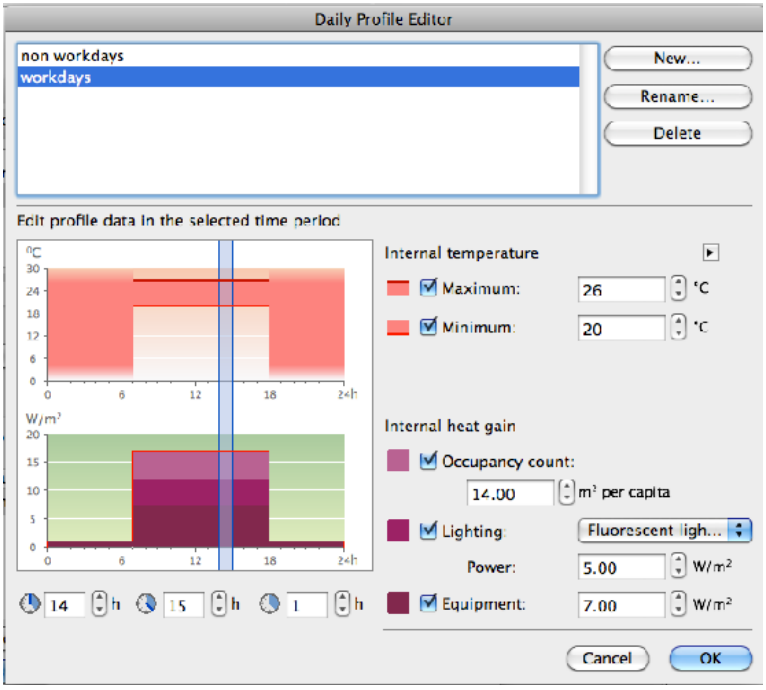
Below, view the Occupancy Data of the selected Operation Profile.

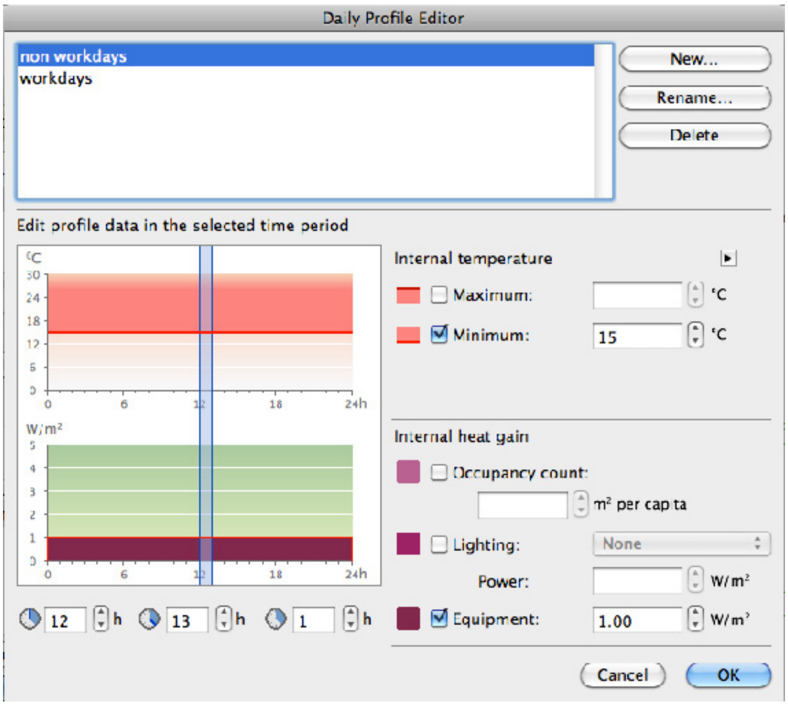
Change any of these values if needed to better reflect the thermal block's function.

- Occupancy type: either Residential or Non-residential
- Human heat gain: the amount of heat produced by the human bodies in the building (W/ capita)
- Service hot-water load: amount of hot water necessary per person, as associated to the selected building function (l/day, per capita)
- Humidity Load: the amount of water vapor that gets into the internal air as a result of the building's operation (l/day)

5.7.3 Daily Profile Editor

Select “Edit Daily Schedules” to open the Daily Profile Editor. This dialog displays two daily occupation profile graphs with corresponding key values to the right of each graph. These controls are used to specify the required Internal temperature range as well as Occupancy count, Lighting power density (LPD, in W/m2) and Equipment power density (LPD, in W/m2), which will drive the Internal heat gains.





Theoretically, it is possible to define different operation conditions for each hour of the reference year with the Daily Profile Editor.

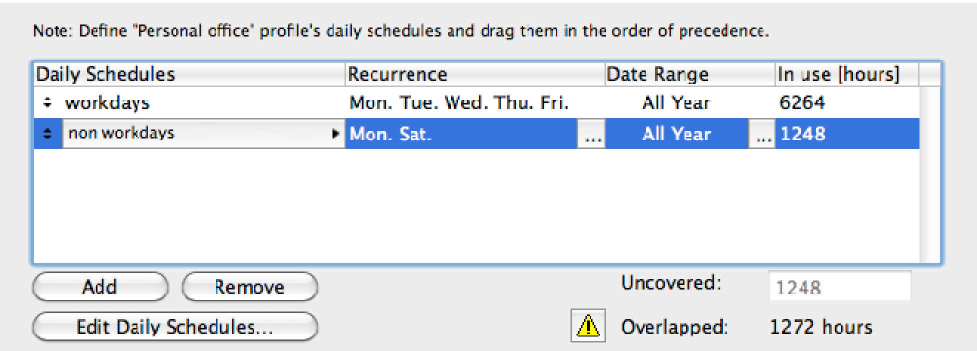
Internal temperature: Set the hourly allowed internal air temperature range (maximum and/or minimum) during the day.

Internal heat gain: Define the factors that result in energy emission (internal heat gain) during the day, per m2 of internal floor area (W/m2).

- **Occupancy count:** Refer to local regulations to enter a value that describes the density of human occupation for the selected operation.
- **Lighting:** Check the Lighting box, then select a lighting type from the dropdown list. The default Power value for the selected Interior Lighting type appears in the Power field. You can fine-tune this value manually if the lighting design of the project is available at the time of the evaluation.
- **Equipment:** Refer to local regulations to enter a value that describes the density of appliances (E.g.: TVs, Computers, servers) for the selected operation.

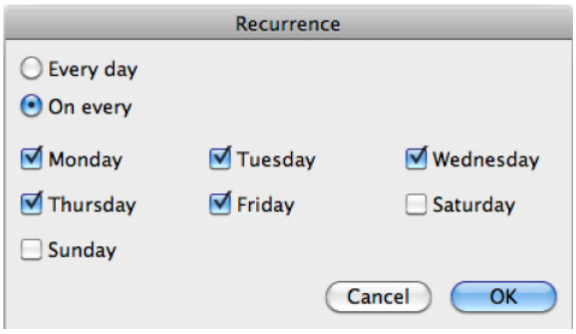
5.7.4 Yearly Operation Scheduler

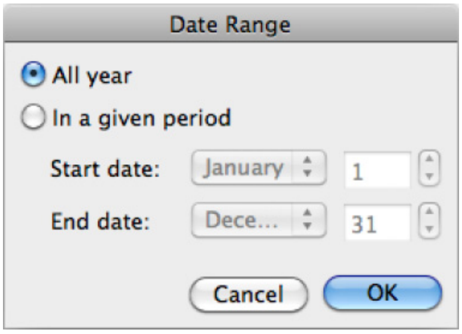
Since these data will vary by day of the week and over the course of the year, the Operation Profile consists of any number of daily schedules, which correspond to specific date ranges and days of the week.



For each daily schedule, you can define the following characteristics:

- Recurrence: days of the week when the particular schedule is in effect
- Date Range: periods of the simulation year during which the schedule occurs





Recurrence and Date Range define the In use hours (the total number of hours during which the selected Daily Schedule is in effect).

If the Uncovered hours counter on the bottom right corner of the Yearly Operation Scheduler shows any number but 0, it means that further modifications in Recurrence and Date Range are necessary because there are some hours of the reference year without operation schedule assigned to them.

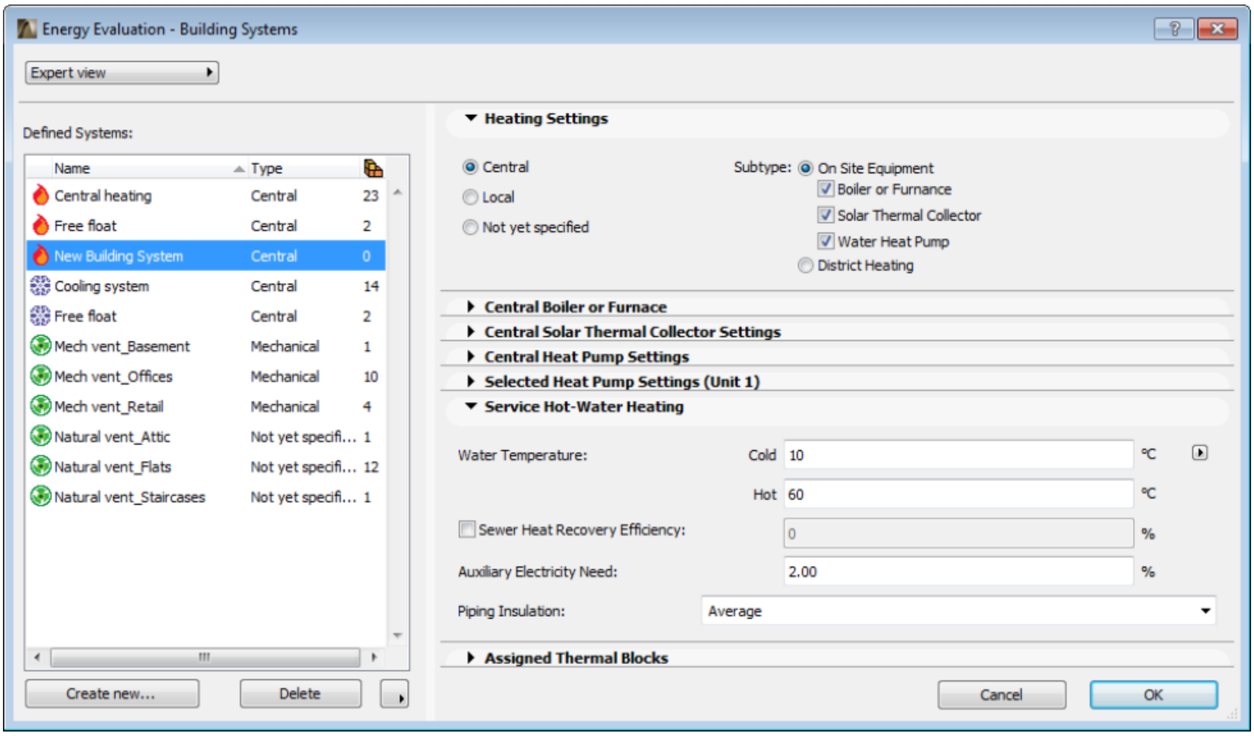
If the Overlapped hours counter on the bottom right corner of the Yearly Operation Scheduler shows any number except 0, it means that further modifications in Recurrence and Date Range are necessary because there are some hours of the reference year with more than one operation schedules assigned to them.

5.8 Building Systems

Use this dialog box to define Building Systems settings that will maintain the internal comfort conditions (as specified by the Operation Profiles dialog) for the thermal blocks of your building model. Use the Building Systems dialog to edit the properties of existing building systems, to create new ones and to assign them to thermal blocks.

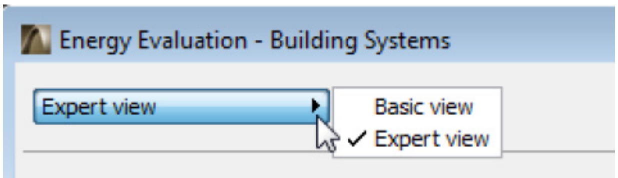
You can define as many Building Systems (whether Heating, Cooling, Ventilation, Wind Energy or Solar Photovoltaic systems) as you need.

Open the Building Systems dialog box from the Model Review Palette’s pop-up at the top right, from **Design** > **Energy Evaluation** > **Building Systems**, or from the Thermal Blocks page of the Energy Model Review palette.



5.8.1 Building Systems Data Options: Expert vs. Basic

In the Building Systems dialog box, choose either Expert or Basic view.

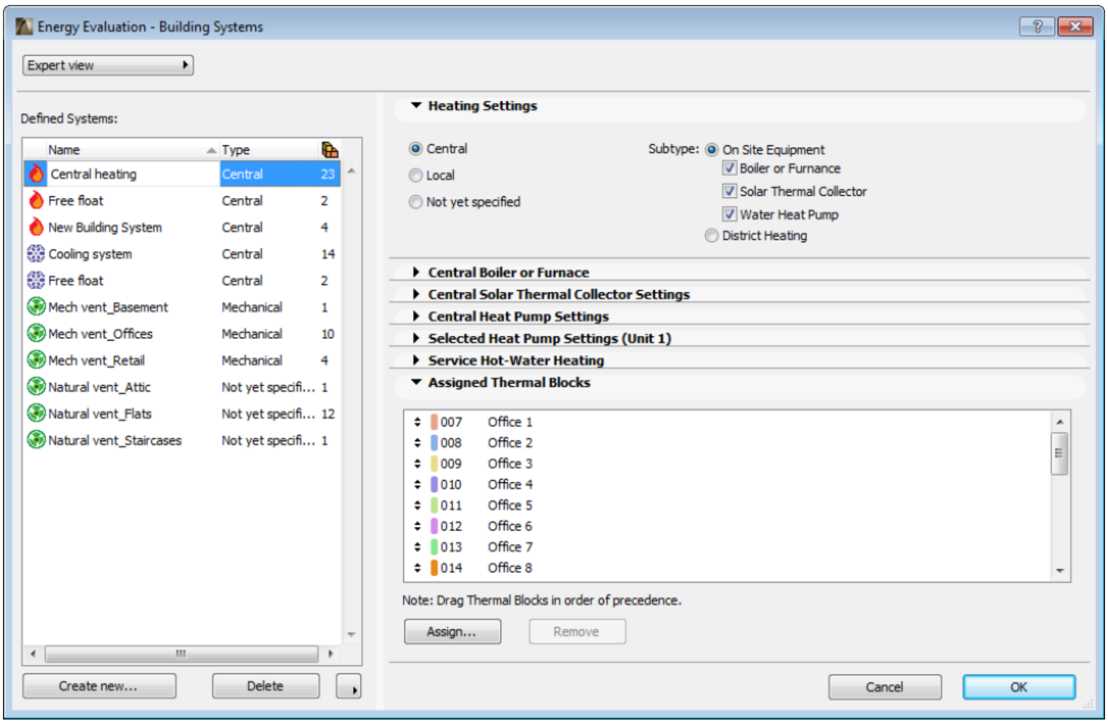


- The **Expert view** provides scope for much more detailed user data input on your project's MEP systems. Use Expert if your building has already been designed and the MEP systems documentation is available. In this case, you can expect maximum accuracy in the resulting Energy Evaluation Performance Report.
- The **Basic view** options correspond to the Building Systems dialog box in ArchiCAD's built-in Energy Evaluation feature. (*See ArchiCAD Help for information on those controls*.) Use the Basic view to perform a preliminary energy evaluation during the design phase, or if you do not have access to the MEP systems design documentation.

The Building Systems dialog box lists each Building System on the left, and the options for each on the right. The content of the building system options on the right changes depending on which system configuration is selected.

5.8.2 Assigned Thermal Blocks

In this panel, view or edit the list of thermal blocks that use the selected system.



Note: It is also possible to assign Building Systems to thermal blocks via the Thermal Blocks page of the Energy Model Review palette.

Note: Wind and Solar Photovoltaic Energy systems are independent of thermal blocks in the building and thus are not assigned.

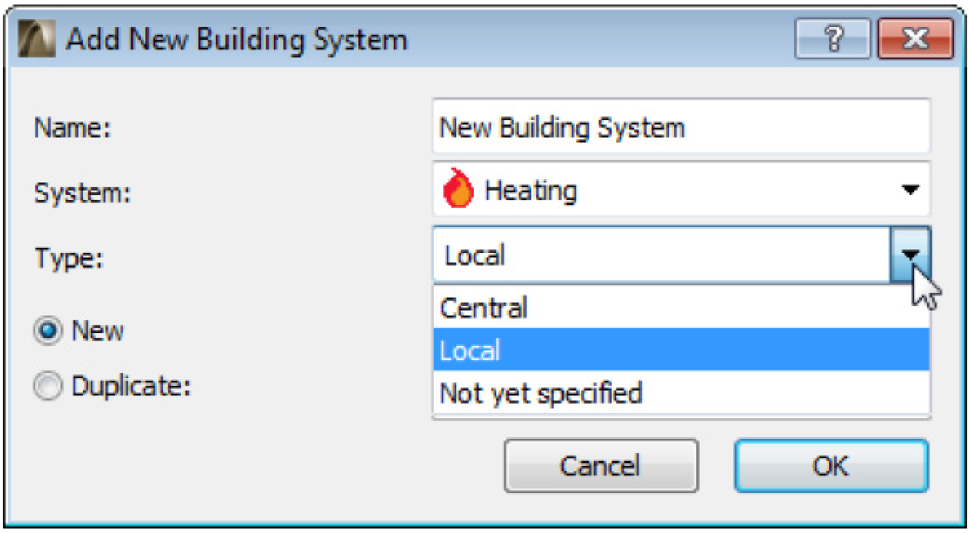
5.8.3 Create New or Duplicate Building System

At the bottom left of the Building Systems dialog box, click **Create New**.

In the appearing dialog box:

If you want a **New** system

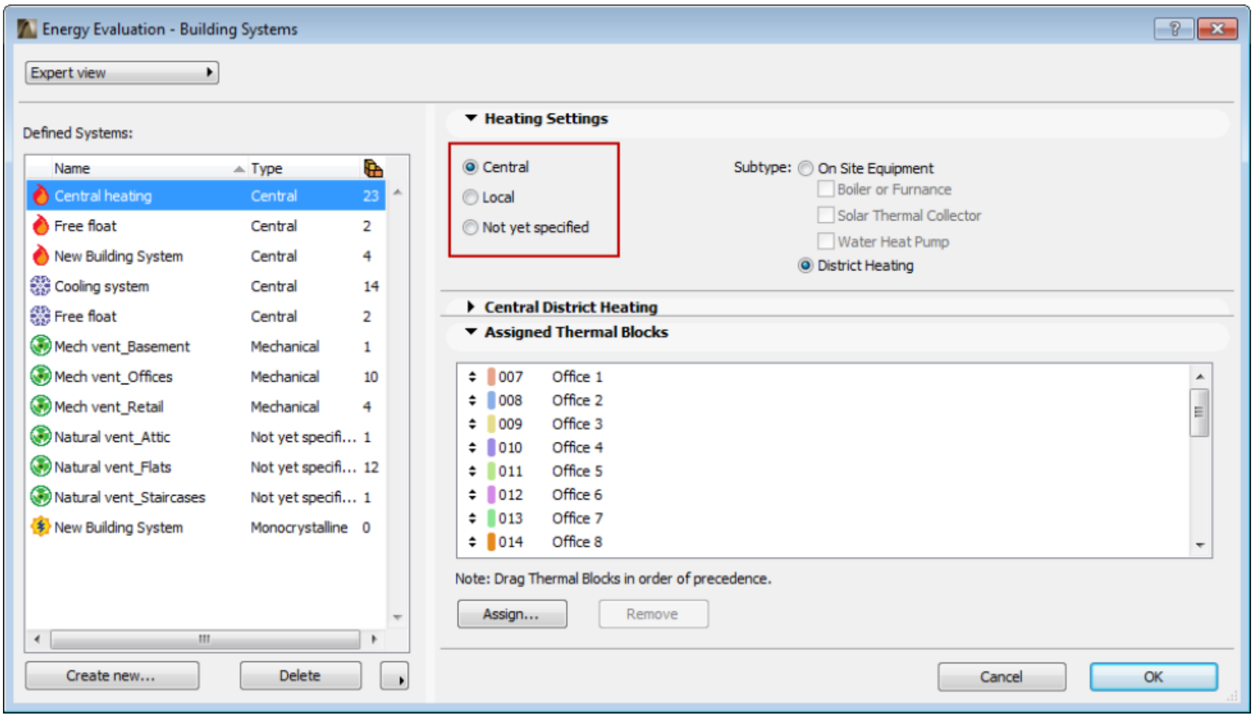
- use the System pop-up to choose the Building System – Heating, Cooling, Ventilation, Wind Energy or Solar Photovoltaic
- use the Type pop-up to define its type as applicable



Or click **Duplicate** to rename the currently selected Building System, so you can edit its settings without overwriting them. Click OK. The newly created Building System is now listed in the left side of the dialog box. Highlight it, then use the panels at right to edit its settings.

5.8.4 Heating and Service Hot-Water Heating

Choose either **Central**, **Local** or **Not yet Specified** to describe your project's Heating system.



Not Yet Specified

Choose this option for Thermal Blocks that are to be heated, but you do not yet know which type of system will be used.

For such thermal blocks, the energy simulation will take into account the substitution values defined by the ASHRAE 90.1 standard.

If you use Central Heating

A Central Heating system means that it is assigned (that is, provides heating) to more than one Thermal Blocks.

Choose a **subtype** to correspond to your system: either **On Site Equipment** or **District Heating**.

- **District heating** means that the evaluated building's heating and/or hot water needs are supplied by an external plant in the form of hot water or steam through a pipeline.
- **On Site Equipment** means that heating/hot water needs are provided by one or more of the following devices on site (choose all that apply):
    - Boiler or Furnace
    - Solar Thermal Collector
    - Water Heat Pump

If you use Local Heating

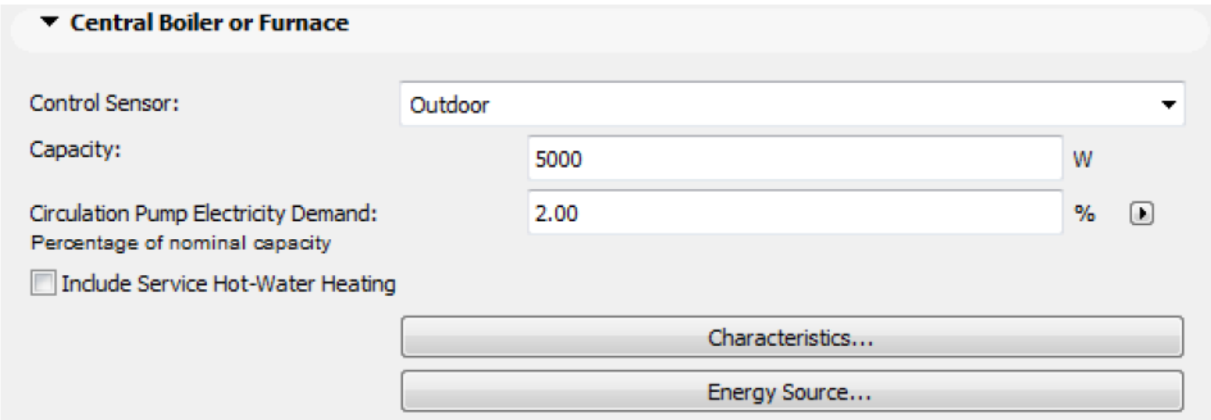
Choose a subtype to correspond to your system: either **Water-circulating** or **Direct Expansion (DX)**.

- **Water-circulating** means that the local equipment circulates heated water to the assigned thermal block(s), using one or more of the following devices on site (choose all that apply):
  - Boiler or Furnace
  - Solar Thermal Collector
  - Water Heat Pump
- **Direct Expansion (DX):** In a direct expansion heating system, the working fluid from the heat pump's outdoor evaporator circulates in the internal condenser as a heat transfer medium and condenses there. This direct expansion does not require an intermediate heat exchanger, in contrast to water-based systems that rely on a circulating pump to move water through a pipe.

Each option's settings are located on the corresponding dialog box panels below.

Boiler or Furnace

This panel is available if you have checked Boiler or Furnace as one of the subtypes used by either a Local or Central heating system.



- **Control Sensor:** Input the type of sensor used to gauge temperature (either indoor or outdoor) and thereby control the heating system. If your system has both, choose "Outdoor."
- **Capacity:** Enter your system's nominal heating capacity.
- **Circulation Pump Electricity Demand:** Enter how much electricity the circulation pump requires, either as a percentage of the nominal heating capacity or measured in watts. (Click the arrow to choose a unit.)

Specify whether to **Include Service Hot-water Heating** (that is, whether the central heating unit also provides service hot water**).** If you check this box, the additional Service Hot-Water Heating tab page appears in the dialog box. *(See below.*)

The Heating System Characteristics dialog box (click **Characteristics**…) is a temperature graph. Use it to set the allowable temperature range for your heating system's Supply and Return Temperatures in relation to the external air temperature.

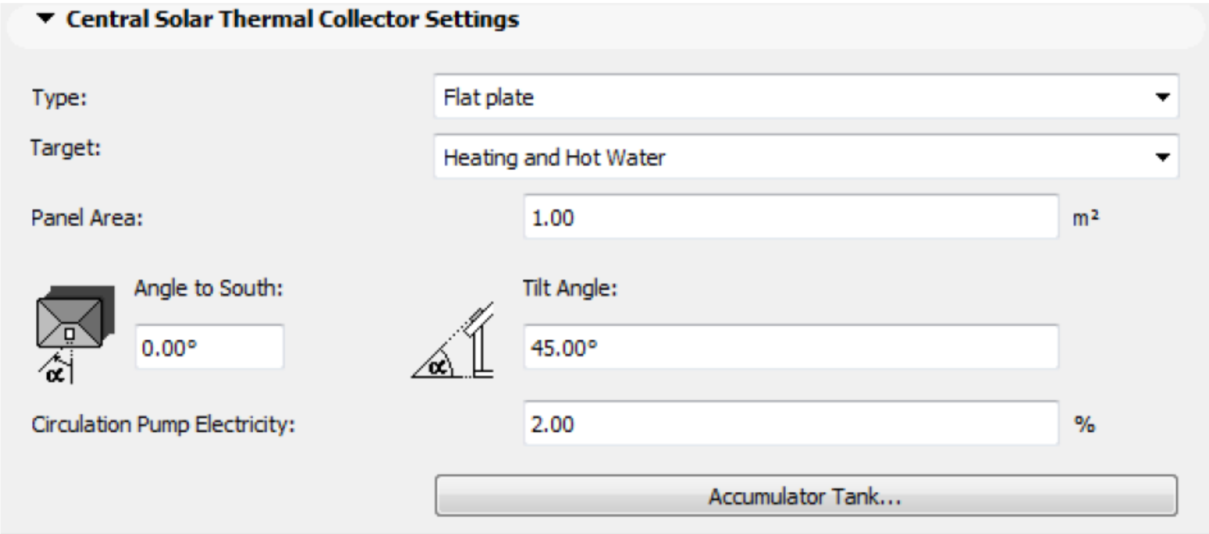
Set the maximum and minimum supply and return temperatures you want to achieve, at the maximum and minimum external temperatures (also entered by you).

Use the **Energy Source** button to define the source or multiple sources of energy consumed by the heating system, as applicable. *(See Energy Source dialog box.*)

Solar Thermal Collector Settings

Solar thermal collector panels are designed to collect heat by absorbing sunlight and converting the energy in solar radiation into a more usable form.

This panel is available if you have checked Solar Thermal Collector as one of the subtypes used by either a Local or Central heating system.



- **Type:** Choose either Flat Plate or Evacuated tube.
- **Target:** Set the target for the recovered solar energy: Heating, Hot Water, or both.

  Note: If solar collectors are used for multiple targets, then Hot water generation always has the higher priority. This means that if the solar collector is unable to generate enough energy to feed all targets, then it is going to feed the water heater first and use the remaining available energy for heating.

Specify the collector geometry data required for the calculations:

- **Panel Area**
- **Tilt Angle**
- **Angle to South** (or to the North, for southern hemisphere locations)

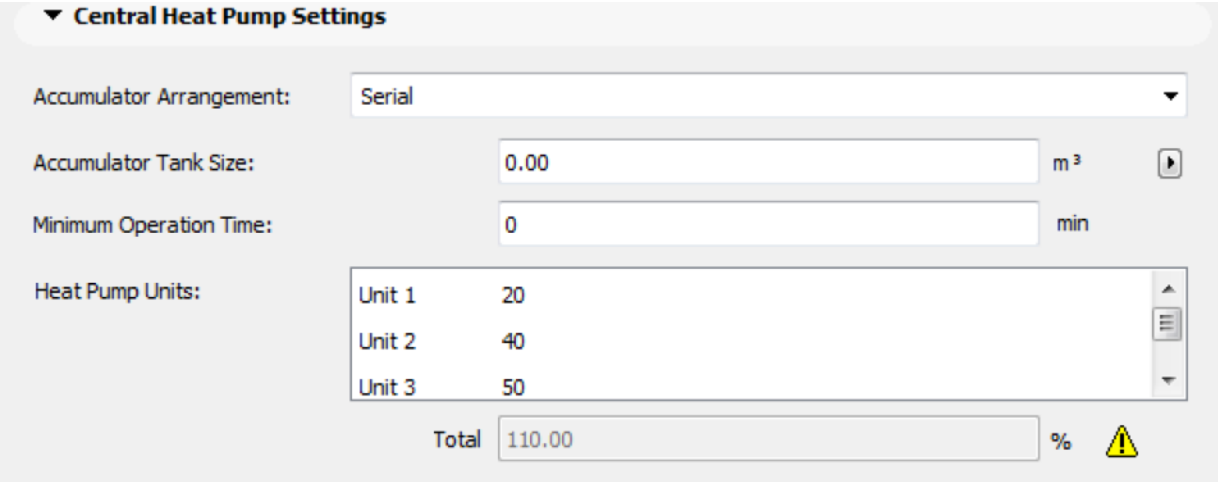
Circulation Pump Electricity: Enter how much electricity the circulation pump requires, as a percentage of the total capacity of the Solar Thermal Collector.

Accumulator Tank: Click this to enter the properties of the accumulator tank used by your Solar Thermal Collector.

Heat Pump Settings

This panel is available if you have checked Water Heat Pump as one of the subtypes used by either a Local or Central heating system.

You can define multiple Central Heat Pump units – this enables efficient operations even during partial- load periods.



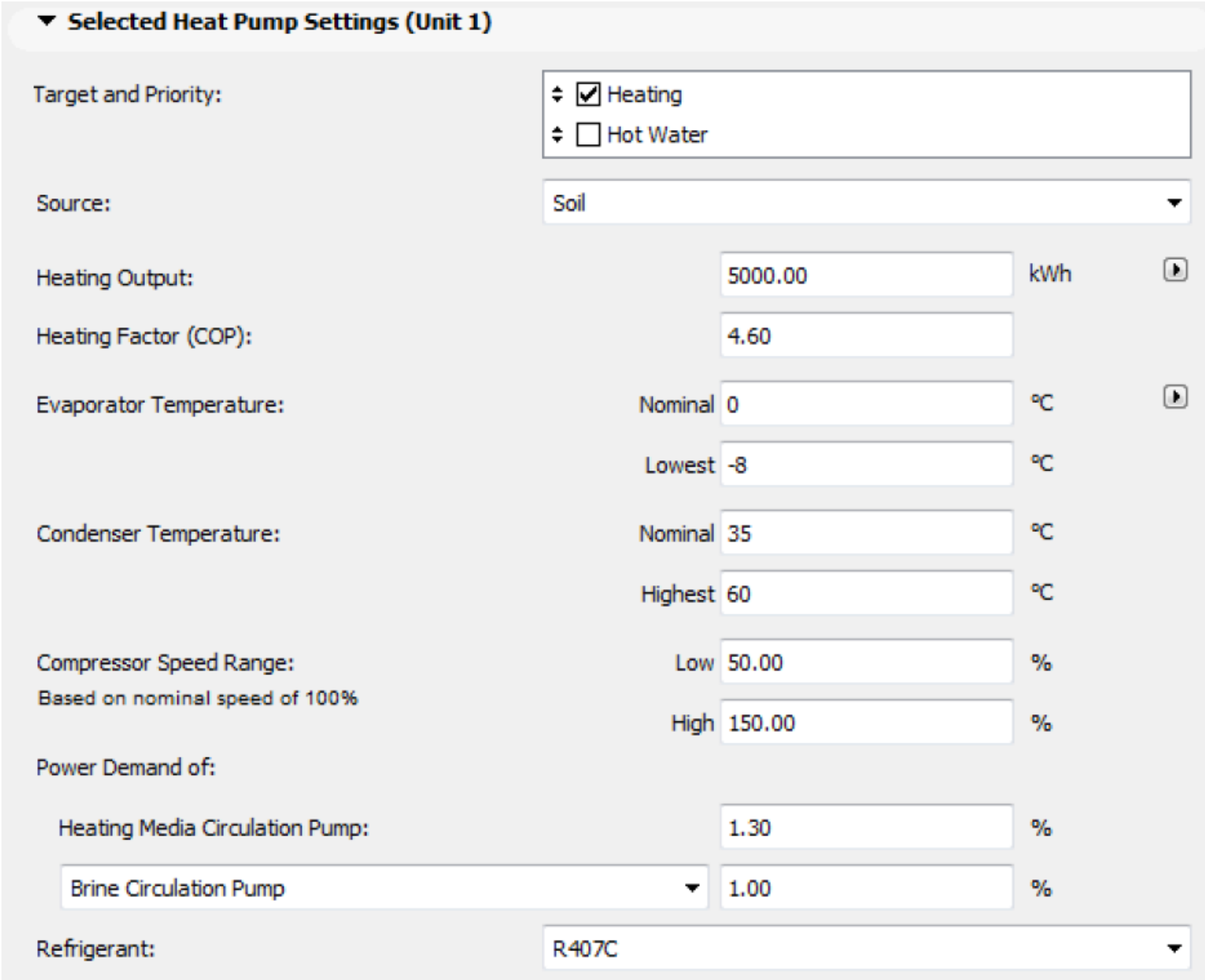
Enter data to describe the configuration of your water heat pump system:

- Arrangement (Serial or Parallel)
- Tank Size
- Minimum Operation Time

In the Heat Pump Units table, click the Plus sign to add as many heat pump units as you have.

For each unit listed here, use the dedicated panel (e.g. Selected Heat Pump Settings (Unit 3)) to set its properties:

Selected Heat Pump Settings (by Unit)



For each Heat Pump Unit, specify the following data, which are defined by the particular specifications of your device:

- Target (Heating, Hot Water or both) – that is, how the energy will be used.
- Priority (drag-and drop the list items to indicate which target – heating or hot water - should be met first, if the system cannot generate enough energy to feed all targets simultaneously).
- Source (Air, sea, geothermal, or soil) – that is, where the energy comes from.
- Heating Output (in kWh or kBtu).
- Heating Factor (COP): the Coefficient of Performance, that is, the ratio of heat energy produced per unit of energy consumed.
- Evaporator and Condenser Temperature: these data depend on the particular specifications of your device. The Nominal value is a reference value for the design phase; Lowest/Highest define the temperatures at which the heater will be turned off.
- Compressor Speed Range – Compressor speed can vary to ensure maximum efficiency of operation. These values are your compressor’s maximum/minimum speeds, based on nominal speed of 100%.

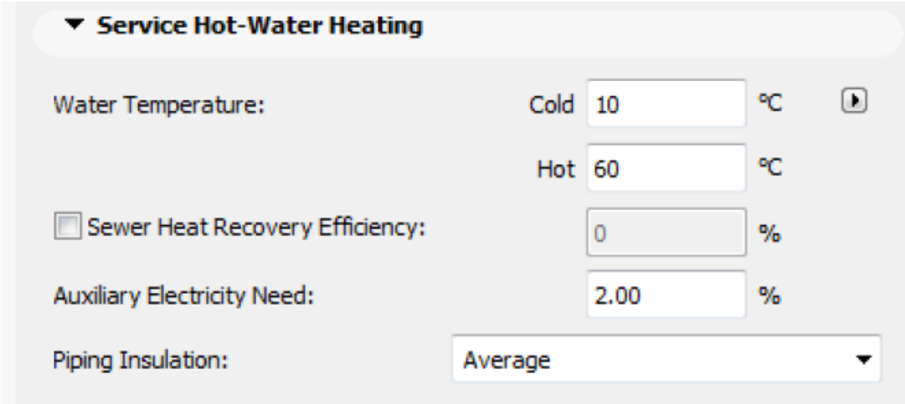
Power Demand: Enter a relative value for how much auxiliary energy is required to operate auxiliary circulation devices, as a percentage of the actual capacity of the heat pump unit.

- Heating Media Circulation Pump
- Evaporator Fan OR Brine Circulation Pump

Refrigerant: Select the name of the Refrigerant used by your heat pump.

Service Hot Water Heating

This panel is available if you have checked **Include Service Hot-water Heating** in the Boiler or Furnace panel, or at Solar Thermal Collector or Heat Pump Settings.



Enter Cold and Hot water temperature target values. The calculation engine uses this data to calculate the energy consumption related to hot water generation.

To change the temperature scale (Celsius or Fahrenheit), click the arrow button next to the input field.

Sewer Heat Recovery Efficiency: Check this box if your system recovers heat from wastewater; enter a percentage value of heat recovery.

Auxiliary Electricity Need: Enter the percentage of the service hot-water heating energy need (this is the electricity demand of the service hot-water system).

Piping Insulation: Estimate the insulation quality of the piping of your heating system: Poor, Average or Good.

Local Heating - Direct Expansion (DX) Settings

- Heating Output (in kWh or kBtu)
- Heating Factor (COP): the Coefficient of Performance, that is, the ratio of heat energy produced per unit of energy consumed
- Evaporator and Condenser Temperature: these data depend on the particular specifications of your device. The Nominal value is a reference value for the design phase; Lowest/Highest define the temperatures at which the heater will be turned off.

- Compressor Speed Range – Compressor speed can vary to ensure maximum efficiency of operation. These values are your compressor's maximum/minimum speeds, based on nominal speed of 100%.

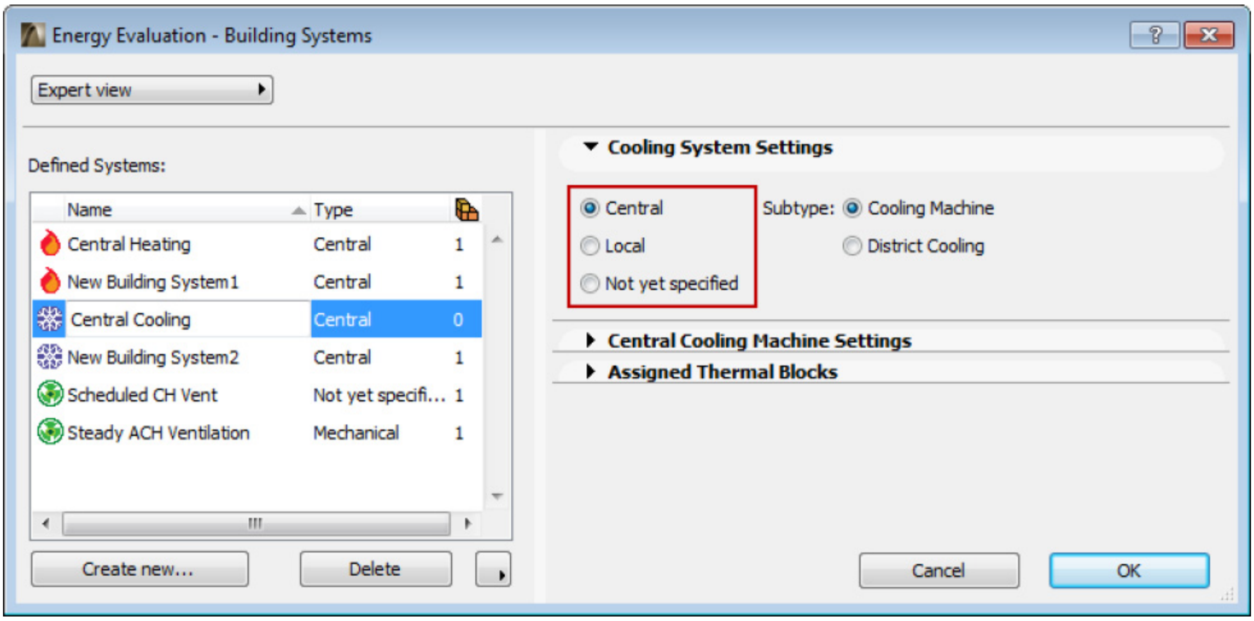
Power Demand: Enter a relative value for how much auxiliary energy is required to operate auxiliary circulation devices, as a percentage of the actual capacity of the heat pump unit.

- Heating Media Circulation Pump
- Evaporator Fan OR Brine Circulation Pump

Refrigerant: Select the name of the Refrigerant used by your heat pump.

5.8.5 Cooling

Choose either **Central**, **Local** or **Not yet Specified** to describe your project's Cooling system.



Not Yet Specified

Choose this option for Thermal Blocks that are to be cooled, but you do not yet know which type of system will be used.

For such thermal blocks, the energy simulation will take into account the substitution values defined by the ASHRAE 90.1 standard.

If you use Central Cooling

A Central Cooling system means that it is assigned (that is, provides cooling) to more than one Thermal Blocks.

Choose a **subtype** to correspond to your system: either **Cooling Machine** or **District Cooling**.

- **Cooling Machine** means that some type of cooling system is to be installed in the building.
- **District Cooling**: In certain countries, cooled air may be obtained from an external source.

If you use Local Cooling

A Local Cooling system means that it is assigned (that is, provides cooling) to a single Thermal Block.

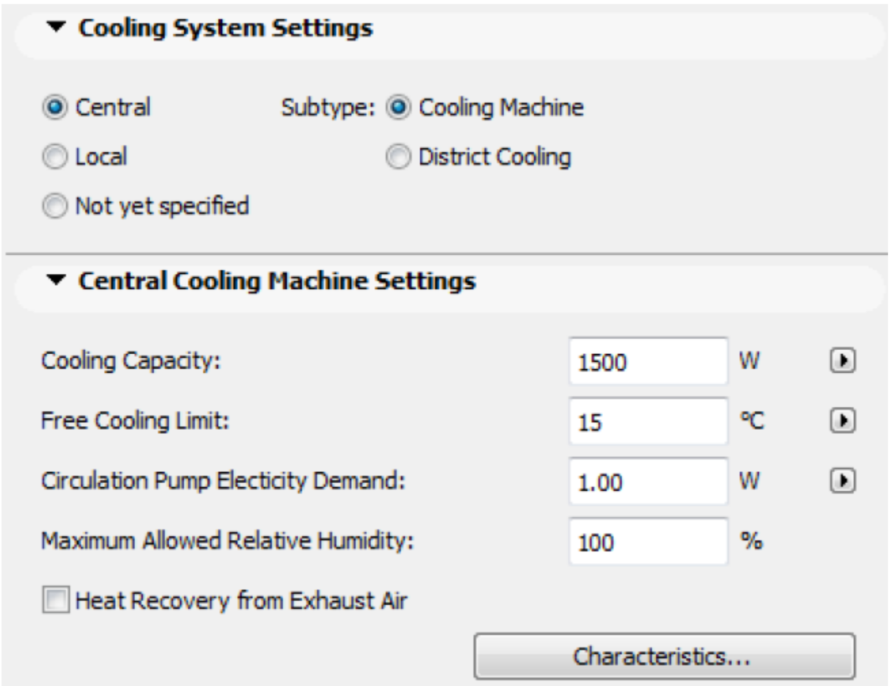
Choose a subtype to correspond to your system: either **Cooling Machine** or **Direct Expansion (DX)**.

- **Direct Expansion (DX):** In a direct expansion system, the working fluid from the heat pump's outdoor condenser circulates in the internal evaporator as a heat transfer medium and evaporates there. This direct expansion does not require an intermediate heat exchanger, in contrast to water-based systems that rely on a circulating pump to move water through a pipe.

Each option's settings are located on the corresponding dialog box panels below.

Cooling Machine Settings

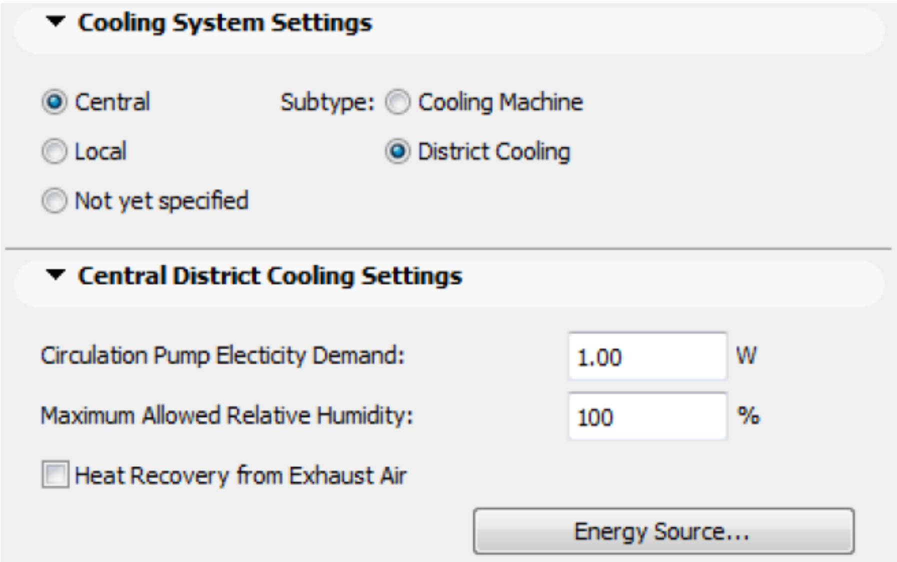
This panel is available if you have checked Cooling Machine as one of the subtypes used by either a Local or Central cooling system.



- **Cooling Capacity:** Enter your system's nominal cooling capacity. (Click the arrow to choose a unit.)
- **Free Cooling Limit:** Free cooling refers to the method that uses naturally cool air or water instead of mechanical refrigeration. The **Free Cooling Limit** value is the outdoor temperature below which there is no need to operate the cooling machine. If the outdoor temperature falls below this limit, then there is no need to run the compressor that transmits the cooling medium, because the cooling requirement is met by the cooling water flowing through the outdoor condenser. (Click the arrow to choose a temperature unit.)

- **Circulation Pump Electricity Demand:** Enter how much electricity the circulation pump requires, either as a percentage of the nominal cooling capacity or measured in watts. (Click the arrow to choose a unit.)
- **Maximum Allowed Relative Humidity:** This value is the maximum humidity rate allowable indoors (in the thermal block to which the current cooling system is assigned). If the indoor humidity level exceeds this limit, the cooling system is turned off – even if the target temperature is not yet achieved.
- **Heat Recovery from Exhaust Air:** Check this box if your system can recover exhaust air energy.

District Cooling Settings



- **Circulation Pump Electricity Demand:** Enter how much electricity the circulation pump requires, measured in watts.
- **Maximum Allowed Relative Humidity:** This value is the maximum humidity rate allowable indoors. If the indoor humidity level exceeds this limit, the cooling system is turned off – even if the target temperature is not yet achieved.
- **Heat Recovery from Exhaust Air:** Check this box if your system can recover exhaust air energy.

Local Cooling - Direct Expansion (DX)

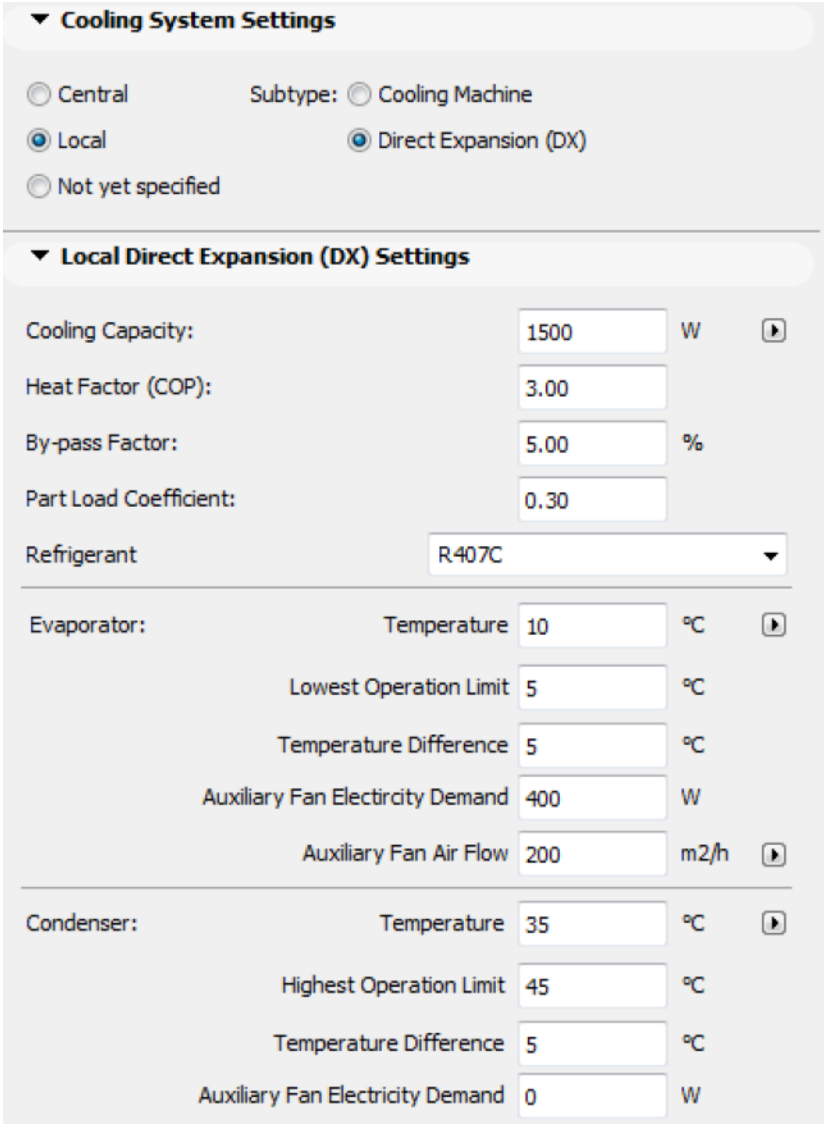
Enter the following data based on the particular specifications of your device:

- Cooling Capacity (in kWh or kBtu)
- **Heat Factor (COP):** the Coefficient of Performance, that is, the ratio of heat energy produced per unit of energy consumed
- **By-pass Factor:** the By-Pass Factor is used to express a cooling coil's efficiency.
- Part Load Coefficient
- **Refrigerant:** Select the name of the Refrigerant used by your heat pump.

Evaporator and Condenser Data

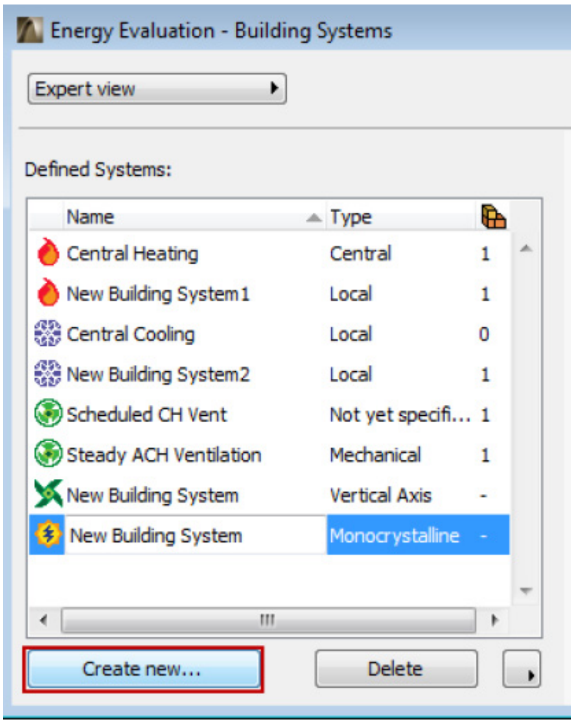
These data depend on the particular specifications of your device.

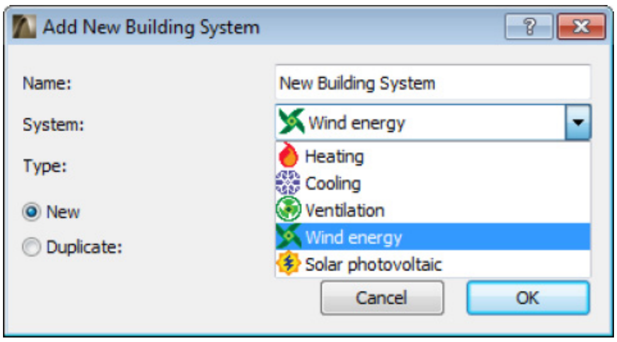
- Temperature: Nominal working temperature of the Evaporator/Condenser
- The Lowest/Highest values define the temperatures at which the cooler will be turned off.
- Temperature Difference: Nominal temperature difference between cooling medium and the coil surface on the Evaporator/Condenser.

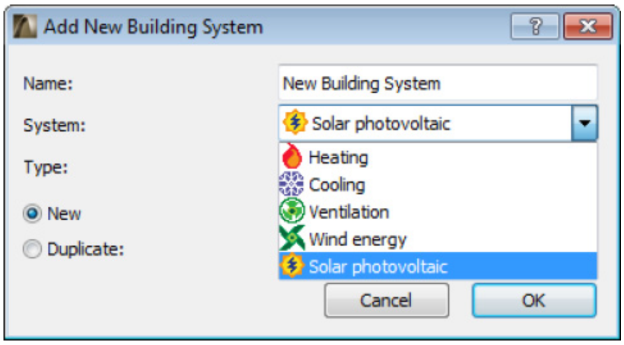


5.8.6 On-Site Renewables

If your project includes a wind turbine and/or Solar Photovoltaic panels, you can create the corresponding Building Systems by clicking **Create New** in the Building Systems dialog box.





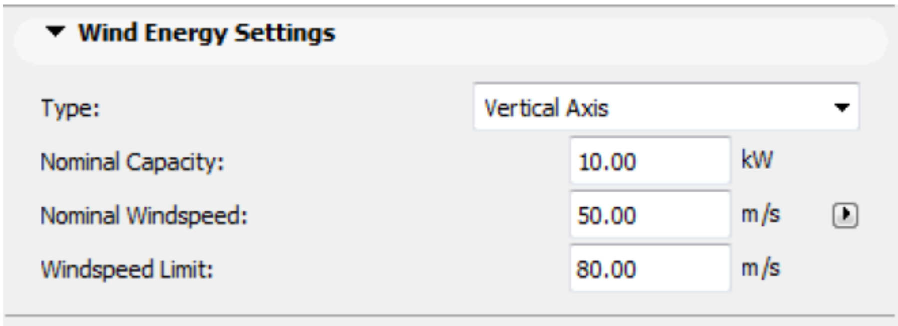


- These Building Systems (Wind energy and Solar photovoltaic) produce renewable energy but are not directly connected to the building structure; so they are not assigned to any Thermal Blocks.
- Electrical energy produced by these Building Systems is assumed to be used locally to power the rest of the Building Systems, and is not fed back into the power grid.
- The data from these Building Systems are reflected in the Energy Cost and Carbon Footprint sections of the Energy Performance Evaluation Report.
- These Building Systems are taken into account as renewable energy sources for the LEED certification.

- These Building Systems are available only in the Expert view of the Building Systems dialog for EcoDesigner STAR. However, if the project is opened in ArchiCAD without the EcoDesigner STAR license, any data previously entered for Wind energy/Solar photovoltaic systems are taken into account - but these data are not accessible or editable, except in EcoDesigner STAR.

Wind Energy Settings

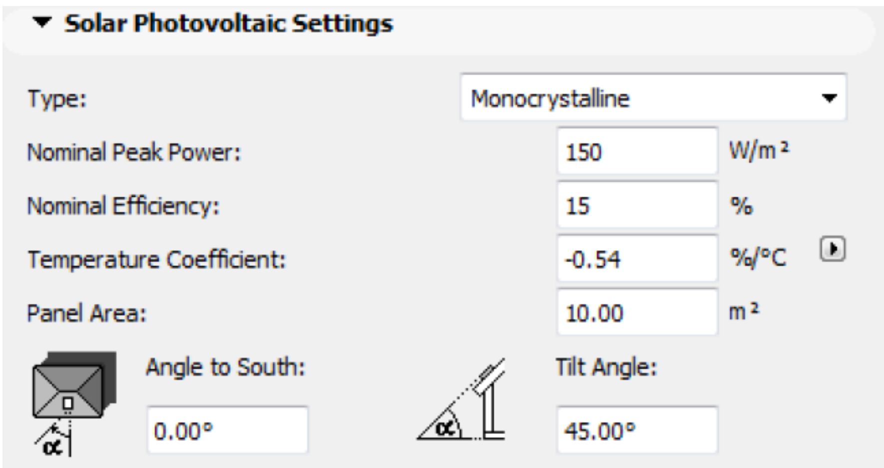
Enter the data depending on the particular specifications of your wind turbine.



- **Type:** Choose the type of your Wind Turbine: Vertical Axis or Horizontal Axis.
- Nominal Capacity (in kW)
- **Nominal Windspeed:** Enter a value in m/s or in knots. (Click the arrow to choose a unit.)
- **Windspeed Limit:** If windspeed exceeds this limit, the turbine will be turned off.

Solar Photovoltaic Settings

Enter the data depending on the particular specifications of your PV panels.



- **Type:** Choose the type of Solar PV panel you use: Monocrystalline, Polycrystalline or Amorphous.

- **Nominal Peak Power:** This value (in Watts/m2) is the amount of electricity generated on one unit of panel area. (Under standard test conditions: irradiance of 1,000 W/m², solar spectrum of AM 1.5 and module temperature at 25°C).
- **Nominal Efficiency:** The efficiency of a panel determines the area of a panel given the same rated output - an 8% efficient 230 watt panel will have twice the area of a 16% efficient 230 watt panel.
- **Temperature Coefficient**: Energy efficiency of the panel varies depending on temperature. (Click the arrow to choose a temperature unit.)

If you look at the manufacturer's data sheet you will see a term called "temperature coefficient". For example the temperature coefficient of a Suntech 190 W (monocrystalline) solar panel is –0.48%. What this means is that for each degree over 25˚C, the maximum power of the panel is reduced by 0.48%.So on a hot day in the summer – where solar panel temperature on the roof might reach 45˚C or so – the amount of electricity would be 10% lower. Conversely, on a sunny day in the spring, fall, or even winter – when temperatures are lower than 25˚C – the amount of electricity produced would actually increase above the maximum rated level. Therefore, in most northern climates – the days above and below 25˚C would tend to balance each other out. However, in locations closer to the equator the problems of heat loss could become substantial over the full year and warrant looking at alternatives.

Specify the panel geometry data required for the calculations:

- Panel Area
- Tilt Angle
- Angle to South (or to the North, for southern hemisphere locations)

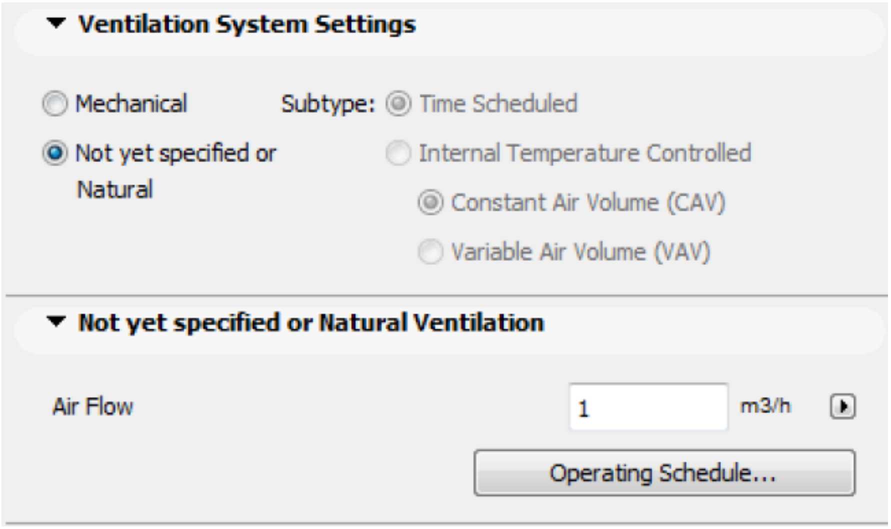
5.8.7 Ventilation

Specify the type of ventilation used in the building: "Not Yet Specified Or Natural," or "Mechanical".

Not Yet Specified Or Natural Ventilation

Use **Not Yet Specified** for Thermal Blocks that are to be ventilated, but you do not yet know which type of system will be used. For such thermal blocks, the energy simulation will take into account the substitution values defined by the ASHRAE 90.1 standard.

Natural Ventilation involves no MEP systems: natural air currents drive fresh air into the building and used air out of it. From an ecological point of view, natural ventilation is preferable to mechanical solutions, but due to its limited controllability its use is largely limited to residential buildings.



Air Flow: Describe the air flow if you are using natural/unspecified ventilation. This target value depends on national standards, and will vary depending on the building's function and the local climate.

Click the arrow at right to choose a unit:

- Cubic meters per hour
- Liters per second
- Air Change per hour (ACH): how many times the air volume of thermal block is replaced per hour

Click **Operating Schedule** to open the dialog box that describes the typical air flow over one or more date/time ranges over the course of a year.

See Operating Schedule for details.

Mechanical

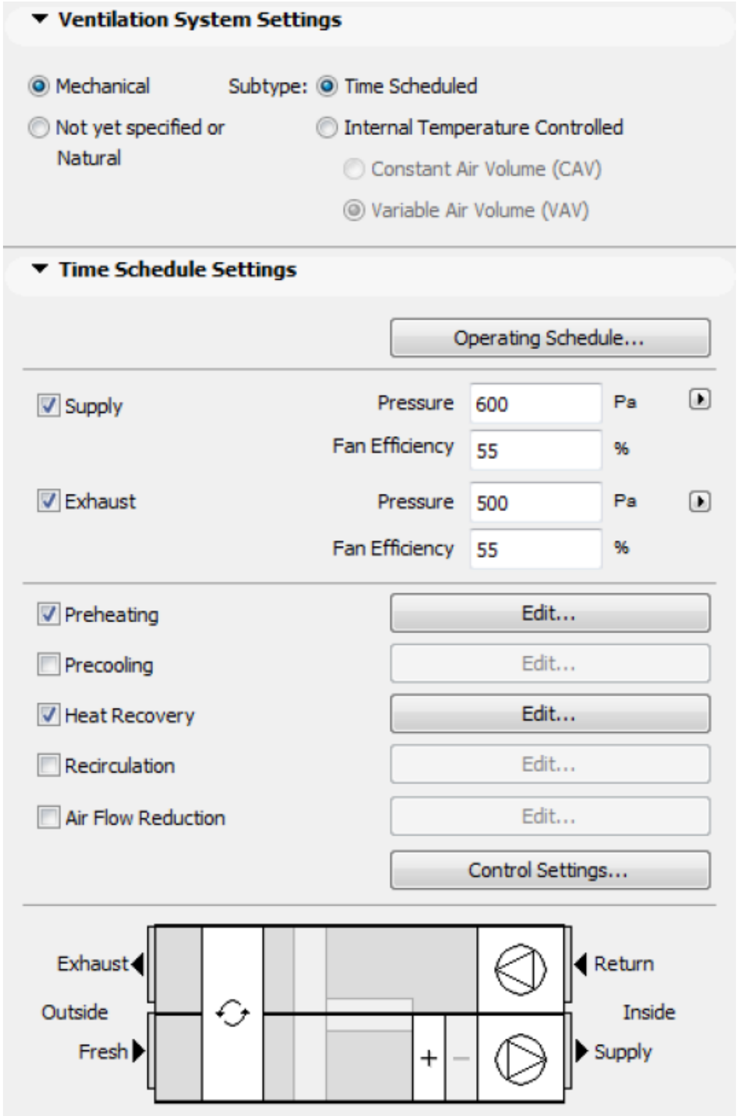
For building functions that fall under strict target air exchange standards, a mechanical ventilation system of some sort is needed.

Choose a **subtype** to correspond to your system:

- **Time Scheduled** ventilation systems vary their operations depending on the target air exchange values of each pre-set daily/yearly schedule.
- **Internal Temperature Controlled** ventilation systems vary their operations not by date/time, but as a function of the current internal temperature. There are two types of this system:
  - Constant Air Volume (CAV), or
  - Variable Air Volume (VAV)

Each subtype's settings are located on the corresponding dialog box panels below.

Time Schedule Settings



Supply/Exhaust Data

Check Supply, Exhaust, or both to describe your mechanical ventilation system.

Notice the sketch of the air handling unit below: the corresponding (supply/exhaust) fans are either shown or greyed out, depending on your settings.

- Supply-only systems rely on fans to drive fresh air into the thermal block.
- Exhaust-only systems rely on fans to extract used air from the thermal block.
- Supply and exhaust systems mechanically control both the air intake and outlet procedure.

Enter nominal **Pressure** and **Fan Efficiency** data to describe the fans used for supply and/or exhaust. (Choose a Pressure unit from the pop-up at right.)

Additional Functions of the Air Handling Unit

Your mechanical ventilation system may include some or all of the following functions: **Preheating, Precooling, Heat Recovery, Recirculation,** and **Air Flow Reduction.**

The values depend on the particular specifications of your device.

Check all that apply. Again, notice the sketch of the air handling unit below: the corresponding parts of the drawing are either shown or greyed/hidden, depending on your choices.

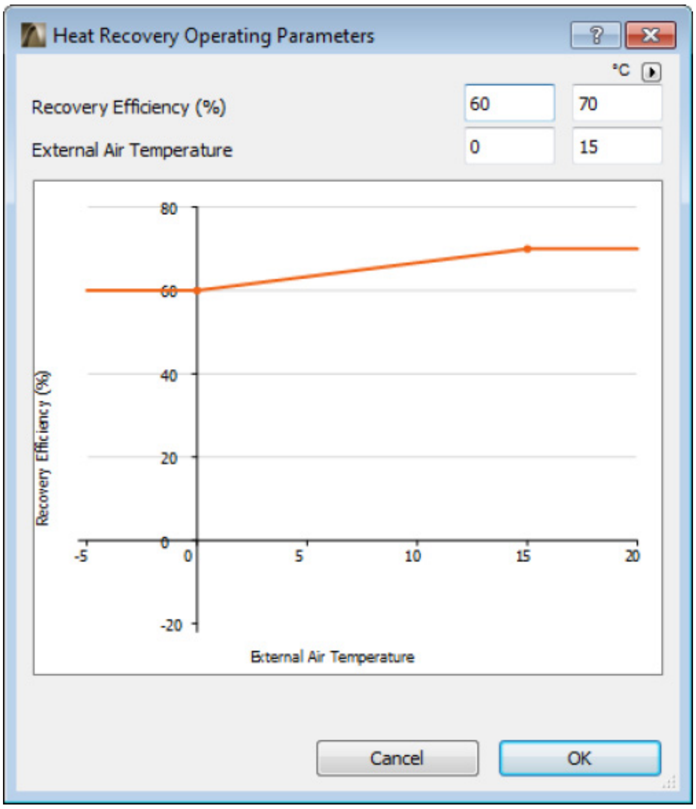
For each checked function, click **Edit** to specify the parameters for each: the Operating Parameters graph shows how the temperature of the supplied air varies with the external air temperature.

- **Preheating** and **Precooling**: These functions cool and/or heat the fresh air before it is transmitted to the indoor space. (If you use both, the effect of cooling, then heating the air will reduce its humidity.)

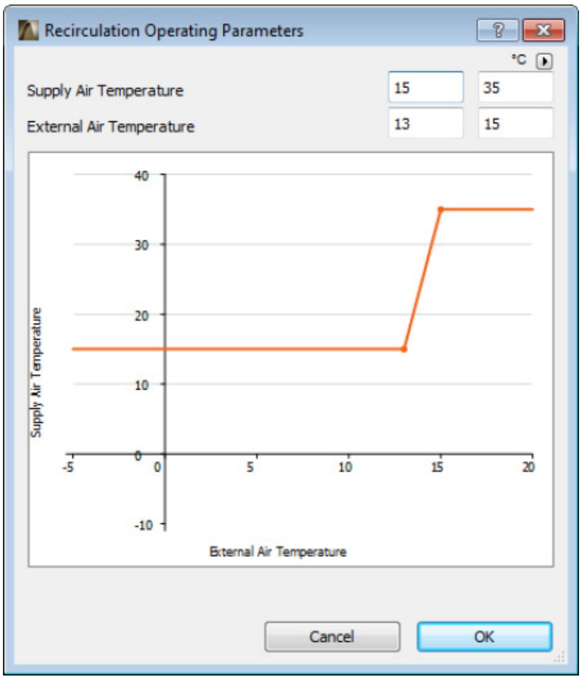
The next three functions – Heat Recovery, Recirculation, and Air Flow Reduction – help to optimize the energy efficiency of the air handling unit, by reducing the amount of energy needed to heat the incoming air.

- **Heat Recovery:** This function regains a percentage of the heat content of mechanically expelled ventilation air, by way of a heat exchange between the (warmer) exhaust air and the (cooler) supplied air.

Specify the target Recovery Efficiency data for the entered minimum and maximum External Air Temperature values.

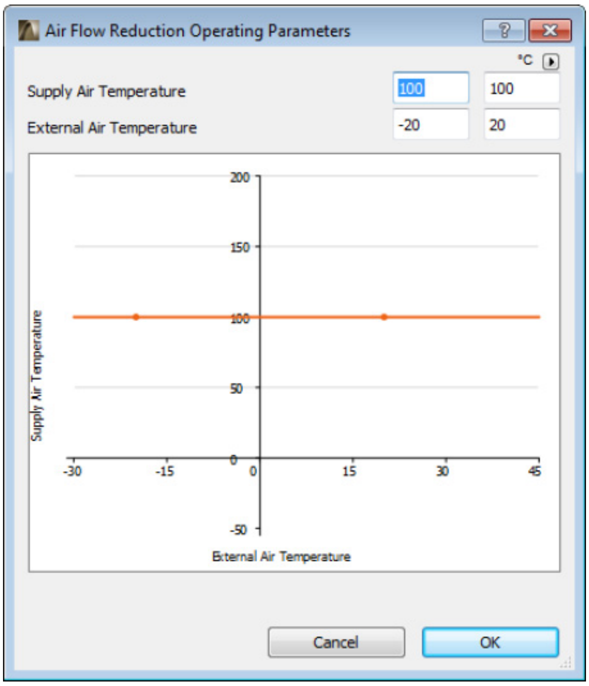


- **Recirculation**: This function uses a set of dampers to enable a certain amount of exhaust air to be recirculated indoors. Set the parameters to define the target supply air temperature.



- **Air Flow Reduction**: This function reduces the amount of incoming air flow (and consequently modifies the Air Change per Hour, notwithstanding the Air Flow target value you entered). Your system may employ Air Flow Reduction at times when the incoming air supply is very cold; reducing the air flow reduces the amount of energy needed to heat air supply.

Set the parameters to define the target supply air temperature.



Control Settings

This button is available from the Time Schedule Settings panel (if you are using a Time-Scheduled, Mechanical ventilation system). The Control Settings dialog box contains additional options related to the operations of your air handling unit. These are recommended for expert users only; most users should retain the default settings.

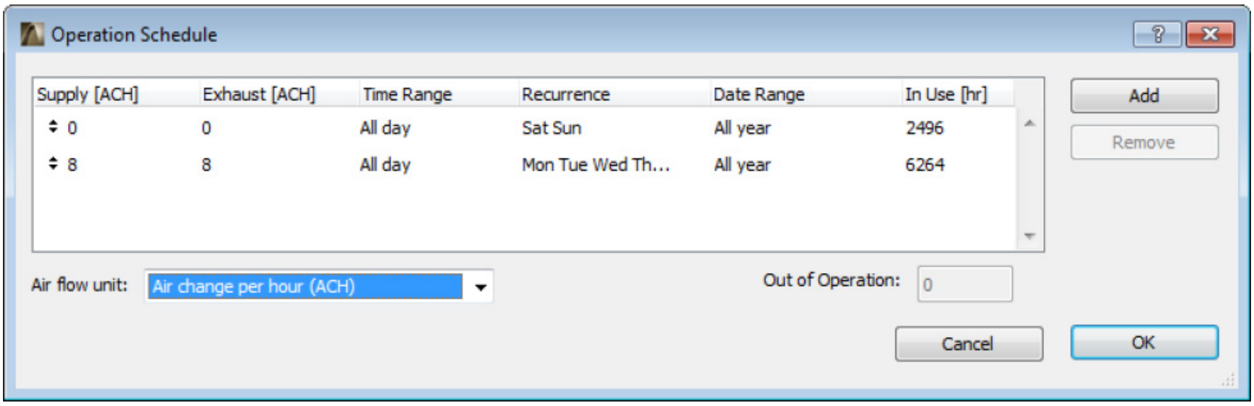
Operating Schedule

Click this button (available in the Time Schedule Settings panel if you are using a Mechanical ventilation system that is time-scheduled, or if you choose Natural/Not Yet Specified ventilation).

Supply and exhaust data may vary by day of the week and over the course of the year. The ventilation Operation Schedule can consist of any number of daily schedules, which correspond to specific date ranges and days of the week.

Specify the desired **Air flow unit** (ACH, m3/h, or l/s) in the pop-up in the lower left corner.

This target value depends on national standards, and will vary depending on the building’s function and the local climate.



For each daily schedule, you can define the following characteristics:

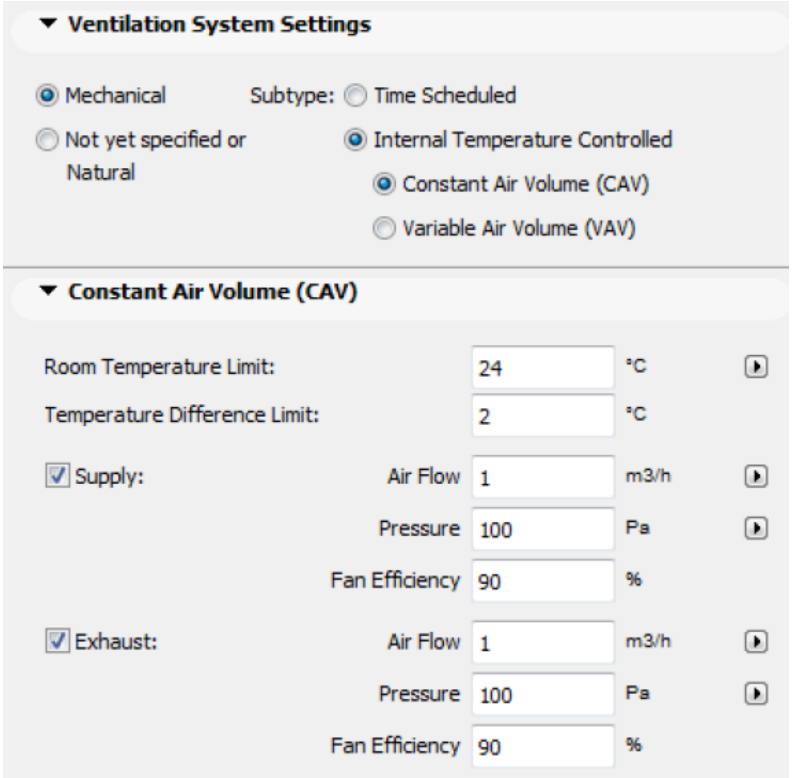
- **Recurrence**: days of the week when the particular schedule is in effect
- **Date Range**: periods of the simulation year during which the schedule occurs

Recurrence and Date Range define the **In use hours** (the total number of hours during which the selected Daily Schedule is in effect).

If the Overlapped hours counter appears at the bottom right corner of the Yearly Operation Scheduler, it means that further modifications in Recurrence and Date Range are necessary because there are some hours of the reference year with more than one operation schedules assigned to them.

Constant Air Volume (CAV) Settings

This panel is available if you have a Mechanical ventilation system that is Internal Temperature Controlled, with a Constant Air Volume. That is, the Thermal Block is supplied with a constant volume of air, whose temperature is varied as needed.



Room Temperature Limit: If the internal temperature exceeds this limit, the ventilation unit will go into operation. Once the room temperature is within the **Temperature Difference Limit** (e.g. 2 degrees) of the target Room Temperature, the system stops. This works if it is cooler outside than inside.

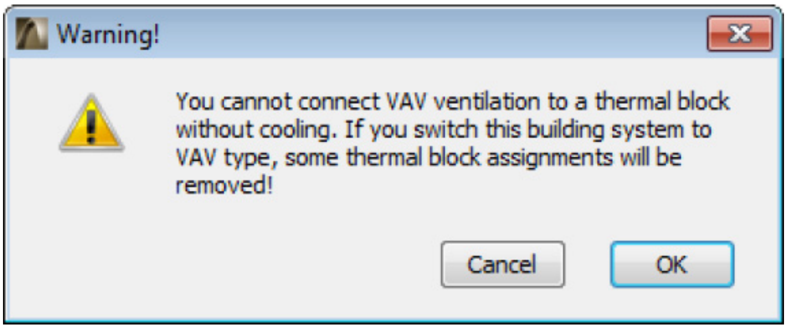
Enter **Air Flow, Pressure** and **Fan Efficiency** data for the ventilation air supply and exhaust.

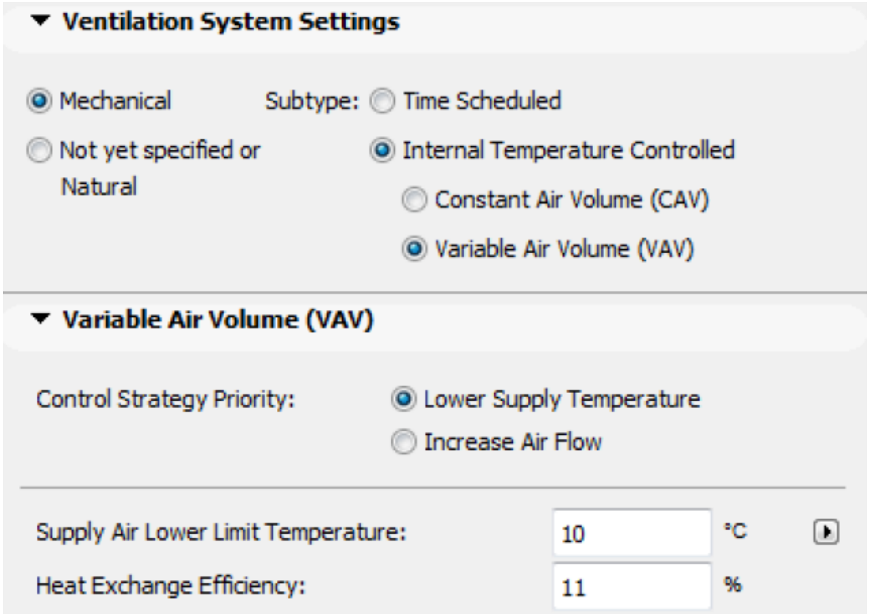
- Specify the desired Air flow unit (ACH, m3/h, or l/s) in the pop-up at right
- Choose a Pressure unit from the pop-up at right

Variable Air Volume (VAV) Settings

This panel is available if you have a Mechanical ventilation system that is Internal Temperature Controlled, with a Variable Air Volume. That is, air is supplied to the Thermal Block at varying volumes to maintain the desired internal temperature.

The Variable Air Volume system is available only if the Thermal Block to which it is assigned also has a cooling system.





Control Strategy Priority: Choose the priority mechanism for varying the air supply temperature:

- **Lower Supply Temperature:** In this case, the cooling system cools down the air supply first.
- **Increase Air Flow:** In this case, the preferred mechanism is to increase the amount of supplied air first.

Both mechanisms will operate in any case, but the setting here determines which will be used first.

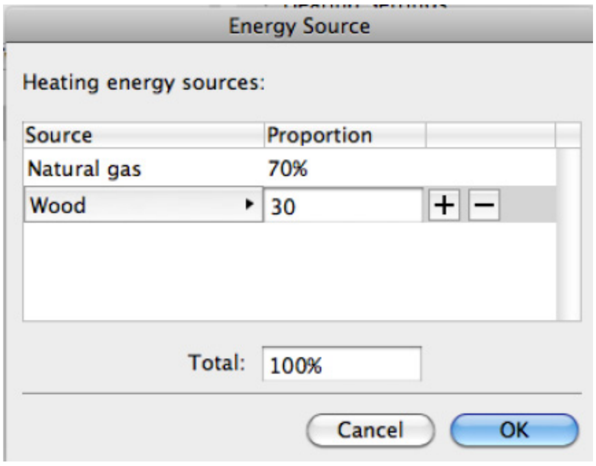
Supply Air Lower Limit Temperature: Enter the lower limit for the temperature of the supplied air.

> **Note:** If supplied air at the lower-limit temperature is not cold enough to meet cooling needs, then the air flow is increased.

Heat Exchange Efficiency: If your ventilation system includes a heat recovery unit, enter its effectiveness (as a percentage) here. This function regains a percentage of the heat content of mechanically expelled ventilation air, by way of a heat exchange between the (warmer) exhaust air and the (cooler) supplied air.

Energy Source

Press the Energy Source button from either the Boiler or Furnace tab page (Heating System) or the District Cooling Settings tab page (Cooling System).



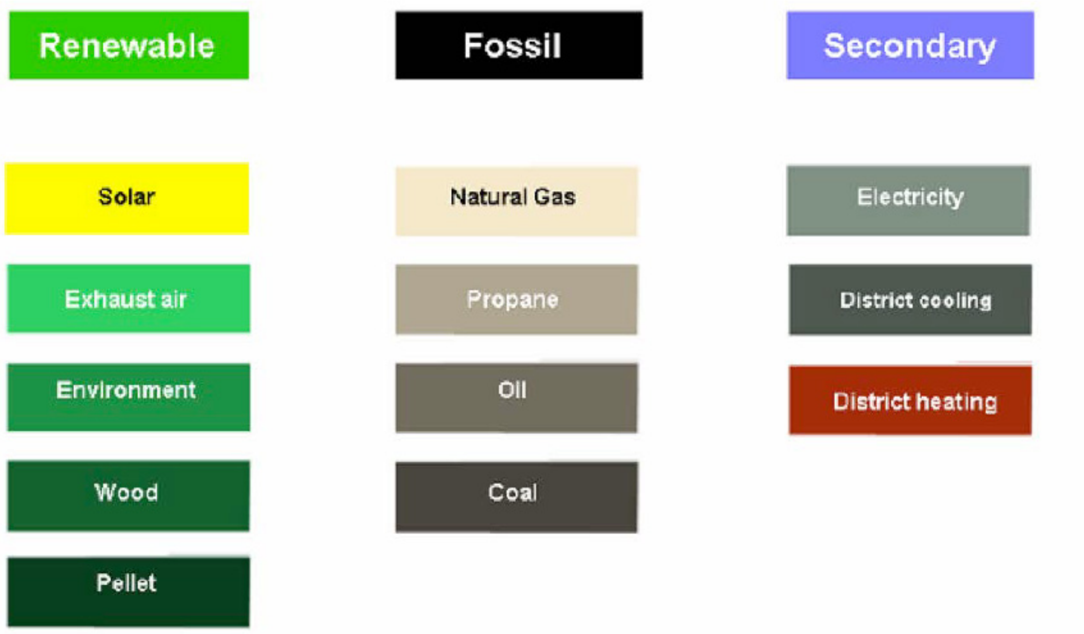
In the appearing Energy Source dialog box, click on a listed Source item and use the dropdown to specify energy sources (Natural gas, Propane, Oil, Wood, Coal, Electricity or Pellet) for the Boiler/Furnace or Cooling System.

If you use more than one energy source for a function, click the + (plus) button, then choose an additional energy source.

Define the proportion of each source used so that the Total add ups to 100%.

To remove a row, click the – (minus) button.

In the table below, the energy sources used by EcoDesigner STAR are listed according to their type and with their colors as displayed on the Energy Balance Evaluation report.

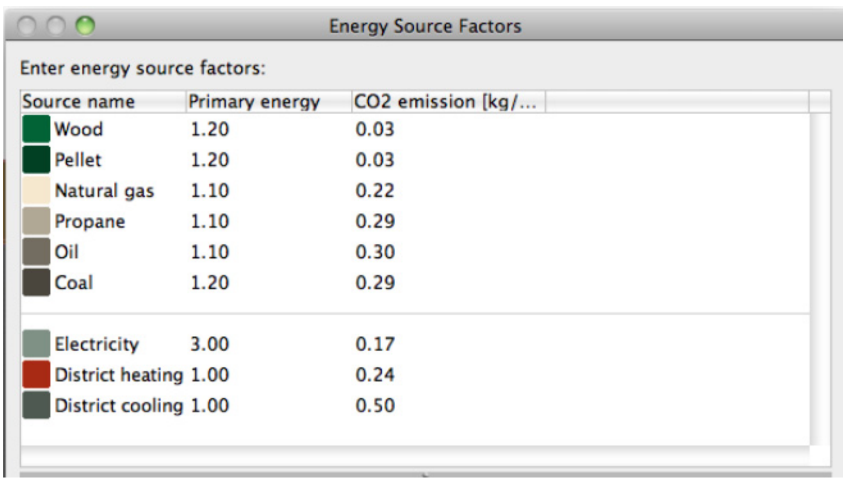


5.9 Energy Source Factors

Open this dialog box from the Model Review Palette's pop-up at the top right, from **Design > Energy Evaluation > Environment Settings**.

5.9.1 Primary Energy and CO2 Emission Factors

For each energy source, default values are shown for primary energy and CO2 emission factors. These default values, which vary according to Project Location, are based on standard DINV-18599.

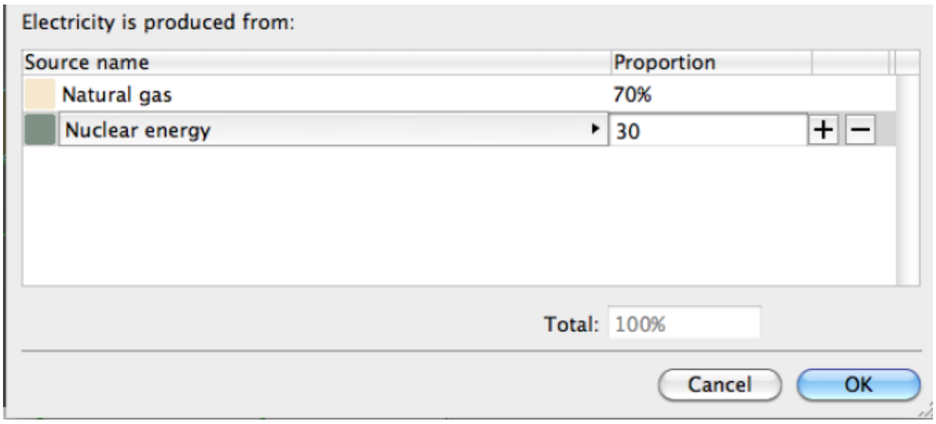


Source name	Primary energy	CO2 emission [kg/...
Wood	1.20	0.03
Pellet	1.20	0.03
Natural gas	1.10	0.22
Propane	1.10	0.29
Oil	1.10	0.30
Coal	1.20	0.29
Electricity	3.00	0.17
District heating	1.00	0.24
District cooling	1.00	0.50

Use these default values, or enter other region-specific data if available.

5.9.2 Sources of Electricity Production

At the bottom of the Energy Source Factors dialog, define the building's source or multiple sources of electricity. Click on a listed Source item and use the dropdown to specify the source of electricity (Natural gas, Propane, Oil, Wood, Coal, Nuclear energy, Wind energy, Solar energy, Water energy or Unknown).

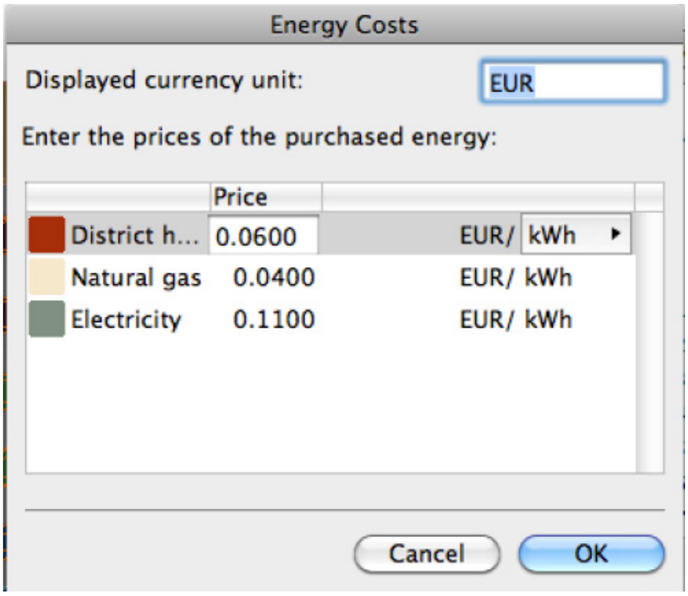


If you use more than one energy source, click the + (plus) button, then choose an additional source. Define the Proportion of each source used so that they add up to 100%. To remove a row, click the - (minus) button.

5.10Energy Costs

Open this dialog box from the Model Review Palette's pop-up at the top right or from **Design > Energy Evaluation > Environment Settings**.

In the top part of the panel, enter the currency name or its abbreviation in the Displayed currency unit field.



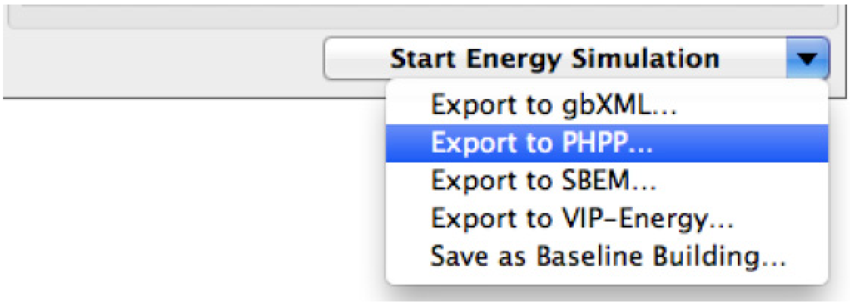
Use the bottom part of the panel to define the Prices of purchased energy. These prices, of course, vary by location and therefore must be entered numerically by the user. Select the Unit of energy (e.g. kWh) from the dropdown list. Next, select a row representing a source of energy, and then enter the price, in the currency you chose.

6. Building Energy Simulation

6.1 Building Geometry and Material Property Data Export

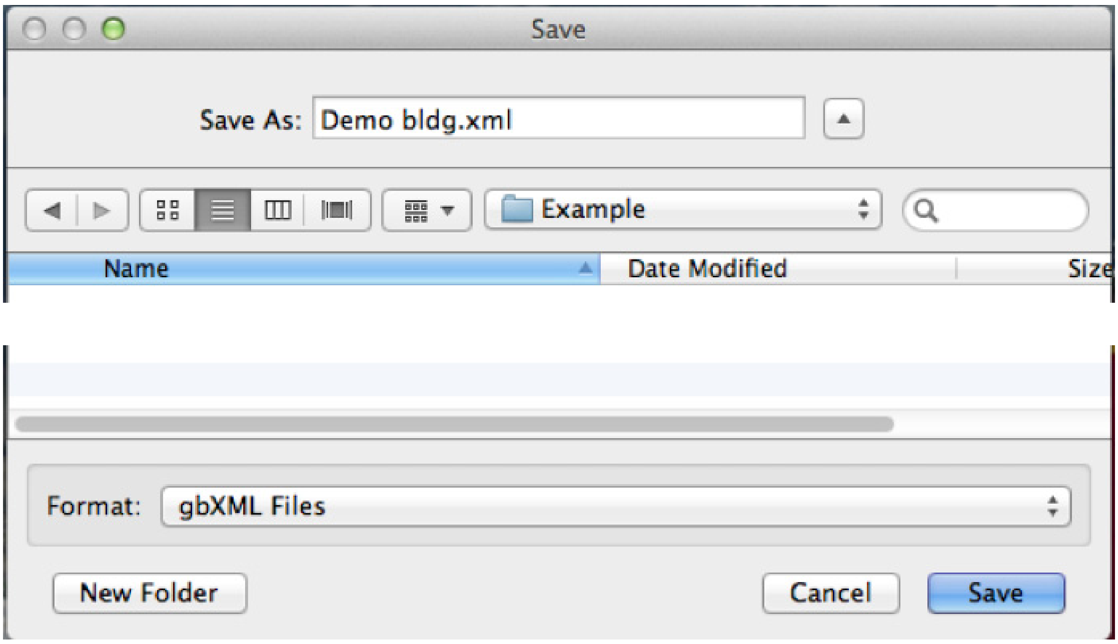
EcoDesigner STAR enables ArchiCAD model geometry and material property data export to 3rd party building energy calculation software. Use these communication platforms to enable the direct transfer of building model information to engineering analysis tools, eliminating the need for time consuming plan takeoffs, this removing a significant cost barrier from the design project.

Click the arrow next to the Start Energy Simulation button to display the available data export file formats



6.1.1 Export to gbXML

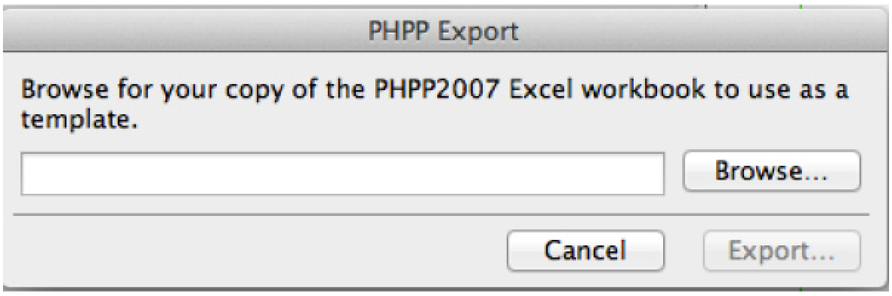
Use the dedicated export panel to save the project in gbXML file format.



The Green Building XML (gbXML) open schema helps facilitate the transfer of relevant BIM properties to building energy analysis tools. Supported by both the leading 3D BIM vendors and the major engineering analysis tools, gbXML is the industry standard Building Geometry and Material Property Data Export schema.

6.1.2 Export to PHPP

The Export to PHPP button activates the PHPP Export dialog box, which enables you to send building information model data to the PHPP Excel workbook you specify, for post processing.

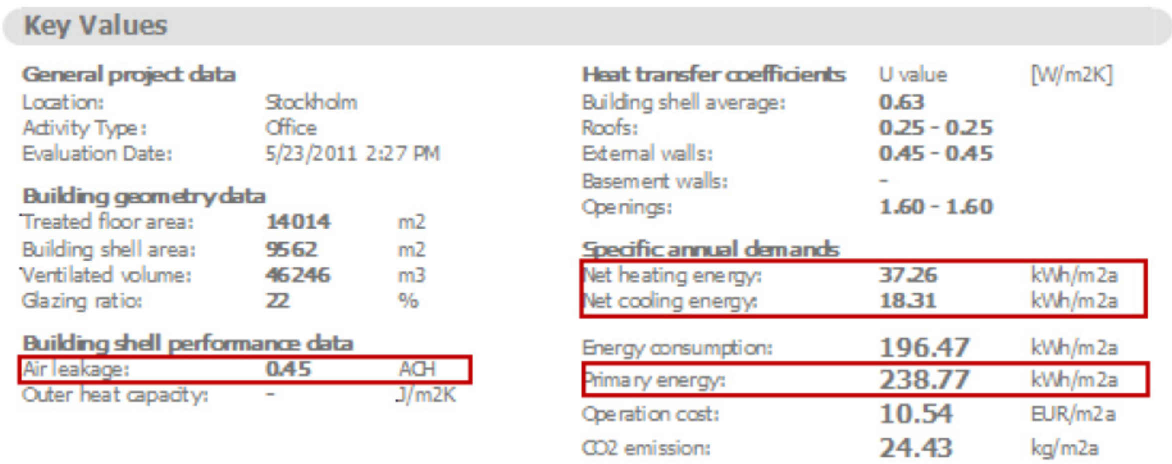


PHPP is the official Excel workbook created by the Darmstadt Passivhaus Institute, to calculate the energy demands of Passivhaus projects. Passivhaus is a design directive that aims to realize extremely low energy projects (mainly small scale residential) in a relatively simple manner, by following certain strict yet straightforward design guidelines.

Note: the PHPP Excel workbook is an independent product of the Darmstadt Passivhaus Institute and is not a part of GRAPHISOFT EcoDesigner. For more information on PHPP and the Passivhaus Institute visit the official website at http://www.passiv.de/

The directive sets stringent threshold values for the Specific annual net heating and cooling demands (15 kilo watt hours per square meter, year maximum), total annual specific primary energy demand (less than 120 kilo watt hours per square meter, year), and average infiltration (maximum 0.6 1/h).

Note: The Key Values section of the EcoDesigner Building Energy Evaluation Report displays these performance data, as calculated by The VIP-Core Calculation Engine.



Use the PHPP Export panel to browse for the official PHPP Excel workbook to be used as a template, then save the project-specific PHPP Excel file under a different name.

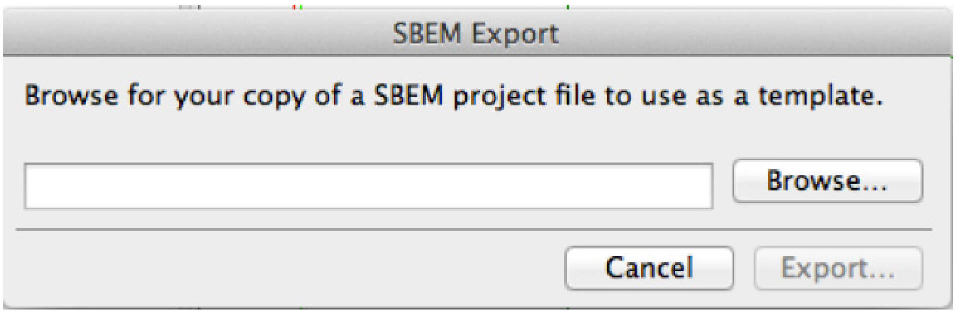
The following ArchiCAD building model data are exported to the respective fields of the project-specific PHPP workbook:

Data location in EcoDesigner	Data location in PHPP
Structures	Areas
Building shell elements	Area Input entries
Orientation	Building Element Description
Building structure	Building Assembly Description
Area	Area Input / User Determined
Thermal Property Assignment	Corresponding Building Element Assembly
U-value Calculator	U-Values
Skin Name	Area Section
External heat transfer coefficient	Heat Transfer Resistance exterior (reciprocal of the External heat transfer coefficient)
Internal heat transfer coefficient	Heat Transfer Resistance interior (reciprocal of the Internal heat transfer coefficient)
Thermal Conductivity	Thermal Conductivity
Thickness	Thickness
Thermal Conductivity	Thermal Conductivity
Openings	Windows
Openings on building shell entry (combined*)	Windows list entry (each ArchiCAD opening individually)
Orientation	Description; Deviation from North; Angle of Inclination from the Horizontal
(From ArchiCAD building model)	Window Rough Openings / Width and Height
(From ArchiCAD building model)	Installed in Area in the Areas worksheet

***Note:** Openings are not listed one by one in EcoDesigner; instead, the data are totaled for the opening type and orientation. However, they are exported to PHPP individually.

6.1.3 Export to SBEM

Use EcoDesigner STAR’s SBEM Export panel to browse for the official SBEM file to be used as a template, then save the project-specific SBEM file under a different name.



SBEM is a software tool developed by BRE that provides an analysis of a building's energy consumption. SBEM stands for: Simplified Building Energy Model. SBEM is used for non domestic buildings in support of the British National Calculation Methodology (NCM), the Energy Performance of Buildings Directive (EPBD) and the Green Deal.

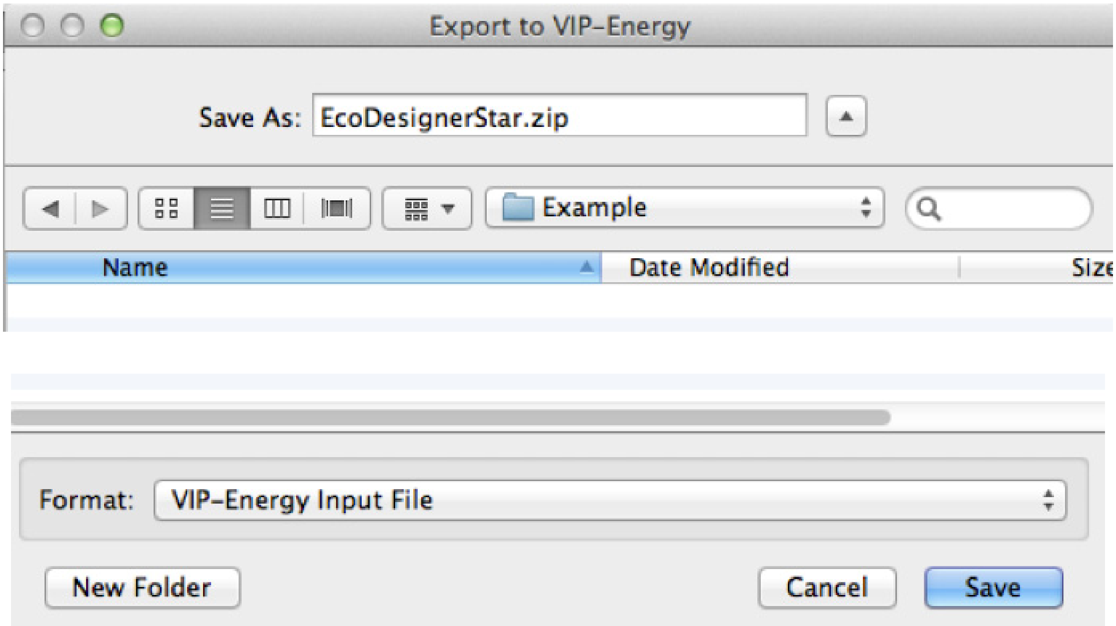
The tool is currently used to determine CO_2 emission rates for new buildings in compliance with Part L of the Building Regulations (England and Wales) and equivalent Regulations in Scotland, Northern Ireland, the Republic of Ireland and Jersey. It is also used to generate Energy Performance Certificates for non-domestic buildings on construction and at the point of sale or rent.

The latest version of the SBEM tool and its accompanying user interface, iSBEM, can be downloaded free of charge from the dedicated National Calculation Methodology website at http://www.ncm.bre.co.uk/ (opens in a new window).

Note: source of quote in italics: *http://www.bre.co.uk/page.jsp?id=706*

6.1.4 Export to VIP-Energy

The Export to VIP-Energy button activates the dedicated dialog box, which enables you to save all calculation input data in a .zip file archive that contains the VIP Energy input file package.



The saved file can be opened by the StruSoft VIP-Energy software for detailed energy analysis of the designed building.

6.1.5 Save as Baseline Building

Use this option to save the project as a Baseline Building reference data file (in BAS file format).

See the Performance-Rating Workflow chapter for more information regarding the Baseline Building concept.

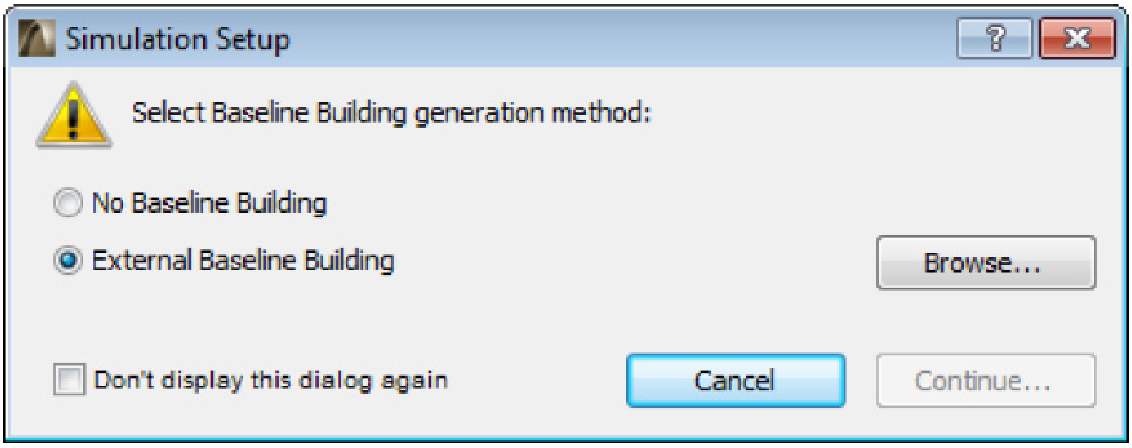
6.2 Start Energy Simulation

Once all necessary input data are obtained by means of geometry analysis and user input, the data input into the VIP-Core calculation engine built into ArchiCAD.

Select the Start Energy Simulation button to launch the VIP-Core Calculation Engine, which performs the dynamic energy analysis. EcoDesigner STAR calculates the energy balance of a building during a period of one year, and displays the results on the Energy Performance Evaluation Report.

6.2.1 Simulation Setup

The Simulation Setup dialog appears after the Start Energy Simulation button is pressed only if the "Select Baseline Building Preference at Start of Simulation" option is checked on the Energy Simulation Options panel.



Select No Baseline Building to execute the building energy simulation without performance rating, or Browse for the Baseline Building reference data file to enable the performance rating calculation.

Performance-Rating Workflow

Performance Rating means that the designed building's energy performance is compared with a so-called baseline building. Different building energy standards define baseline buildings differently. Usually it is a modified version of the design project specified to comply with minimum building energy efficiency requirements or to represent the statistical average for similar constructions.

Use EcoDesigner STAR's performance rating workflow to compare the designed building's energy efficiency with the performance of a baseline version of the same project.

- Create a baseline building PLN file (Baseline Building.PLN) by saving a copy of the design project PLN (Designed Building.PLN)
- Modify Baseline Building.PLN according to the relevant energy performance rating standard's instructions

- Use the Save as Baseline Building command to create the Baseline Building reference data file (Baseline Building.BAS)
- Open Designed Building.PLN and click the Start Energy Simulation button
- Import Baseline Building.BAS into Designed Building.PLN
- Select Continue to proceed with the energy simulation
- View the results of the comparative calculations (Designed Building.PLN's energy performance vs. Baseline Building.PLN) using the Building Energy Performance Evaluation report chapters dedicated to Performance Rating

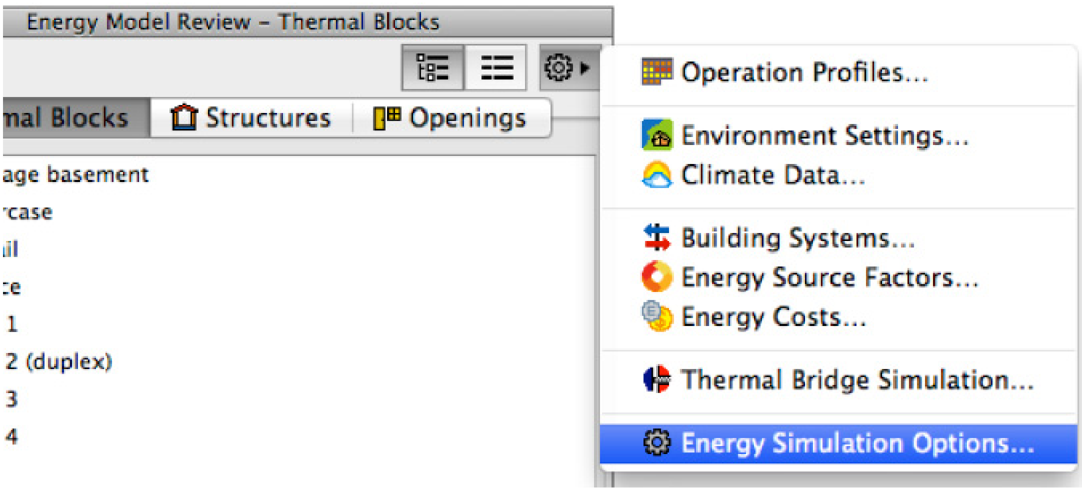
Baseline Building Reference File Processing Options

There are two different ways EcoDesigner STAR can use the baseline building reference file:

- Straight-up performance comparison with the designed building's performance
- The baseline building reference data is first automatically processed by the program according to the ASHRAE 90.1 Standard (LEED Energy) and the resultant data is then used for energy performance comparison.

Select Energy Simulation Options from the Energy Evaluation functions list. The list can be opened in two ways:

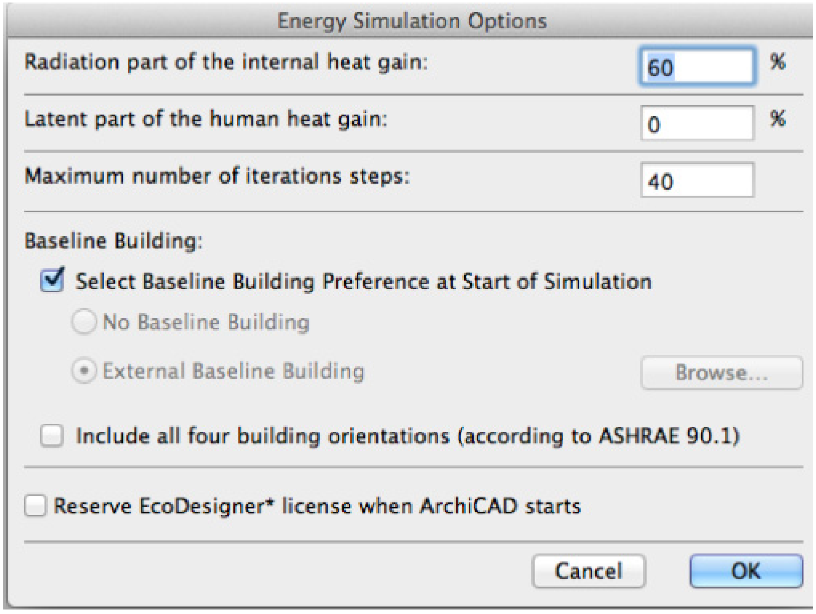
- Select Energy Evaluation from the Design menu
- By clicking the button on the upper right corner of the Energy Model Review palette



Under Baseline building, checkmark the Select Baseline Building Preference at Start of Simulation option or Browse for the baseline building reference file directly.

Simple Baseline Building Processing

Uncheck the “Include all four building orientations” option on the Energy Simulation Options panel to skip the ASHRAE 90.1 Baseline Building processing functionality (see next chapter for details) and use only one baseline building simulation run for the designed building’s energy performance rating.



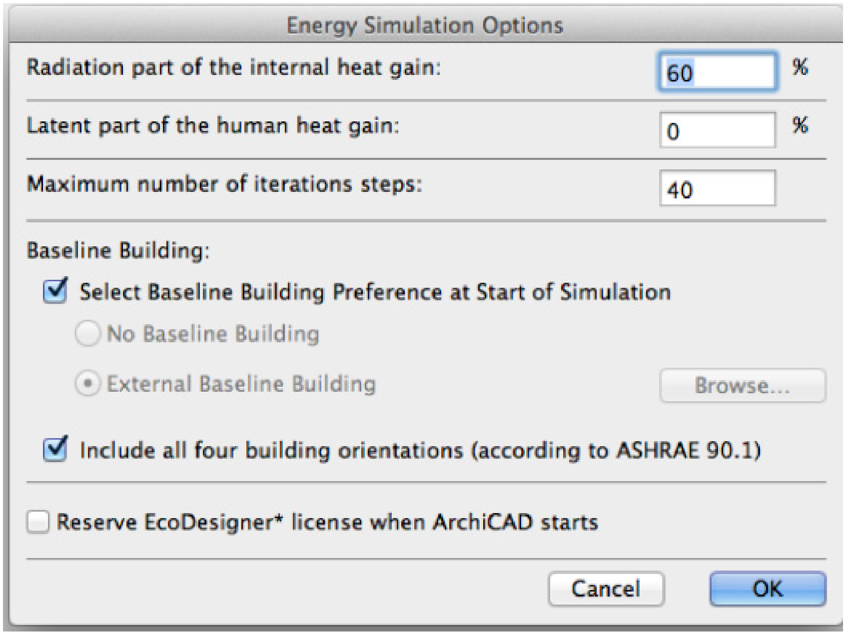
The simple baseline building method that only requires two simulations (one for the designed building and another for the baseline building).

ASHRAE 90.1 Baseline Building Processing

This EcoDesigner STAR functionality complies with Building energy performance rating standard ASHRAE 90.1_2007 Appendix G: Performance Rating Method as referenced by USGBC LEED – Energy 2007.

The program automatically rotates the baseline building by 90 degrees three times, re-analyzing the project after each rotation. Eventually, the four baseline building variations’ energy performance is averaged and the resultant data set is used for the performance rating of the designed building.

According to ASHRAE, the baseline building performance data generated this way represents the average design solution better, because it disregards differences in orientation caused by specific architectural solutions.



ASHRAE 90.1 (LEED Energy) baseline building reference data processing requires five simulations (designed building plus four baseline building versions). The simulation runtime with this baseline building processing type is therefore longer than with the simple baseline building processing method.

EcoDesigner STAR-s automatic baseline building processing functionality is also a great tool for checking the designed building's orientation whether it is truly optimized or perhaps a rotated layout with the thermal blocks facing different orientations would actually be more energy efficient.

6.3 Advisory Messages

The "Advisory Messages" dialog box appears if:

- the required input data are insufficient

See Additional Data Assignment and Input.

- there are simulation errors

See VIP-Core Dynamic Simulation Engine.

Errors will be required to be resolved before continuing. However, resolving Warnings is optional.

6.3.1 Errors And Recommended Solutions

(mandatory to resolve before continuing)

- Thermal properties of a used materials (cut fill type) are not defined.
  - Error icon: "Fill Types with missing properties"
  - List of cut fill types - hatch pattern, name
  - To-do: "Select the relevant Fill Type from the Fill Types dialog box and enter the missing values (values are required to be more than zero) in the Physical Properties panel."
- "Climate data is not available." (missing or the server is not accessible)
  - Error icon, "Climate Data is not available."
  - "To edit the Climate Data, open the Environment Settings dialog box from the Model Review palette."
- "One or more used Fill Type/Composite Structure is missing." (attribute definition of an used fill were deleted)
  - Error icon, "Structures with missing attributes."
  - List of structures with missing cut fills - orientation, type, area
- "Select the relevant model elements and edit its Cut Fill attribute."
- "Energy simulation runtime error." (engine errors during the hourly energy simulation)
  - Error icon, "Simulation engine errors."
  - List of <Engine error code + description>.
  - To-do: "Contact technical support:"
- "No valid Operation Profile selected."
  - Error icon, "Operation Profile is missing or not defined."
  - To-do: "Select an available profile from the Operation Profile dialog."
- "Energy model analysis error."
  - Error icon, "Energy model analysis did not found any structure or openings."
  - To-do: "Check the geometry of the Zones and update them using the Update Zones command."

6.3.2 Warnings And Recommended Solutions

(optional to resolve before continuing)

- "Zones are outdated and/or have errors." (i.e. not up to date, overlapped zones, visible zones which are not assigned to any TB) - zones on hidden layers will not appear
  - "Outdated zones:"
  - List of Zones - Zone ID, zone name, thermal block name
  - To-do: "Check the geometry of the above Zones and update them using the Update Zones command."

- “Location data varies between project location and climate data.”
    - Warning icon, “Location data does not match between project location and climate data.”
    - To-do: “Either modify the project location from the Project Location dialog box or modify the climate settings from the Environment Settings dialog box accessed via the Model Review palette.”
- Simplified building system is attached to a Thermal Block.

“Thermal Blocks with simplified building system:”

- List of Thermal Blocks - color swatch, number, name
- To-do: “Choose detailed settings from the Building Systems dialog and add the relevant details of HVAC systems used within building.”

- “Building shell contains one or more empty opening(s).”
    - Warning icon, “Building shell is not closed because external wall contains empty opening.”
    - To-do: “Review the Opening list and modify empty opening if necessary.”

On the Structures and Openings lists, a yellow warning exclamation mark appears next to those entries which contain faulty or missing data. (The problematic list items are also highlighted in pink.)

See Additional Data Assignment and Input.

6.3.3 Show List in Browser

Press the Show List in Browser button of the Advisory Messages dialog to display the list of errors and warnings in a browser window. This way the list can remain open for reference while you fix the building model in ArchiCAD following the instructions of the Suggestions / Notes field.

6.4 VIP-Core Dynamic Simulation Engine

6.4.1 Specification

The VIP energy simulation software module integrated in ArchiCAD (a.k.a. engine) is a result of more than 20 years of research and commercial use. It relies entirely on dynamic models, in which every model is broken down to a level where facts and behavior are known. Each component group is analyzed separately. The calculation is repeated every hour. The accuracy of each model has been validated and verified against real buildings under real usage. In calculating a building’s energy consumption, the program utilizes known or measured facts about all parts of the energy flow.

VIP-Energy is produced by Structural Design Software in Europe AB http://www.strusoft.com/

For technical information about VIP-Energy and for a more detailed explanation of the different calculating models, see http://vip.strusoft.com/.

6.4.2 Validation of Calculation Accuracy

EcoDesigner STAR uses the same simulation kernel as EcoDesigner STAR add-on for ArchiCAD. This kernel is validated with ANSI/ASHRAE Standard 140-2007: Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs.

> **Note:** To produce code-compliant energy simulation results, the expert user interface of EcoDesigner STAR is necessary.

The ASHRAE Standard 140 test documentation for EcoDesigner STAR will be available on the official product website, following the add-on's release.

The stand-alone VIP Energy product, which also uses the same simulation kernel as EcoDesigner STAR, is also validated with the following tests:

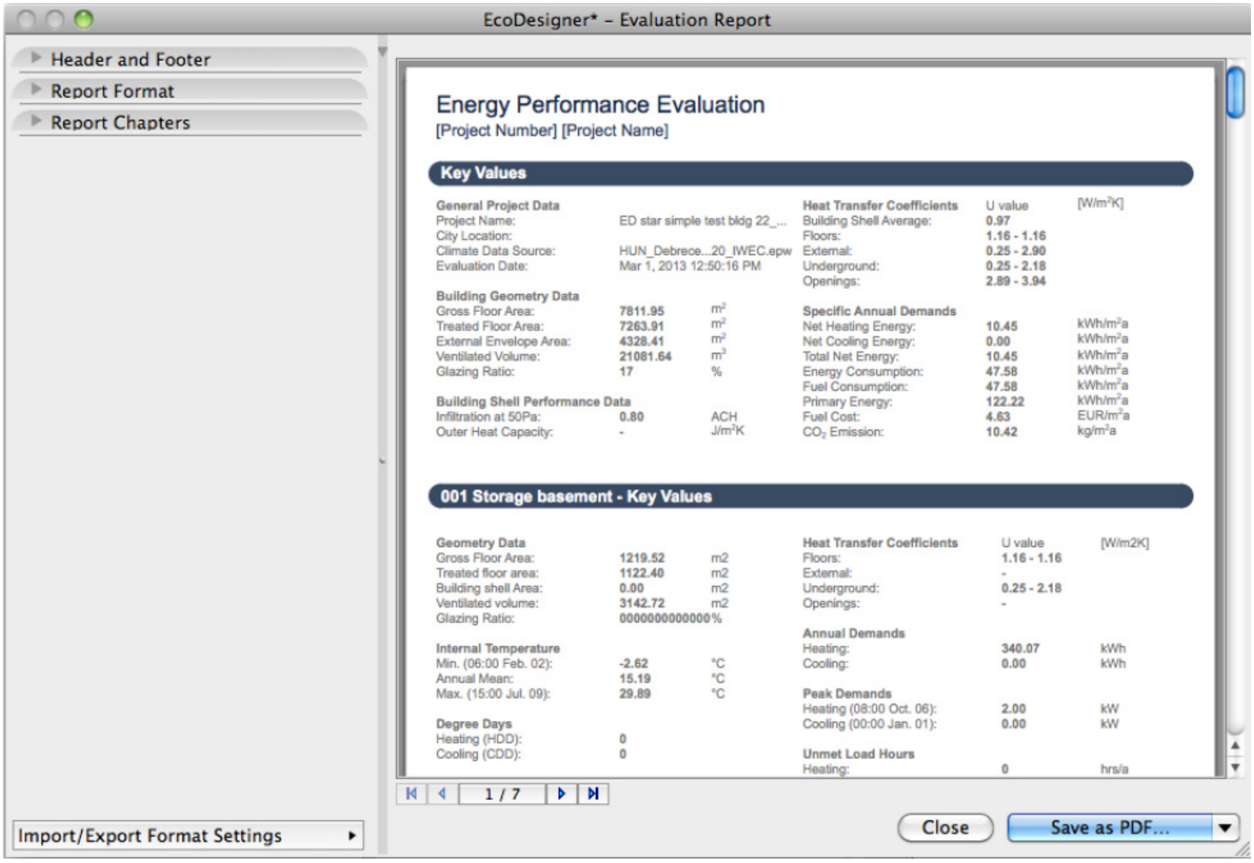
- EN-15265
- IEA-BESTEST
- ASHRAE-BESTEST (ANSI/ASHRAE Standard 140-2001)
- StruSoft-BESTEST

Validation results can be read at *http://www.strusoft.com/index.php/en/validationvip*

7. Energy Performance Evaluation Report

7.1 Evaluation Report Dialog

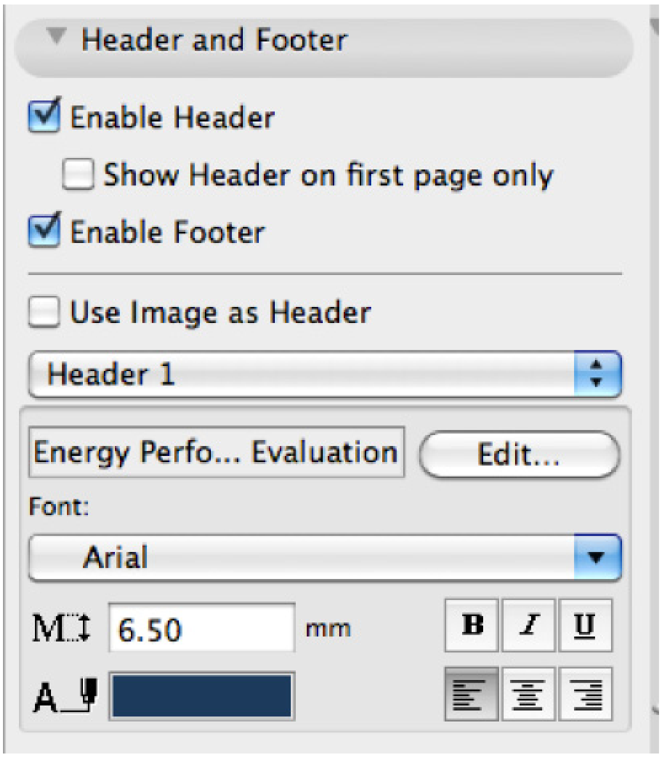
After the dynamic energy simulation is finished, the Evaluation Report dialog appears. Use the controls on the left side to customize certain aspects of the Energy Performance Evaluation report's content before saving it.



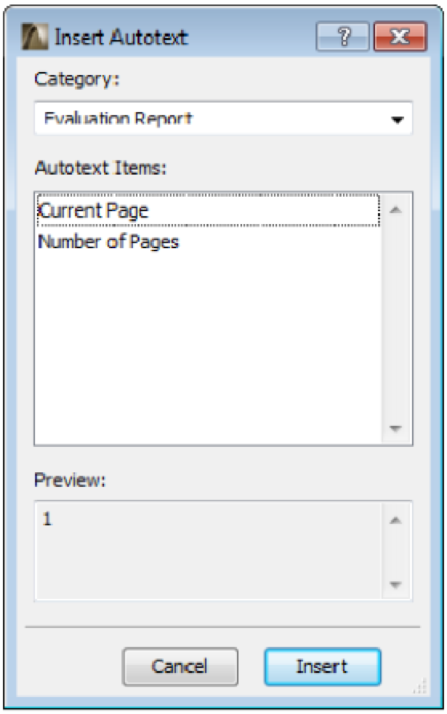
The right side of the dialog contains a preview of the Energy Performance Evaluation report PDF document.

7.1.1 Header and Footer Settings

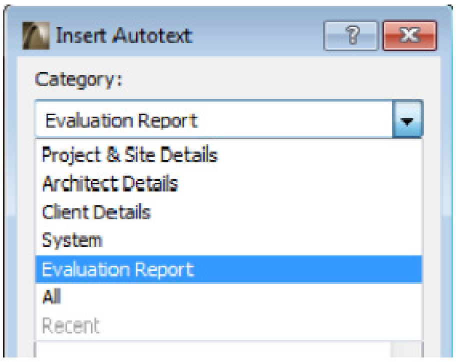
Use the controls of the Header and Footer Settings dialog to fill the two Header rows as well as the Footer of the PDF Energy Performance Report with custom content.



This content can also be an Image or even Autotext, which allows for a wide range of smart report title customization.



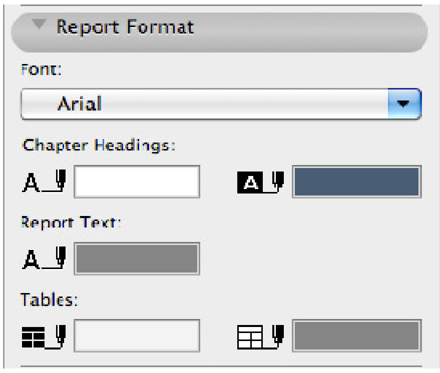
Insert Autotext



Autotext categories

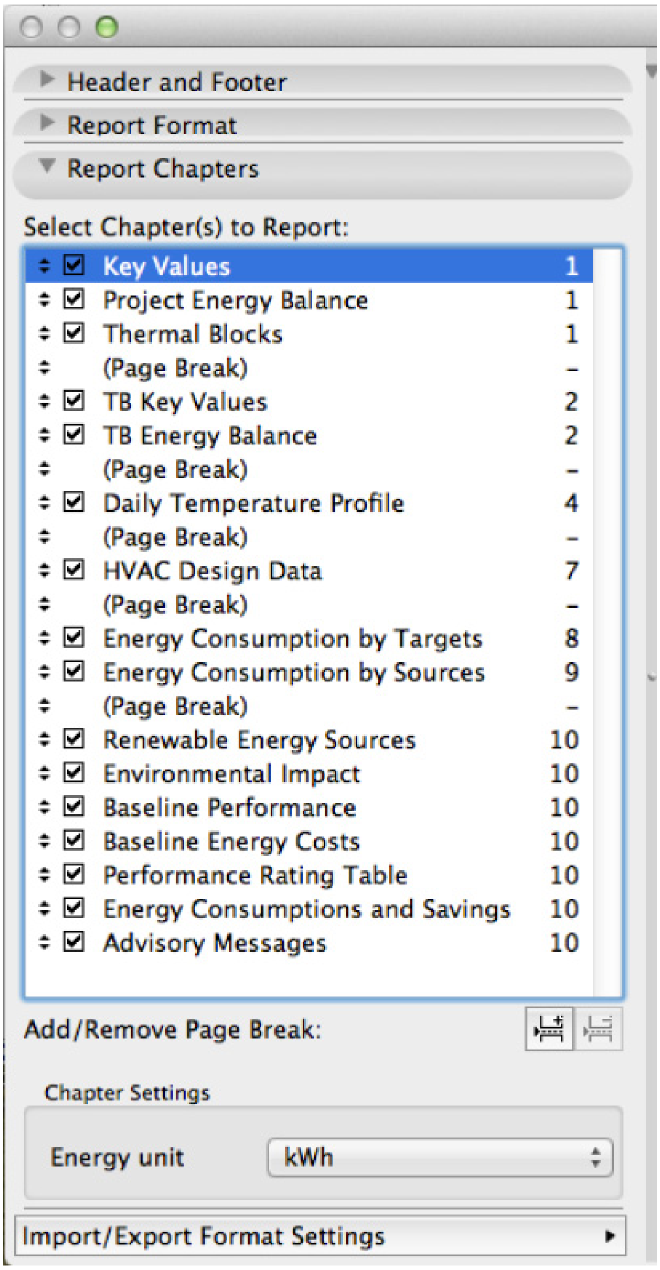
7.1.2 Report Format

This dialog defines font format and pen colors used for the Energy Performance Evaluation report PDF.



7.1.3 Report Chapter Settings

The Report Chapters section lists the content of the Energy Performance Evaluation report PDF.

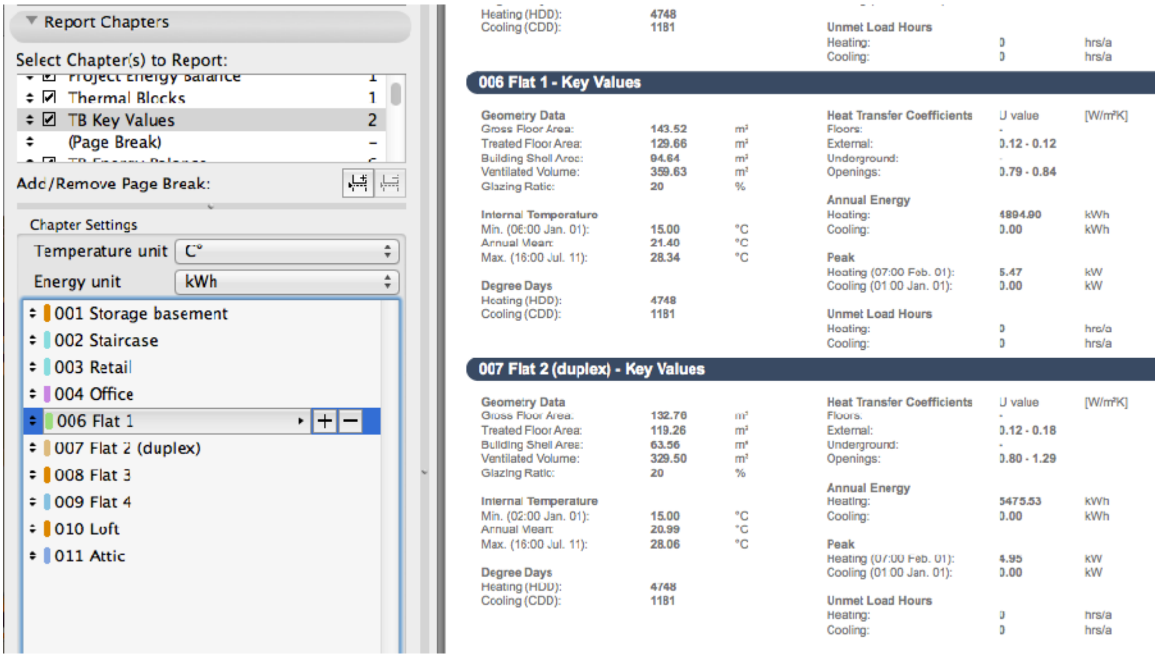


Change the order of the chapters by grabbing them with the arrows displayed before their names and dragging them. Use the buttons below the list to Add/Remove Page Breaks.

Chapter-Specific Settings

Some of the report chapters can be further customized by applying certain chapter-specific settings:

- **Key Values** Chapter Settings: Choose one of the three available Energy unit options: kWh, kBtu, MJ.
- **Project Energy Balance** Chapter Settings: Choose Weekly or Monthly for Time interval, and specify the Energy unit (kWh, kBtu, MJ). It is also possible to customize the colors of the bar chart.
- **Thermal Block Key Values** Chapter Settings: Choose Celsius Centigrade or Fahrenheit for Temperature unit, and specify the Energy unit (kWh, kBtu, MJ).

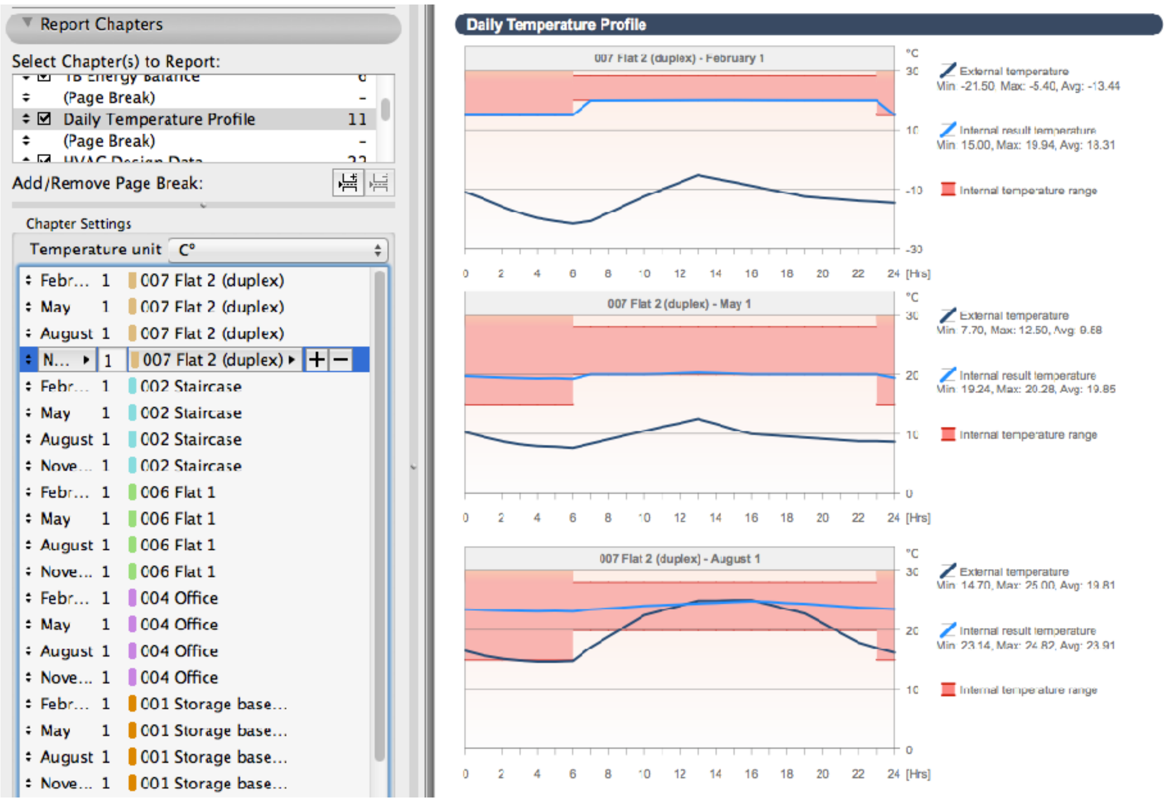


Edit the list of thermal blocks to add, remove or reorder the thermal block-specific Key Values chapters in the Energy Performance Evaluation PDF document.

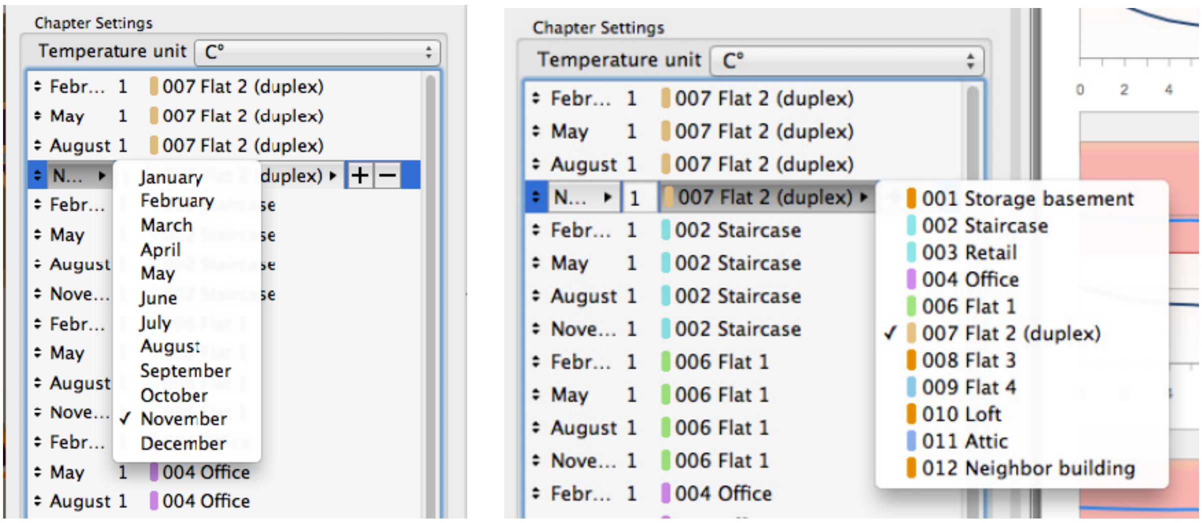
- **Thermal Block Energy Balance** Chapter Settings: Choose Weekly or Monthly for Time interval, and specify the Energy unit (kWh, kBtu, MJ). It is also possible to customize the colors of the bar chart.

Edit the list of thermal blocks to add, remove or reorder the thermal block-specific Energy Balance chapters in the Energy Performance Evaluation PDF document.

- **Daily Temperature Profile** Chapter Settings: Edit the list of thermal blocks to add, remove or reorder the thermal block-specific **Daily Temperature Profiles** in the Energy Performance Evaluation PDF document.



Use the controls that appear at the selected list items to set the Date for the Temperature Profile diagram you want to display.

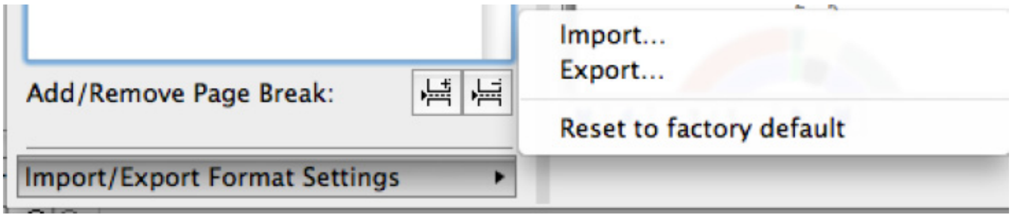


- **HVAC Design Data** Chapter Settings: Choose Celsius Centigrade or Fahrenheit for Temperature unit, and specify the Energy unit (kWh, kBtu, MJ).

- **Energy Consumption by Targets and by Sources** Chapters - Settings: Set the Energy unit and toggle between Pie or Bar Chart Display.
- **Renewable Energy Sources, Baseline Performance, Environmental Impact, Energy Consumptions and Savings, Performance Rating Table** Chapters - Settings: the Energy unit (kWh, kBtu, MJ) can be specified for each of these chapters individually.

Import/Export Format Settings

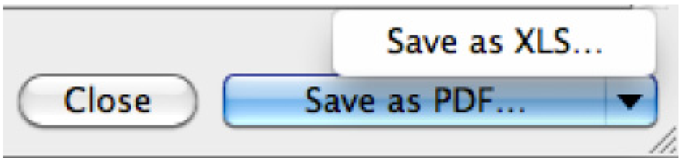
This button on the bottom left corner of the Evaluation Report dialog makes it possible to migrate PDF report formats between projects (e.g. to apply a company template format to the Energy Performance Evaluation report PDFs of every project).



There's also an option to reset the format of the Energy Performance Evaluation report to factory default.

7.1.4 Close and Save as Commands

At the bottom of the Evaluation Report:



- The Close button takes you back to the Energy Model Review palette, allowing you to further adjust the input data.
- Save as PDF lets you specify a location to which to save the Evaluation Report in PDF format.

See Energy Performance Evaluation - PDF Report.

- Click the button with the triangle in the bottom right corner to save the detailed monthly energy balance data in Microsoft Excel file format.

See Energy Performance Evaluation - XLS Reports.

7.2 Energy Performance Evaluation - PDF Report

7.2.1 Project Data Report Chapters

The following chapters present data regarding the entire project’s energy performance.

PDF Header

Energy Performance Evaluation

[Project Number] Simple Test Building

The PDF header displays custom project information as defined on the Header / Footer Settings dialog.

Key Values

The Key Values section of the PDF Evaluation Report displays the most important project data.

Key Values

General Project Data			**Heat Transfer Coefficients**	U value	[W/m^2K]
Project Name:	Simple Test Building		Building Shell Average:	**0.30**	
City Location:			Floors:	**0.39 - 0.39**	
Climate Data Source:	HUN_Debre...0_IWEC.epw		External:	**0.12 - 0.23**	
Evaluation Date:	Dec 20, 2013 9:13:52 PM		Underground:	**0.17 - 0.17**	
			Openings:	**0.71 - 1.33**	
Building Geometry Data					
Gross Floor Area:	**1173.22**	m^2	Net Heating Energy:	**27.52**	kWh/m^2a
Treated Floor Area:	**1016.19**	m^2	Net Cooling Energy:	**4.76**	kWh/m^2a
External Envelope Area:	**876.40**	m^2	Total Net Energy:	**32.27**	kWh/m^2a
Ventilated Volume:	**3088.75**	m^3	Energy Consumption:	**78.74**	kWh/m^2a
Glazing Ratio:	**17**	%	Fuel Consumption:	**72.60**	kWh/m^2a
			Primary Energy:	**105.81**	kWh/m^2a
Building Shell Performance Data			Fuel Cost:	**3.49**	EUR/m^2a
Infiltration at 50Pa:	**1.00**	ACH	CO_2 Emission:	**15.90**	kg/m^2a
Outer Heat Capacity:	**157.40**	J/m^2K			

General Product Data

Under General Project Data, basic information is given, such as Location and Climate Data Source, as specified by the user. The date of the evaluation is also shown.

Building Geometry Data

This section contains results of the model geometry analysis such as areas, volume and glazing ratio for the project as a whole.

See Automatic Model Geometry and Material Property Analysis.

Building Shell Performance Data

This section displays overall Air Leakage in air change per hour (also called air exchange rate - the number of interior volume air changes that occur per hour in 1/h). Outer heat capacity (measures the capacity of building structures to store heat against changing outside air temperature) is also an important building envelope performance metric.

Heat Transfer Coefficients

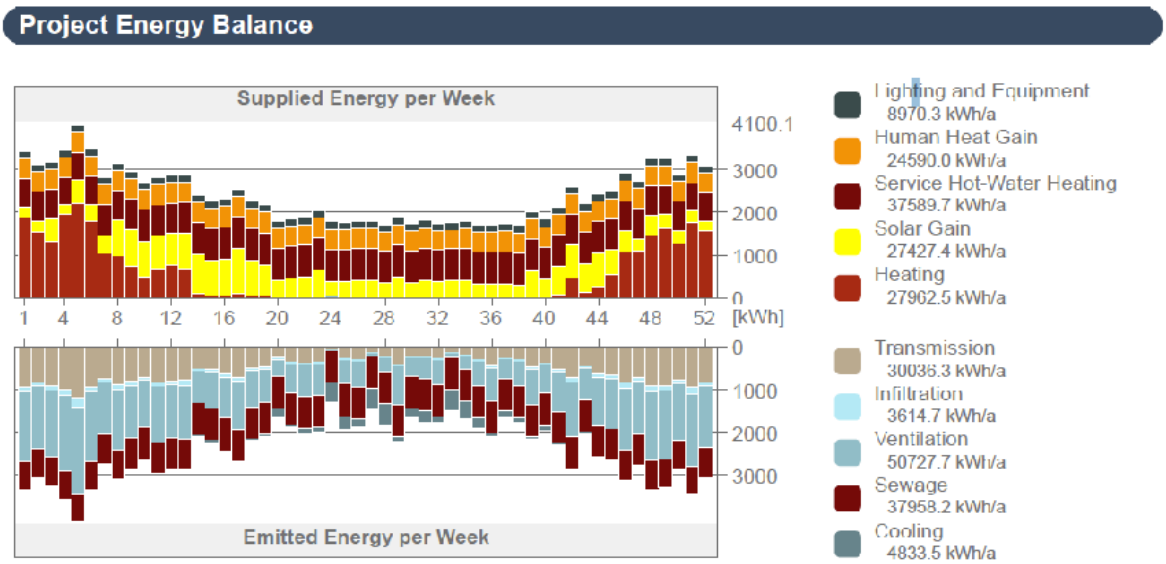
Also in the Key Values section, the minimum and maximum values of the Calculated heat transfer coefficients are listed for the entire building, for every Building structure group and for the openings on the building shell.

Specific Annual Energy data

Here, the most important energy performance data (net demand and gross consumption-related data) - projected to a unit area of the building - are listed, making the comparison of different sized projects possible.

Project Energy Balance

The Project Energy Balance bar chart is a graphical display of the amount of energy the entire building emits (bottom part of chart), as well as the building's Supplied energy: the amount of energy it absorbs from the environment and its own internal heat sources (top part of chart), by month or week (depending on Energy Performance Evaluation Report Chapter Settings).



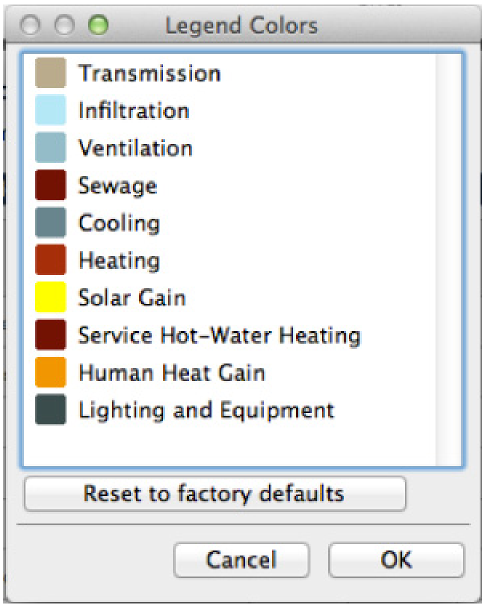
According to the energy balance equation - which is the foundation of building physics - the Emitted energy and Supplied energy bars must be equal every month (week). The vertical axis of the chart shows an energy scale. The horizontal axis represents the 12 months (52 weeks) of the year.

The Project Energy Balance Bar Chart shows the cumulative results of the hourly energy balance calculations executed by The VIP-Core Calculation Engine.

Energy Supply and Emission Types

To the right of the Monthly Energy Balance diagram, the energy flows that make up the bars of the chart are listed. The number and type of these energy balance components that appear on a particular Energy Evaluation Report depend on the settings on the evaluated building's Building Systems dialog. Total annual energy flow quantities are displayed in kWh/a.

The table below lists all energy supply and emission types with their default Energy Balance bar chart display color.



Note: Human Heat Gain contains Latent Heat within the thermal block, as well.

Energy Consumption by Targets

This section of the Evaluation Report contains two tables and several charts.

The table's far-left column lists energy Targets by name, plus their color codes used in the pie chart. The Quantity column lists the magnitude [e.g. kWh/a] while the Cost column shows the price [currency/a] of energy spent on each target in one year. The table's far-right column shows the carbon footprints associated with the listed energy target magnitudes.

Energy Consumption by Targets

Target Name	Energy Quantity kWh/a	Energy Primary kWh/a	Energy Cost EUR/a	CO_2 Emission kg/a
Heating	6749	6868	446	146
Cooling	0	0	0	0
Service Hot-Water	0	0	0	0
Ventilation Fans	3608	10824	721	779
Lighting & Appliances	3018	9054	603	651
Total:	13375	26747	1771	1577

The Distribution by Targets charts graphically display the percentages of the

- Energy quantities
- Primary energy
- Costs
- Carbon footprints

associated with each energy target.

The Target Energy Quantities by Primary Targets bar chart helps users to compare the magnitude of energy consumption with primary energy consumption.

It is possible to display the Energy Consumption chart in either bar or pie chart format.

See Report Chapter Settings.

Primary Energy

The primary energy value is the “common denominator” among different energy source consumption types, when determining the building’s total energy consumption. Not only does it indicate the net energy source consumed, but it also incorporates the energy needed for the manufacturing, transportation and the raw material processing of the energy source, as well as its transportation to the place of use. Minimizing the specific primary energy demand is a great way to improve the designed buildings’ overall performance.

The primary energy factors assigned to the energy sources differ according to building location.

See Project Location.

Use the Energy Source Factors dialog to enter the region-specific primary energy factors if available, or evaluate the project using the default assignments (based on standard DINV-18599).

Energy Consumption by Sources

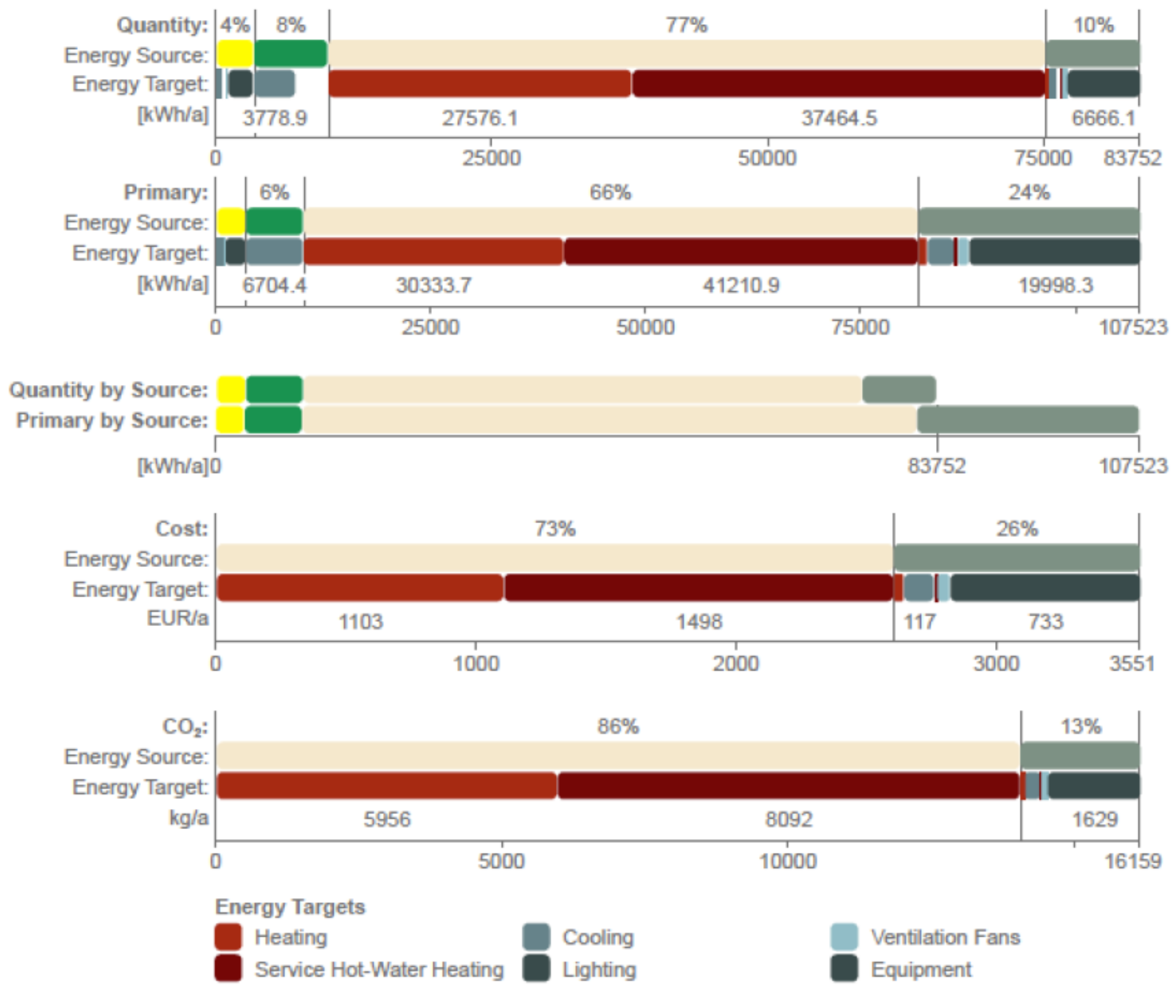
This section of the Evaluation Report contains one table and several charts.

The table’s far-left column lists energy Sources by **type** (Renewable, Fossil and Secondary) and **name**, plus their color codes used in the pie chart. The **Quantity** column lists the magnitude [e.g. kWh/a] while the **Cost** column shows the price [currency/a] of each energy source consumed in one year.

The table’s far-right column shows the **carbon footprints** associated with the listed energy source magnitudes.

Energy Consumption by Sources

Source Type	Energy Source Name	Quantity kWh/a	Primary kWh/a	Cost EUR/a	CO_2 Emission kg/a
Renewable	Solar (Thermal & PV)	3374	3374	NA	0
	External Air	6704	6704		0
Fossil	Natural Gas	65040	71544	2601	14048
Secondary	Electricity	8633	25899	949	2110
	Total:	83752	107523	3551	16159



The Distribution by Sources charts graphically display the percentage distributions of the

- Energy quantities
- Primary energy

- Costs
- Carbon footprints

of the used energy sources.

[redacted]

The Source Energy Quantities by Primary Sources bar chart helps users to compare the magnitude of energy consumption with primary energy consumption.

It is possible to display the Energy Consumption chart in either bar or pie chart format.

See Report Chapter Settings.

Environmental Impact

This chapter summarizes the environmental impact of the building's operation, by displaying Carbon Footprint and Primary Energy, according to Energy Sources.

Environmental Impact

Source Type	Source Name	Primary Energy kWh/a	CO_2 emission kg/a
Renewable	Solar (Thermal & PV)	3374	0
	External Air	6704	0
Fossil	Natural Gas	71544	14048
Secondary	Electricity	25899	2110
	Total:	**107523**	**16159**

Renewable Building System Summary

This chapter lists the amounts of energy generated by building systems that utilize renewable energy. The table also includes the related costs.

Renewable Building System Summary

Building System	Annual Energy Generated kWh	Renewable Energy Cost EUR
Photovoltaic system	3374	0.0
Total LEED Renewable Energy:	3374	0
Total:	**3374**	**0**

Advisory Messages Report

This chapter lists every warning message that occurred before the simulation was started.

Please consult the Advisory Messages chapter for the detailed description of simulation input data-related errors and warnings.

7.2.2 Thermal Block Report Chapters

Thermal Blocks

The table in this chapter tabulates the thermal blocks with their geometry data and Operation Profiles.

Thermal Blocks

Thermal Block	Zones Assigned	Operation Profile	Gross Floor Area m²	Volume m³
001 Storage basement	1	@unconditioned_f...	147.55	368.87
002 Staircase	6	@unconditioned_f...	41.22	344.02
003 Retail	1	@Retail shop/dep	145.11	500.61
004 Office	1	@Personal office	142.91	359.63
006 Flat 1	1	@Residential_red...	143.52	359.63
007 Flat 2 (duplex)	2	@Residential_red...	132.76	329.50
008 Flat 3	1	@Residential_red...	66.20	164.75
009 Flat 4	1	@Residential_red	143.52	359.63
010 Loft	2	@Residential_red...	189.50	290.33
011 Attic	1	@unconditioned	9.17	1.86
012 Neighbor building	6	@Neighbour bldg FF	11.77	1.91
Total:	**23**		**1173.22**	**3088.75**

Thermal Block Key Values

The Key Values chapters of the PDF Evaluation Report display important calculation result data for a specific thermal block.

003 Retail - Key Values

Geometry Data		
Gross Floor Area:	146.11	m²
Treated Floor Area:	133.54	m²
Building Shell Area:	124.27	m²
Ventilated Volume:	500.61	m³
Glazing Ratio:	29	%
Internal Temperature		
Min. (08:00 Feb. 01)	12.34	°C
Annual Mean:	20.93	°C
Max. (07:00 Jul. 11):	26.12	°C
Degree Days		
Heating (HDD):	4748	
Cooling (CDD):	1181	

Heat Transfer Coefficients	U value	[W/m²K]
Floors:	-	
External:	0.17 - 0.17	
Underground:	0.17 - 0.17	
Openings:	0.71 - 1.28	
Annual Energy		
Heating:	3959.42	kWh
Cooling:	3333.93	kWh
Peak		
Heating (09:00 Feb. 02):	9.19	kW
Cooling (16:00 Jul. 08):	7.30	kW
Unmet Load Hours		
Heating:	0	hrs/a
Cooling:	0	hrs/a

Geometry Data

This section contains result of the model geometry analysis such as areas, volume and glazing ratio for a specific thermal block.

See Automatic Model Geometry and Material Property Analysis.

Internal Temperature section**:** Minimum, Annual Mean and Maximum internal temperature values are displayed here.

Degree Days

Degree days data is defined as the integral of dry bulb temperature as a function of time, relative to a base temperature (18 Centigrade Celsius in EcoDesigner SATR). The Heating / Cooling requirements for a given structure at a specific location are considered to be directly proportional to the number of degree days at that location.

Heat Transfer Coefficients

Also in the Key Values section, the minimum and maximum values of the steady state heat transfer coefficients are listed for the thermal block, for every opaque structure group and for all openings on the thermal block's shell.

Annual Energy the total heating and cooling energy quantity associated with the thermal block throughout the simulation reference year can be found here.

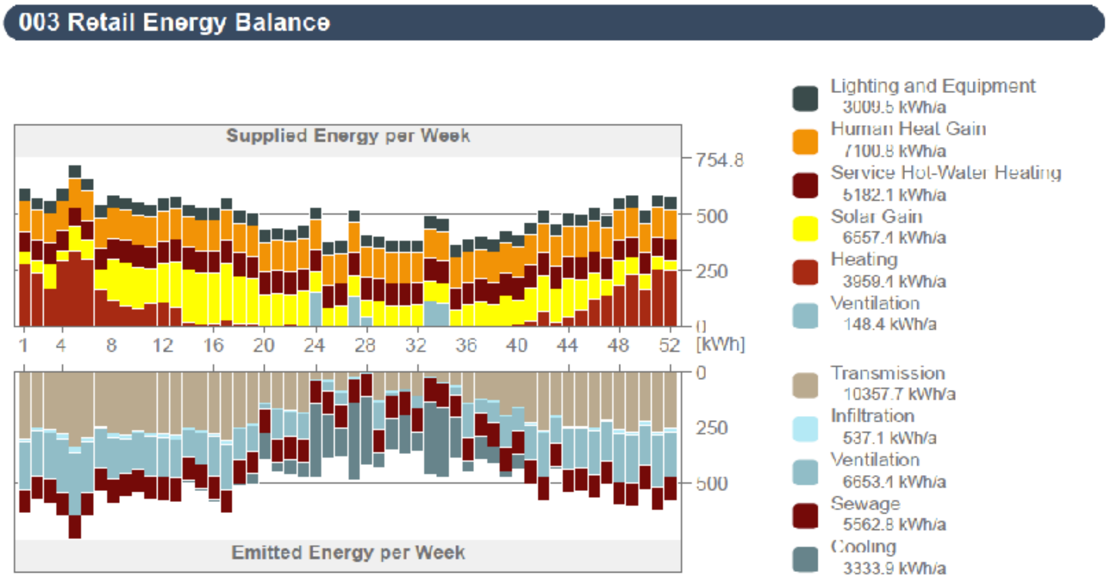
Peak Energy section: maximum heating and Cooling loads associated with the thermal block are displayed here, with date and time of occurrence.

Unmet Load Hours

The number of hours during a year when the internal temperature is out of the comfort range defined for the thermal block in the operation profile.

Thermal Block Energy Balance

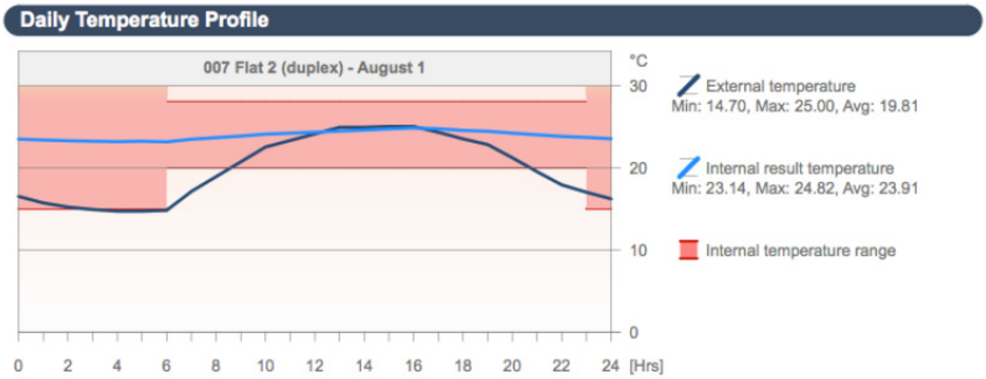
The Thermal Block Energy Balance bar chart is a graphical display of the amount of energy the thermal block emits (bottom part of chart), as well as the Supplied energy: the amount of energy it absorbs from the environment and its own internal heat sources (top part of chart), by month or week (depending on Energy Performance Evaluation Report Chapter Settings).



The Thermal Block Energy Balance Bar Chart shows the cumulative results of the hourly energy balance calculations executed by The VIP-Core Calculation Engine.

Daily Temperature Profile

The Daily Temperature Profile diagram is a graphical display of the hourly temperatures inside the thermal block and in the outside environment during the course of a day defined in the Report Chapter Settings.



The red area on the diagram shows the acceptable internal temperature range as defined in the Operation Profile assigned to the thermal block.

HVAC Design Data

This chapter contains the Yearly and Hourly Heating and Cooling Demands and the Internal Minimum and Maximum temperatures (with dates and hours of occurrence) for each thermal block, in a table format.

HVAC Design Data

Thermal Block	Heating Demand Yearly [kWh]	Heating Demand Hourly Peak [kW]	Cooling Demand Yearly [kWh]	Cooling Demand Hourly Peak [kW]	Internal Temperature Min. [°C]	Internal Temperature Max. [°C]
001 Storage basement	0	0.0 --	0	0.0 --	13.2 06:00 Feb. 01	26.4 16:00 Jul. 11
002 Staircase	28	1.3 08.00 Feb. 01	0	0.0 --	5.0 01.00 Jan. 01	28.4 11.00 Jul. 09
003 Retail	9438	16.8 09.00 Feb. 01	1328	6.0 16.00 Jul. 11	12.0 08.00 Jan. 02	28.9 16.00 Jul. 08
004 Office 1	4352	9.6 09:00 Feb. 01	982	4.5 16:00 Jul. 09	15.0 06:00 Jan. 01	28.1 16:00 Jul. 08
006 Flat 1	4594	5.2 07:00 Feb. 01	92	1.0 19:00 Jul. 09	15.0 06:00 Jan. 01	28.0 19:00 Jun. 15
007 Flat 2 (duplex)	5019	4.6 07:00 Feb. 01	36	0.8 19:00 Jul. 09	15.0 02:00 Jan. 01	28.0 19:00 Jun. 16
008 Flat 3	2454	2.4 07:00 Feb. 01	37	0.5 19:00 Jul. 10	15.0 05:00 Jan. 01	28.0 19:00 Jun. 15
009 Flat 4	4080	5.0 07:00 Feb. 01	183	1.2 19:00 Jul. 10	15.0 06:00 Jan. 01	28.1 06:00 Jul. 10
010 Loft	3204	4.4 07:00 Feb. 01	392	1.6 19:00 Jul. 09	15.0 04:00 Jan. 01	28.4 24:00 Jul. 10
011 Attic	0	0.0 --	0	0.0 --	3.8 09:00 Feb. 02	32.5 18:00 Jul. 11
012 Neighbor building	0	0.0 --	0	0.0 --	11.9 15:00 Jan. 01	26.9 04:00 Jul. 12
All Thermal Blocks:	**33172**	**45.2** **09:00 Feb. 01**	**3054**	**14.7** **16:00 Jul. 11**		

This data can be used for building system sizing only if the simulation has been run in Demand Calculation mode. If building system types other than Not Yet Specified are assigned to any of the project's thermal blocks, then the data in this table makes no sense. Therefore, please make sure to only use this table in demand calculation documentations.

Note: For more information regarding system sizing and demand calculation please consult Annex 2.

7.2.3 Performance Rating Report Chapters

The following report chapters display the results of the performance rating calculation.

Note: Please consult the Simulation Setup chapter for more information regarding the Performance Rating and the Baseline Building concepts.

Baseline Performance

This table lists the annual and peak energy consumptions of the baseline building, according to energy sources.

Baseline Performance

Energy Type	Annual Energy & Peak Demand	Baseline Design				
		0°	90°	180°	270°	Average
External Air	Energy Use (kWh)	29079	18686	23961	25515	24310
	Peak Demand (kW)	50	43	45	45	45
Electricity	Energy Use (kWh)	34049	31138	32699	33042	32732
	Peak Demand (kW)	17	15	18	17	17
District Heating	Energy Use (kWh)	115069	117378	119910	115092	116862
	Peak Demand (kW)	74	78	78	76	76
Total Energy Use: (kWh/a)		178197	167202	176570	173649	173904

- If Simple Baseline Building Processing is selected at the Baseline Building Reference Processing Options prior to the simulation, then only two result columns (0 degrees and Average) contain calculation data.
- If ASHARE 90.1 Baseline Building Processing is selected at the Baseline Building Reference Processing Options prior to the simulation, then all five result columns contain calculation data.

Baseline Energy Costs

This table lists energy costs associated with the baseline building, according to energy sources.

Baseline Energy Costs

Energy Type	Baseline Cost				Baseline Building Performance
	0° EUR/a	90° EUR/a	180° EUR/a	270° EUR/a	EUR/a (average)
Electricity	3745	3425	3596	3634	3600
District Heating	5753	5868	5995	5754	5843
Sum:	9498	9293	9591	9388	9443

Performance Rating Table

This table compares the annual energy uses and peak demands of the proposed design with the baseline building.

Performance Rating Table

Energy Use	Units	Proposed Design Results	BaseLine Building Results	Savings %
Heating	Energy Use (kWh)	27962.54	66422.01	57.90
	Peak Demand (kW)	31.34	70.23	55.37
Cooling	Energy Use (kWh)	4833.46	17504.09	72.39
	Peak Demand (kW)	12.52	33.67	62.82
Service Hot-Water	Energy Use (kWh)	37589.68	51340.66	26.78
	Peak Demand (kW)	5.77	7.33	21.20
Ventilation Fans	Energy Use (kWh)	655.14	669.65	2.17
	Peak Demand (kW)	0.18	0.18	2.24
Lighting	Energy Use (kWh)	3987.08	19197.92	79.23
	Peak Demand (kW)	1.05	6.89	84.82
Equipment	Energy Use (kWh)	4983.20	5158.34	3.40
	Peak Demand (kW)	1.17	1.22	3.87
Total Annual Energy Use: (kWh/a)		**80011.11**	**160292.67**	**50.08**
Annual Process Energy: (kWh/a)		**8970.28**	**24356.27**	**63.17**

Energy Consumptions and Savings

This table compares the energy consumption (Purchased and On Site Renewable) and related costs of the proposed design with the baseline building.

Energy Consumptions and Savings

Purchased Energy	Proposed Design		Baseline Building		Saving	
	Energy Use	Cost	Energy Use	Cost	Energy Use	Cost
		EUR/a		EUR/a	%	%
Natural Gas (kWh)	65040	2601				
Electricity (kWh)	8633	949	32732	3600	74	74
District Heating (kWh)	0	0	116862	5843	100	100
Subtotal: (kWh)	73673	3551	149595	9443	51	62

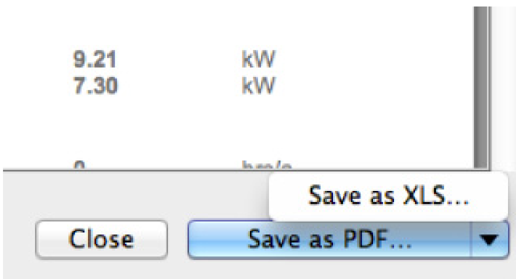
On Site Renewable Energy	Energy Generated kWh/a	Energy Cost EUR/a
Photovoltaic system	3374	0
Subtotal:	3374	0

	Proposed Design		Baseline Building		Saving	
	Energy Use	Cost	Energy Use	Cost	Energy Use	Cost
	kWh/a	EUR/a	kWh/a	EUR/a	%	%
Total:	77048	3551	149595	9443	48	62

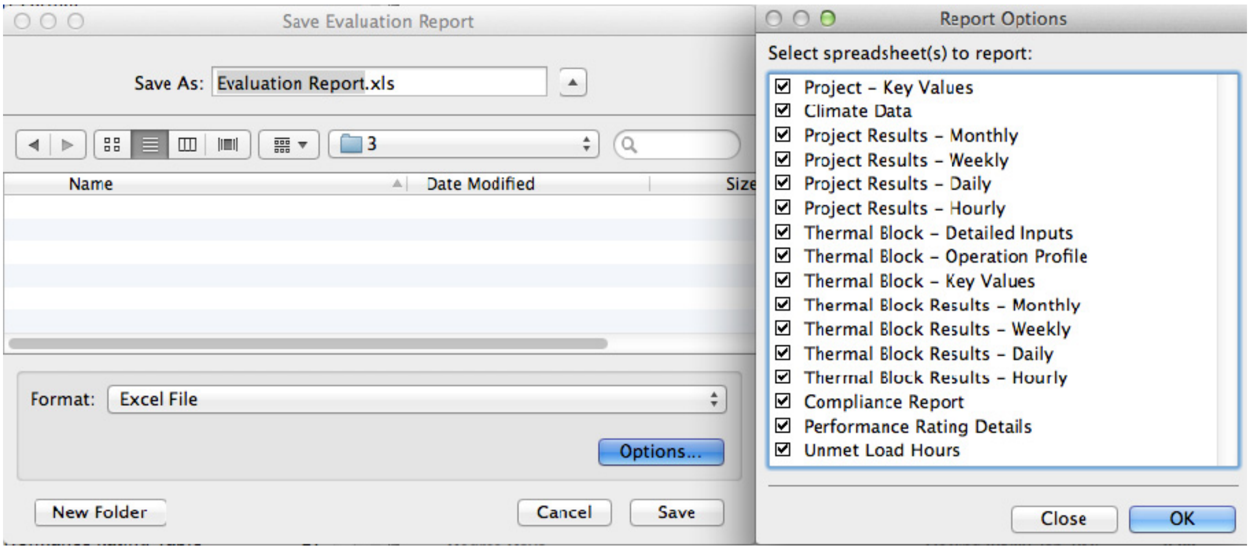
7.3 Energy Performance Evaluation - XLS Reports

The content of the Energy Performance Evaluation - XLS Reports is rather similar to the Energy Performance Evaluation PDF report, but the XLS Reports contain extra information.

Click the Save as XLS button with the triangle in the bottom right corner of the Energy Model Review palette (next to the Save as PDF button) to save the detailed monthly energy balance data in Microsoft Excel file format.



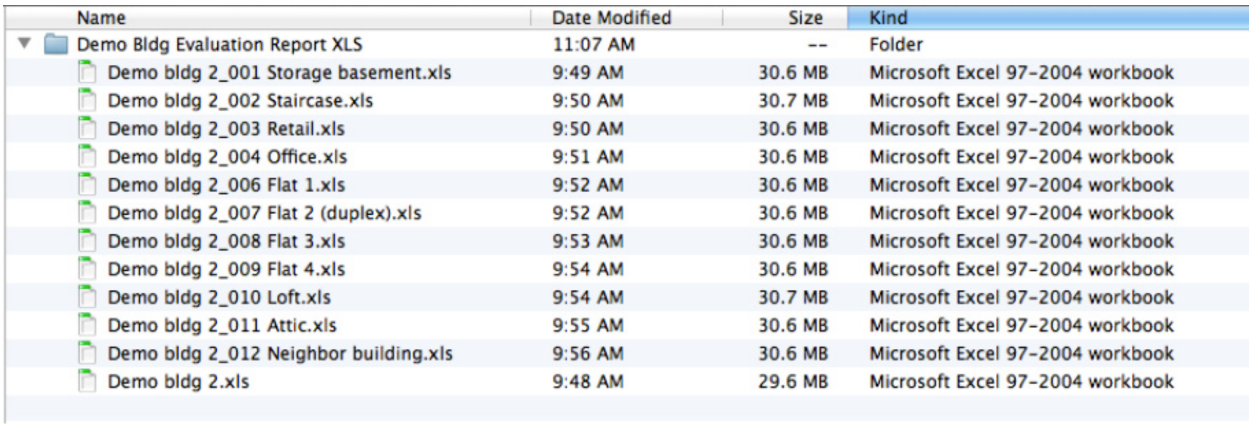
Select Options from the Save Evaluation Report dialog to display the Report Options panel.



Use the Report Options dialog to define which pages to include in the building Energy Performance Evaluation report XLS spreadsheets.

> **Note:** Some of the pages (e.g. Thermal Blocks – Daily) contain very large amount of information. Including these pages in the documentation increases the processing time of the XLS spreadsheets.

The number of the building Energy Performance Evaluation report XLS spreadsheets created by EcoDesigner STAR depends on the report content defined by the user on the Report Options panel and the number of the project's thermal blocks.



Name	Date Modified	Size	Kind
Demo Bldg Evaluation Report XLS	11:07 AM	--	Folder
Demo bldg 2_001 Storage basement.xls	9:49 AM	30.6 MB	Microsoft Excel 97-2004 workbook
Demo bldg 2_002 Staircase.xls	9:50 AM	30.7 MB	Microsoft Excel 97-2004 workbook
Demo bldg 2_003 Retail.xls	9:50 AM	30.6 MB	Microsoft Excel 97-2004 workbook
Demo bldg 2_004 Office.xls	9:51 AM	30.6 MB	Microsoft Excel 97-2004 workbook
Demo bldg 2_006 Flat 1.xls	9:52 AM	30.6 MB	Microsoft Excel 97-2004 workbook
Demo bldg 2_007 Flat 2 (duplex).xls	9:52 AM	30.6 MB	Microsoft Excel 97-2004 workbook
Demo bldg 2_008 Flat 3.xls	9:53 AM	30.6 MB	Microsoft Excel 97-2004 workbook
Demo bldg 2_009 Flat 4.xls	9:54 AM	30.6 MB	Microsoft Excel 97-2004 workbook
Demo bldg 2_010 Loft.xls	9:54 AM	30.7 MB	Microsoft Excel 97-2004 workbook
Demo bldg 2_011 Attic.xls	9:55 AM	30.6 MB	Microsoft Excel 97-2004 workbook
Demo bldg 2_012 Neighbor building.xls	9:56 AM	30.6 MB	Microsoft Excel 97-2004 workbook
Demo bldg 2.xls	9:48 AM	29.6 MB	Microsoft Excel 97-2004 workbook

One spreadsheet contains the Project Data and Performance Rating report pages. The number of the additional spreadsheets containing the Thermal Block Report Pages equal the number of thermal blocks of the documented project.

7.3.1 Report Page Types

Calculation Input Data Report Pages

Most building energy performance rating standards require all the calculation input data to be included in the documentation. Therefore certain pages of the EcoDesigner STAR XLS report spreadsheet are dedicated to calculation input data documentation. These pages are:

- Climate Data page
- Thermal Block – Detailed Inputs page
- Thermal Block – Operation Profile page

Calculation Output Data Report Pages

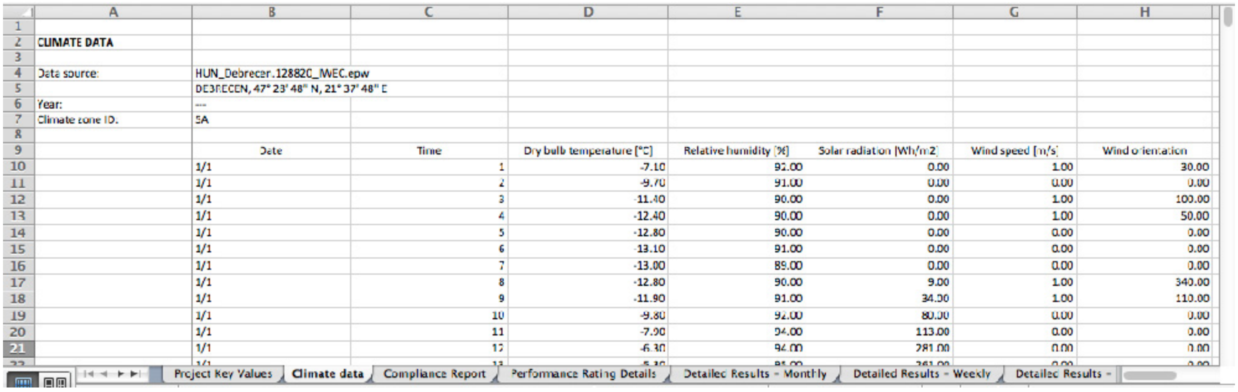
The Following Energy Performance Evaluation XLS Report pages document the EcoDesigner STAR building energy analysis calculation results:

- Project - Key Values Page
- Project Results - Monthly Page
- Project Results – Weekly Page
- Project Results – Daily Page
- Project Results – Hourly Page
- Thermal Block – - Key Values Page
- Thermal Block Results - Monthly Page
- Thermal Block Results – Weekly Page
- Thermal Block Results – Daily Page
- Thermal Block Results – Hourly Page
- Compliance Report
- Performance Rating Details
- Unmet Load Hours

7.3.2 Project Data Report Pages

Climate Data Page

This page displays the climate file's content in Excel spreadsheet format.



	A	B	C	D	E	F	G	H
1								
2	CLIMATE DATA							
3								
4	Data source:	HUN_Debrecen.128820_IWEC.epw						
5		DEBRECEN, 47° 23' 48" N, 21° 37' 48" E						
6	Year:	---						
7	Climate zone ID.	5A						
8								
9		Date	Time	Dry bulb temperature [°C]	Relative humidity [%]	Solar radiation [Wh/m2]	Wind speed [m/s]	Wind orientation
10		1/1	1	-7.10	92.00	0.00	1.00	30.00
11		1/1	2	-9.70	91.00	0.00	0.00	0.00
12		1/1	3	-11.40	90.00	0.00	1.00	100.00
13		1/1	4	-12.40	90.00	0.00	1.00	50.00
14		1/1	5	-12.80	90.00	0.00	0.00	0.00
15		1/1	6	-13.10	91.00	0.00	0.00	0.00
16		1/1	7	-13.00	89.00	0.00	0.00	0.00
17		1/1	8	-12.80	90.00	9.00	1.00	340.00
18		1/1	9	-11.90	91.00	34.00	1.00	110.00
19		1/1	10	-9.80	92.00	80.00	0.00	0.00
20		1/1	11	-7.90	94.00	113.00	0.00	0.00
21		1/1	12	-6.30	94.00	281.00	0.00	0.00

Project Key Values Page

Content similar to the Key Values section of the Energy Performance Evaluation PDF report.

	A	B	C	D
1				
2		Evaluation Date:	Jan 10, 2014 6:11:46 PM	
3	**PROJECT DATA**			
4		Project Name:	Simple Test Building	
5		Project Location:		
6		Latitude:	47° 29' 0" N	
7		Longitude:	21° 38' 0" E	
8	**CLIMATE DATA**			
9		Climate Data Source:	IWEC file	
10		Location:	DEBRECEN, 47° 28' 48" N, 21° 37' 48" E	
11		Year:		
12		File name:	HUN_Debrecen.128820_IWEC.epw	
13	**KEY VALUES**			
14		Gross Floor Area:	1173.22	m²
15		Treated Floor Area:	1016.19	m²
16		External Envelope Area:	876.40	m²
17		Ventilated Volume:	3088.75	m³
18		Glazing Ratio:	17.21	%
19		Air Leakage:	1.00	ACH
20		Outer Heat Capacity:	157.40	J/m²K
21	**U-VALUES**			
22		Building Shell Average:	0.30	W/m²K
23		Floors:	0.39 - 0.39	W/m²K
24		External:	0.12 - 0.23	W/m²K
25		Underground:	0.17 - 0.17	W/m²K
26		Openings:	0.71 - 1.33	W/m²K
27	**DESIGN LOADS**			
28		Heating:	27.61	kWh/m²a
29		Cooling:	4.76	kWh/m²a
30		Unmet Heating Hours:	0.00	h
31		Unmet Cooling Hours:	0.00	h
32	**ADVISORY MESSAGES**			
33		Warning:		
34			None	
35				
36		Baseline Building Warning:		
37			Zones are outdated and/or have errors.	
38			One or more purchased energy source has not defined cost.	
39	**SPECIFIC ANNUAL DEMAND**			
40		Net Heating Energy:	27.61	kWh/m²a
41		Net Cooling Energy:	4.76	kWh/m²a
42		Total Net Energy:	32.36	kWh/m²a
43		Energy Consumption:	48.1033	kWh/m²a
44		Fuel Consumption:	41.8666	kWh/m²a
45		Primary Energy:	72.1248	kWh/m²a
46		Fuel Cost:	2.2697	EUR/m²a
47		CO2 Emission:	9.285	kg/m²a
48				

Project Key Values | Climate data | Compliance Report | Performance Rati

Extra Information

- Project location's Latitude and Longitude
- Heating and cooling system Design Loads are simulation results that indicate gross system magnitudes.

  Note: this project level data is not for sizing systems and equipment. The design loads under Project Key Values are only displayed for your information. System sizing is only possible with the Thermal Block Report Pages.
- Advisory Messages display the errors and warnings that occurred before and during the simulation.

See Advisory Messages Report chapter.

Project Results - Monthly Page

This page is a summary table of the energy balance calculation output (monthly sum of hourly energy balance result data, for all thermal blocks of the project combined). This content is the numeric data visualized on the Project Energy Balance PDF report chapter (in monthly view), but the table contains more details.

	A	B	C	D	E	O	P	Q	R
1									
2		**Monthly Values**							
3		**Energy flows**	**MEP System type**	**Target**		**October**	**November**	**December**	**Annual Total [kWh]**
4		**All numbers are in [kWh]**							
42					Service hot-water heating	0.00	0.00	0.00	**0.00**
43					Circulation pump	0.00	0.00	0.00	**0.00**
44				Heat pump		0.00	0.00	0.00	**0.00**
45					Service hot-water heating	0.00	0.00	0.00	**0.00**
46					Auxiliary systems	0.00	0.00	0.00	**0.00**
47				District		0.00	0.00	0.00	**0.00**
48					Service hot-water heating	0.00	0.00	0.00	**0.00**
49					Circulation pump	0.00	0.00	0.00	**0.00**
50				Sewer recovery		2541.57	1828.26	1400.31	**26375.19**
51				Not yet specified		0.00	0.00	0.00	**0.00**
52		Cooling				-124.54	0.00	0.00	**-4834.23**
53			Central			0.00	0.00	0.00	**0.00**
54				Mechanical		0.00	0.00	0.00	**0.00**
55					Cooling	0.00	0.00	0.00	**0.00**
56					Auxiliary systems	0.00	0.00	0.00	**0.00**
57				District		0.00	0.00	0.00	**0.00**
58					Cooling	0.00	0.00	0.00	**0.00**
59					Circulation pump	0.00	0.00	0.00	**0.00**
60			Local			-124.54	0.00	0.00	**-4834.23**
61				Mechanical		-124.54	0.00	0.00	**-4834.23**
62					Cooling	-174.98	0.00	0.00	**-6705.49**
63					Auxiliary systems	50.44	0.00	0.00	**1871.26**
64				DX Cooling		0.00	0.00	0.00	**0.00**
65					Cooling	0.00	0.00	0.00	**0.00**
66					Auxiliary systems	0.00	0.00	0.00	**0.00**
67			Not yet specified			0.00	0.00	0.00	**0.00**
68		Ventilation				-4105.65	-5683.33	-6666.85	**-50709.48**
69			Mechanical			-2037.08	-3485.46	-4136.58	**-25852.41**
70				Ventilation		-2092.63	-3540.10	-4190.85	**-26507.56**
71				Ventilation Fans		55.55	54.64	54.27	**655.14**
72			Not yet specified or Natural			-3064.36	-4461.75	-5327.28	**-40272.83**
73			Air to air recovery			995.79	2263.88	2797.01	**15415.76**
74		Lighting and Equipment				778.87	748.47	738.02	**8970.28**
75			Lighting			347.54	333.57	326.14	**3987.08**
76			Equipments			431.33	414.90	411.89	**4983.20**
77		Sewage				-3176.96	-2285.32	-1750.38	**-32968.99**
78		**Supplied energy**				**9708.99**	**11146.57**	**12665.82**	**121800.25**
79		**Emitted energy**				**-10045.26**	**-11649.65**	**-12770.64**	**-122159.00**
80		**Difference**				**-336.27**	**-503.08**	**-104.82**	**-358.75**
81									
82		**Auxiliary systems**				117.89	125.14	183.37	**3043.09**
83									
84		**On-site electricity**				163.85	72.90	43.34	**3326.49**
85				Solar photovoltaic		163.85	72.90	43.34	**3326.49**
86				Wind energy		0.00	0.00	0.00	**0.00**
87			Potential production			372.00	149.00	102.00	**5623.00**
88				Solar photovoltaic		372.00	149.00	102.00	**5623.00**
89				Wind energy		0.00	0.00	0.00	**0.00**

Project Key Values | Climate data | Compliance Report | Performance Rating Details | **Detailed Results – M**

Extra Information

- Auxiliary energies of all systems appear separately
- Heating and Cooling are further broken down according to system types and specific target (Space heating, Hot water generation)...

- Lighting and Equipment electricity consumptions are listed separately
- Auxiliary systems summary
- Utilized monthly on-site electricity versus potential production

Project Results – Weekly Page

This page is a summary table of the energy balance calculation output (weekly sum of hourly energy balance result data, for all thermal blocks of the project combined). This content is the numeric data visualized on the Project Energy Balance PDF report chapter (in weekly view), but the table contains more details.

Extra Information

- Auxiliary energies of all systems appear separately
- Heating and Cooling are further broken down according to system types and specific target (Space heating, Hot water generation)...
- Lighting and Equipment electricity consumptions are listed separately
- Auxiliary systems summary
- Utilized monthly on-site electricity versus potential production

Project Results – Daily Page

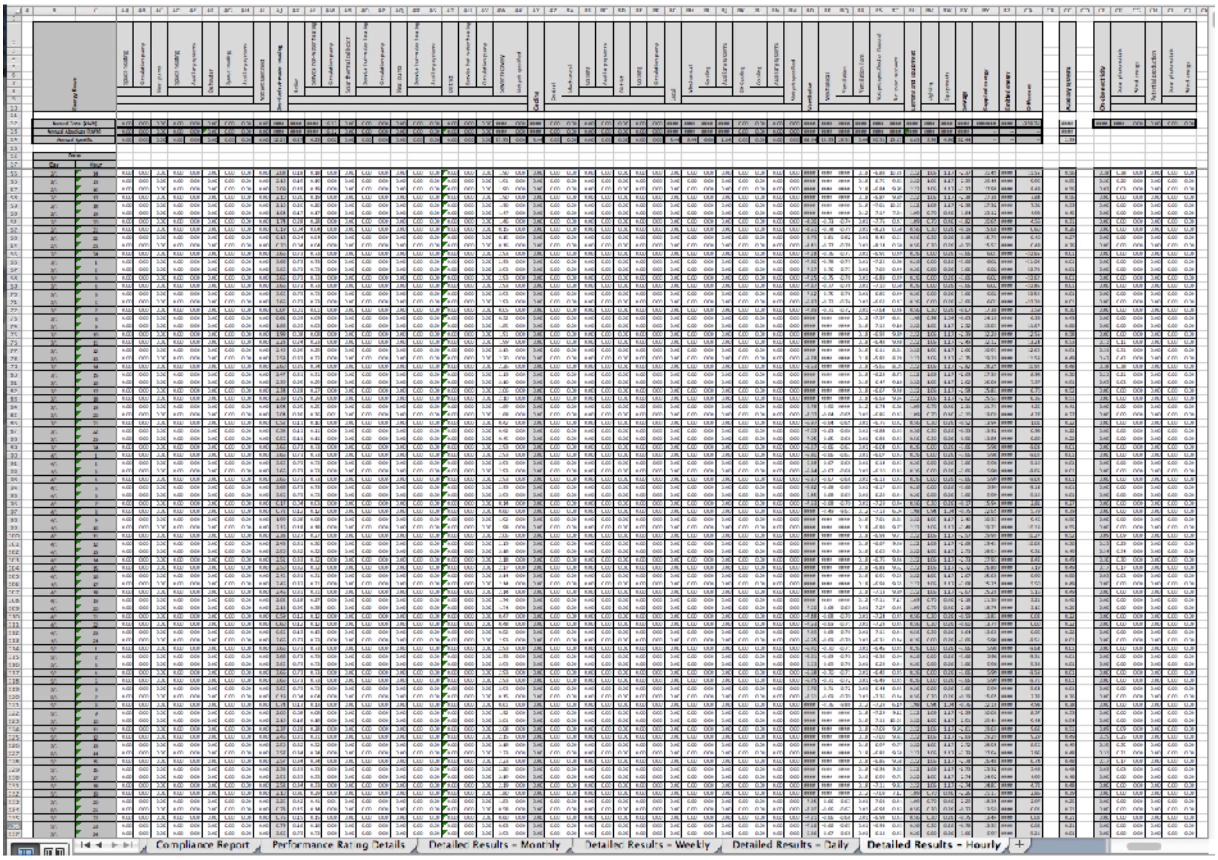
This page is a summary table of the energy balance calculation output (Daily sum of hourly energy balance result data, for all thermal blocks of the project combined).

Extra Information

- Auxiliary energies of all systems appear separately
- Heating and Cooling are further broken down according to system types and specific target (Space heating, Hot water generation)...
- Lighting and Equipment electricity consumptions are listed separately
- Auxiliary systems summary
- Utilized monthly on-site electricity versus potential production

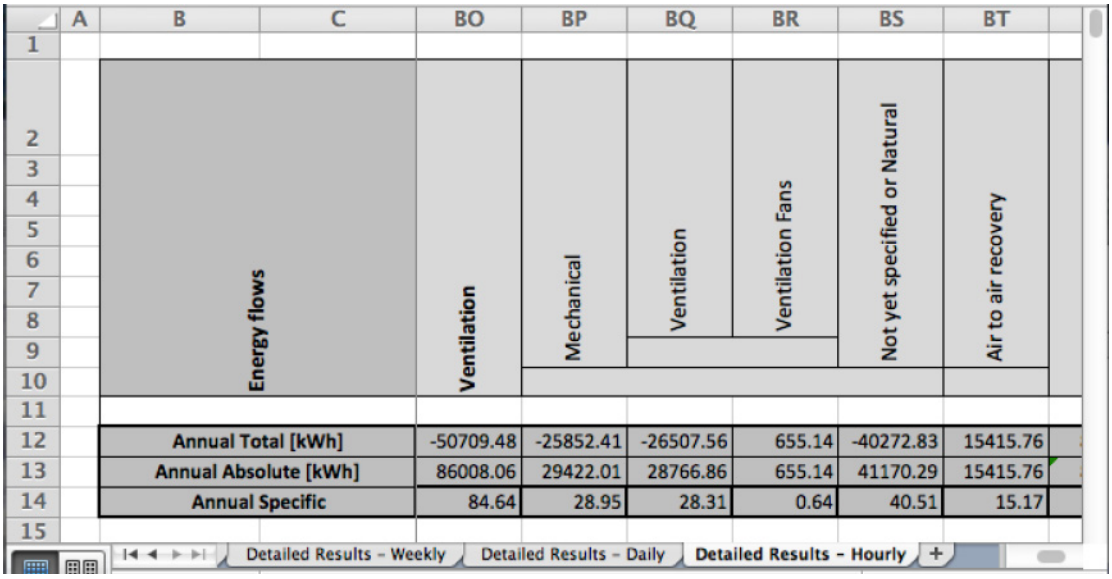
Project Results –Hourly Page

This page is the table that contains the hourly energy balance of all the thermal blocks, combined. The hourly results that are summarized on the other Project Results tables appear here.



Extra Information

- The data summary includes the Annual Absolute values beside the Annual Total values. For energy flows (e.g. ventilation) that can be both gains and losses depending on the time of the reference year, these two result values can be significantly different.



Energy flows	Ventilation	Mechanical	Ventilation	Ventilation Fans	Not yet specified or Natural	Air to air recovery
Annual Total [kWh]	-50709.48	-25852.41	-26507.56	655.14	-40272.83	15415.76
Annual Absolute [kWh]	86008.06	29422.01	28766.86	655.14	41170.29	15415.76
Annual Specific	84.64	28.95	28.31	0.64	40.51	15.17

7.3.3 Thermal Block Report Pages

Thermal Block - Detailed Inputs Page

The following thermal block calculation input data is detailed on this page: Name, Operation Profile, Floor Area, Volume, Structures, Openings, Building Systems, Zones Assigned.

	A	B	C	D	E	F	G
1	**Thermal Block:**	009 Flat 4					
2	**Operation Profile:**	@Residential_reduced SHWH and Lighting					
3	**Gross Floor Area:**	143.52	m²				
4	**Building Volume:**	359.63	m³				
5							
6	**STRUCTURES**						
7		**Orientation**	**Category**	**Type**	**Complexity**	**Name**	**Area [**
8		Inner	Internal	Masonry Block - Filler	Straight	Wall	
9		Inner	Internal	Reinforced Concrete - Stru	-----	Slab	1
10		Inner	Internal	Masonry Block - Filler	Straight	Wall	
11		West	External	@External Wall_good	Straight	Wall	
12		South	External	@External Wall_good	Straight	Wall	
13		East	External	@External Wall_good	Straight	Wall	
14		North	External	@External Wall_good	Straight	Wall	
15		Inner	Internal	Reinforced Concrete - Stru	-----	Slab	1
16		-----	-----	Thermal Bridge	-----	D-02 Detail	-----
17							
18	**OPENINGS**						
19		**Orientation**	**Type**	**Glazing Area [m²]**	**Glazing U-value [W/m²K]**	**TST %**	**DST %**
20		West	Window	3.04	0.60	52.00	
21		West	Window	1.82	0.60	52.00	
22		South	Window	1.82	0.60	52.00	
23		South	Window	3.85	0.60	52.00	
24		South	Window	3.04	0.60	52.00	
25		East	Window	1.82	0.60	52.00	
26		East	Window	1.82	0.60	52.00	
27		East	Window	1.82	0.60	52.00	
28							
29	**BUILDING SYSTEMS**						
30		**System Type**	**System Name**				
31		Ventilation	Flats_Natural				
32		Heating	Heating				
33		Cooling	Flat 4_Mech				
34							
35	**ZONES ASSIGNED**						
36		**Zone ID**	**Zone Name**	**Zone Category**			
37		008	Flat	Residential and Recreation			
38							

Detailed Inputs | Operation Profile | Detailed Results - Monthly | Detailed Results - Weekly | Detailed Results -

Thermal Block – Operation Profile Page

This table contains the hourly schedule of internal temperature requirements and internal gains.

	A	B	C	D	E	F
1						
2		**Profile name:**	@Residential_reduced SHWH and Lighting			
3		**Occupancy type:**	residential			
4		**Human heat gain:**	70.00	**W/capita**		
5		**Service hot-water load:**	80.00	**l/day per capita**		
6		**Humidity load:**	2.00	**l/day**		
7						
8				Internal temperature		Internal heat gain
9			Hour of the year	Max	Min	
10				[°C]	[°C]	W/m²
508			498	28.00	20.00	2.33
509			499	28.00	20.00	2.83
510			500	28.00	20.00	2.83
511			501	28.00	20.00	2.83
512			502	28.00	20.00	2.83
513			503	28.00	20.00	2.83

Detailed Inputs | Operation Profile | Detailed Results - Monthly | Detailed Results - Weekly | Detailed Results - Daily

Thermal Block – Key Values

Content is similar to the Thermal Block - Key Values section of the Energy Performance Evaluation PDF report.

Extra Information

- Annual hourly 1°C zone air temperature bin frequencies from –20°C to 70°C: this table groups the hours of the reference year when the internal air temperature is the same.

Annual hourly 1°C zone air temperature bin frequencies from –20°C to 70°C

Row	Temperature [°C]	Frequency [Hrs]	[%]
67	12	0.00	0%
68	13	0.00	0%
69	14	0.00	0%
70	15	38.00	0%
71	16	229.00	3%
72	17	496.00	6%
73	18	341.00	4%
74	19	1367.00	16%
75	20	2443.00	28%
76	21	678.00	8%
77	22	815.00	9%
78	23	650.00	7%
79	24	673.00	8%
80	25	455.00	5%
81	26	331.00	4%
82	27	212.00	2%
83	28	32.00	0%
84	29	0.00	0%
85	30	0.00	0%
86	31	0.00	0%
87	32	0.00	0%

Thermal Block Results –Monthly Page

This page is a summary table of the energy balance calculation output (monthly sum of hourly energy balance result data for the thermal block). This content is the numeric data visualized on the Thermal Block Energy Balance PDF report chapter (in monthly view), but the table contains more details.

	A	B	C	D	E	O	P	Q	R
1									
2		**Thermal Block Name:**	009 Flat 4						
3		**Gross Floor Area:**	143.52		m²				
4		**Treated Floor Area:**	129.66		m²				
5		**Volume:**	359.63		m³				
6									
7		**Monthly Values**							
8		**Energy flows**	**MEP System type**		**Target**	**October**	**November**	**December**	**Annual Total [kWh]**
9		**All numbers are in [kWh]**							
63					Cooling	0.00	0.00	0.00	**0.00**
64					Circulation pump	0.00	0.00	0.00	**0.00**
65			Local			0.00	0.00	0.00	**-8.53**
66				Mechanical		0.00	0.00	0.00	**-8.53**
67					Cooling	0.00	0.00	0.00	**-11.62**
68					Auxiliary systems	0.00	0.00	0.00	**3.08**
69				DX Cooling		0.00	0.00	0.00	**0.00**
70					Cooling	0.00	0.00	0.00	**0.00**
71					Auxiliary systems	0.00	0.00	0.00	**0.00**
72			Not yet specified			0.00	0.00	0.00	**0.00**
73		Ventilation				-583.57	-868.50	-1066.02	**-7700.20**
74			Mechanical			0.00	0.00	0.00	**0.00**
75				Ventilation		0.00	0.00	0.00	**0.00**
76				Ventilation Fans		0.00	0.00	0.00	**0.00**
77			Not yet specified or Natural			-583.57	-868.50	-1066.02	**-7700.20**
78			Air to air recovery			0.00	0.00	0.00	**0.00**
79		Lighting and Equipment				14.07	13.61	14.07	**165.63**
80			Lighting			14.07	13.61	14.07	**165.63**
81			Equipments			0.00	0.00	0.00	**0.00**
82		Sewage				-566.60	-370.18	-247.91	**-5661.16**
83		**Supplied energy**				**1391.82**	**1684.82**	**1969.16**	**17414.80**
84		**Emitted energy**				**-1411.26**	**-1713.00**	**-1970.26**	**-17403.57**
85		**Difference**				**-19.44**	**-28.18**	**-1.10**	**11.22**
86									
87		**Auxiliary systems**				2.14	14.21	24.16	**99.63**
88									

Detailed Results - Monthly | Detailed Results - Weekly | Detailed Results - Daily | Detailed Results - Hourly

Extra Information

- Auxiliary energies of all systems appear separately
- Heating and Cooling are further broken down according to system types and specific target (Space heating, Hot water generation)...
- Lighting and Equipment electricity consumptions are listed separately
- Auxiliary systems summary

- Additional in-depth analysis result data

	A	B	C	D	E	O	P	Q	R
1									
2		Thermal Block Name:	009 Flat 4						
3		Gross Floor Area:	143.52		m²				
4		Treated Floor Area:	129.66		m²				
5		Volume:	359.63		m³				
6									
7		Monthly Values							
8		Energy flows	MEP System type		Target	October	November	December	Annual Total [kWh]
9		All numbers are in [kWh]							
88									
89		Internal temperature			°C	20.44	19.44	19.17	
90		Wet bulb temperature			°C	13.20	10.96	9.78	
91		Average internal pressure			Pa	-5.01	-7.91	-9.45	
92		Room moisture			g/kg	6.68	4.85	3.87	
93		Outdoor moisture			g/kg	6.29	4.47	3.50	
94		Room relative moisture			%	64.00	57.00	54.00	
95		Added moisture			mg/s	29.95	29.95	29.95	
96		Sensible cooling load to evaporator			kWh	0.00	0.00	0.00	0.00
97		Latent cooling load to evaporator			kWh	0.00	0.00	0.00	0.00
98		Latent cooling demand in room air			kWh	0.00	0.00	0.00	0.00
99		Sensible cooling demand in room air			kWh	0.00	0.00	0.00	8.53
100		Cooling fan at outdoor condenser			kWh	0.00	0.00	0.00	0.00
101		Cooler circulation fan electricity			kWh	0.00	0.00	0.00	0.00
102		Prime heat demand			kWh	0.00	0.00	0.00	0.00
103		Convective solar radiation			kWh	97.46	70.36	44.80	775.15
104		Solar radiation through windows			kWh	323.57	234.35	149.35	2583.41
105		Solar radiation towards building			kWh	6684.96	3940.02	2610.40	83611.21
106									

Detailed Results - Monthly | Detailed Results - Weekly | Detailed Results - Daily | Detailed Results - Hourly

Thermal Block Results – Weekly Page

This page is a summary table of the energy balance calculation output (weekly sum of hourly energy balance result data, for the thermal blocks). This content is the numeric data visualized on the Thermal Block Energy Balance PDF report chapter (in weekly view), but the table contains more details.

Extra Information

- Auxiliary energies of all systems appear separately
- Heating and Cooling are further broken down according to system types and specific target (Space heating, Hot water generation).
- Lighting and Equipment electricity consumptions are listed separately
- Auxiliary systems summary
- Additional in-depth analysis result data *(See Thermal Block Results –Monthly Page)*

Thermal Block – Daily Page

This page is a summary table of the energy balance calculation output (Daily sum of hourly energy balance result data, for the thermal block).

Extra Information

- Auxiliary energies of all systems appear separately
- Heating and Cooling are further broken down according to system types and specific target (Space heating, Hot water generation)...

- Lighting and Equipment electricity consumptions are listed separately
- Auxiliary systems summary
- Additional in-depth analysis result data *(See Thermal Block Results –Monthly Page)*

Thermal Block –Hourly Page

This page is the table that contains the actual hourly energy balance calculation output. The hourly results that are summarized on the other Thermal Block Results tables appear here.

Extra Information

The data summary includes the Annual Absolute values beside the Annual Total values. For energy flows (e.g. ventilation) that can be both gains and losses depending on the time of the reference year, these two result values can be significantly different. *(See Project Results –Hourly Page)*

7.3.4 Performance Rating Report Pages

Compliance Report Page

Content similar to the Performance Rating Report Chapters of the Energy Performance Evaluation PDF:

- The content of the Proposed and Baseline Building Performance table is similar to the Performance Rating Table PDF report chapter.
- The content of the Baseline Building Energy Cost table is similar to the Baseline Energy Costs PDF report chapter.

- The content of the Proposed and Baseline Building Energy Cost and Consumption table is similar to the Energy Consumptions and Savings PDF report chapter.

	A	B	C	D	E	F	G	H	I
1									
2	PROPOSED AND BASELINE BUILDING PERFORMANCE								
3		Energy Use [kWh]							
4		System	Baseline 0	Baseline 90	Baseline 180	Baseline 270	Baseline	Proposed	Savings [%]
5		Transmission	-98958.57	-92814.81	-92027.7	-93678.03	-94369.7775	-30032.52	68.18
6		Infiltration	-12535.27	-12420.19	-12093.73	-11990.84	-12260.0075	-3613.78	70.52
7		Ventilation	-76227.65	-72461.3	-72223.97	-72080.28	-73248.3	-50709.48	30.77
8		Cooling	-20920.65	-13484.39	-17248.16	-18363.18	-17504.095	-4834.23	72.38
9		Solar Gain	93966.11	74144.23	74037.42	81448.23	80898.9975	27442.31	66.08
10		Human Heat Gain	25582.7	25584.24	25579.76	25575.18	25580.47	24589.99	3.87
11		Lighting and Equipment	24356.27	24356.27	24356.27	24356.27	24356.27	8970.28	63.17
12		Heating	64604.03	66944.6	69521.77	64625.96	66424.09	28052.28	57.77
13		Service Hot-Water Heating	51330.44	51344.17	51348.86	51330.84	51338.5775	32745.4	36.22
14		Sewage	-51115.89	-51115.89	-51115.89	-51115.89	-51115.89	-32968.99	35.50
15		ENERGY BALANCE	81.52	76.93	134.63	108.26	100.335	-358.74	457.54
16									
17	BASELINE BUILDING ENERGY COST								
18		Energy Cost [EUR]							
19		Source	Baseline 0	Baseline 90	Baseline 180	Baseline 270	Baseline		
20		Electricity [kWh]	3745.43	3425.26	3596.94	3634.71	3600.585		
21		District Heating [kWh]	5753.48	5868.92	5995.54	5754.63	5843.1425		
22		External Air	0	0	0	0	0		
23		COST TOTAL	9498.91	9294.18	9592.48	9389.34	9443.7275		
24									
25	PROPOSED AND BASELINE BUILDING ENERGY COST AND CONSUMPTION								
26			Baseline		Proposed			Savings [%]	
27		Purchased Energy	Energy Use	Cost [EUR]	Energy Use	Cost [EUR]	CO2 Emission	Energy Use	Cost [EUR]
28		Natural Gas [kWh]	0	0	33905.79	1356.23	7323.65	#DIV/0!	#DIV/0!
29		Electricity [kWh]	32732.58	3600.58	8638.66	950.25	2111.64	73.61	73.61
30		District Heating [kWh]	116862.91	5843.15	0	0	0	100.00	100.00
31		Subtotal	149595.49	9443.73	42544.45	2306.48	9435.29	71.56	75.58
32		On-Site Renewable Energy							
33		Photovoltaic system			3375	0	0		
34									
35									
36		TOTAL	149595.49	9443.73	45919.45	2306.48	9435.29	69.30	75.58
37									
38	LEED CERTIFICATION								
39			Energy cost savings [%]		LEED Points				
40		EA CREDIT 1	75.58		19				
41									

Project Key Values | Climate data | Compliance Report | Performance Rating Details | Detailed Results - Month

Extra Information

- All energy flows appear on the Proposed and Baseline Building Performance, not only the ones that require fuels.
- Energy-related LEED points

Performance Rating Details Page

Content of the tables on this page is the same as the PDF Report Chapters with similar names.

ANNEX 1: Definitions

A

Absorbance (also called absorption factor/attenuation coefficient): The physical process of absorbing light. This is a quantity that characterizes how easily a material or medium can be penetrated by a beam of light, sound, particles, or other energy or matter. A large attenuation coefficient means that the beam is quickly "attenuated" (weakened) as it passes through the medium, and a small attenuation coefficient means that the medium is relatively transparent to the beam. Attenuation coefficient is measured using units of reciprocal length. The terms "attenuation coefficient" and "absorption coefficient" are generally used interchangeably.

> **Note:** "Attenuation coefficient." Wikipedia the Free Encyclopedia. 14 May. 2010 *http://en.wikipedia.org/wiki/Attenuation_coefficient*

Absorption factor: see Absorbance

Adiabatic wall: walls of the building shell that separate heated spaces. They are called adiabatic due to the absence of heat transfer through them. These walls do not contribute to heat losses but they do contribute to the thermal inertia (heat storage mass).

Air change per hour (also called air exchange rate) is the number of interior volume air changes that occur per hour, and has units of 1/h. An air change does not represent a complete change of all air in the enclosure or structure unless it can be considered "plug flow". The actual percentage of an enclosure's air, which is exchanged in a period depends on the airflow efficiency of the enclosure and the methods used to ventilate it. The actual amount of air changed in a well- mixed ventilation scenario will be 63.2% after 1 hour and 1 ACH. Examples: kitchens 20–60, Public bathrooms 6, Class rooms 3–4, Laboratories 6–12, Smoking rooms 10–15, Warehousing 1–2. See also: Ventilation

> **Note:** "Air changes per hour." Wikipedia the Free Encyclopedia. 14 May. 2010 *http://en.wikipedia.org/wiki/Air_changes_per_hour*

Air exchange rate: see Air change per hour

Air leakage: see Infiltration

Air to air energy recovery: (a.k.a. heat recovery ventilation, HRV, mechanical ventilation heat recovery or MVHR) is an energy recovery ventilation system, using equipment known as a heat recovery ventilator, heat exchanger, air exchanger or air-to-air exchanger, that employs a counter-flow heat exchanger between the inbound and outbound air flow. Heat recovery ventilation provides fresh air and improved climate control, while also saving energy by reducing the heating (or cooling) requirements.

Attenuation coefficient: see Absorbance

B

Building volume (net): the volume of the conditioned air space of a building measured by its internal dimensions.

C

Carbon footprint: the carbon dioxide emissions caused by the operation of the building. The carbon footprint is a subset of the ecological footprint and of the more comprehensive Life Cycle Assessment (LCA). Once the size of a carbon footprint is known, a strategy can be devised to reduce it, e.g. by technological developments or consumption strategies. The mitigation of carbon footprints through the development of alternative projects, such as solar or wind energy, represents a way of reducing a carbon footprint and is often known as Carbon offsetting.

Note: "Carbon footprint." Wikipedia the Free Encyclopedia. 14 May. 2010 *http://en.wikipedia.org/wiki/Carbon_footprint*

Carbon offsetting: see Carbon footprint

Climate data: see Weather data

Cold bridge: see Thermal bridge

Conditioned area: is the sum of the floor areas of spaces that are heated or cooled.

D

Direct Shade Factor Reduction: defines the percentage of heat energy that reaches the interior space due to solar irradiation.

District cooling: Working on broadly similar principles to district heating, district cooling delivers chilled water or other media to multiple buildings for cooling. The cooling (actually heat rejection) is usually provided from a dedicated cooling plant.

Note: "District cooling." Wikipedia the Free Encyclopedia. 14 May. 2010 *http://en.wikipedia.org/wiki/District_cooling*

District heating (also called Teleheating): is a system for distributing heat generated in a centralized location for residential and commercial heating requirements such as space heating and water heating. The heat is often obtained from a cogeneration plant burning fossil fuels but increasingly biomass, although heat-only boiler stations, geothermal heating and central solar heating are also used, as well as nuclear power. District heating plants can provide higher efficiencies and better pollution control than localized boilers.

Note: "District heating." Wikipedia the Free Encyclopedia. 14 May. 2010 *http://en.wikipedia.org/wiki/District_heating*

E

Energy evaluation: Information about the project's energy performance based on building geometry analysis, weather data and some user input. As a result, yearly energy consumption, carbon footprint and monthly energy balance is available.

Energy fluctuation: irregular energy flow through a building structure (e.g. a wall)

F

Fenestration: products that fill openings in a building envelope, such as windows, doors, skylights, curtain walls, etc., that permit the passage of light.

Fluorescent light: is a gas-discharge lamp that uses electricity to excite mercury vapor. The excited mercury atoms produce short-wave ultraviolet light that then causes a phosphor to fluoresce, producing visible light. A fluorescent lamp converts electrical power into useful light more efficiently than an incandescent lamp. Lower energy cost typically offsets the higher initial cost of the lamp. The lamp is more costly because it requires a ballast to regulate the flow of current through the lamp.

Fresh air heating: Combined heating – air conditioning system, which gains the heat of the taken air, and heats up the fresh air in an air-handling unit, before being exhaled back out into the room. Cold and hot pipes, or more advanced technology is used to control the temperature of the air as it passes through the system. All of this is usually controlled from a basement or a control box somewhere secluded in the building.

G

Green energy: Green energy in EcoDesigner consists of energy obtained by air to air energy recovery, solar collectors and heat pumps. For further info, see these definitions.

H

Heat capacity: see Heat storage mass

Heat pump: is a machine or device that moves heat from one location (the ‘source’) to another location (the ‘target’, ‘sink’ or ‘heat sink’) using mechanical work. Most heat pump technology moves heat from a low temperature heat source to a higher temperature heat sink. Most commonly, heat pumps draw heat from the air or from the ground. The reversing valve switches the direction of refrigerant through the cycle and therefore the heat pump may deliver either heating or cooling to a building. In the cooler climates the default setting of the reversing valve is heating. The default setting in warmer climates is cooling.

> **Note:** “Heat pump.” Wikipedia the Free Encyclopedia. 14 May. 2010 *http://en.wikipedia.org/wiki/Heat_pump*

Heat source: A heat source is anything that can heat up a building. Heat sources can be external (from outside the building) or internal (from inside the building). External heat sources include: the Sun, reflected sunlight, any kind of fuel, electricity and released heat from the ground. Internal heat sources can be electric equipment, people, lightning systems, etc.

Heat storage mass (also known thermal mass, thermal capacitance or heat capacity - Cth): is the capacity of a body to store heat. It is typically measured in units of J/°C or J/K (which are equivalent). If the body consists of a homogeneous material with sufficiently known physical properties, the thermal mass is simply the mass of material present times the specific heat capacity of that material. Thermal mass as a concept is most frequently applied in the field of building design. In this context, thermal mass provides “inertia” against temperature fluctuations, sometimes known as the thermal flywheel effect. For example, when outside temperatures are fluctuating throughout the day, a large thermal mass within the insulated portion of a house can serve to “flatten out” the daily temperature fluctuations, since the thermal mass will absorb heat when the surroundings are hotter than the mass, and give heat back when the surroundings are cooler. This is distinct from a material's isolative value, which reduces a building's thermal conductivity, allowing it to be heated or cooled relatively separate from the outside, or even just retain the occupants' body heat longer.

Note: "Thermal mass." Wikipedia the Free Encyclopedia. 14 May. 2010 *http://en.wikipedia.org/wiki/Thermal_mass*

Heat transfer coefficient: is used in calculating the heat transfer, typically by convection or phase change between two aggregates. The heat transfer coefficient has SI units in watts per meter squared-kelvin [h=W/m2K].

H=Q/AxΔTxΔt) where

H = heat transfer coefficient, [W/m2K]

ΔQ = heat input or heat lost, [J]

A = heat transfer surface area, [m2]

ΔT = difference in temperature between the solid surface and surrounding fluid area, [K]

Δt = time period, [s]

Note: "Heat transfer coefficient." Wikipedia the Free Encyclopedia. 14 May. 2010 *http://en.wikipedia.org/wiki/ Heat_transfer_coefficient*

Hot water generation: Typical domestic uses of hot water are for cooking, cleaning, bathing, and space heating. In industry, both hot water and water heated to steam have many uses. Appliances for providing a more-or-less constant supply of hot water are variously known as water heaters, boilers, heat exchangers, calorifiers, or geysers depending on whether they are heating potable or non-potable water, in domestic or industrial use, their energy source, and in which part of the world they are found. In domestic installations, potable water heated for uses other than space heating is sometimes known as domestic hot water (DHW). In many countries the most common energy sources for heating water are fossil fuels: natural gas, liquefied petroleum gas, oil, or sometimes solid fuels. These fuels may be consumed directly or by the use of electricity. Alternative energy such as solar energy, heat pumps, hot water heat recycling, and sometimes geothermal heating, may also be used as available, usually in combination with backup systems supplied by gas, oil or electricity. In some countries, district heating is a major source of water heating.

Note: "Water heating." Wikipedia the Free Encyclopedia. 14 May. 2010 *http://en.wikipedia.org/wiki/ Water_heating*

Human heat gain: the amount of heat produced by the human bodies in the building.

I

Incandescent light: is a source of electric light that works by incandescence (a general term for heat-driven light emissions, which includes the simple case of black body radiation). An electric current passes through a thin filament, heating it to a temperature that produces light. The enclosing glass bulb contains either a vacuum or an inert gas to prevent oxidation of the hot filament. Incandescent bulbs are also sometimes called electric lamps, a term also applied to the original arc lamps.

Note: "Incandescent light bulb." Wikipedia the Free Encyclopedia. 14 May. 2010
http://en.wikipedia.org/wiki/ Incandescent_light_bulb

Infiltration (air leakage/air permeability): is the unintentional or accidental introduction of outside air into a building, typically through cracks in the building envelope and through use of doors for passage. Infiltration is caused by wind, building pressurization and stack effect. The infiltration rate is the volumetric flow rate of outside air into a building, typically in cubic feet per minute (CFMs) or liters per second (LPSs).

Note: "Infiltration (HVAC)." Wikipedia the Free Encyclopedia. 14 May. 2010
http://en.wikipedia.org/wiki/ Infiltration_(HVAC)

Internal heat gain: may result from the heat output of human bodies, lamps motors and appliances. In buildings such as office buildings, commercial stores, shopping centers, entertainment halls etc. much of the overheating problem during the summer can be caused by heat produced by equipment or by a high level of artificial lighting.

Internal target temperature: the temperature (range) needed in a room or building when it is used. Based on the activities in the building, the profile may vary by workdays/non-working days, needed temperature and daily period.

L

LED light: A light-emitting-diode lamp is a solid-state lamp that uses light-emitting diodes (LEDs) as the source of light. Since the light output of individual light-emitting diodes is small compared to incandescent and compact fluorescent lamps, multiple diodes are used together. LED lamps can be made interchangeable with other types. Most LED lamps must also include internal circuits to operate from standard AC voltage. LED lamps offer long life and high efficiency, but initial costs are higher than those of fluorescent lamps.

Note: "LED lamp." Wikipedia the Free Encyclopedia. 14 May. 2010
http://en.wikipedia.org/wiki/ LED_lamp

Lighting power density (LPD): the maximum lighting power per unit area of a building classification of space function. Examples for a whole building in W/ft2: Convention Center 1.22, Hospital 1.23, Hotel 1.02, Museum 1.11, Parking garage 0.27, School/University 1.2, Transportation 1.0, Warehouse 0.82.

Linear thermal currents: According to the second law of thermodynamics (a.k.a. the Clausius statement), thermal currents are induced inside a (building) material, if there is a temperature difference between its two sides. Theories of fundamental thermal physics are only valid if these thermal currents are perpendicular to the surface (one dimensional). This, in reality, could occur only if the structures were infinitely large and the composite layers were homogenous and parallel to each-other. Still, general external building shell elements are evaluated supposing that the nature of heat flow through them is linear, because the result obtained using this method is within the error margin, compared to actual measurements. For further info on thermal currents, see also: Multi-dimensional thermal currents and Transmission.

M

Mechanical cooling: Air refrigeration is provided through the removal of heat. The definition of cold is the absence of heat; all mechanical air cooling systems work on this basic principle. Heat can be removed through the process of radiation, convection, and heat cooling through a process called the refrigeration cycle. The conduction mediums, such as water, air, ice, and chemicals, are referred to as refrigerants.

Note: "HVAC." Wikipedia the Free Encyclopedia. 14 May. 2010
http://en.wikipedia.org/wiki/ HVAC

Mechanical ventilation (a.k.a. forced ventilation): through an air handling unit or direct injection to a space by a fan. A local exhaust fan can enhance infiltration or natural ventilation, thus increasing the ventilation air flow rate. See also Natural ventilation and Infiltration.

Note: "Ventilation (architecture)." Wikipedia the Free Encyclopedia. 14 May. 2010
http://en.wikipedia.org/wiki/Ventilation_(architecture)

Monthly energy balance: according to the Conservation of Energy law of physics, when monitoring all energy flows related to the building, the amount of energy the building emits must equal the amount of energy supplied to the building. The Monthly Energy Balance bar chart on EcoDesigner's Energy Balance Evaluation report is the graphical representation of these energy flows.

Multi-dimensional thermal currents: According to the second law of thermodynamics (a.k.a. the Clausius statement), thermal currents are induced inside a (building) material, if there is a temperature difference between its two sides. In reality, multi-dimensional thermal currents occur at places of:

- material change
- change
- in geometry
- change
- in construction

For further info on thermal currents, see also: Linear thermal currents and Transmission.

N

Natural heating: this Heating type option in EcoDesigner has been developed for warm climate countries, where the annual energy required for heating is very low. The installation of a heating system is not necessary, if the fact that the internal air temperature drops below the prescribed level on a couple of chilly nights or mornings a year is tolerated by the inhabitants. Set Heating type to natural in such cases, for the calculation engine of EcoDesigner to assume that the external air is sufficient for heating purposes.

Natural heat source: see Natural heating

Natural ventilation: is the process of supplying and removing air through an indoor space by natural means. There are two types of natural ventilation in buildings: wind driven ventilation and stack ventilation. The pressures generated by 'the stack effect', also known as buoyancy, are quite low (typical values: 0.3 Pa to 3 Pa) while wind pressures are usually far greater (~1 Pa to 35 Pa). The majority of buildings employing natural ventilation rely primarily on wind driven ventilation, but stack ventilation has several benefits. The most efficient design for a natural ventilation building should implement both types of ventilation.

Note: "Natural ventilation." Wikipedia the Free Encyclopedia. 14 May. 2010
http://en.wikipedia.org/wiki/Natural_ventilation

P

Pellet (wood): is a type of wood fuel, generally made from compacted sawdust. Pellets are usually produced as a by- product of sawmills and other wood-related industry. The pellets are extremely dense and can be produced with a low humidity content (below 10%) that allows them to be burned with very high combustion efficiency.

Note: "Wood pellet." Wikipedia the Free Encyclopedia. 14 May. 2010
http://en.wikipedia.org/wiki/Wood_pellet

Primary heat source: In EcoDesigner, primary heat sources include natural gas, propane, oil, wood, coal or Pellet. See also Secondary heat source.

Primary hot water source: In EcoDesigner, primary hot water sources include natural gas, propane, oil, wood, coal or Pellet. See also Secondary heat source.

R

R-value (Thermal resistance coefficient): The inverse of the U value. A measure of thermal resistance used in the building and construction industry. Under uniform conditions it is the ratio of the temperature difference across an insulator and the heat flux. The bigger the number, the better the building insulation's effectiveness. Typically it is measured in square-metre kelvins per watt or $m^2 \cdot K/W$ (or equivalently to $m^2 \cdot {}^\circ C/W$). A thermal barrier that is composed of several layers will have several thermal resistors in the analogous circuit, each in series. Increasing the thickness of an insulating layer increases the thermal resistance.

Note: "R-value (insulation)." Wikipedia the Free Encyclopedia. 14 May. 2010
http://en.wikipedia.org/wiki/R-value_(insulation)

S

Secondary heat source: Energy produced from a primary heat source by a power plant, then fed to the building. In EcoDesigner, secondary heat sources include electricity, district cooling and district heating. See also Primary heat source, District cooling and District heating.

Solar collector (solar thermal collector panels): a collector designed to collect heat by absorbing sunlight. A collector is a device for converting the energy in solar radiation into a more usable or storable form. The energy in sunlight is in the form of electromagnetic radiation from the infrared (long) to the ultraviolet (short) wavelengths. The solar energy striking the earth's surface depends on weather conditions, as well as location and orientation of the surface, but overall, it averages about 1,000 watts per square meter under clear skies with the surface directly perpendicular to the sun's rays.

Note: "Solar thermal collector." Wikipedia the Free Encyclopedia. 14 May. 2010 *http://en.wikipedia.org/wiki/Solar_thermal_collector*>

Solar gain (a.k.a. solar heat gain or passive solar gain) refers to the increase in temperature in a space, object or structure that results from solar radiation. The amount of solar gain increases with the strength of the sun, and with the ability of any intervening material to transmit or resist the radiation. Objects struck by sunlight absorb the short-wave radiation from the light and reradiate the heat at longer infrared wavelengths. Where there is a material or substance (such as glass) between the sun and the objects struck that is more transparent to the shorter wavelengths than the longer, then when the sun is shining the net result is an increase in temperature - solar gain.

Note: "Solar gain." Wikipedia the Free Encyclopedia. 14 May. 2010 *http://en.wikipedia.org/wiki/Solar_gain* >

Solar irradiation decreasing constants: Shadows cast upon the building shell by external objects (Façade Shadings/ Shading) are taken into consideration in EcoDesigner by applying numeric reduction percentage values, which may be set for each orientation individually.

Solar transmission: The percentage of incident solar radiation transmitted by an object which includes the direct Solar Transmission plus the part of the Solar Absorption reradiated inward. TST (Total Solar Transmission) divided by 100 equals Solar Heat Gain Coefficient (SHGC) or g-value.

Space heating: is a kind of heating using a self-contained device for heating an enclosed area. It is also known as a portable heater, a room heater or an auxiliary heater. Space heating generally warms a small space, and is usually held in contrast with central heating, which warms many connected spaces at once. Space heating does not include water heating, unless it is used for hydronic heating.

Note: "Space heater." Wikipedia the Free Encyclopedia. 14 May. 2010 *http://en.wikipedia.org/wiki/Space_heater*

T

Teleheating: see District heating

Thermal bridge (also called cold bridge): is created when materials that are poor insulators come in contact, allowing heat to flow through the path created. Insulation around a bridge is of little help in preventing heat loss or gain due to thermal bridging; the bridging has to be eliminated, rebuilt with a reduced cross-section or with materials that have better insulating properties, or with an additional insulating component (a thermal break). Thermal bridges are characterized by multi-dimensional heat flows that are typically approximated by one-dimensional models of calculation, which are used in norms and standards for the thermal performance of buildings.

Note: "Thermal bridge." Wikipedia the Free Encyclopedia. 14 May. 2010 *http://en.wikipedia.org/wiki/Thermal_bridge*

Thermal conductivity (k): is the property of a material that indicates its ability to conduct heat. Thermal conductivity is measured in watts per kelvin metre [W/K, m]. Multiplied by a temperature difference (in kelvins, K) and an area (in square metres, m2), and divided by a thickness (in metres, m) the thermal conductivity predicts the power loss (in watts, W) through a piece of material.

Note: “Thermal conductivity.” Wikipedia the Free Encyclopedia. 14 May. 2010 http://en.wikipedia.org/wiki/ Thermal_conductivity

Thermal mass: see Heat storage mass

Thermal resistance coefficient: see R-value

Total shade factor reduction: defines the percentage of total heat energy that reaches the interior space.

Total solar transmission: see Solar transmission.

Transmission (Heat transfer) is the transition of thermal energy from a hotter mass to a cooler mass. When an object is at a different temperature than its surroundings or another object, transfer of thermal energy, also known as heat flow or heat exchange, occurs in such a way that the body and the surroundings reach thermal equilibrium; this means that they are at the same temperature. Heat transfer always occurs from a higher-temperature object to a cooler-temperature one as described by the second law of thermodynamics (a.k.a. the Clausius statement). Where there is a temperature difference between objects in proximity, heat transfer between them can never be stopped; it can only be slowed. In case of building physics, thermal currents are induced inside a (building) material, if there is temperature difference between its two sides. See also: Linear thermal currents and Multi-dimensional thermal currents

Note: “Heat transfer.” Wikipedia the Free Encyclopedia. 14 May. 2010 http://en.wikipedia.org/wiki/ Heat_transfer

U

U-value: the measure of the rate of heat loss through a material. Thus in all aspects of home design one should strive for the lowest U-values possible because, the lower the U-value, the less heat that is needlessly escaping. It is measured as the amount of heat lost through a one square meter of the material for every degree difference in temperature either side of the material. It is indicated in units of Watts per Meter Squared per Degree Kelvin or W/m2K. U-value is the inverse of the R-value.

V

Ventilation: the intentional movement of air from outside a building to the inside. It is the V in HVAC. Types of Ventilation are Mechanical forced ventilation, Natural ventilation and Infiltration. See also: Air changes per hour

W

Weather data (or climate data): searchable records of climatology and historical weather for all locations, worldwide. The weather data used by EcoDesigner contains hourly records of air temperature, relative humidity, wind speed and solar radiance for a reference year.

Wind velocity: The horizontal direction and speed of air motion. It is a scalar quantity, the magnitude of the vector of motion.

Note: "Wind speed." Wikipedia the Free Encyclopedia. 14 May. 2010 *http://en.wikipedia.org/wiki/ Wind_speed*

Y

Yearly energy consumption: The annual amount of energy the project needs in order to fulfill the interior climate **criteria** specified for the function of the building.

ANNEX 2: EcoDesigner STAR Sample Workflow

1. Introduction

Welcome to the GRAPHISOFT EcoDesigner STAR Sample Workflow.

GRAPHISOFT EcoDesigner STAR is a revolutionary step forward in Building Energy Modeling. It offers building energy simulation that fulfills the most rigorous standards, delivering accurate energy analysis for any building type in any climate!

EcoDesigner STAR is fully integrated with ArchiCAD, and requires no previous building energy simulation expertise to create energy performance reports at any stage of the design process.

Climate Analysis

Our sustainable building design workflow begins with Climate Analysis. This chapter demonstrates how to create accurate **weather statistics** (including annual and monthly temperature values, relative humidity, solar-radiation and wind speed) for any given building site on the globe and how to compare the project's comfort requirements with the local climate.

EcoDesigner STAR generates a detailed report about the building site's weather characteristics and **project-specific comfort conditions.** Based on this report, the most appropriate low-energy building design solutions can be chosen for the architectural design project.

Building Energy Model Calibration

Calibration step helps to ensure **data input accuracy**, which greatly affects the accuracy of the energy evaluation. To make sure that all the energy-related characteristics of the zones, structures, openings and building systems are correctly set, it is worth performing the model calibration process for every Building Energy Model.

This chapter presents one scenario from the **ASHARE 140 standard** to explain a typical model calibration workflow. An overview of the ASHARE 140 standard demonstrates how EcoDesigner STAR complies with this widely used international simulation standard.

Project Specific Low-Energy Building Solution Set

There are several ways to make a building more energy efficient, but a solution that works well for a certain project at one location might actually be counter-productive in another location.

This chapter presents how to choose the most **appropriate solution** for your project.

In this workflow, we run an hourly building energy simulation to test several architectural solutions on our example project. Using a method called **sensitivity analysis**, the calculation results are then compared to determine the best low-energy building solutions for the project.

Low-Energy Demand Architectural Design

This chapter presents how to use ArchiCAD to **implement the chosen low-energy architectural solution** on a building information model (BIM) using EcoDesigner STAR's features.

EcoDesigner STAR extracts the majority of the data needed for dynamic energy simulation directly from the ArchiCAD BIM. Using this data, it automatically creates the building energy model (BEM). Here, the industry-first **direct BIM-to-BEM technology** is demonstrated.

Finally, the workflow examines the results of the simulation.

Building System Efficiency Optimization

This chapter shows how to test different strategies, and then determine the optimal low-energy building solution set for the project and how to **evaluate overall building energy efficiency** (with building systems included).

First, we add the necessary baseline building systems to our example Baseline Building model and document it for the purpose of performance rating.

As the next step, the sensitivity analysis method is used on the building systems, to determine optimal low-energy building system solution set and renewable energy solution set.

Then we use the EcoDesigner STAR Building Systems dialog to implement these solution sets on the example model.

Finally, the energy simulation is run in **building energy performance rating** mode to produce results that enable the quick and effective comparison of the Designed Building's energy performance with the Baseline Building's energy performance.

Besides the building energy performance rating, **fuel consumption, fuel cost, carbon-dioxide equivalent emission and primary energy calculations** are also executed at this final stage. The detailed results include all output data required by the energy section of the leading sustainable building design standards (e.g. LEED, Green Star). They can be documented for further design optimization or post-processed for submittal.

Summary

We hope that you will find this workflow useful in your everyday design practice.

GRAPHISOFT ArchiCAD and EcoDesigner STAR is easy to learn and fun to use!

2. Climate Analysis

This chapter presents how to generate and document the weather statistics needed to choose the best sustainable design solution for your architectural design project.

For detailed Climate Analysis, the following aspects must be considered:

Annual and monthly lowest, highest and average of the

- external air temperature
- relative humidity
- solar radiation
- wind speed

All these are directly derived from the online “weather file”. In the following, we will show you how to obtain such weather files and use them to produce the above mentioned annual and monthly statistics.

We will also present how to calculate the so-called “Degree Days” using the above statistics. This information will be later used to support design decisions regarding architectural solutions (e.g. building shape, zoning, materials etc.) as well as heating and cooling systems in the building.

We will also determine the so-called “Unmet Load Hours” data for the weather at the project’s location, taking into consideration the intended use of the building, to find out how many hours of the year is the climate too cold or too hot for the designated purpose.

“Degree Days” and “Unmet Load Hours” are metrics basic on the climatic characteristics of the building site, and taking into account the intended use of the building. These data help architectural designers choose the right sustainable solution.

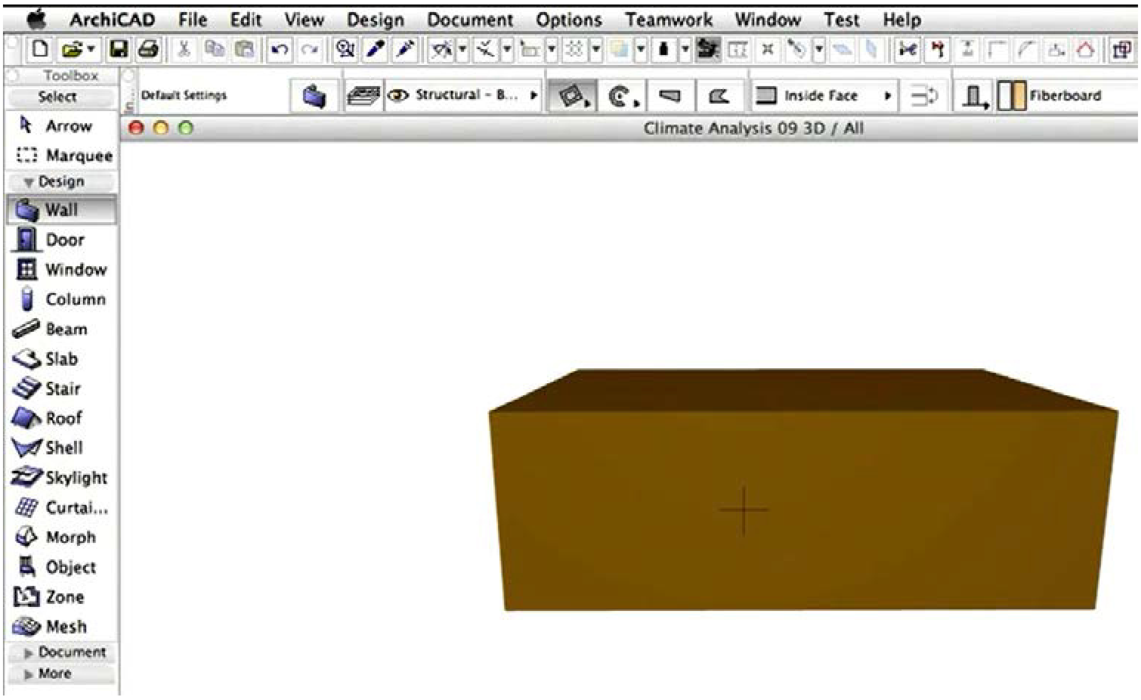
By definition:

- “**Degree Days**” are the integral of dry bulb temperature as a function of time, relative to a base temperature. The Heating and Cooling requirements for a given structure at a specific location are considered to be directly proportional to the number of “Degree Days” at that location.
- **“Unmet Load Hours”** are the number of hours during a year when the internal temperature is out of the comfort range defined in the operation profile.

If Heating and Cooling “Unmet Load Hours” are calculated for a climate file, taking into consideration the building’s intended use, then they represent the total number of hours throughout a year that are outside of the comfort range. This information is a very useful indicator of how friendly or un-friendly a particular climate is.

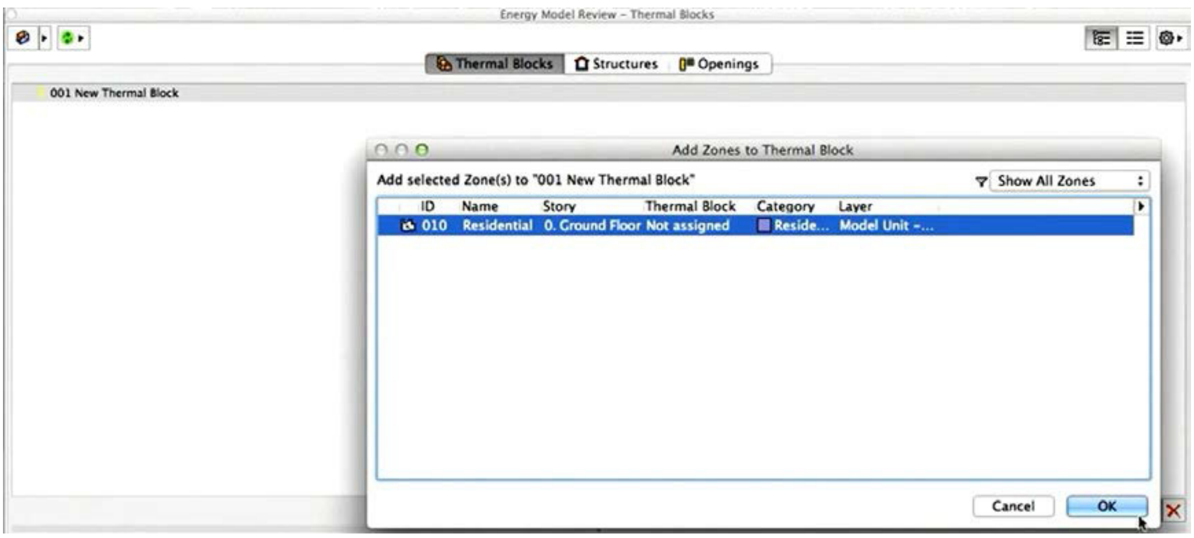
2.1 Draw Climate Analysis Reference Building

Open an empty ArchiCAD project. The first step is to create a so-called “Climate Analysis Reference” building. To be able to define the internal temperature, define an extremely simple internal space. Make it a very simple room defined by four walls, a floor slab and a roof. Insert a 3D Zone. These are all standard ArchiCAD elements. Here’s our simple building in 3D.

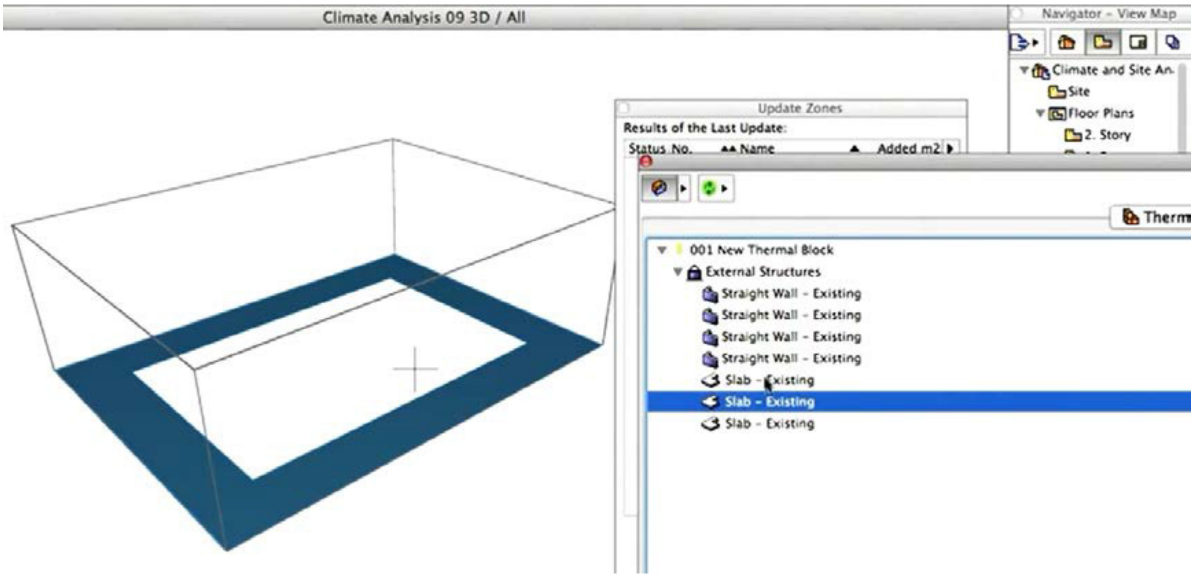


We used very thin, 10 mm exterior structures: this is technically a “paper box” space whose sole purpose now is to **define an internal space**.

Display the “Energy Model Review” palette, and switch to the Thermal Blocks page. Define a Thermal Block based on the previously created Zone. Thermal Blocks are necessary for the building energy analysis.



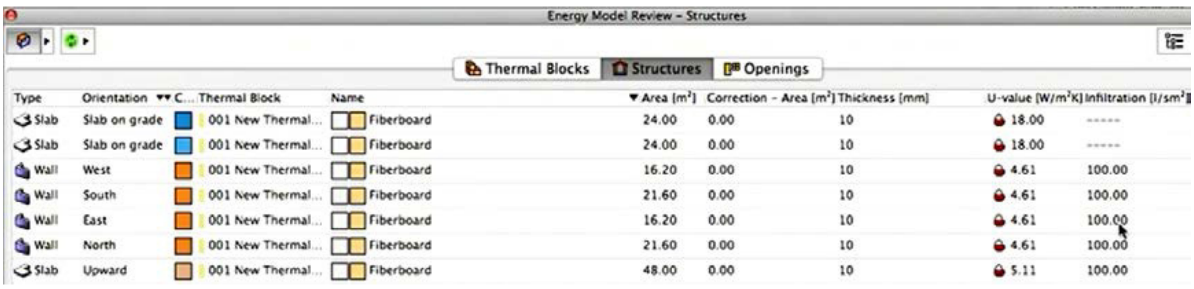
Visualize the new Thermal Block in 3D. Note that all the relevant geometric and physical properties of the individual **3D building elements** - walls, slab and roof - **are automatically mapped** by the newly created thermal block and linked to it, for the purpose of energy simulation. You can select the individual elements in the list, and their 3D representation is instantly highlighted in the 3D window for easier identification.



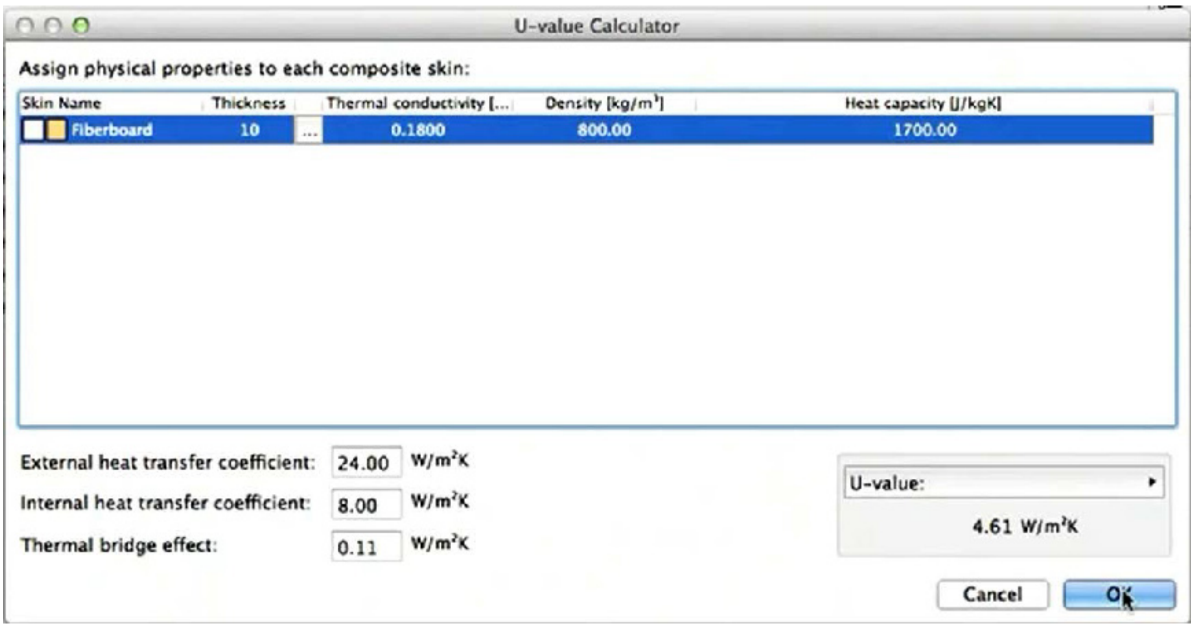
The floor slab is automatically subdivided, because it has direct contact with the ground. The slab strip along the perimeter has different building-energy related characteristics than the internal part of the slab, which is further away from the external environment.

Remember: the goal here is to create minimum resistance structures so that their internal space has a climate similar to the external weather. This internal space is necessary because we want to draw conclusions about the external weather conditions with respect to **internal thermal comfort requirements**.

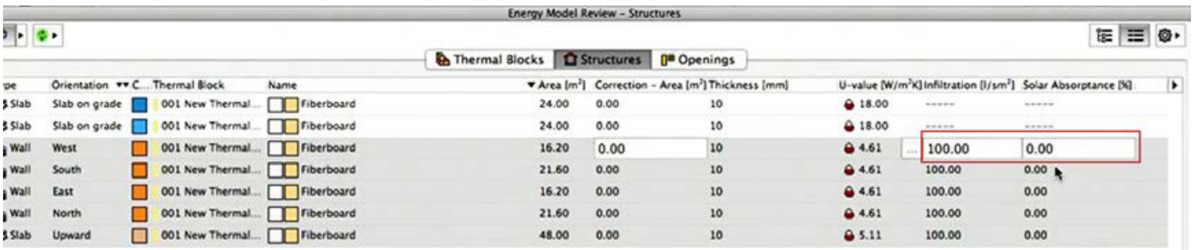
To **define minimal resistance structures**, display the “Structures” page of the “Energy Model Review” palette. All elements are made of a thin layer of fiberboard, with high “U” value representing low thermal resistance.



Shown here are the default thermal properties (density, heat capacity and thermal conductivity) of the fiberboard material, which result in the high “U” value.



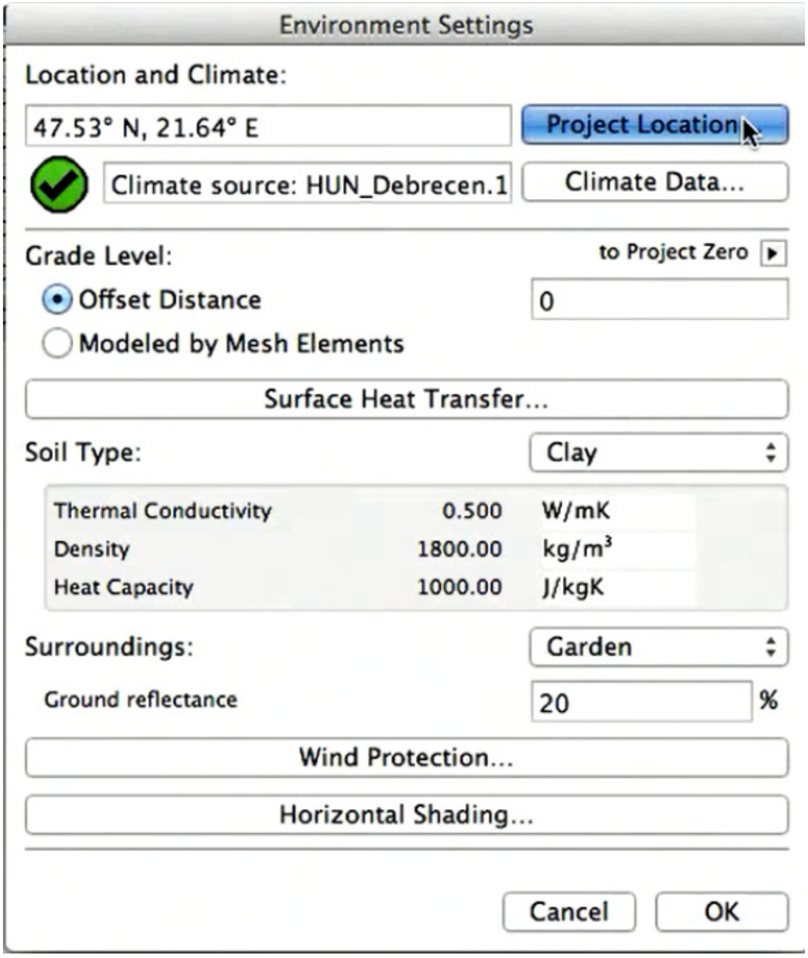
Set the infiltration value to its maximum and enter zero for the “solar absorptance” values.



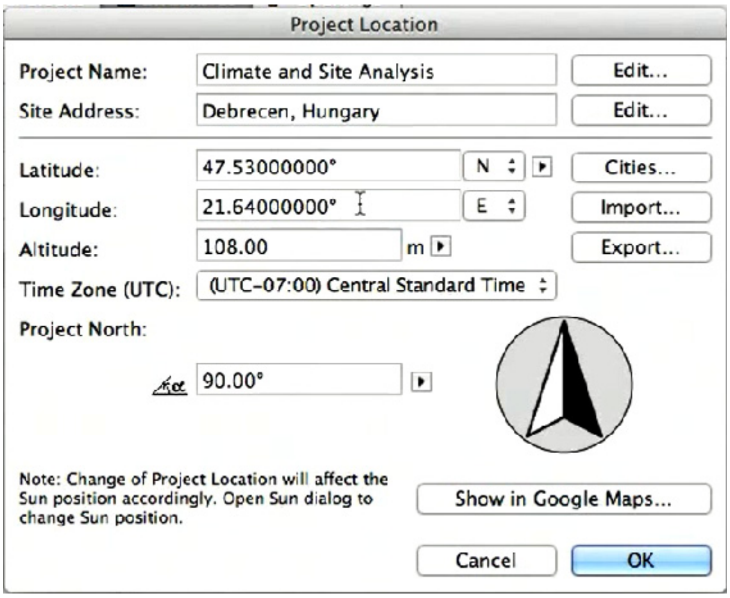
This way, the internal and external climate characteristics will match. The goal is to avoid the wind resistance and the heat absorptance of the external structures, otherwise solar irradiation would heat up the internal space.

2.2 Set Location and Climate

Display the Environmental Settings dialog to define the project location and climate.



Enter the name and address of the project here. You could also define the location by entering the latitude and longitude values numerically.

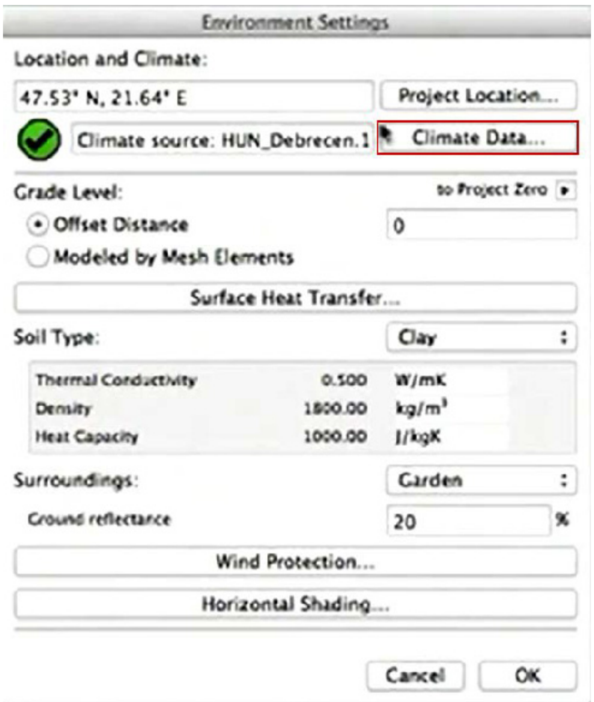


Another way to check **Project Location** is to use Google Maps, which automatically displays the previously entered project location.

The Altitude value must be defined precisely, because the external air pressure value depends on the altitude, and external pressure has a strong effect on energy balance calculation.

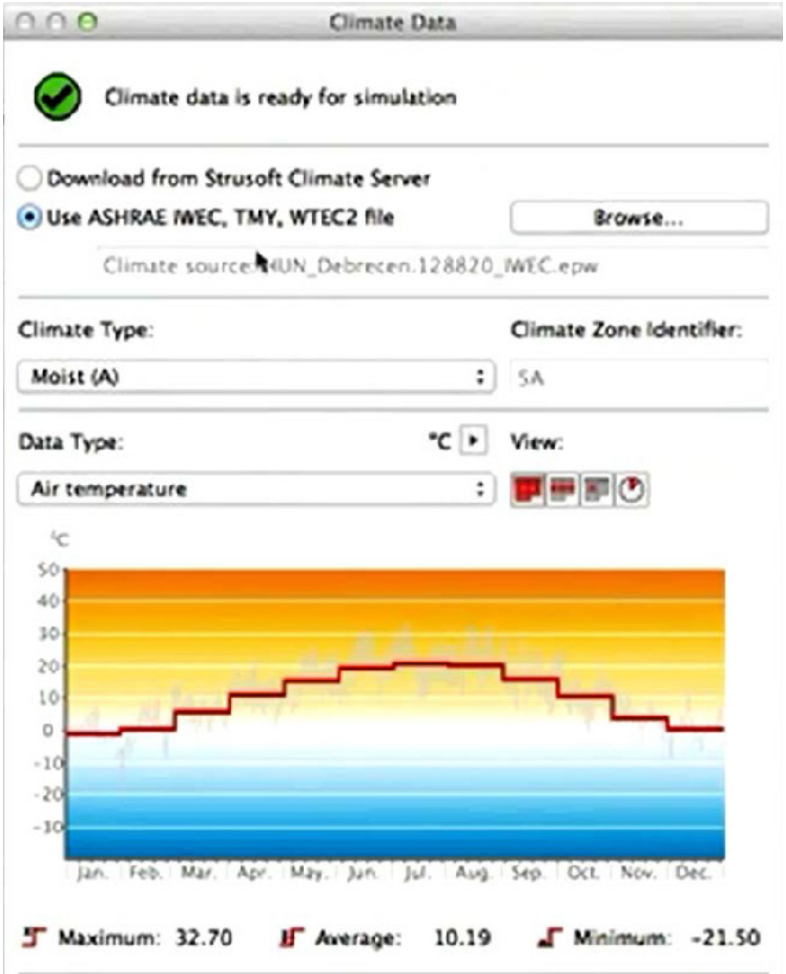
The time zone must be set up correctly to ensure accurate Solar Analysis.

In Environment Settings, display the **Climate Data** dialog.



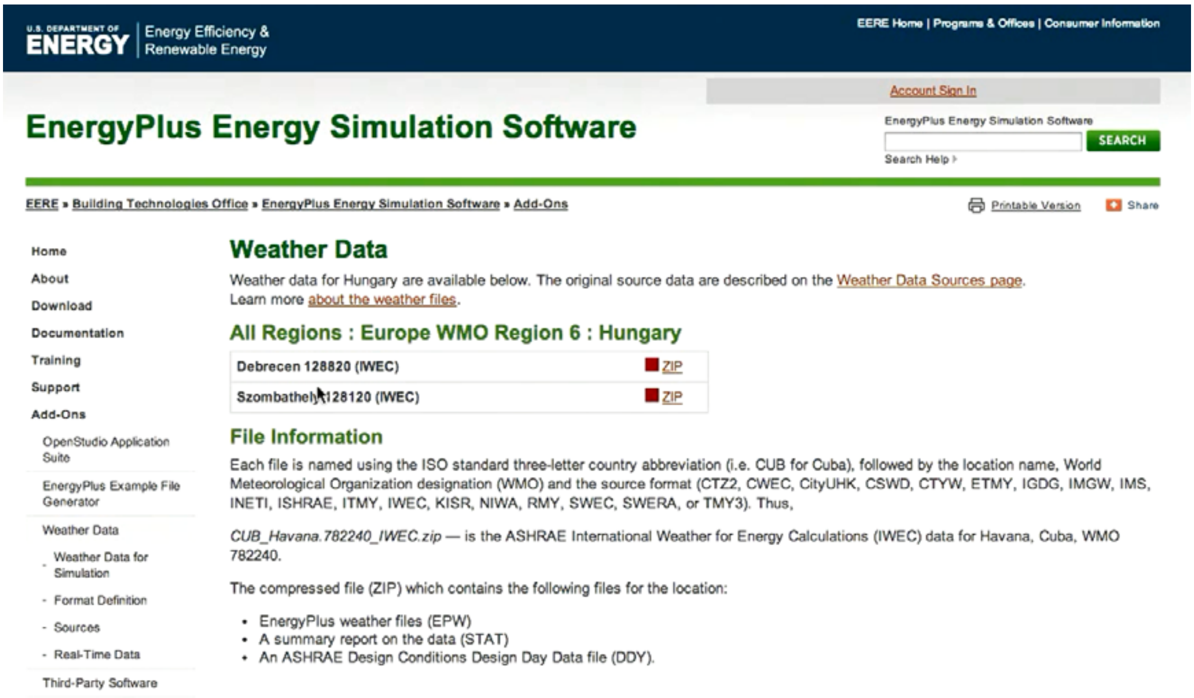
EcoDesigner STAR offers two ways to obtain the hourly climate data file necessary for the energy simulation:

- Download the weather data file from the StruSoft server.
- Import climate data files from other sources.



For instance, we can import ASHRAE analytic climate data provided by United States Department of Energy. To obtain the climate file, access the US Department of Energy website.

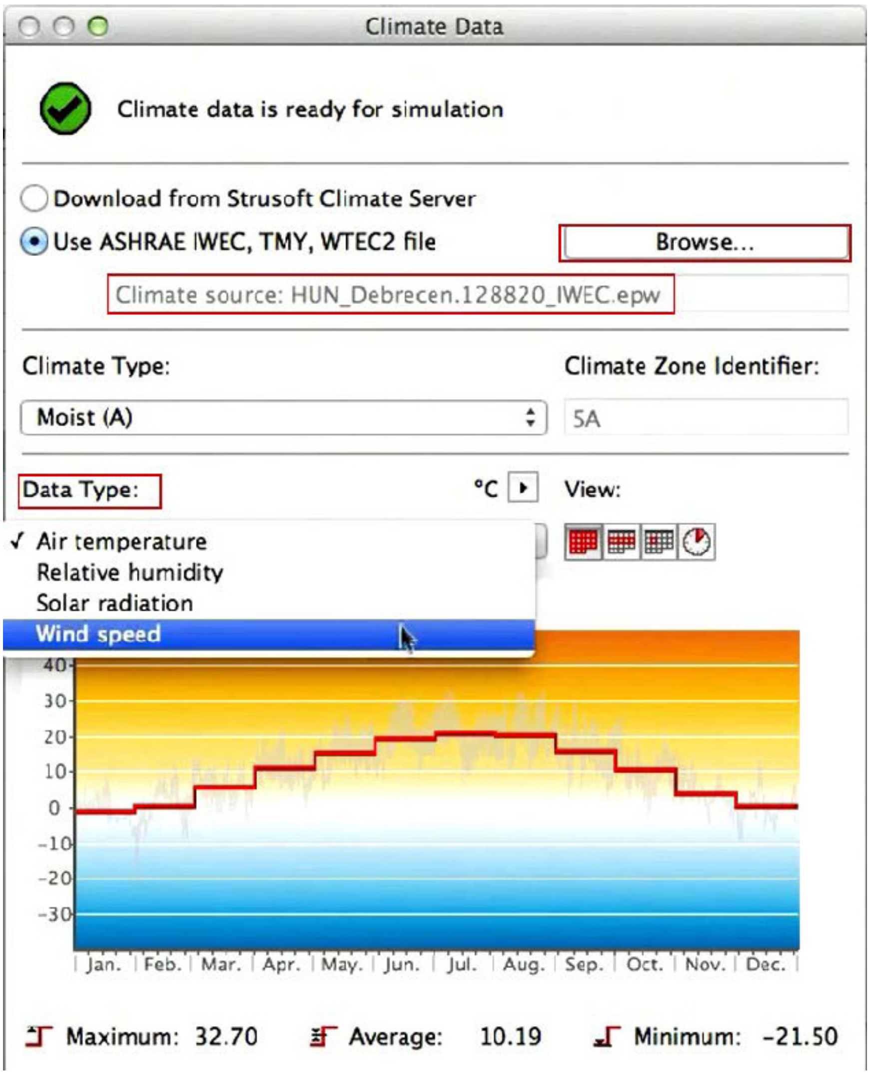
Navigate to the “Add-Ons” Weather Data site, then browse the geographic location of your building site.



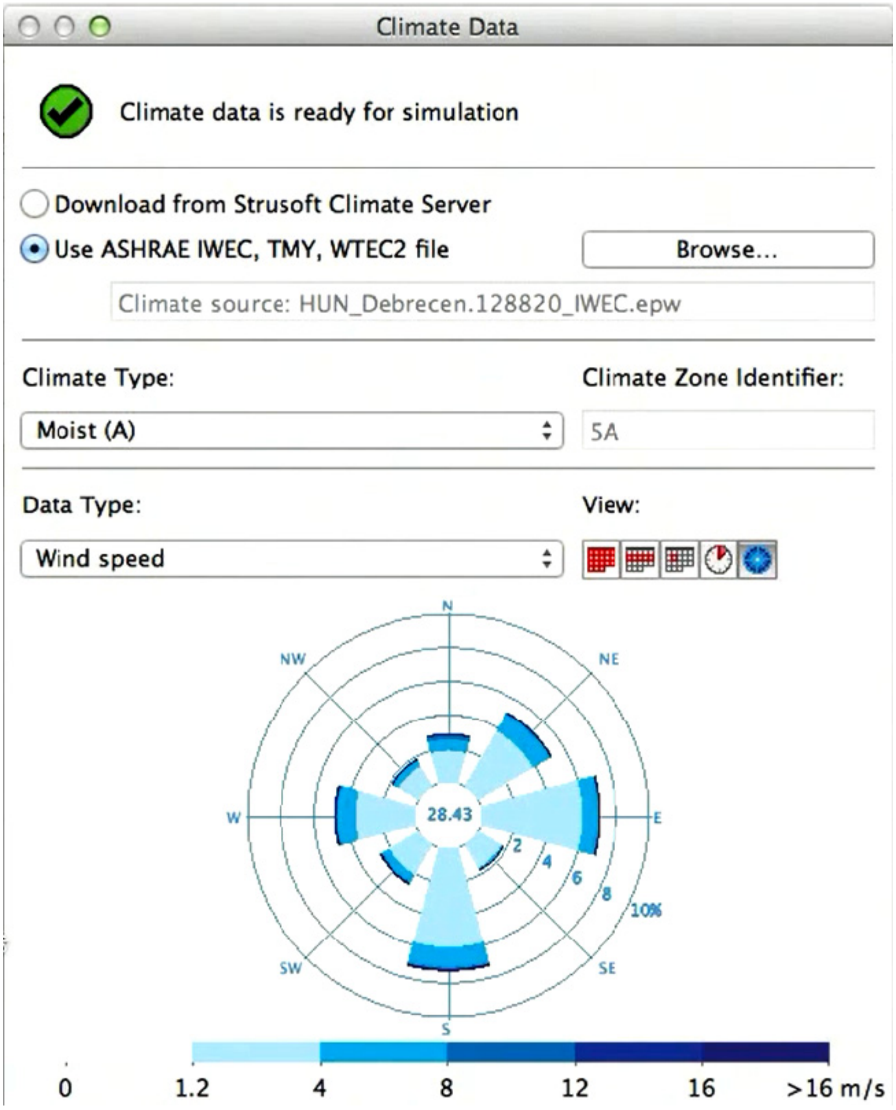
Download the weather file as a ZIP file to your computer. The unzipped file contains weather data in EPW file format.

Import the EPW file to EcoDesigner STAR by clicking the “Browse” button.

The imported weather data is shown instantly: **Air Temperature, Relative Humidity, Solar Radiation and Wind Speed diagrams** can be displayed in monthly, weekly, daily and hourly time intervals.



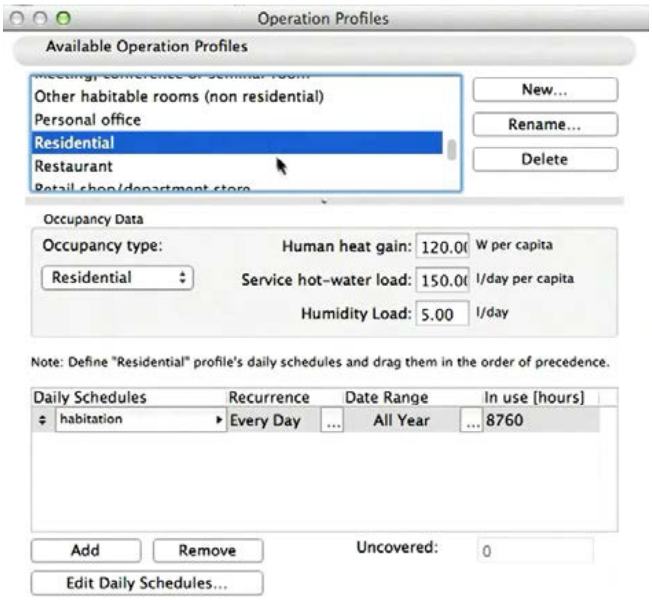
For example, below is the colored wind speed diagram, showing maximum, minimum and average values. For the Air temperature value, display units can be toggled between Celsius and Fahrenheit degrees.



2.3 Set Operation Profile

The next step is to define **the internal thermal comfort requirements**. First, define an "Operation Profile" for the thermal block created earlier.

From the Energy Model Review palette, display the Operation Profiles dialog and select the predefined "Residential" operational profile.



As needed, modify this Operation Profile to suit your purpose. (To implement these modifications without losing the default content, first duplicate the existing Residential operation profile and then work on the copy.)

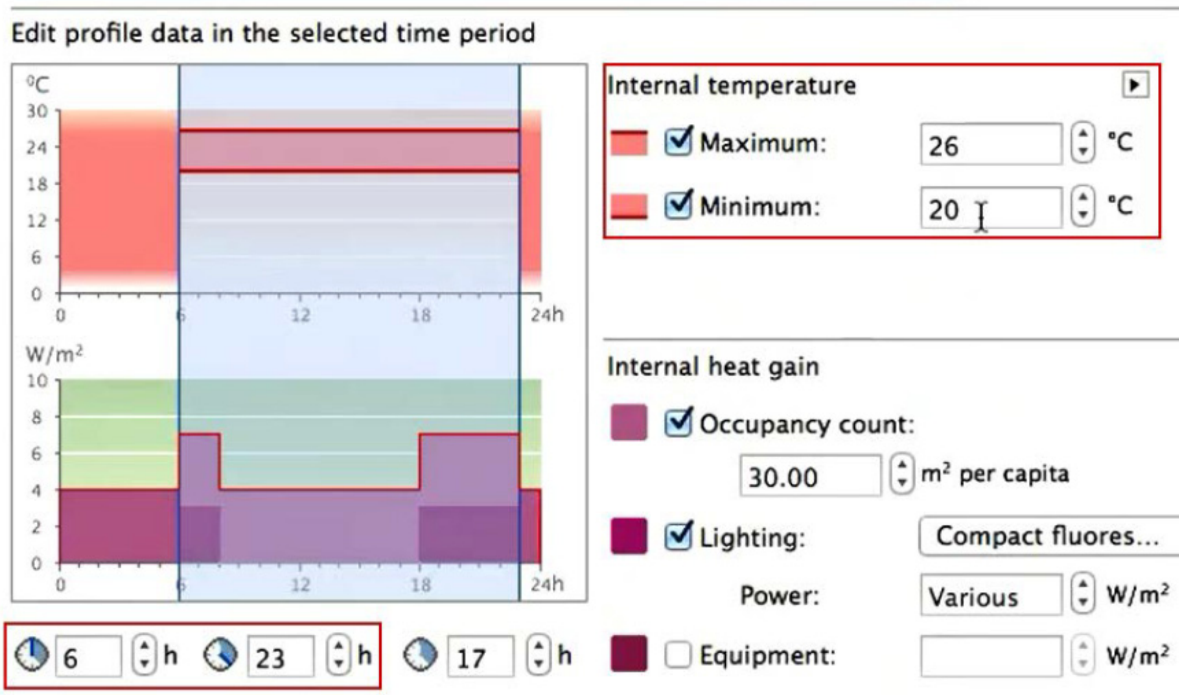
The aim is to avoid any extra humidity load and consider only the humidity characteristics defined by the local weather.

Open the Profile Editor dialog to edit the daily schedules. The upper diagram displays the hourly temperature limits for a residential interior space over one day.

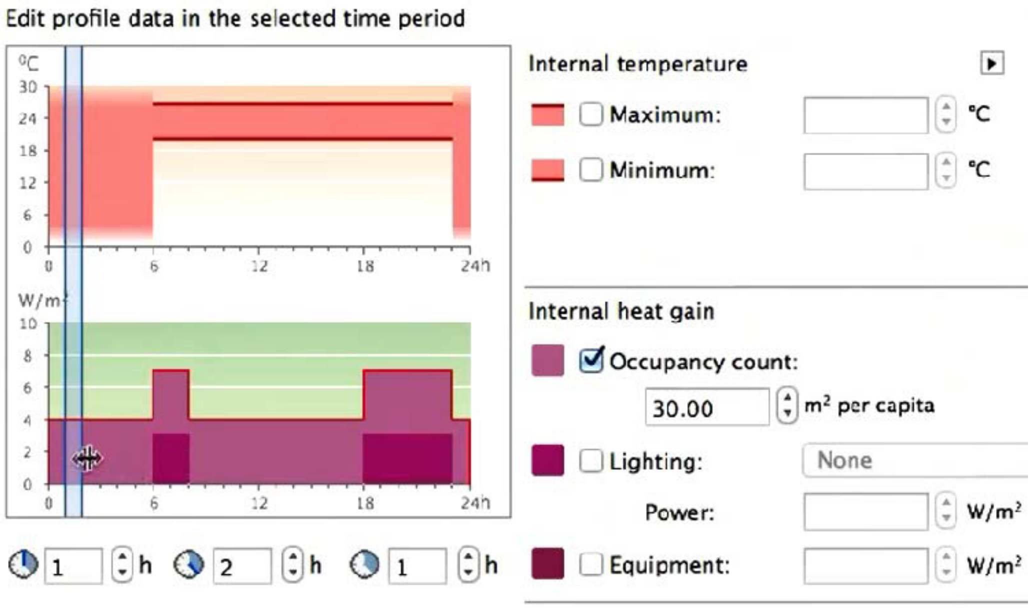
In this example, the **internal air temperature limit values** for the time interval between 6 AM and 11 PM:

- The maximum is set to 26 degrees Celsius and the minimum to 20 degrees Celsius.

- For the rest of the day, the internal temperature is allowed to free-float (there are no specific maximum or minimum temperature limit values defined from 11PM till 6AM).

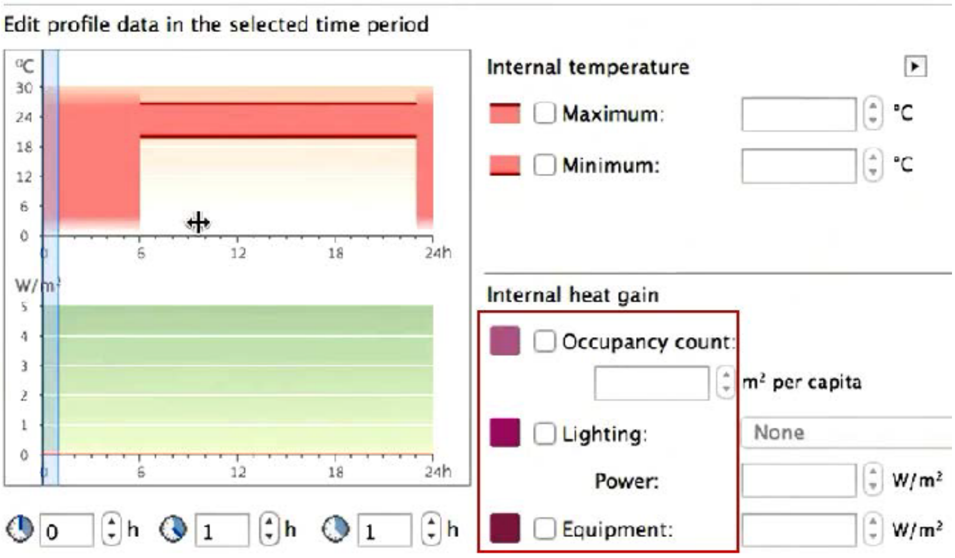


The lower diagram displays the internal heat-gain, which is the sum of several individual components, including heat emitted by the occupants, by the artificial lighting and by other equipment.



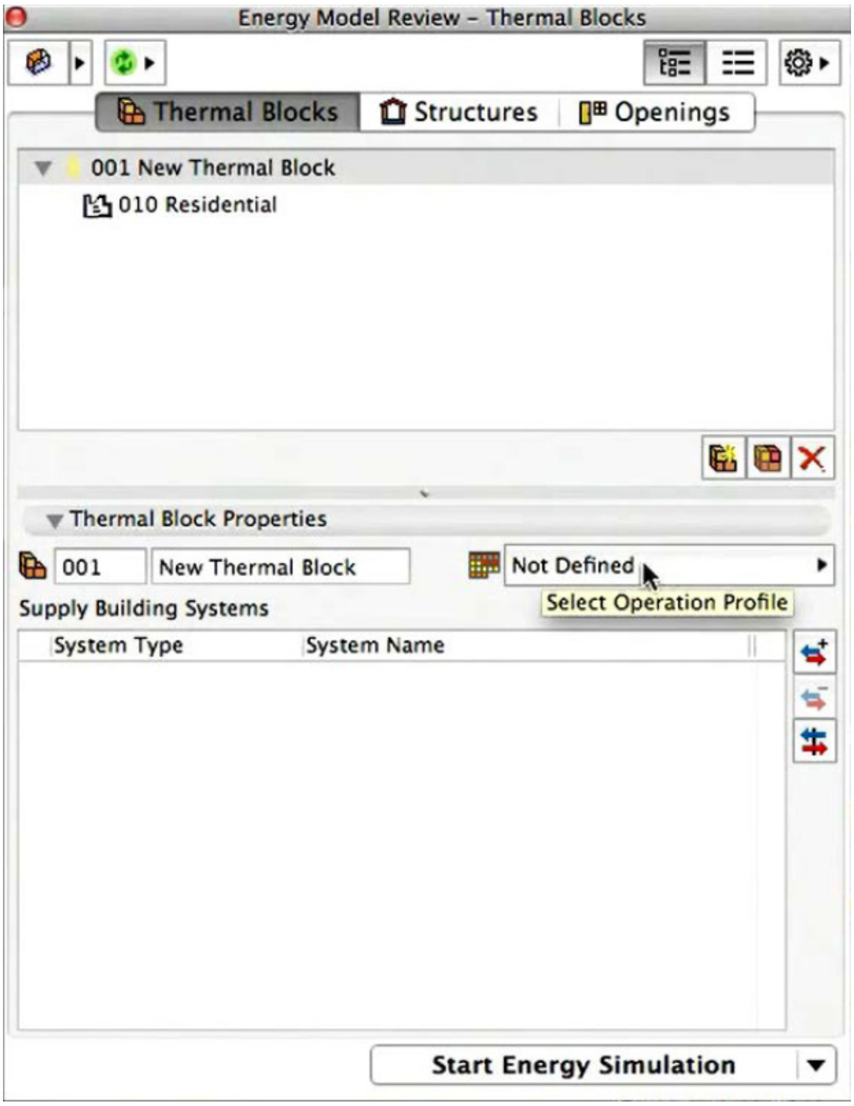
The aim is to determine how often the local climate conditions meet the internal thermal comfort requirements defined by the internal temperature limit values.

To find out, **turn off all internal heat-gains** and use only the previously defined maximum and minimum temperature values for the simulation.



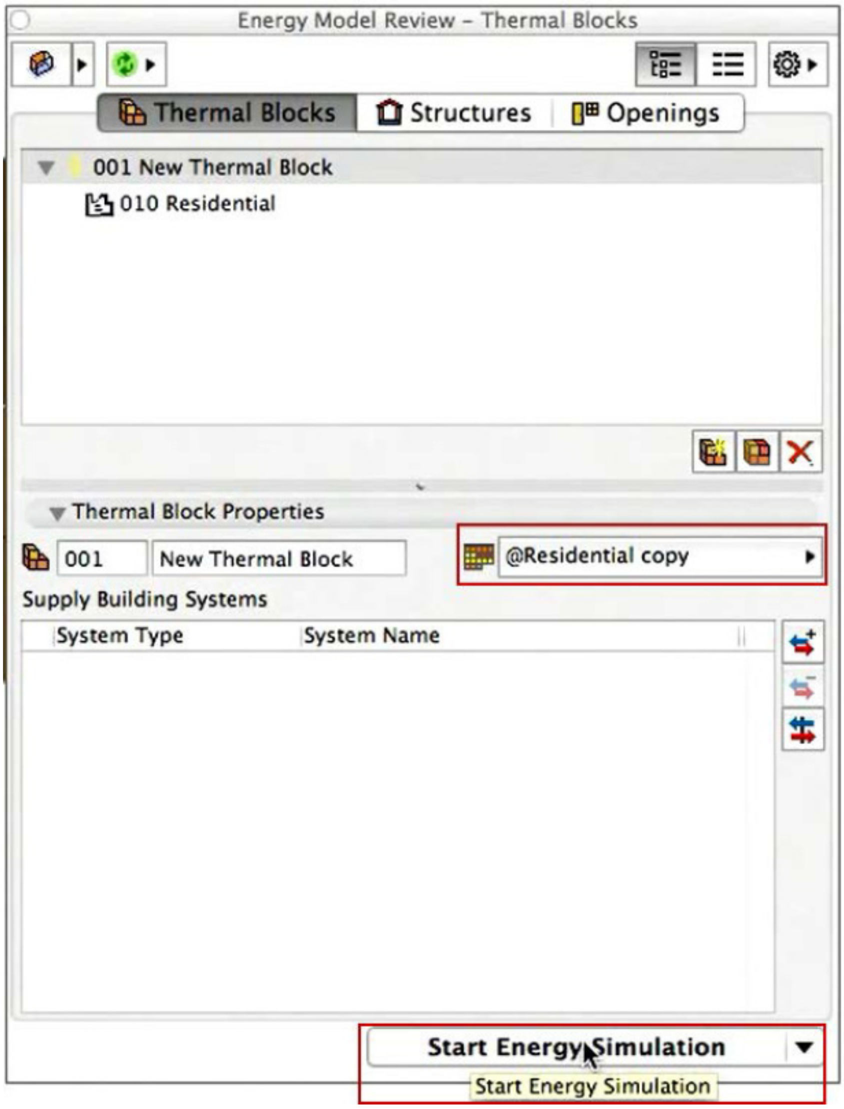
In fact, there are several places on Earth where the external temperature is mostly between 20 and 26 degrees Celsius throughout the entire year. In these climates, our internal thermal comfort requirements would largely be met automatically, with only a few unmet load hours.

Now you can determine how “friendly” the climate of your sample building project is. A**ssign** the new, custom **operation profile to the thermal block** we created earlier.



2.4 Run Energy Simulation

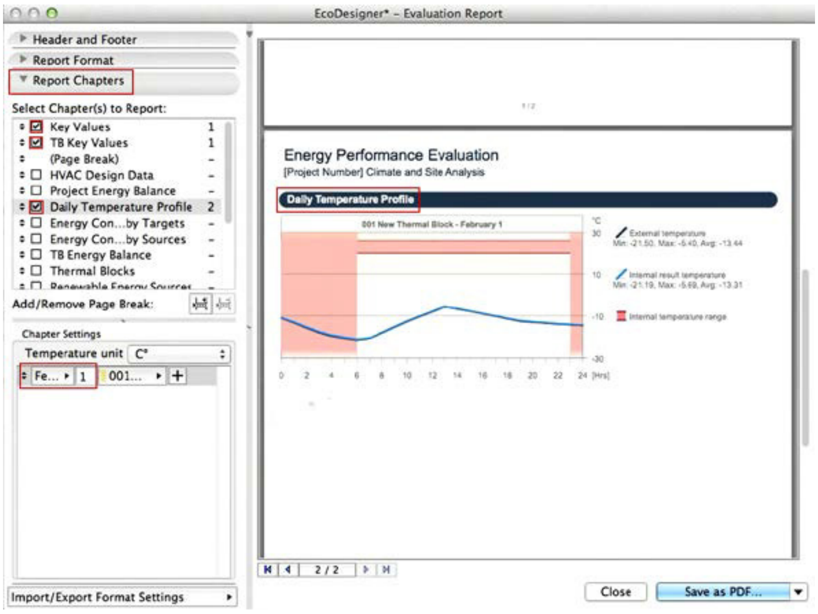
Start the Energy Simulation by pressing the corresponding button on the Energy Model Review palette.



ArchiCAD detects if the design has changed since the last simulation and warns us if the Zones must be updated. Let's update the energy model, to make sure the program will consider the building-energy related effects of last minute design changes, then start the energy simulation.

The EcoDesigner **Evaluation Report dialog** opens. On the left side, various properties of the report can be set.

On the “Report Chapters” page, check just those chapters you wish to publish in the PDF report.



Here, select “Key values” and “Thermal Block Key Values” - the chapter that contains the “unmet load hours”, among other values.

Continue by selecting the “Daily Temperature Profiles” chapter.

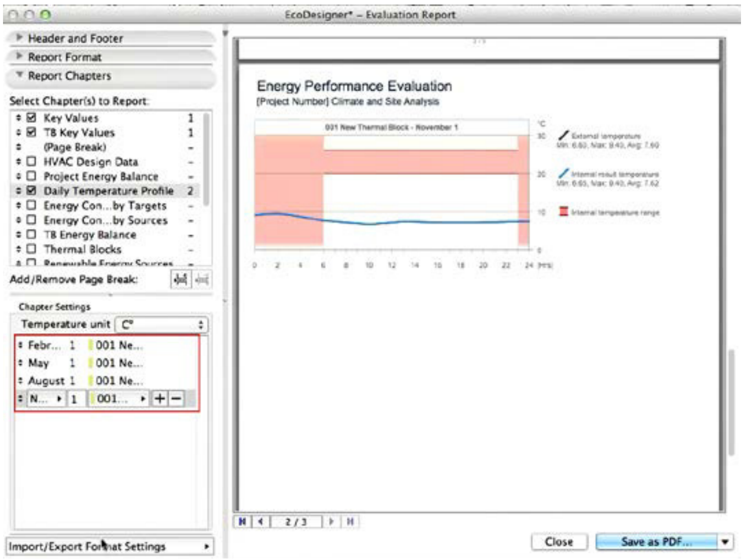
Use the chapter-specific settings on the bottom left of the dialog to define four days that represent the four seasons in the reference year.

Select the following four days:

- February 1 (winter)
- May 1 (spring)
- August 1 (summer)

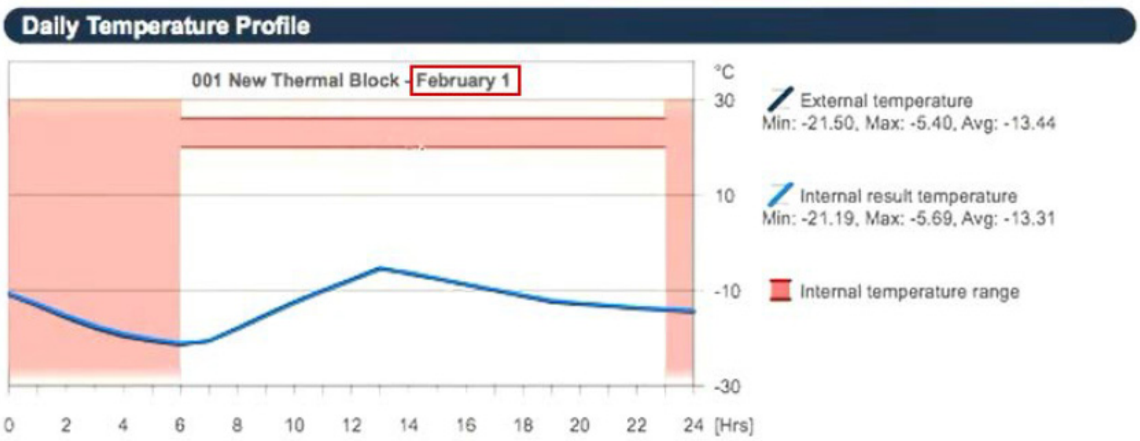
- November 1 (fall)

  Note that the diagram on the right is automatically updated.

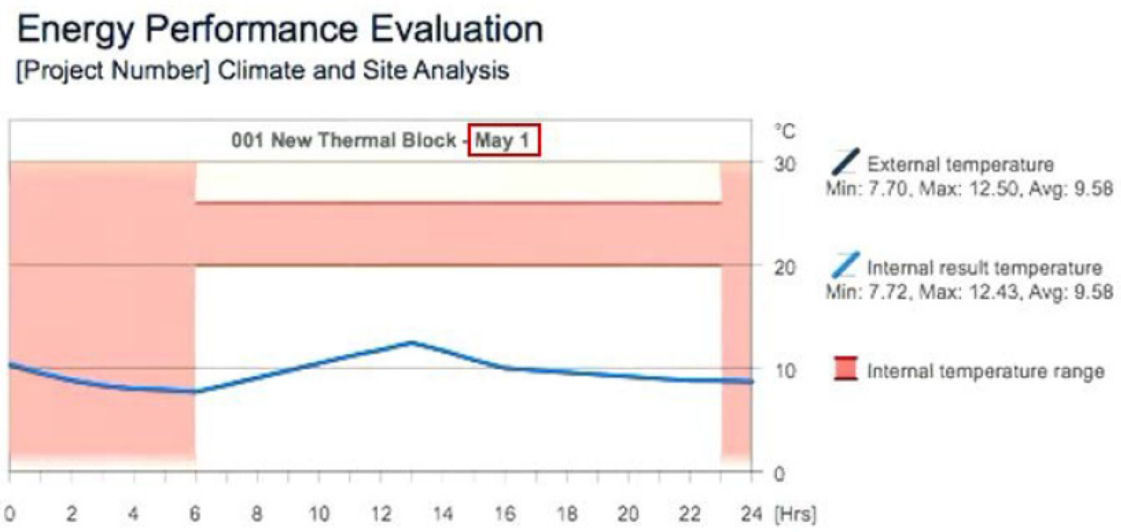


If the external and internal temperature graphs (dark and light blue lines respectively) practically overlap, then there is no heat trapped inside the building. In other words: the low resistance energy model of our climate analysis reference building is valid.

Note that the air temperature in winter is below the temperature requirements defined in the Operation Profile (shown in red on the **Daily Temperature Profile diagram**).

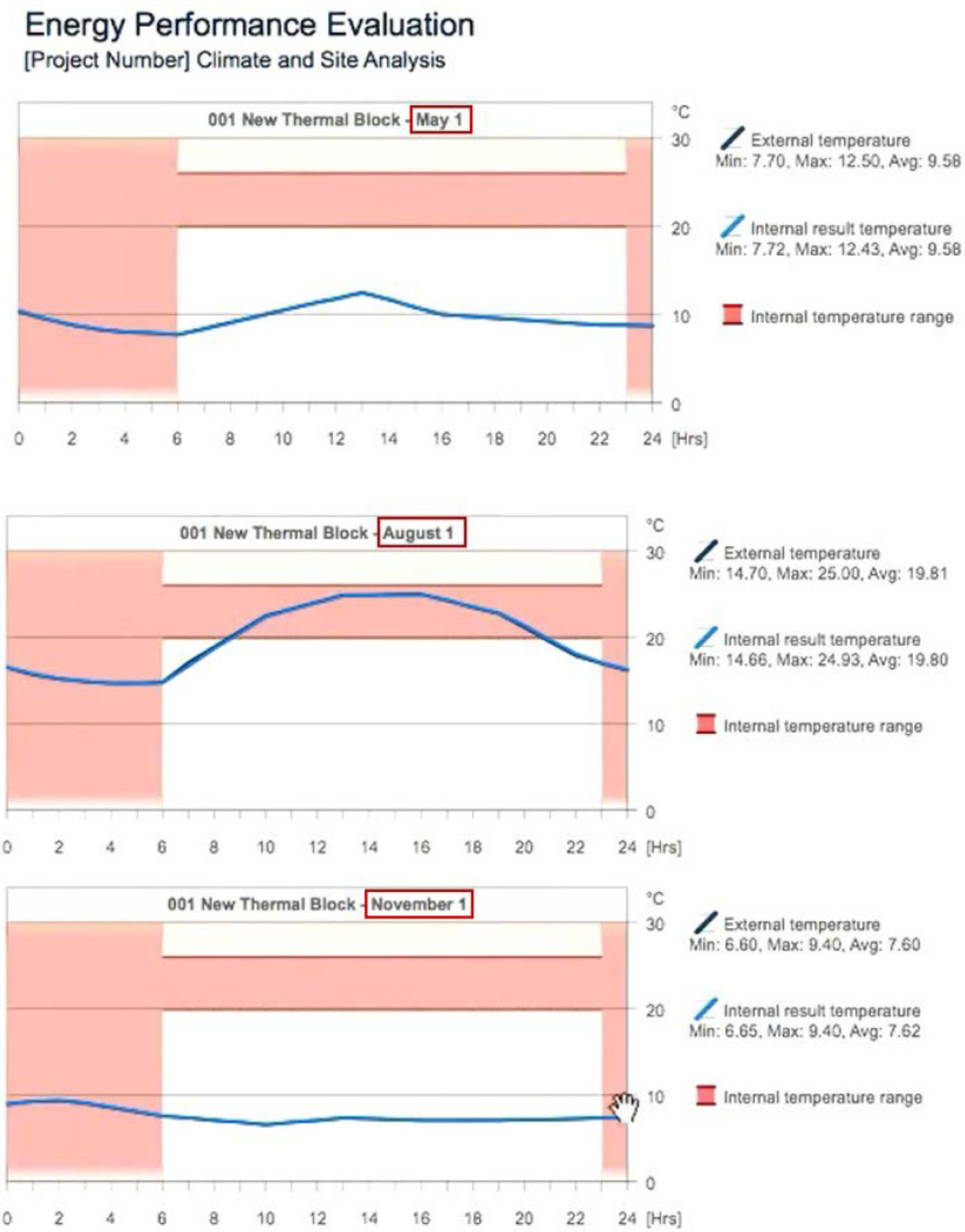


In spring, the situation is similar, though the temperature is not as low as it was in the winter.



Scroll down to see the temperature diagrams in the summer. The external temperature values in the summer are within the requirements defined in the Operation Profile.

Finally the external temperature is below the requirements in the fall.

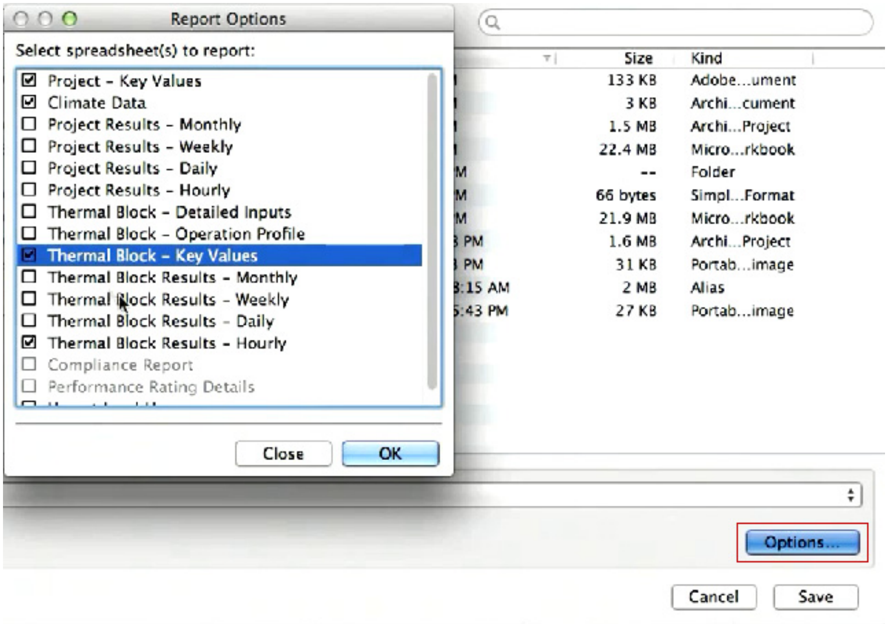


Save this **energy evaluation report** as a **PDF** document to your computer.

Save the calculation output, plus the parts of the calculation input relevant for the climate analysis, as an **Excel spreadsheet**.

From the Report Options dialog, select the report pages (chapters) we wish to include in the XLS documentation:

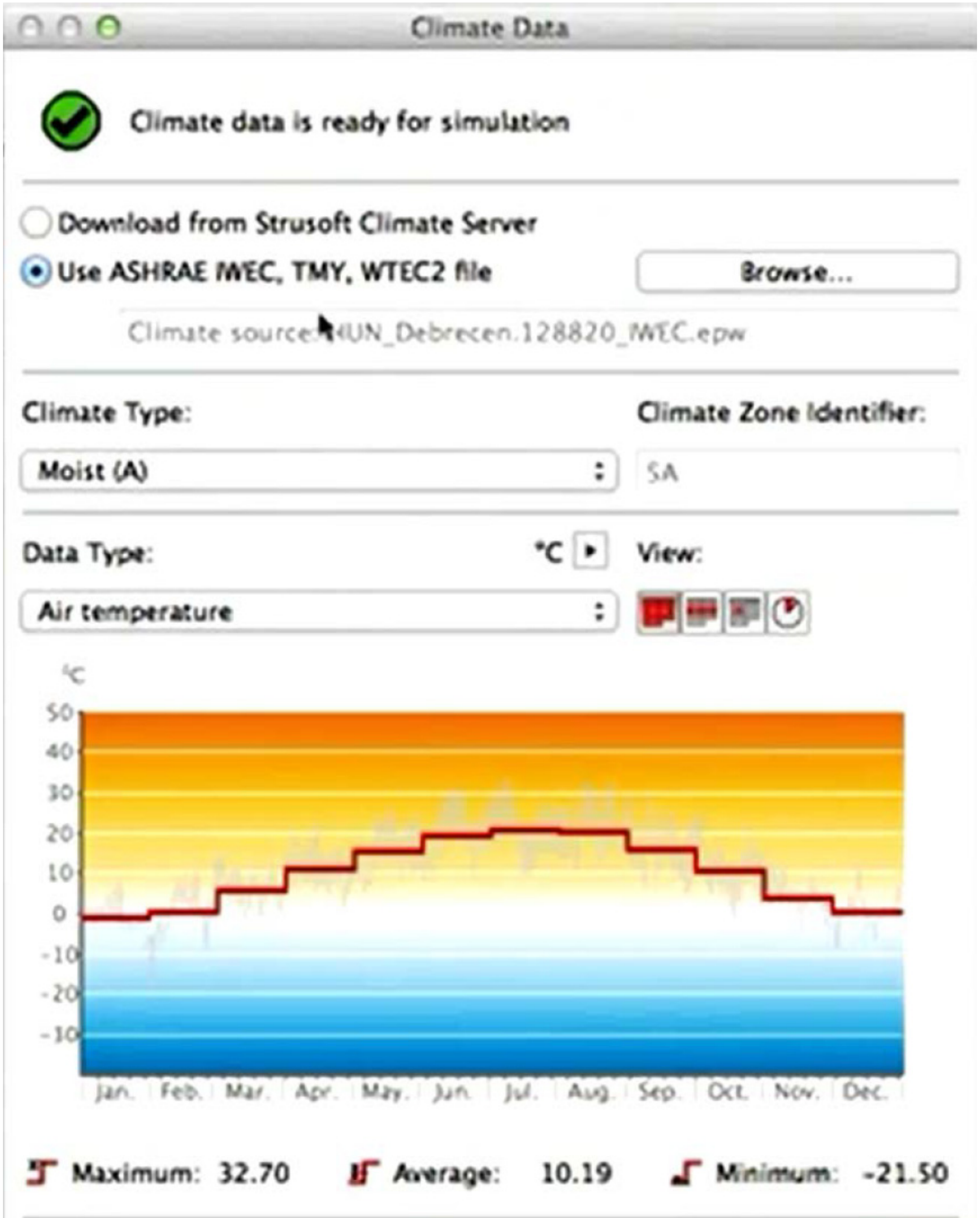
- Project Key Values
- Climate Data
- Thermal Block - key values
- Thermal Block - hourly results



Save the Excel Spreadsheet.

2.5 Document Climate Statistics

Close the Evaluation Report dialog and look at the results displayed in the Excel Spreadsheet First displaying the **Climate Analysis page** of the report. This page extracts and processes data from the Climate Data page of the report.



The Climate Data page essentially contains the climate data file used for the simulation, in Excel spreadsheet format. It lists temperature, relative humidity, solar radiation, wind speed and wind orientation as hourly values for the entire year.

The Climate Analysis page of the report displays the **weather statistics**, including the lowest, highest and average temperature data, on a monthly basis. The Annual Statistics column displays the annual extreme temperature values plus the annual mean temperature data.

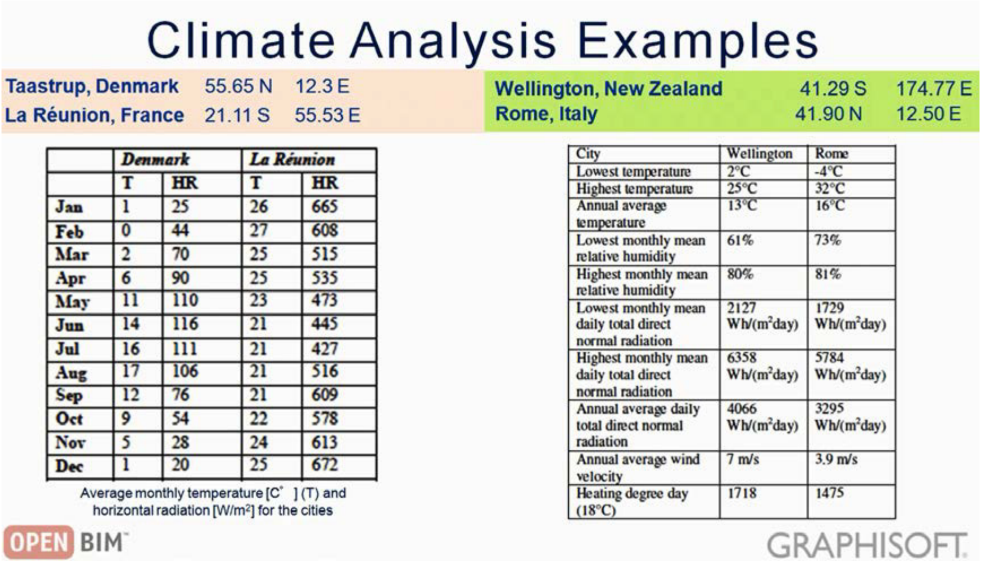
B	C	D	E	F	G	H	I	J	K	L
Cliamte data source			HUN_Debrecen.128820_IWEC.epw							
Location			DEBRECEN, 47.48° N, 21.63° E							
			Annual Statistics			Monthly Statistics				
				Date	Time	Jan	Feb	Mar	Apr	May
Dry bulb temperature [°C]	Lowest		-22	1/2	6	-13	-22	-3	-2	4
	Highest		33	9/7	16	9	13	15	22	27
	Average		10	NA	NA	-1	0	6	11	15
		Lowest monthly	-1	Jan	NA	NA	NA	NA	NA	NA
		Highest monthly	21	Jul	NA	NA	NA	NA	NA	NA
Relative humidity [%]	Lowest		26	31/3	14	47	31	26	33	31
	Highest		100	7/1	24	100	99	99	100	99
	Average		77	NA	NA	92	80	74	65	71
		Lowest monthly	65	Apr	NA	NA	NA	NA	NA	NA
		Highest monthly	92	Jan	NA	NA	NA	NA	NA	NA
Solar radiation [Wh/m2]	Lowest		0	1/1	1	0	0	0	0	0
	Highest		916	23/5	12	344	550	633	832	916
	Average		142	NA	NA	41	79	120	176	229
		per Day [Wh/m2,day]	3418	NA	NA	NA	NA	NA	NA	NA
		Lowest monthly	33	Dec	NA	NA	NA	NA	NA	NA
		Highest monthly	256	Jul	NA	NA	NA	NA	NA	NA
		Lowest monthly, per day [Wh/m2,day]	802	Dec	NA	NA	NA	NA	NA	NA
		Highest monthly, per day [Wh/m2,day]	6142	Jul	NA	NA	NA	NA	NA	NA
Wind speed [m/s]	Lowest		0	1/1	2	0	0	0	0	0
	Highest		14	27/3	10	10	8	14	13	9
	Average		3	NA	NA	2	2	4	4	3
		Lowest monthly	2	Jul	NA	NA	NA	NA	NA	NA
		Highest monthly	4	Apr	NA	NA	NA	NA	NA	NA
Heating degree days [°day]			4748	NA	NA	NA	NA	NA	NA	NA
Cooling degree days [°day]			1181	NA	NA	NA	NA	NA	NA	NA

Project Key Values | Climate data | Climate Analysis | Detailed Results – Hourly | Thermal Block – Key Values | +

The Relative humidity and Wind speed data are also displayed on this page, while the Solar Irradiation-related statistics are even more detailed. These values are important for the design of passive (e.g. external fenestration, solariums, double-skin facades etc.) and active (e.g. solar thermal collectors and photovoltaics) solar systems.

The bottom of the report displays the annual **heating and cooling degree days**. These are directly proportional to the heating and cooling requirements.

Here are some Climate Analysis **examples from different parts of the world**. The table on the right compares climate values in Italy and in New Zealand. The diagram on the left compares climate values between Denmark and France. Different climates typically require different sustainable design concepts and solutions.

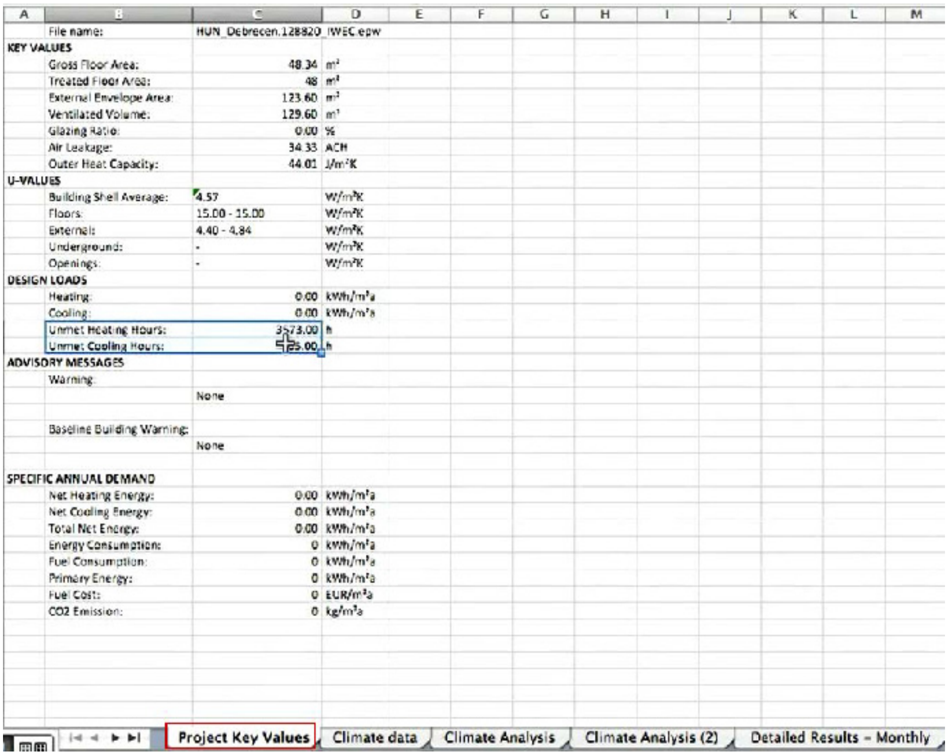


	Denmark		La Réunion	
	T	HR	T	HR
Jan	1	25	26	665
Feb	0	44	27	608
Mar	2	70	25	515
Apr	6	90	25	535
May	11	110	23	473
Jun	14	116	21	445
Jul	16	111	21	427
Aug	17	106	21	516
Sep	12	76	21	609
Oct	9	54	22	578
Nov	5	28	24	613
Dec	1	20	25	672

Average monthly temperature [C°] (T) and horizontal radiation [W/m²] for the cities

City	Wellington	Rome
Lowest temperature	2°C	-4°C
Highest temperature	25°C	32°C
Annual average temperature	13°C	16°C
Lowest monthly mean relative humidity	61%	73%
Highest monthly mean relative humidity	80%	81%
Lowest monthly mean daily total direct normal radiation	2127 Wh/(m²day)	1729 Wh/(m²day)
Highest monthly mean daily total direct normal radiation	6358 Wh/(m²day)	5784 Wh/(m²day)
Annual average daily total direct normal radiation	4066 Wh/(m²day)	3295 Wh/(m²day)
Annual average wind velocity	7 m/s	3.9 m/s
Heating degree day (18°C)	1718	1475

Depending on the purpose of the building energy design documentation and on the location of the project, the **necessary content of the climate analysis** may vary. The report created with EcoDesigner STAR includes all climate data of both the external and internal environments, so you only need to filter and format the results to customize it to fit your specific documentation needs. The Project Key Values chapter displays the **Unmet Heating and Unmet Cooling Load Hours**.



A	B	C	D
	File name:	HUN_Debrecen.128820_IWEC.epw	
KEY VALUES			
	Gross Floor Area:	48.34	m²
	Treated Floor Area:	48	m²
	External Envelope Area:	123.60	m²
	Ventilated Volume:	129.60	m³
	Glazing Ratio:	0.00	%
	Air Leakage:	34.33	ACH
	Outer Heat Capacity:	44.01	J/m²K
U-VALUES			
	Building Shell Average:	4.57	W/m²K
	Floors:	15.00 - 15.00	W/m²K
	External:	4.40 - 4.84	W/m²K
	Underground:	-	W/m²K
	Openings:	-	W/m²K
DESIGN LOADS			
	Heating:	0.00	kWh/m²a
	Cooling:	0.00	kWh/m²a
	Unmet Heating Hours:	3573.00	h
	Unmet Cooling Hours:	[illegible]5.00	h
ADVISORY MESSAGES			
	Warning:		
		None	
	Baseline Building Warning:		
		None	
SPECIFIC ANNUAL DEMAND			
	Net Heating Energy:	0.00	kWh/m²a
	Net Cooling Energy:	0.00	kWh/m²a
	Total Net Energy:	0.00	kWh/m²a
	Energy Consumption:	0	kWh/m²a
	Fuel Consumption:	0	kWh/m²a
	Primary Energy:	0	kWh/m²a
	Fuel Cost:	0	EUR/m²a
	CO2 Emission:	0	kg/m²a

These values can be referenced and displayed on a customized Climate Analysis page. Here these values are shown in red.

A	B	C	D	E	F	G	H	I	J
	Cliamte data source			HUN_Debrecen.128820_IWEC.epw					
	Location			DEBRECEN, 47.48° N, 21.63° E					
				Annual Statistics			Monthly Statistics		
					Date	Time	Jan	Feb	Mar
	Dry bulb temperature [°C]	Lowest		-22	1/2	6	-13	-22	-3
		Highest		33	9/7	16	9	13	15
		Average		10	NA	NA	-1	0	6
			Lowest monthly	-1	Jan	NA	NA	NA	NA
			Highest monthly	21	Jul	NA	NA	NA	NA
	Relative humidity [%]	Lowest		26	31/3	14	47	31	26
		Highest		100	7/1	24	100	99	99
		Average		77	NA	NA	92	80	74
			Lowest monthly	65	Apr	NA	NA	NA	NA
			Highest monthly	92	Jan	NA	NA	NA	NA
	Solar radiation [Wh/m2]	Lowest		0	1/1	1	0	0	0
		Highest		916	23/5	12	344	550	633
		Average		142	NA	NA	41	79	120
			per Day [Wh/m2,day]	3418	NA	NA	NA	NA	NA
			Lowest monthly	33	Dec	NA	NA	NA	NA
			Highest monthly	256	Jul	NA	NA	NA	NA
			Lowest monthly, per day [Wh/m2,day]	802	Dec	NA	NA	NA	NA
			Highest monthly, per day [Wh/m2,day]	6142	Jul	NA	NA	NA	NA
	Wind speed [m/s]	Lowest		0	1/1	2	0	0	0
		Highest		14	27/3	10	10	8	14
		Average		3	NA	NA	2	2	4
			Lowest monthly	2	Jul	NA	NA	NA	NA
			Highest monthly	4	Apr	NA	NA	NA	NA
	Heating degree days [°day]			4748	NA	NA	NA	NA	NA
	Cooling degree days [°day]			1181	NA	NA	NA	NA	NA
			Percentage of unmet load hours in a year						
	Unmet Heating Hours:	3573	41						
	Unmet Cooling Hours:	265	3						

Project Key Values | Climate data | Climate Analysis | Climate Analysis (2) | Detailed Results - Monthly

These values indicate the number of hours in a year the temperature is outside of the comfort zone. The percentage of unmet load hours in a year is also displayed. In this case, 41% of the year the external climate is too cold and in 3% of the year it is too hot - based on the requirements defined in the Operation Profile. Clearly, more effort is needed to ensure appropriate heating for the building. In other words, the design must be optimized for a cold, “heating-dominated” climate.

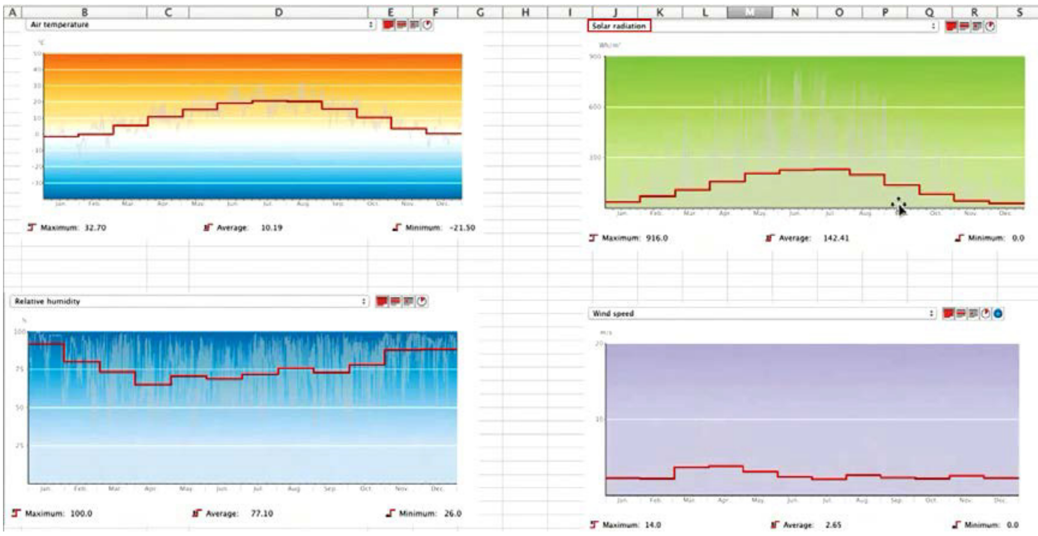
You can also display the colored, graphic charts to illustrate the numeric values, representing the monthly statistics.

Another way to put the Climate Analysis report's numbers in perspective is to **compare the calculated annual average values with the global minimum and maximum annual mean values**. This very simple comparative table can be created in seconds.

B	C	D	E	F	G	H	I	J	K	L	M
Cliamte data source			HUN_Debrecen.128820_IWEC.epw								
Location			DEBRECEN, 47.48° N, 21.63° E								
			Annual Statistics			Monthly Statistics					
				Date	Time	Jan	Feb	Mar	Apr	May	Jun
Dry bulb temperature [°C]	Lowest		-22	1/2	6	-13	-22	-3	-2	4	8
	Highest		33	9/7	16	9	13	15	22	27	31
	Average		10	NA	NA	-1	0	6	11	15	19
		Lowest monthly	-1	Jan	NA	NA	NA	NA	NA	NA	NA
		Highest monthly	21	Jul	NA	NA	NA	NA	NA	NA	NA
Relative humidity [%]	Lowest		26	31/3	14	47	31	26	33	31	42
	Highest		100	7/1	24	100	99	99	100	99	96
	Average		77	NA	NA	92	80	74	65	71	69
		Lowest monthly	65	Apr	NA	NA	NA	NA	NA	NA	NA
		Highest monthly	92	Jan	NA	NA	NA	NA	NA	NA	NA
Solar radiation [Wh/m2]	Lowest		0	1/1	1	0	0	0	0	0	0
	Highest		916	23/5	12	344	550	633	832	916	912
	Average		142	NA	NA	41	79	120	176	229	252
		per Day [Wh/m2,day]	3418	NA	NA	NA	NA	NA	NA	NA	NA
		Lowest monthly	33	Dec	NA	NA	NA	NA	NA	NA	NA
		Highest monthly	256	Jul	NA	NA	NA	NA	NA	NA	NA
		Lowest monthly, per day [Wh/m2,day]	802	Dec	NA	NA	NA	NA	NA	NA	NA
		Highest monthly, per day [Wh/m2,day]	6142	Jul	NA	NA	NA	NA	NA	NA	NA
Wind speed [m/s]	Lowest		0	1/1	2	0	0	0	0	0	0
	Highest		14	27/3	10	10	8	14	13	9	7
	Average		3	NA	NA	2	2	4	4	3	2
		Lowest monthly	2	Jul	NA	NA	NA	NA	NA	NA	NA
		Highest monthly	4	Apr	NA	NA	NA	NA	NA	NA	NA
Heating degree days [°day]			4748	NA	NA	NA	NA	NA	NA	NA	NA
Cooling degree days [°day]			1181	NA	NA	NA	NA	NA	NA	NA	NA
		Percentage of total hours in a year			Annual Average		min	calc.	max		
Unmet Heating Hours:	3573	41			Temperature		-30	10	35		
Unmet Cooling Hours:	265	3			Relative humidity		2	77	98		
					Solar potential		1100	3418	6800		
					Wind potential		3	3	9		

This example displays the mean temperature, average relative humidity, and the solar and wind potential values. The average temperature and relative humidity values represent the global average, while the solar potential is slightly below the global average values, and the wind potential is – unfortunately - close to the global minimum value.

Consider the colored **climate diagrams** below the numeric tables.



The greatest solar potential is available during the summer months. Since we do not need much heating during the summer in this climate, we can best utilize the heat energy of solar radiation via solar thermal collectors, to generate service hot water. We can also use photovoltaic panels in the summer to generate electricity.

But the most intense wind is typically during the spring, rather than in the summer, when the wind would help us optimize the on-site electric power generation, if our goal for this project was net zero energy building design.

Look at the calculation results displayed in the **PDF Energy Evaluation Report** document created earlier.

The first chapter displays some Project **Key Values** of the project. The infiltration value is high, while the outer heat capacity is low, as defined prior to the simulation.

Energy Performance Evaluation

[Project Number] Climate and Site Analysis

Key Values

General Project Data			**Heat Transfer Coefficients**	U value	[W/m²K]
Project Name:	Climate and Site Analysis		Building Shell Average:	**4.80**	
City Location:			Floors:	**18.00 - 18.00**	
Climate Data Source:	HUN_Debre...0_IWEC.epw		External:	**4.61 - 5.11**	
Evaluation Date:	Nov 20, 2013 5:47:52 PM		Underground:	--	
			Openings:	--	
Building Geometry Data					
Gross Floor Area:	**48.28**	m²	Net Heating Energy:	**0.00**	kWh/m²a
Treated Floor Area:	**48.00**	m²	Net Cooling Energy:	**0.00**	kWh/m²a
External Envelope Area:	**123.60**	m²	Total Net Energy:	**0.00**	kWh/m²a
Ventilated Volume:	**129.60**	m³	Energy Consumption:	**0.00**	kWh/m²a
Glazing Ratio:	**0**	%	Fuel Consumption:	**0.00**	kWh/m²a
			Primary Energy:	**0.00**	kWh/m²a
Building Shell Performance Data			Fuel Cost:	--	EUR/m²a
Infiltration at 50Pa:	**343.33**	ACH	CO_2 Emission:	**0.00**	kg/m²a
Outer Heat Capacity:	**60.32**	J/m²K			

Scroll down to the Thermal Block Key Values.

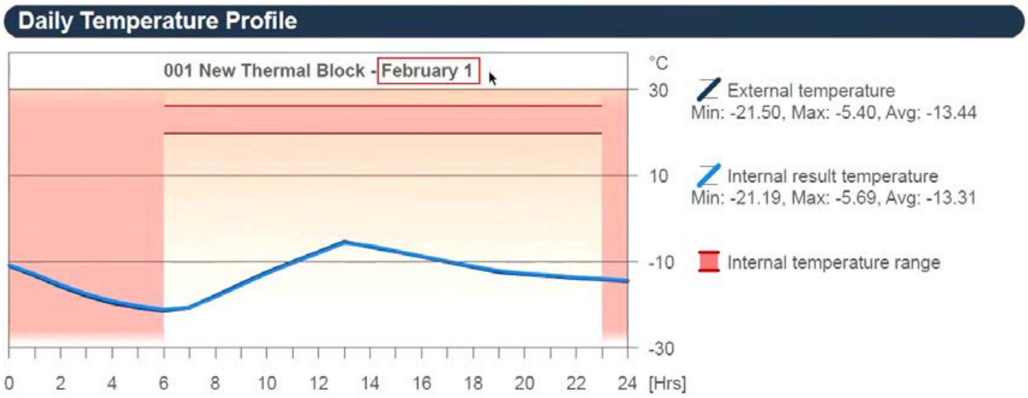
Note that the internal and external temperature data are very similar (which was our intention with the Climate Analysis). This chapter of the report displays the Unmet Load Hours for Heating and Cooling.

001 New Thermal Block - Key Values

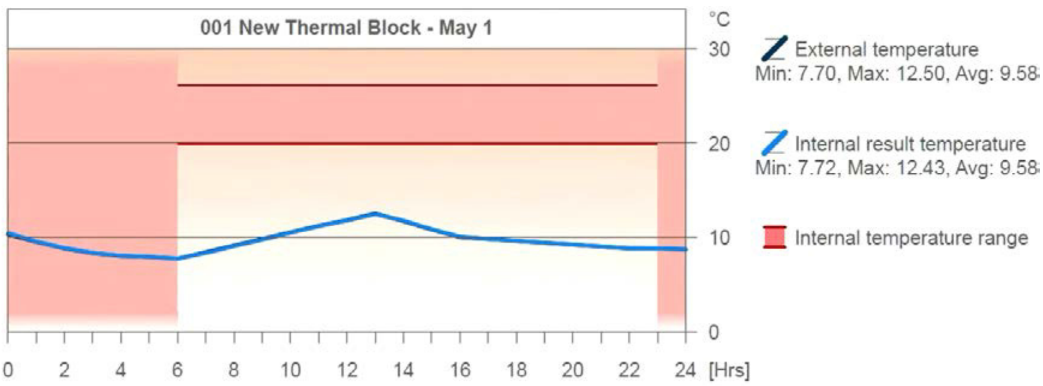
Geometry Data			**Heat Transfer Coefficients**	U value	[W/m²K]
Gross Floor Area:	**48.28**	m²	Floors:	**18.00 - 18.00**	
Treated Floor Area:	**48.00**	m²	External:	**4.61 - 5.11**	
Building Shell Area:	**123.60**	m²	Underground:	-	
Ventilated Volume:	**129.60**	m³	Openings:	-	
Glazing Ratio:	**0**	%			
			Annual Energy		
Internal Temperature			Heating:	**0.00**	kWh
Min. (06:00 Feb. 01):	**-21.19**	°C	Cooling:	**0.00**	kWh
Annual Mean:	**10.20**	°C			
Max. (16:00 Jul. 09):	**32.64**	°C	**Peak**		
			Heating (01:00 Jan. 01):	**0.00**	kW
Degree Days			Cooling (01:00 Jan. 01):	**0.00**	kW
Heating (HDD):	**4748**				
Cooling (CDD):	**1181**		**Unmet Load Hours**		
			Heating:	**4760**	hrs/a
			Cooling:	**309**	hrs/a

The Unmet Load Hours can also be seen in the **Daily Temperature Profile diagrams** for the typical days of the different seasons.

On February 1, for example, we have 17 unmet load hours (the period between 6 AM and 11 PM).



In spring, the temperature is warmer than in February - around 10 Celsius centigrade opposed to the approx. -10 degrees measured in the winter. Still, the same amount of unmet loads hours are present, since the temperature is below the acceptable minimum value in both cases.



In summer, the climate is close to the comfort range, while in the fall it is getting too cold again.

3. Building Energy Model Calibration

This chapter presents how to validate your building energy model (or BEM for short).

EcoDesigner STAR complies with the ASHRAE 140 “Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs”, used for validating energy simulation software. Compliance with this standard ensures that EcoDesigner STAR can perform complex dynamic building energy analyses successfully, with results that are accurate enough for energy performance rating according to LEED, GreenStar and other building standards.

Generation of an accurate building energy report requires a standard compliant software such as EcoDesigner STAR. However, a standard-compliant software alone cannot guarantee that your results will also be accurate. The accuracy of the reports depends on the quality of the input data you provide when creating the model. Therefore, to make sure that your energy-related design input and output is correct, you must calibrate each BEM carefully, using reliable reference data.

By calibrating your building model you will ensure that your Building Energy Model is correctly configured and all generated reports are accurate.

3.1 BEM Validation Types

There are two types of Building Energy Model calibrations.

The first is used to validate the software application that runs building energy simulation. This **software validation** is typically carried out by the software developer. Its results are usually displayed on the developer’s website. For instance, GRAPHISOFT EcoDesigner STAR is compliant with the ASHRAE 140 simulation standards.

The second calibration type is **design model validation.** For accurate energy evaluation, you must provide appropriate and precise input. To make sure that all the energy-related characteristics of the zones, structures and openings, and Operation Profiles are correctly set and modeled, it is worth performing the model calibration for every BEM. This can be done using a **reference model** with known energy performance.

Software validation typically consists of numerous building energy models (cases), each of which is simulated using the tested software. The calculation results for each case are then compared with benchmark values (which are part of the standard). The standardized cases cover a vast range of energy modeling scenarios. If every case is valid, then Building Energy Simulation Standard Compliance is achieved.

This chapter presents a building energy model from the ASHRAE 140 standard. It demonstrates a workflow that can be used to calibrate all other design models. This standardized “case” can be used for two purposes:

- To demonstrate the design model validation workflow in general
- To illustrate the explanation regarding the ASHRAE 140 compliance testing of the EcoDesigner STAR software.

3.2 Obtain Reference Building's Documentation

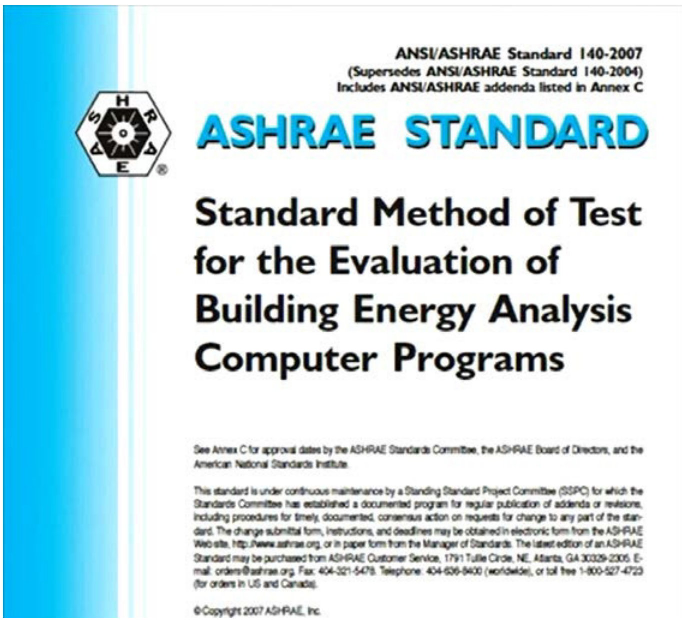
The first step of calibration is to obtain the reference building data. The reference building should be similar to the one you design.

If you do not have a suitable reference building in your archives, then rely on the energy performance documentation of buildings similar in size and operation to the one you are about to design.

For example, the **NREL Reference Building Models** energy data, published by the United States National Renewable Energy Laboratory (NREL), is a vast database of building energy performance information. It contains statistical energy consumption data of many building types built at different locations. The data is grouped according to climate, building construction, size and operation profile (such as residential, office, or retail).

Another source of reference buildings: a model from a building energy simulation standard. In this chapter, we will use one of the **ASHRAE 140 standard building models** to show you how to calibrate a building energy model, and to demonstrate that EcoDesigner STAR complies with the ASHRAE 140 standard. ASHRAE 140 is referenced by all significant green building rating standards, including LEED, GreenStar, BREEAM, CASBEE, DGNB and Section J of the Building Code of Australia.

The ASHRAE 140 standard documentation contains over 100 various cases: architectural tests called building envelope tests and building systems tests for various heating, cooling and ventilation system setups. If a computer application can correctly simulate all ASHRAE 140 test cases and provide appropriate results, then these simulation results are approved as a basis for building energy performance rating as prescribed by LEED, BREEAM, GreenStar and others.



ANSI/ASHRAE Standard 140-2007
(Supersedes ANSI/ASHRAE Standard 140-2004)
Includes ANSI/ASHRAE addenda listed in Annex C

ASHRAE STANDARD

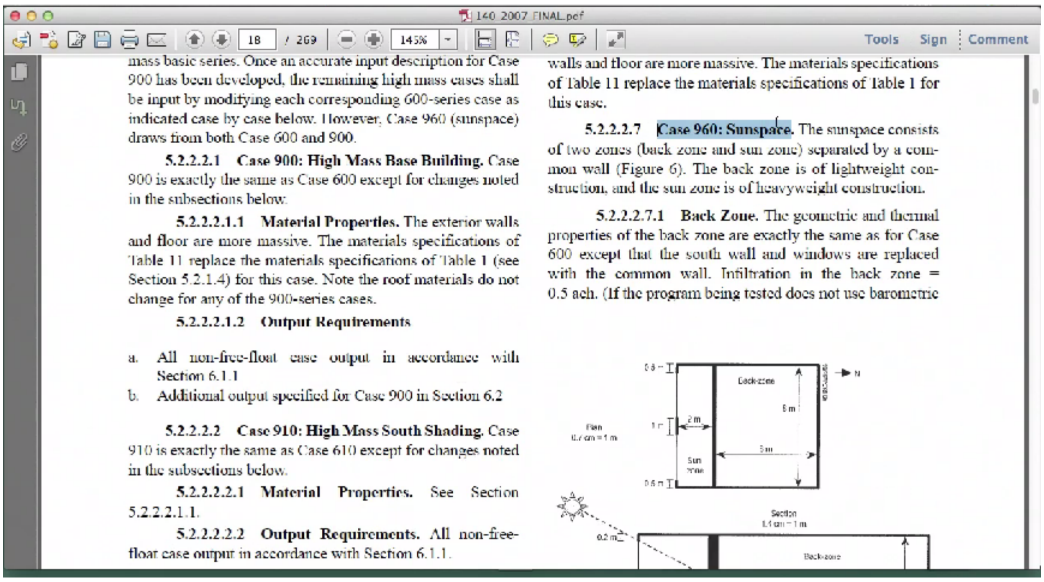
Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs

See Annex C for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, and the American National Standards Institute.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE Web site, http://www.ashrae.org, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada).

©Copyright 2007 ASHRAE, Inc.

In this example, we'll present one of the envelope tests of the ASHRAE 140 standard. This will be the so called **Sunspace Test**, and its case number is 960.



mass basic series. Once an accurate input description for Case 900 has been developed, the remaining high mass cases shall be input by modifying each corresponding 600-series case as indicated case by case below. However, Case 960 (sunspace) draws from both Case 600 and 900.

5.2.2.2.1 Case 900: High Mass Base Building. Case 900 is exactly the same as Case 600 except for changes noted in the subsections below.

5.2.2.2.1.1 Material Properties. The exterior walls and floor are more massive. The materials specifications of Table 11 replace the materials specifications of Table 1 (see Section 5.2.1.4) for this case. Note the roof materials do not change for any of the 900-series cases.

5.2.2.2.1.2 Output Requirements

a. All non-free-float case output in accordance with Section 6.1.1

b. Additional output specified for Case 900 in Section 6.2

5.2.2.2.2 Case 910: High Mass South Shading. Case 910 is exactly the same as Case 610 except for changes noted in the subsections below.

5.2.2.2.2.1 Material Properties. See Section 5.2.2.2.1.1.

5.2.2.2.2.2 Output Requirements. All non-free-float case output in accordance with Section 6.1.1.

walls and floor are more massive. The materials specifications of Table 11 replace the materials specifications of Table 1 for this case.

5.2.2.2.7 Case 960: Sunspace. The sunspace consists of two zones (back zone and sun zone) separated by a common wall (Figure 6). The back zone is of lightweight construction, and the sun zone is of heavyweight construction.

5.2.2.2.7.1 Back Zone. The geometric and thermal properties of the back zone are exactly the same as for Case 600 except that the south wall and windows are replaced with the common wall. Infiltration in the back zone = 0.5 ach. (If the program being tested does not use barometric

Let's have a quick look at the description of this particular case. The standard defines the detailed geometry of the building model on which the test must be run. Below, all the corresponding material properties are also listed in tables.

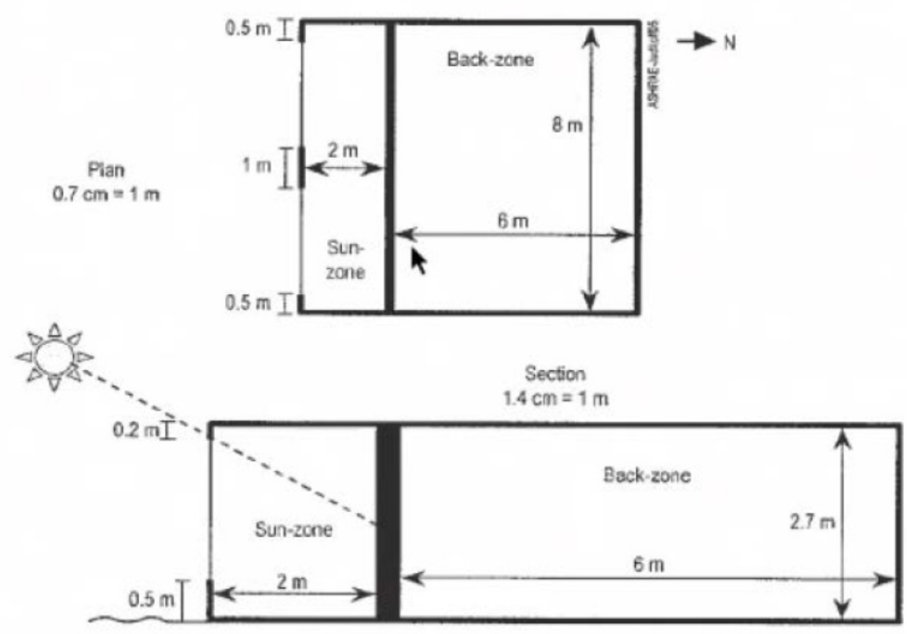


Figure 6 Sunspace plan and section (Case 960).

In case of the Sunspace Test, two thermal blocks must be considered: a “Sun-Zone” with a window, and a “**Back-Zone**” behind it. The parameters defined in the ASHRAE 140 standard must be input into the software application precisely. After the energy simulation is run, its results must match the results defined in the standard.

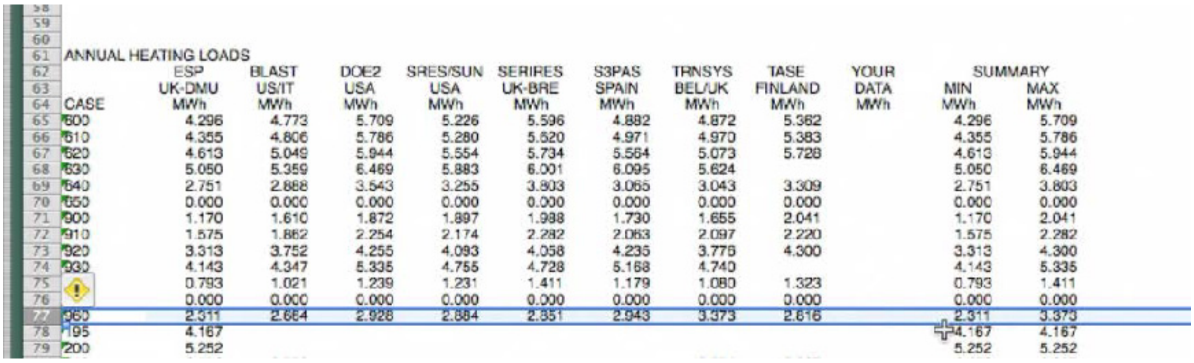
In case of the Sunspace Test, the following **calculation results** must be presented:

- total annual cooling and heating energy for the Back-Zone
- heating and cooling peak-loads for the Back-Zone
- minimum, maximum and annual mean temperatures in the Sun-Zone

The Back-Zone is a so called “conditioned” space and the Sun-Zone is an “unconditioned” space. *(See below.)*

After the building energy simulation is complete, the relevant results must be entered into a **standard result spreadsheet**. Each row represents a test case, defined by a 3-digit number. Here we present Case 960.

This chart, for example, is used to validate the annual heating loads.



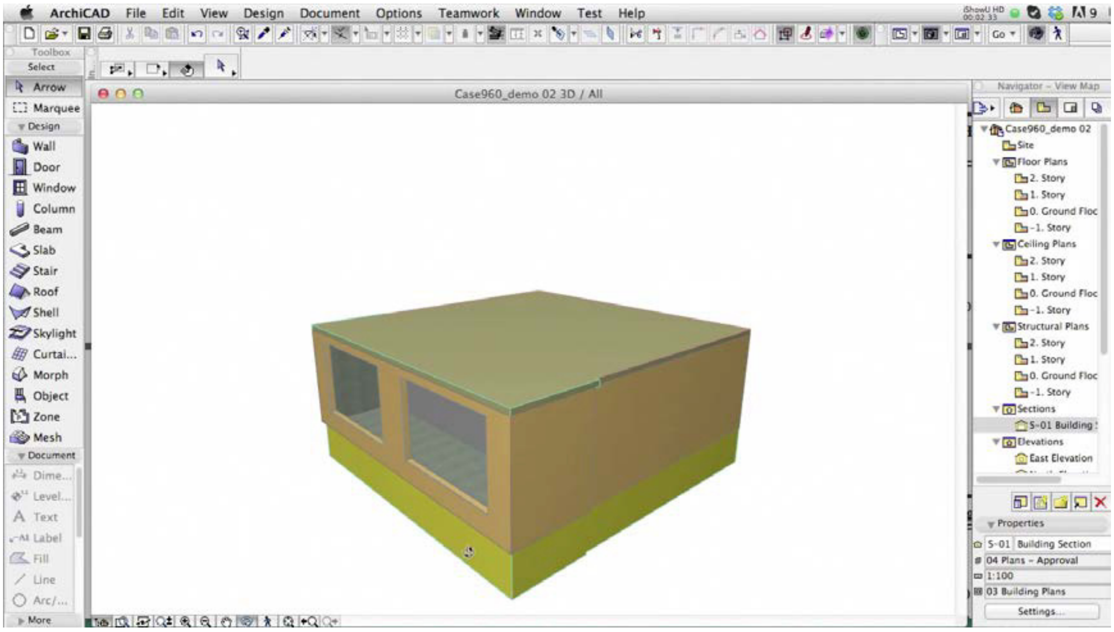
ANNUAL HEATING LOADS

CASE	ESP UK-DMU MWh	BLAST US/IT MWh	DOE2 USA MWh	SRES/SUN USA MWh	SERIRES UK-BRE MWh	S3PAS SPAIN MWh	TRNSYS BEL/UK MWh	TASE FINLAND MWh	YOUR DATA MWh	SUMMARY MIN MWh	SUMMARY MAX MWh
600	4.296	4.773	5.709	5.226	5.596	4.882	4.872	5.362		4.296	5.709
610	4.355	4.806	5.786	5.280	5.620	4.971	4.970	5.383		4.355	5.786
620	4.613	5.049	5.944	5.554	5.734	5.564	5.073	5.728		4.613	5.944
630	5.050	5.359	6.469	5.883	6.001	6.095	5.624			5.050	6.469
640	2.751	2.888	3.543	3.255	3.803	3.065	3.043	3.309		2.751	3.803
650	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000
900	1.170	1.610	1.872	1.897	1.988	1.730	1.655	2.041		1.170	2.041
910	1.575	1.862	2.254	2.174	2.282	2.063	2.097	2.220		1.575	2.282
920	3.313	3.752	4.255	4.093	4.058	4.235	3.775	4.300		3.313	4.300
930	4.143	4.347	5.335	4.755	4.728	5.168	4.740			4.143	5.335
	0.793	1.021	1.239	1.231	1.411	1.179	1.080	1.323		0.793	1.411
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000
960	2.311	2.664	2.928	2.884	2.351	2.943	3.373	2.616		2.311	3.373
195	4.167									4.167	4.167
200	5.252									5.252	5.252

The standard table contains the calculation results of other software applications for reference. The last two columns contain the minimum and maximum values as calculated by the other reference software. To achieve standard compliance, the results of the tested software application must be within this range. There are further tables for annual cooling loads, peak heating and cooling, and so on. All relevant result data for each test case must be processed using the **validation method** described above.

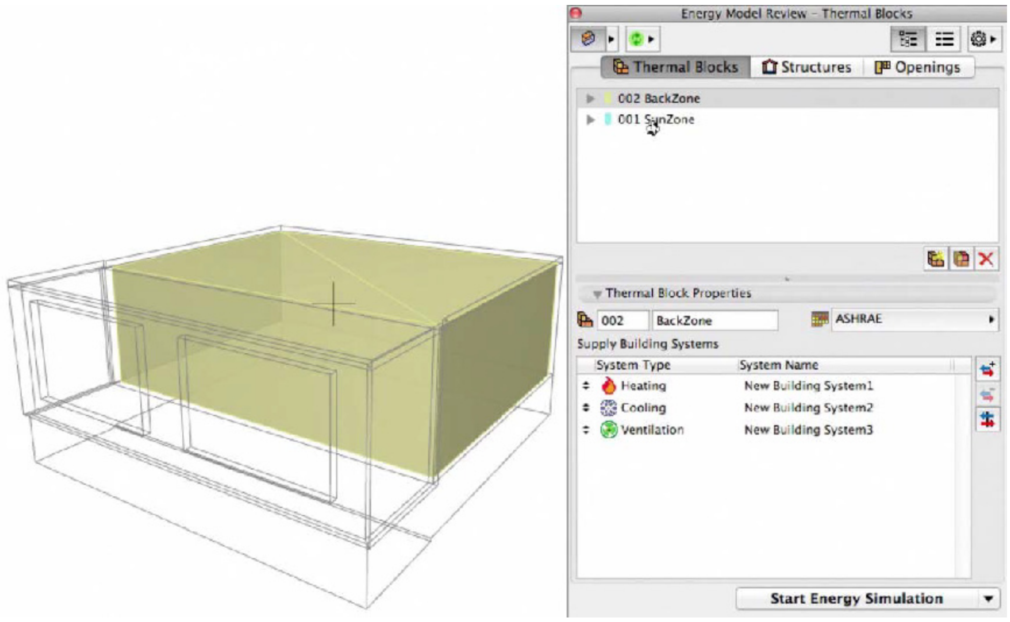
3.3 Create Building with EcoDesigner STAR

The following shows the **building model** of “Case 960” of the “ASHRAE 140”standard in ArchiCAD. This simple building model contains only two thermal blocks: the “Sun-Zone” (a heavy weight construction) and the “Back-Zone” (a lightweight structure).



The **Energy Model Review palette** helps to visualize the 3D geometry as well as all the energy-related characteristics of the building.

- The Thermal Blocks page of the palette presents the zoning of the energy model.
- The Structures page lists all the opaque structural elements with their relevant properties.
- The Openings page presents the energy-related characteristics of the fenestration.

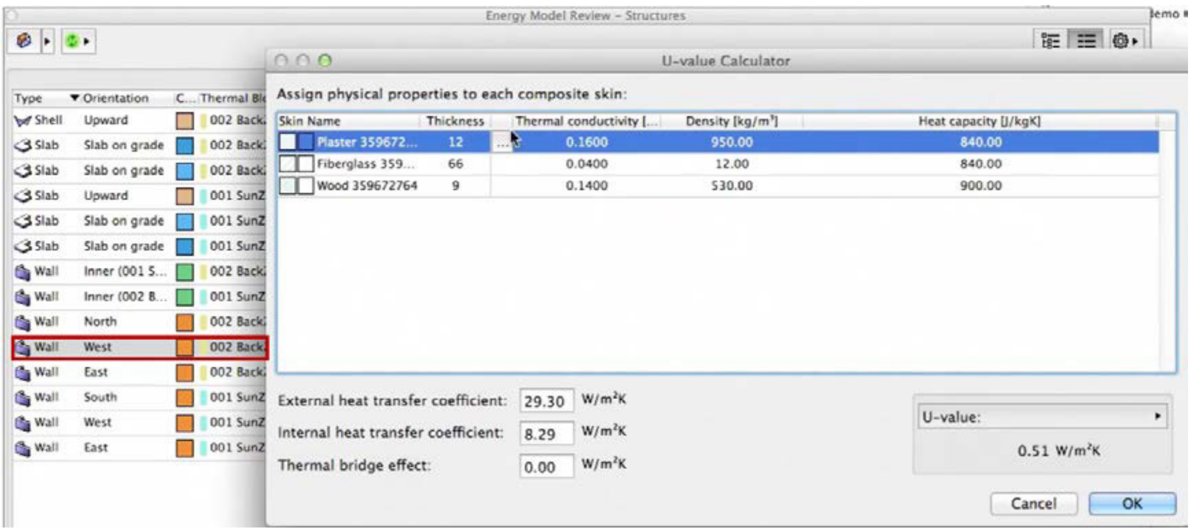


Let’s have a closer look at the specifications of the “Back-Zone”, as defined by the ASHRAE 140 standard. Here you can see the geometry of the zone, while the following page describes the various **structures’ thermal properties**. The names of the individual skins of the composite structural elements with their thickness, thermal conductivity, heat capacity and density are all precisely defined in the standard.

TABLE 11 Material Specification Heavyweight Case

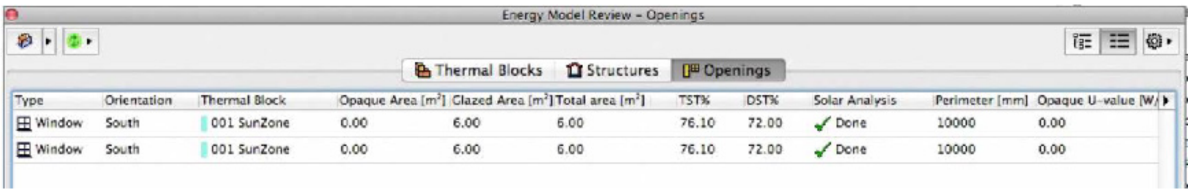
Element	k, W/(m·K)	Thickness, m	U, W/(m²·K)	R, m²·K/W	Density, kg/m³	C_p, J/(kg·K)
Heavyweight Case: Exterior Wall (inside to outside)						
Int Surf Coef			8.290	0.121		
Concrete Block	0.510	0.100	5.100	0.196	1400	1000
Foam Insulation	0.040	0.0615	0.651	1.537	10	1400
Wood Siding	0.140	0.009	15.556	0.064	530	900
Ext Surf Coef			29.300	0.034		
Total air—air			**0.512**	**1.952**		
Total air—surf			**0.556**	**1.797**		
Heavyweight Case: Floor (inside to outside)						
Int Surf Coef [a]			8.290	0.121		
Concrete Slab	1.130	0.080	14.125	0.071	1400	1000
Insulation	0.040	1.007	0.040	25.175	(see Note b)	(see Note b)
Total air—air			**0.039**	**25.366**		
Total air—surf			**0.040**	**25.246**		

Here you can see the Structures list of the Energy Review Palette. It lists all composites used in this test case with the relevant properties of their skins.



For example, the thickness, thermal conductivity, heat capacity and density of the skins of this external wall exactly match the values defined by the ASHRAE 140 standard.

The **openings' characteristics** are also precisely described in the standard. Switch to the Openings page to see all the input parameters used to describe the fenestration in test case 960. We can use the Openings page to scroll, rearrange, filter and sort all the relevant properties.



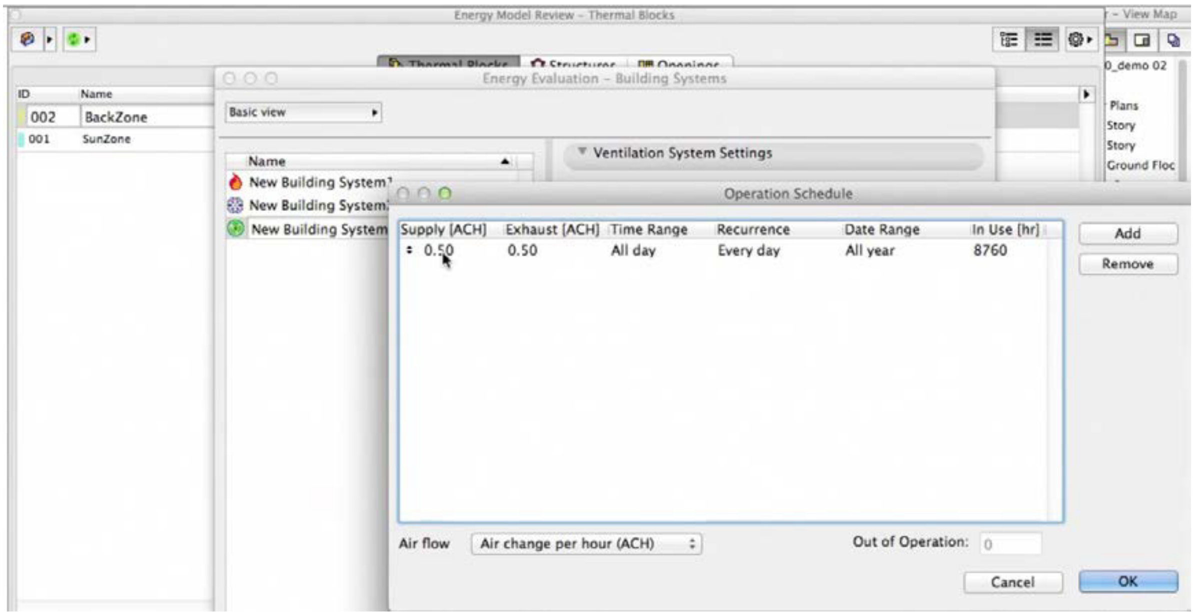
Look at the **infiltration** rate prescribed in the ASHRAE 140 standard. The "Air Change per Hour" is defined as =0.5, a constant value, for both thermal blocks.

TABLE 2 Infiltration Rates Depending on the Presence of Automatic Altitude Adjustment

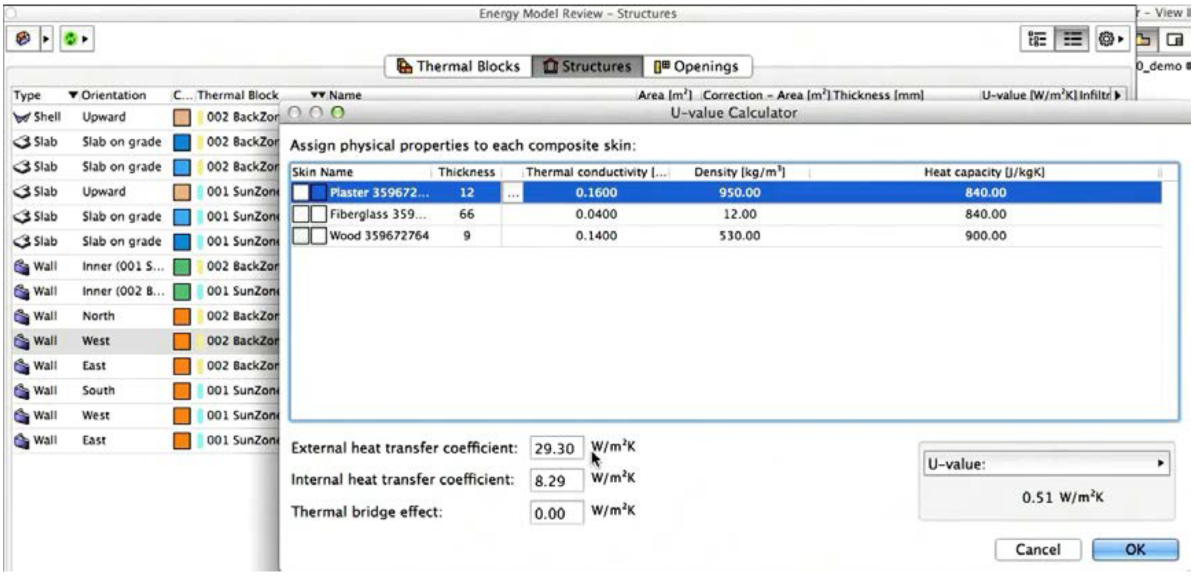
Altitude Adjustment Algorithm	Input Air Changes per Hour (ach)	Adjustment Factor
Programs with automatic altitude adjustment; set altitude to 1609 m above sea level	0.5	1.0
Programs with fixed assumption that site is at sea level (no automatic adjustment)	0.41	0.822[a]

[a](Specified Rate) × 0.822 = (altitude adjusted rate)

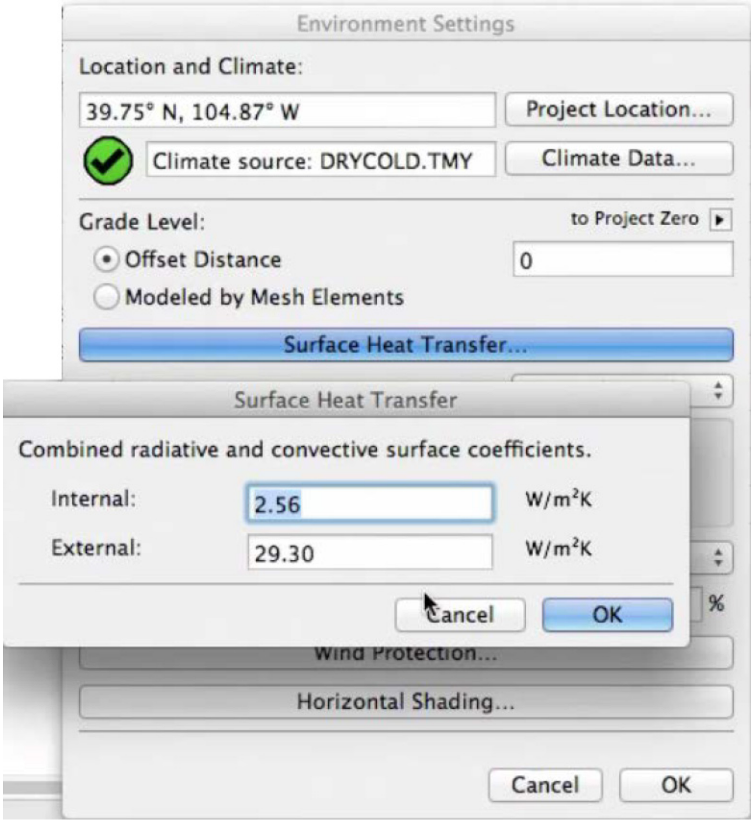
In EcoDesigner STAR, however, the infiltration model is pressure-driven. In other words: it is not constant. To model constant infiltration with EcoDesigner STAR, we must define it as natural ventilation. We've set a "natural air flow" at a steady 0.5 ACH rate for the entire year. This way we fully meet the simplified (constant) infiltration modeling requirements of case 960 of the ASHRAE 140 standard.



Now take a closer look at the **external and internal surface coefficients**' settings for the individual structures and for the overall building energy model. Use the U-Value Calculator to enter the combined surface heat transfer coefficients for the steady state calculation of the structures' U-values.



Then enter the external combined and internal convective surface heat transfer coefficients for the dynamic energy simulation via the Surface Heat Transfer dialog of the Environment Settings panel.



Now examine the Operation Profile of the Back-Zone, which is a so called "**conditioned space**".

By definition: "A conditioned space is an enclosed space within a building where there is intentional control of the internal temperature. It is maintained within a temperature range (defined by limit temperatures), using natural, electrical or mechanical means."

In layman's terms, this means that internal temperature requirements for the thermal blocks must be met with the help of heating and/or cooling systems.

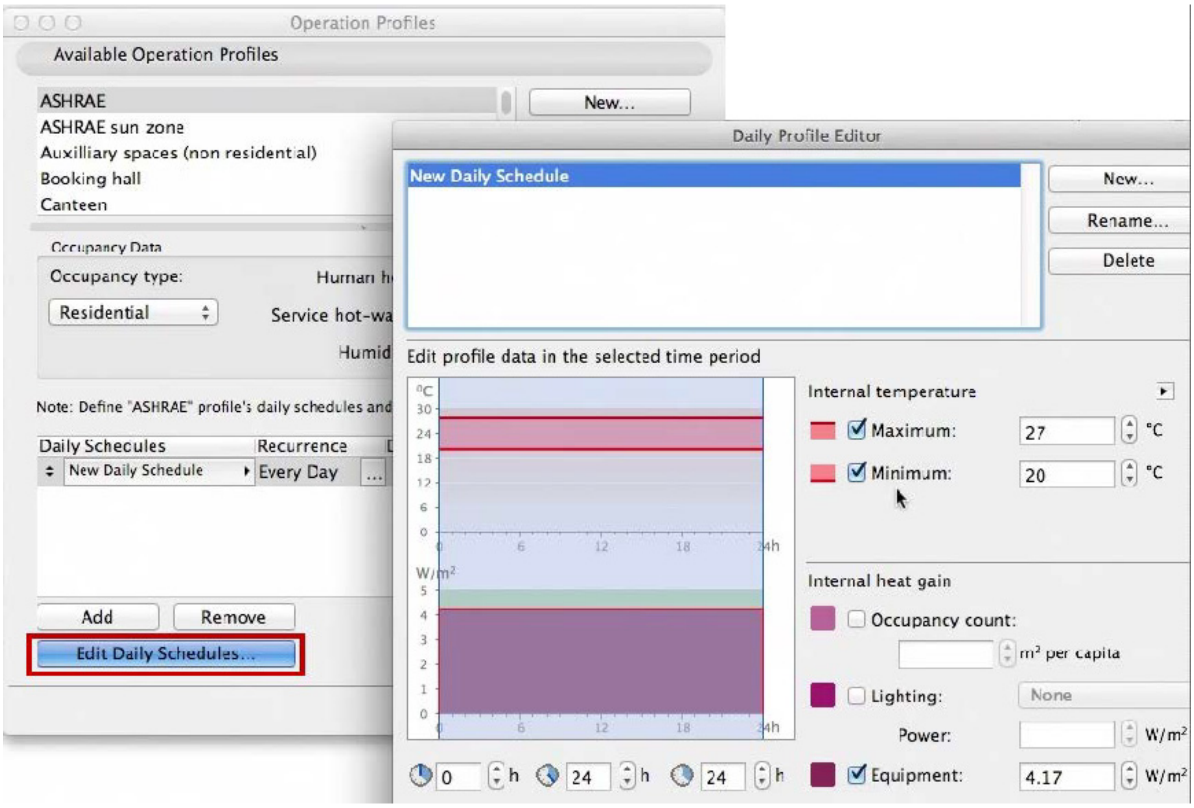
In an "unconditioned space" the internal temperature is not controlled.

Here you can see how the ASHRAE 140 standard defines the thermostat control strategy (**limit temperatures**) for the Back-Zone of Case 960: the heating turns on if the internal temperature drops below 20 Celsius degrees, and the cooling turns on if the internal temperature rises above 27 Celsius degrees.

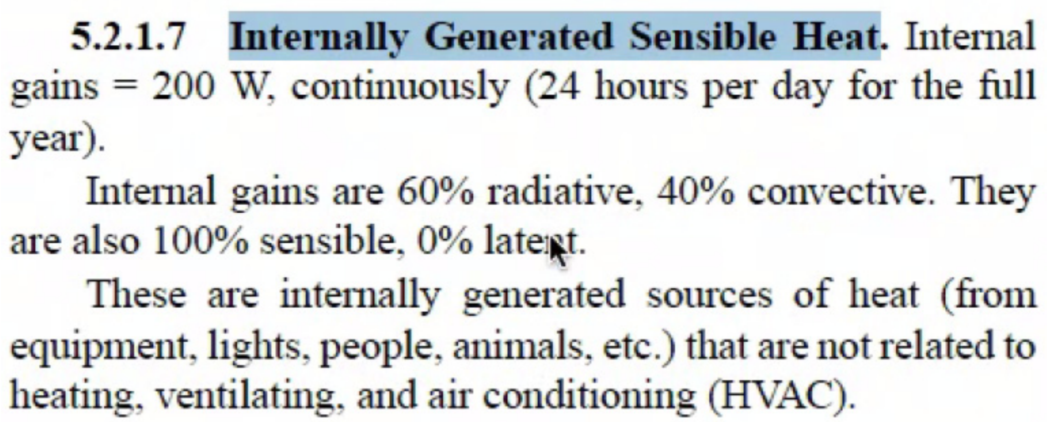
> **5.2.1.13.1 Thermostat Control Strategy.** The thermostat is nonproportional in the sense that when the conditioned-zone air temperature exceeds the thermostat cooling setpoint, the heat extraction rate is assumed to equal the maximum capacity of the cooling equipment. Likewise, when the conditioned-zone air temperature drops below the thermostat heating setpoint, the heat addition rate equals the maximum capacity of the heating equipment. A proportional thermostat model can be made to approximate a nonproportional thermostat model by setting a very small throttling range (the minimum allowed by the program being tested).
>
> The thermostat control strategy for Case 600 is:
> Heat = ON if temperature <20°C; otherwise, Heat = OFF.
> Cool = ON if temperature >27°C; otherwise, Cool = OFF.
>
> ***Note:*** "temperature" refers to conditioned-zone air temperature.

Let's view the operational profile in EcoDesigner STAR that contains the internal temperature limits for the Back-Zone. Display the Operational Profiles dialog, and select the "ASHRAE" profile from the list. Open the "**Daily Profile Editor**".

The upper diagram defines the maximum and minimum temperatures (beyond which heating or cooling must be used) for every hour of the day. The daily profiles defined with this editor must be assigned to the days of the reference year.



Now review the constant **internal heat gain** requirement prescribed by the ASHRAE 140 standard for test case number 960 as “Internally Generated Sensible Heat”. It is defined to be a continuous 200 W throughout the entire year, 60% of which is radiative, 40% convective and 100% sensible.

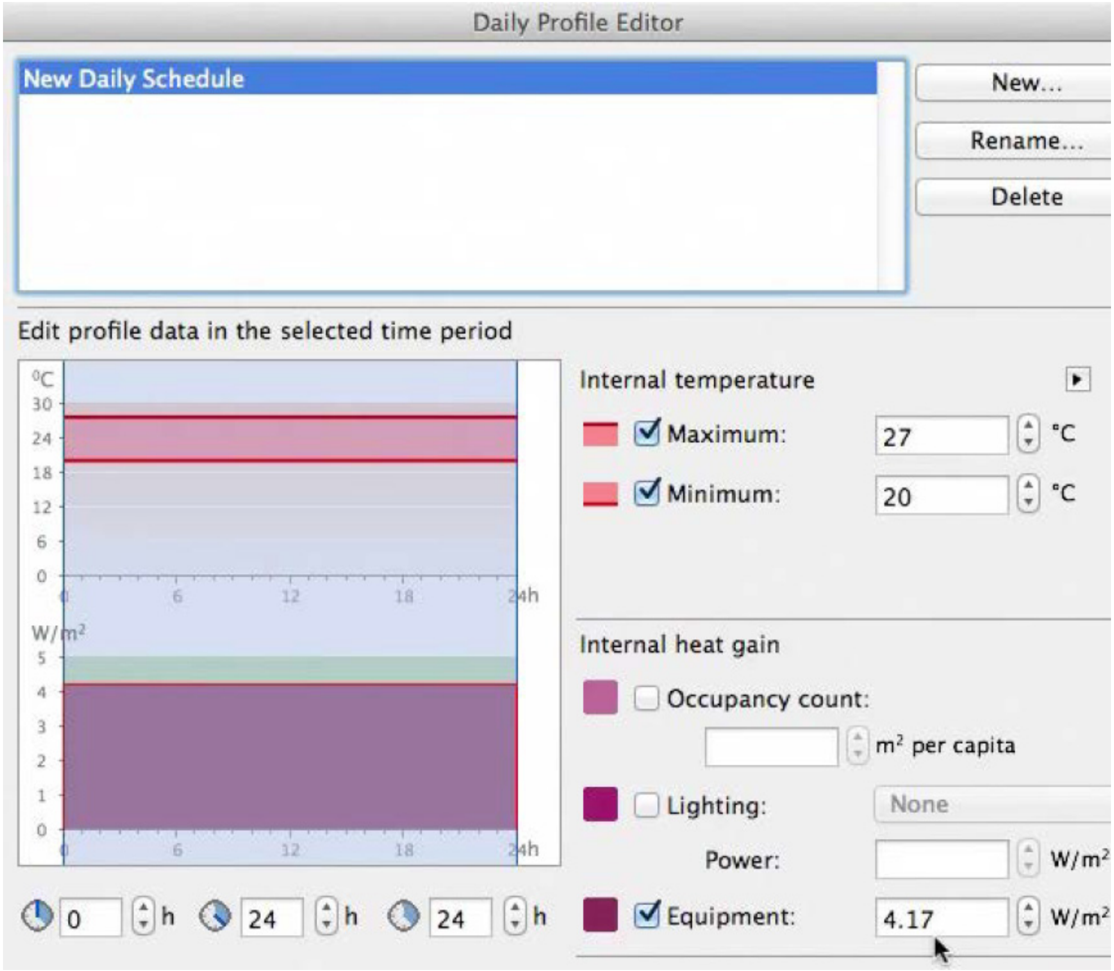


5.2.1.7 Internally Generated Sensible Heat. Internal gains = 200 W, continuously (24 hours per day for the full year).

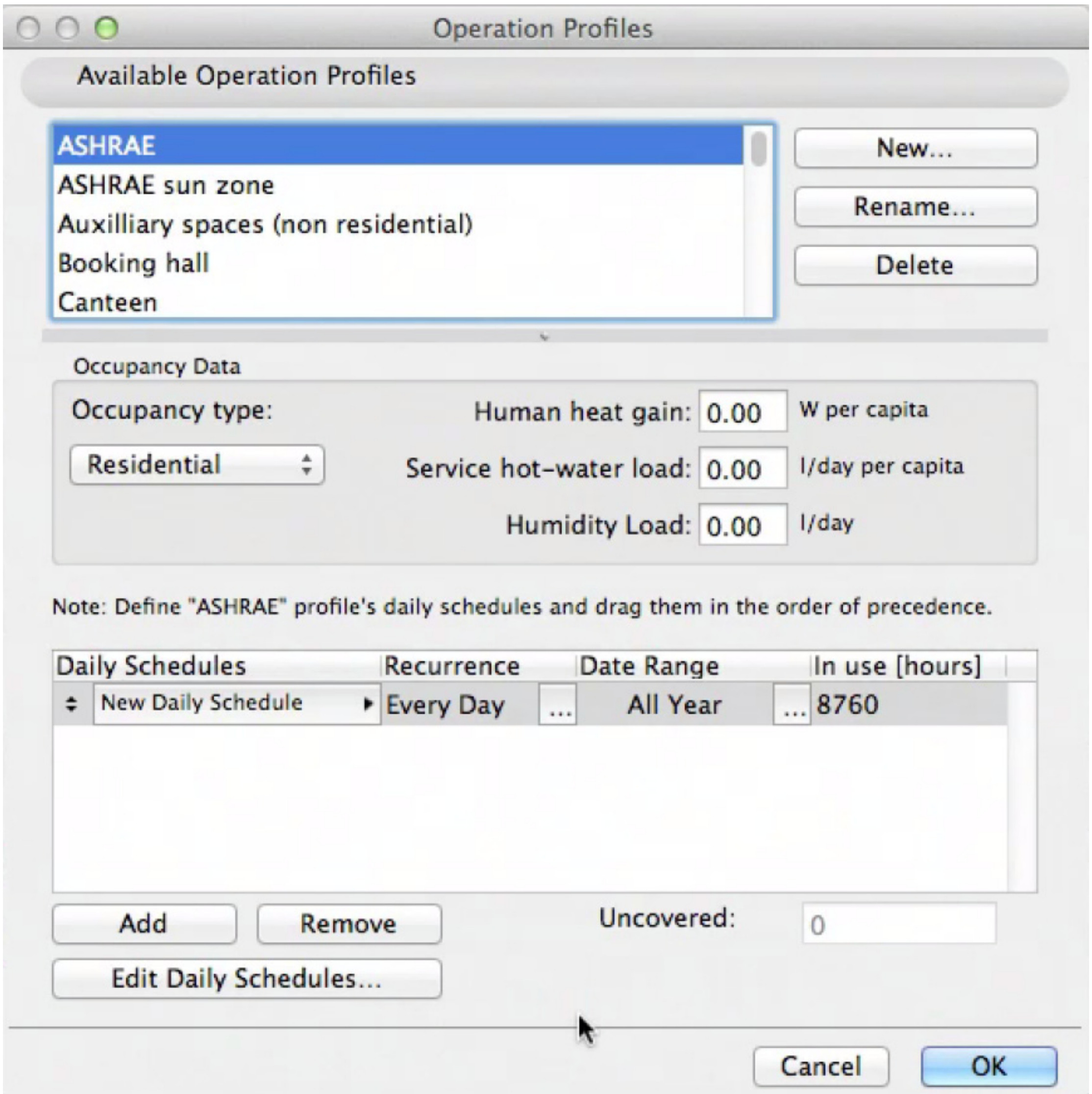
Internal gains are 60% radiative, 40% convective. They are also 100% sensible, 0% latent.

These are internally generated sources of heat (from equipment, lights, people, animals, etc.) that are not related to heating, ventilating, and air conditioning (HVAC).

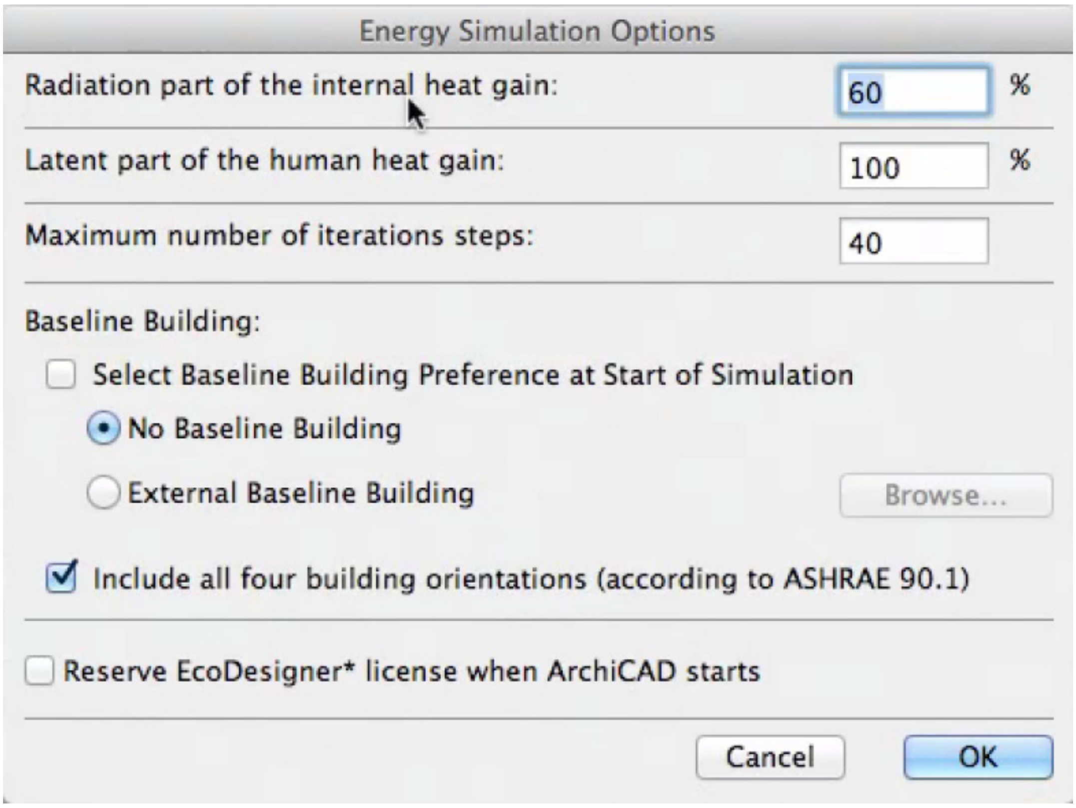
To set these parameters in EcoDesigner STAR, open the Daily Profile Editor again, and view the lower diagram representing the characteristics of internal heat gain. Check the Equipment option and enter 4.17 W/m^2 for every hour of the reference day.



Then use the Operation Profiles dialog to assign this daily profile to every day of the calculation year. If 4.17 W/m^2 is multiplied with the 48 m^2 conditioned area, then the result is a steady 200 Watts of internal heat gain throughout the entire reference year, as prescribed by the standard.



As the last step of setting the input parameters for the internal heat gain calculation, open the Energy Simulation Options dialog and enter 60% for the “Radiation part of the internal heat gain” to precisely match the standard prescription.

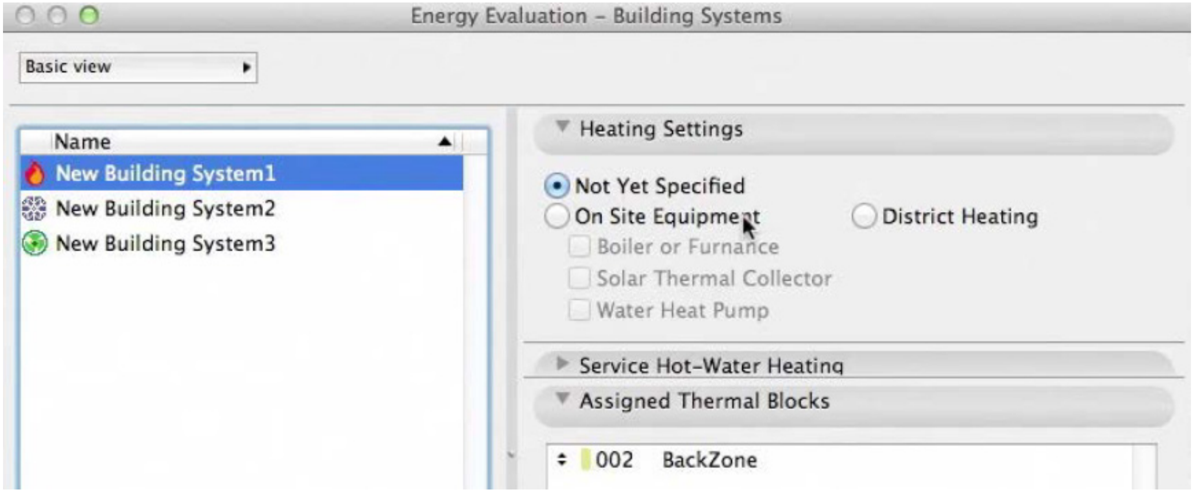


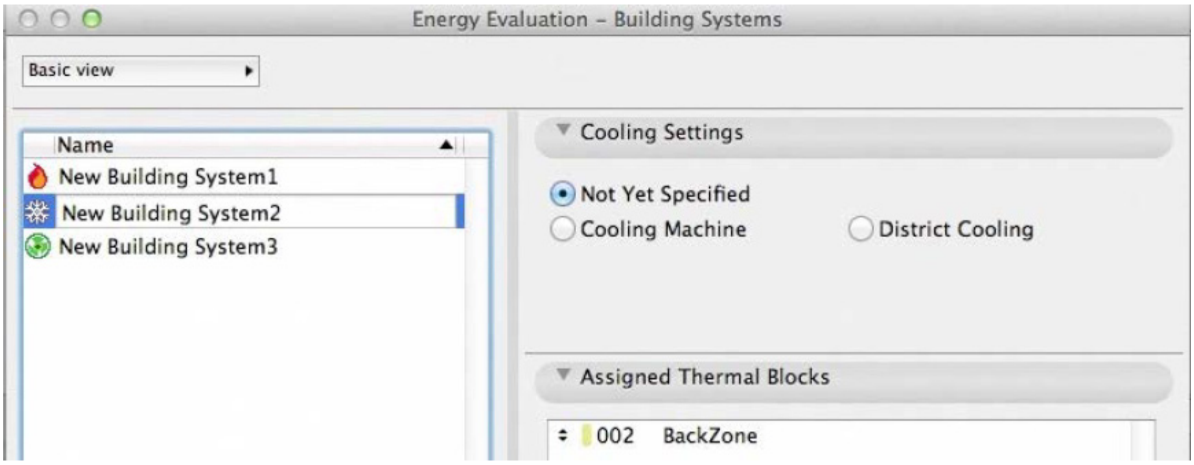
Note: The Energy Simulation Options dialog of EcoDesigner STAR is also used to define the “Latent part of the internal heat gain”. It is set to =0 for Case 960.

Now you must run the building energy simulation, this time in **demand calculation** mode (without specifying any building systems). To determine the heating and cooling demands, we must make EcoDesigner STAR carry out the energy simulation assuming that the heating and cooling systems are capable of satisfying all requirements with 100% efficiency. The building system type in EcoDesigner STAR defined for demand calculation is called “Not Yet Specified”. Not Yet Specified building systems fulfill all heating or cooling demands as they arrive during the hourly building energy simulation throughout the entire reference year. The calculated hourly heating and cooling demands are recorded by the program and displayed on the Building Energy Evaluation reports. Use this demand calculation output to determine building system characteristics.

To set up the demand calculation, assign these **Not Yet Specified building systems** to the thermal zones. Open the Building Systems dialog.

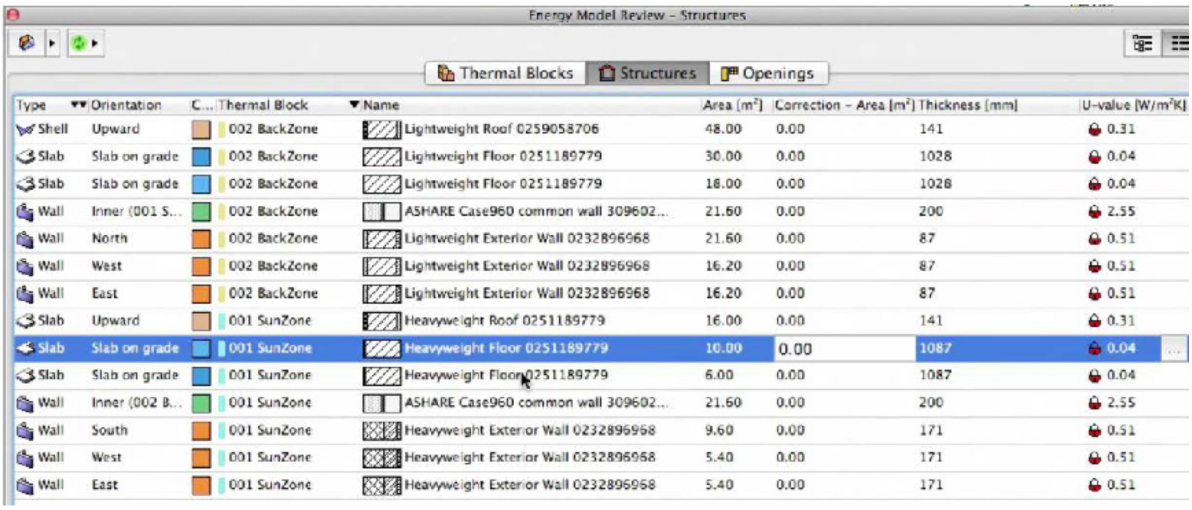
Note that a heating and a cooling system is already created and added to the Back-Zone. Define these systems as Not Yet Specified: there is no need to define any additional system parameters.



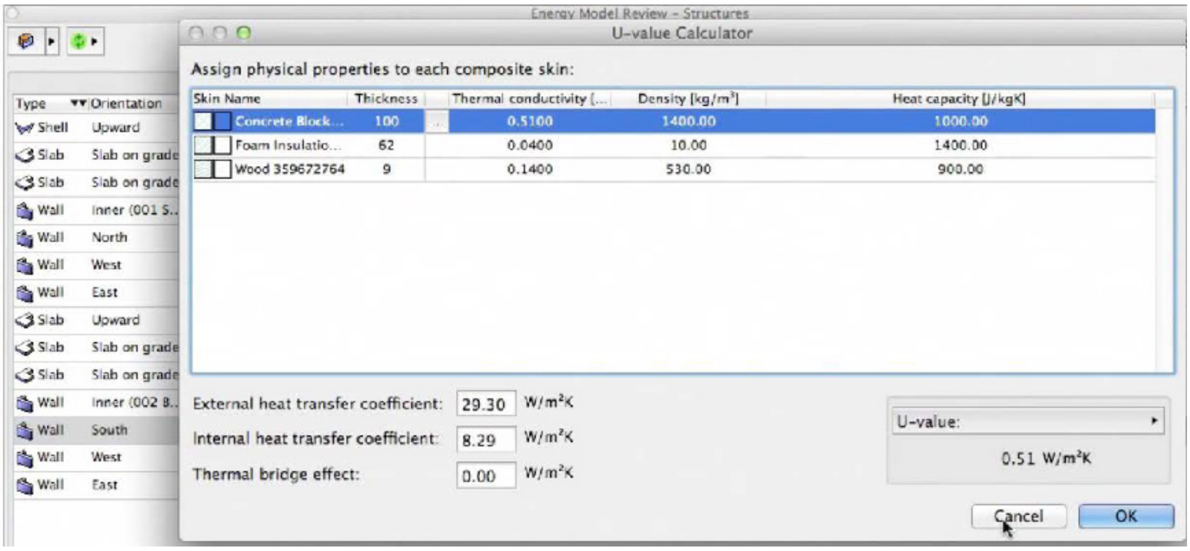


Note: EcoDesigner STAR is capable of modeling building systems in a very detailed way. Case 960 of the ASHRAE 140 standard, however, only requires demand calculation.

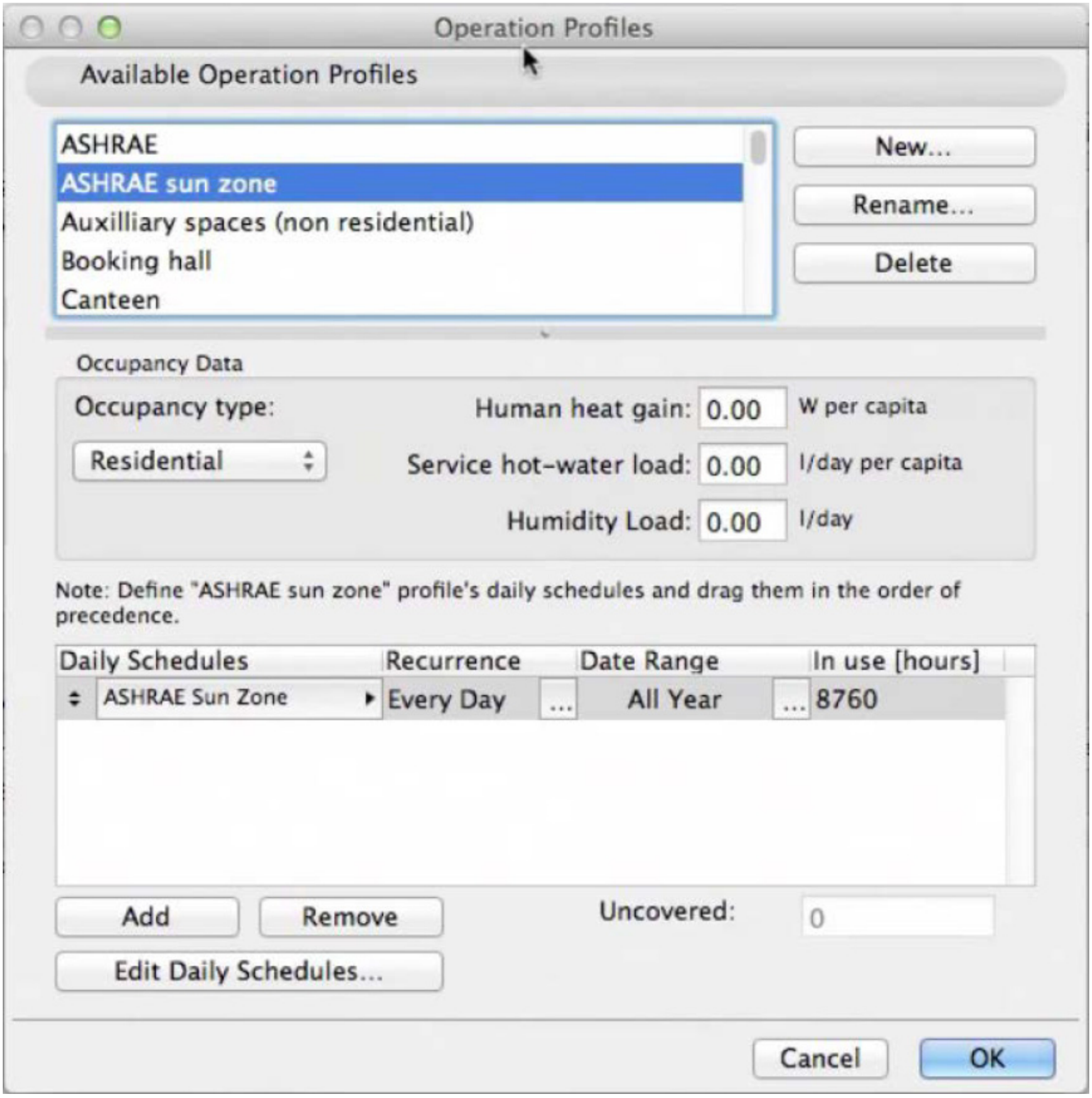
Review the characteristics of the Sun-Zone. It has two windows and a common wall with the Back-Zone. The geometry, material specifications and additional Sun-Zone properties were input into EcoDesigner STAR in accordance with the ASHRAE 140 standard.



For example, you can see the opaque elements' relevant characteristics displayed on the Structures page of the Energy Model Review palette.



Review the Operation Profile of the Sun-Zone. This thermal block is a so-called “unconditioned space”.

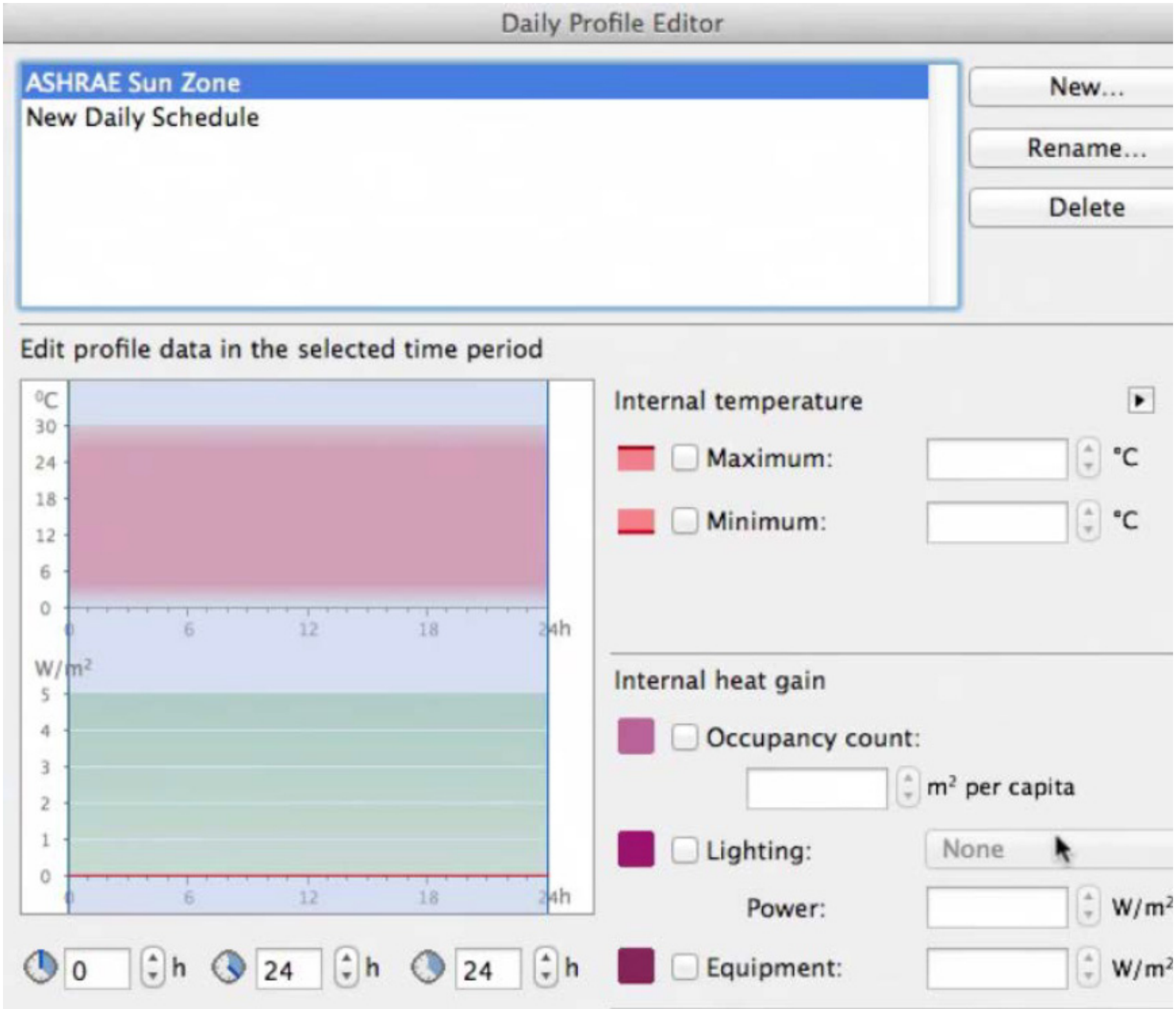


By definition: “An unconditioned space is an enclosed space within a building that does not meet the requirements of a conditioned space. These spaces have no control over thermal conditions but receive thermal energy from adjacent spaces.”

In other words, such spaces do not have any building system assigned to them that would regulate the internal temperature. Without any minimum or maximum limits defined, internal temperature changes without constraints. This phenomenon is called “**free-float internal temperature**”.

To specify an unconditioned space in EcoDesigner STAR, go to the previously created “ASHRAE Sun-Zone” operation profile.

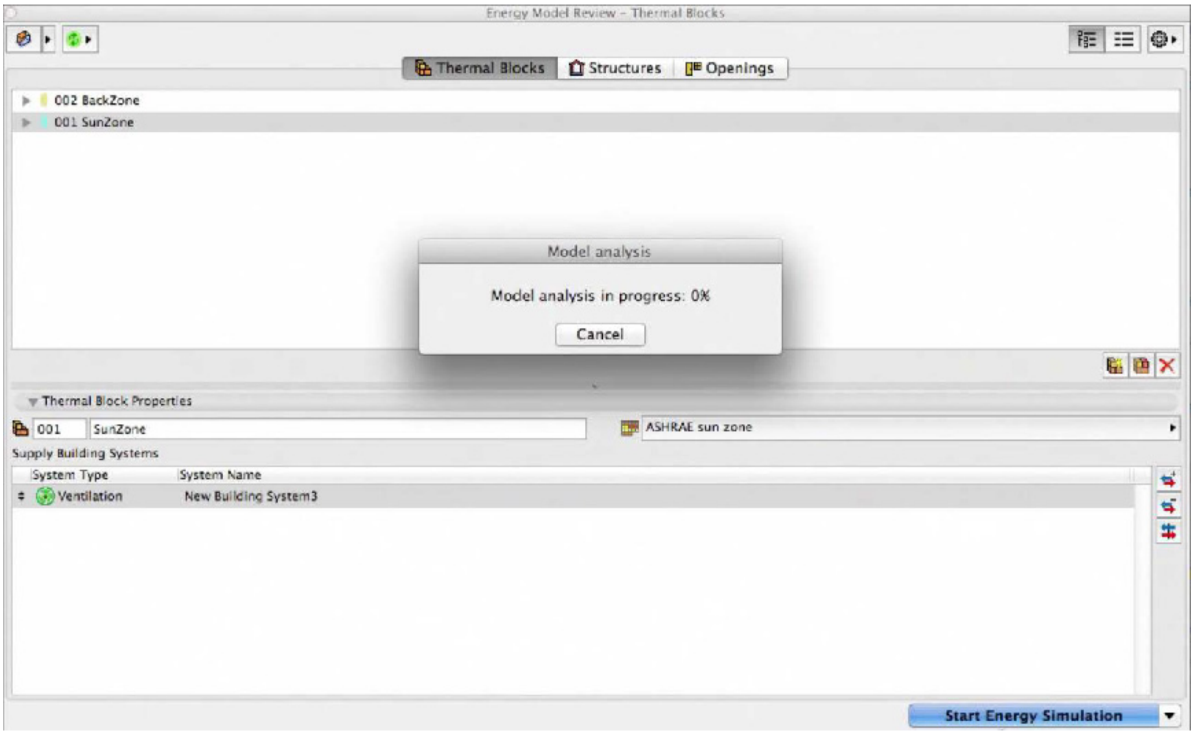
In the Daily Profile Editor, note that there are no maximum or minimum temperature limits defined for this operation profile. Naturally, no building systems are assigned to unconditioned spaces, either.



There are no internal heat gains in the Sun-Zone of case 960, but the steady airflow is added to represent the infiltration defined in the ASHRAE 140 standard.

3.4 Run Energy Simulation

Run the building energy simulation by pressing “Start Energy Simulation”.



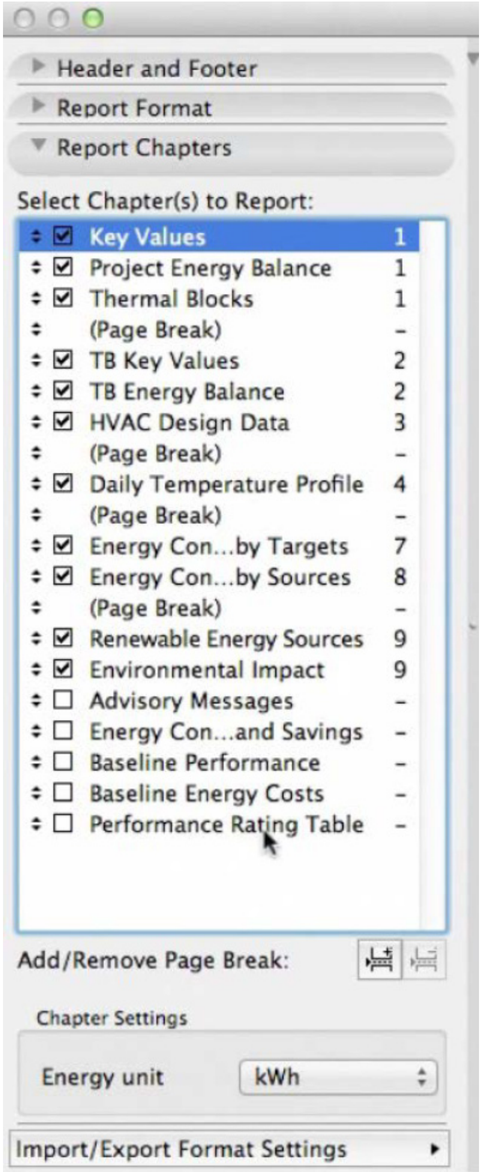
The next step is to specify the chapters to include in the Building Energy Evaluation **PDF report**. Select the required chapters on the left, under the “Report Chapters” page of the dialog. Since case 960 of the ASHRAE 140 standard requires only energy demand calculation, many of the chapters (e.g. fuel consumption, performance rating etc.) do not apply.

First, select chapters that contain **project level results**: check “Key Values” and “Project Energy Balance,” and “Thermal Blocks” chapter.

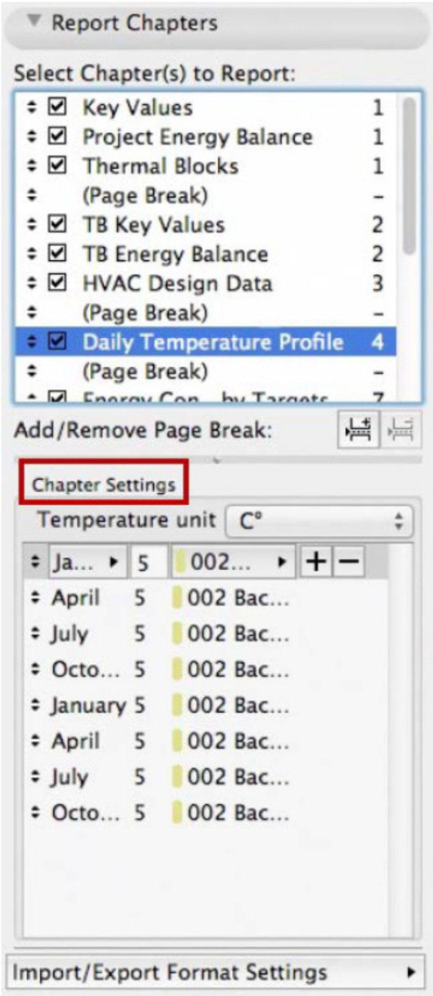
Next, select chapters that contain **thermal block level results**:

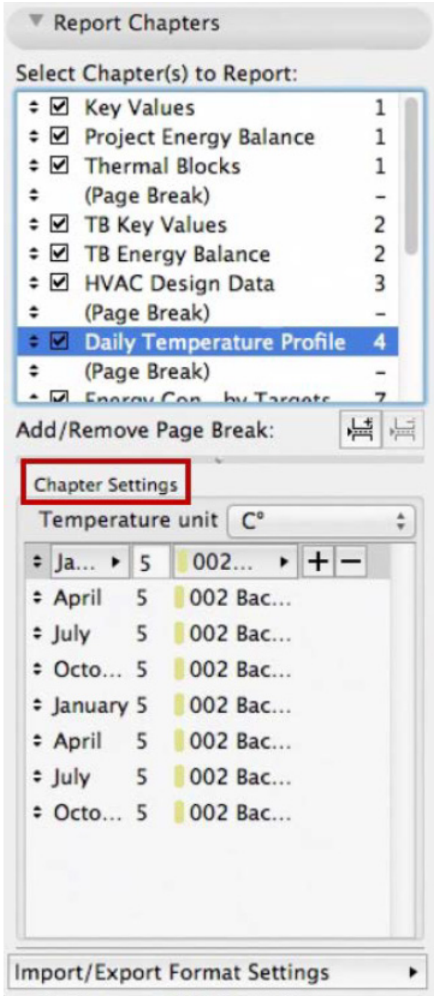
- the “Thermal Block Energy Balance” and “Thermal Block Key Values” chapters display energy performance and comfort data such as total annual energy flows, peak demands, and annual internal temperature averages and extremes.

- The “daily temperature profile” chapter displays the hourly temperatures inside the selected thermal block, on any selected day of the calculation reference year.



Use the “Chapter Settings” panel to select the thermal block and the day of the year.

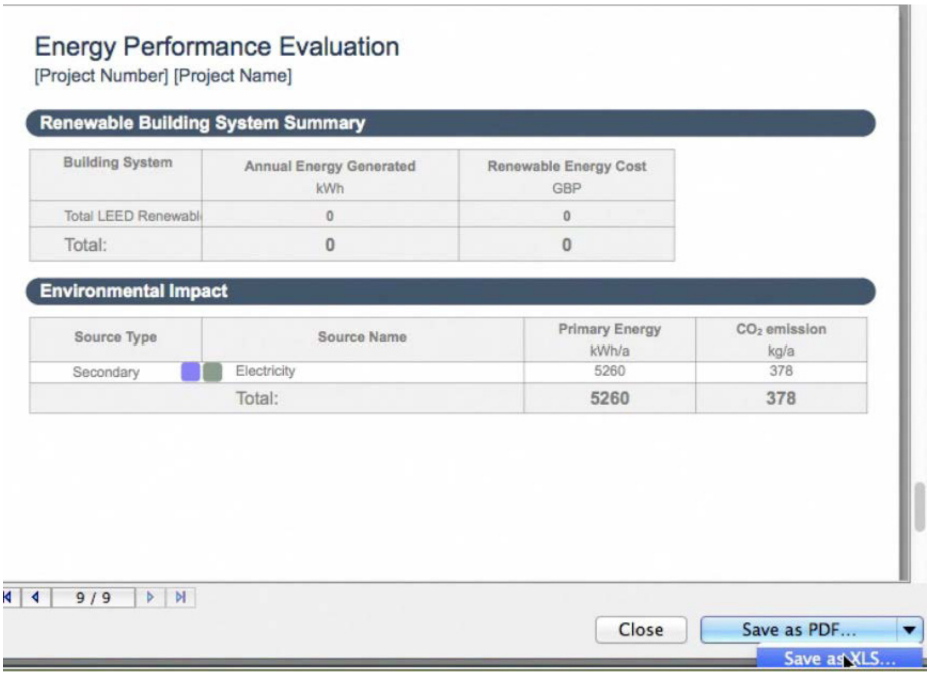




The corresponding internal temperature profile instantly appears among the chapters to be documented, in the preview area of the Evaluation Report dialog. Although Not Yet Specified building systems were used for the demand calculation in this example, it is a good idea to include the “Energy Consumption by Targets” and “Energy Consumption by Sources” chapters in the report, since these chapters provide information about the quality of the building energy model and simulation data processing.

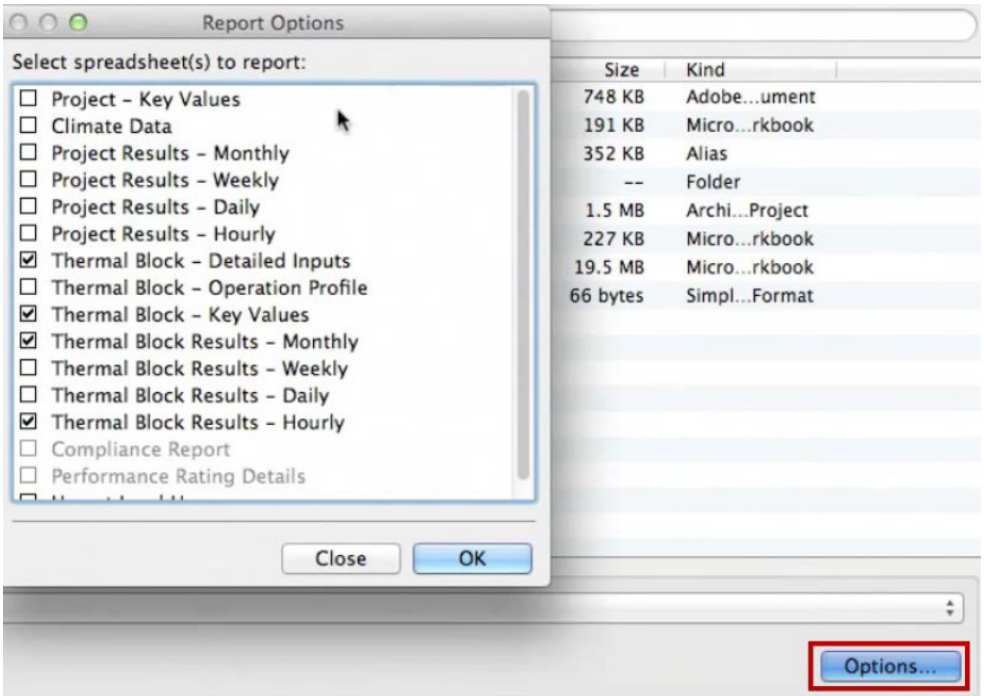
Save the report as a PDF document.

Next, customize and save an **Excel spreadsheet report**. This format provides a more detailed breakdown of energy analysis input and output data that can be easily post-processed.



Specify the required chapters:

- "Thermal Blocks Detailed Inputs"
- "Thermal Block Key Values"
- "Monthly and Hourly Thermal Block Results"



Click OK to **save** the spreadsheet.

3.5 Compare Simulation Results with Reference Documentation

Use the previously created **PDF evaluation report** to review the energy simulation results, chapter by chapter.

The **Project Key Values** chapter displays basic structure geometry and performance information on the right.

Note that the dedicated ASHRAE 140 Climate Data file was used for the simulation.

Energy Performance Evaluation

[Project Number] [Project Name]

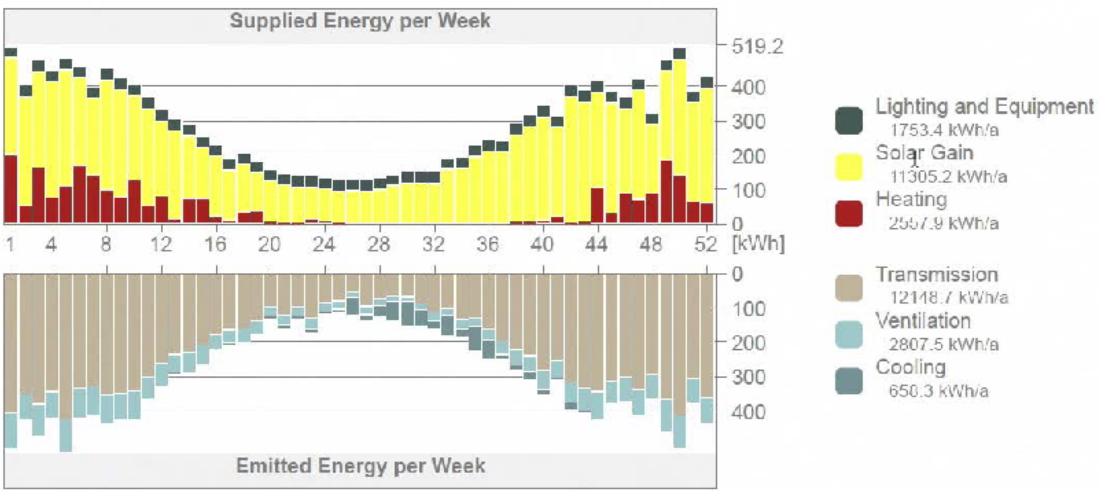
Key Values

General Project Data		
Project Name:	Case960_demo 02	
City Location:		
Climate Data Source:	DRYCOLD.TMY	
Evaluation Date:	Nov 22, 2013 6:40:17 PM	
Building Geometry Data		
Gross Floor Area:	68.36	m²
Treated Floor Area:	64.00	m²
External Envelope Area:	150.40	m²
Ventilated Volume:	172.80	m³
Glazing Ratio:	8	%
Building Shell Performance Data		
Infiltration at 50Pa:	0.67	ACH
Outer Heat Capacity:	103.73	J/m²K

Heat Transfer Coefficients	U value	[W/m²K]
Building Shell Average:	0.63	
Floors:	0.04 - 0.04	
External:	0.31 - 0.51	
Underground:	--	
Openings:	3.00 - 3.00	
Net Heating Energy:	39.97	kWh/m²a
Net Cooling Energy:	10.29	kWh/m²a
Total Net Energy:	50.25	kWh/m²a
Energy Consumption:	77.65	kWh/m²a
Fuel Consumption:	77.65	kWh/m²a
Primary Energy:	82.19	kWh/m²a
Fuel Cost:	--	GBP/m²a
CO_2 Emission:	5.92	kg/m²a

The **Project Energy Balance** displays the sum of all the individual Thermal Block Energy Balances.

Project Energy Balance



View the **Thermal Block Key Values** of the unconditioned Sun-Zone first, then of the conditioned Back-Zone. For the conditioned Back-Zone, the annual heating and cooling energy values are the most significant data, displayed on the right of the Back-Zone Key Values chapter.

002 BackZone - Key Values

Geometry Data			**Heat Transfer Coefficients**	U value	[W/m²K]
Gross Floor Area:	50.54	m²	Floors:	0.04 - 0.04	
Treated Floor Area:	48.00	m²	External:	0.31 - 0.51	
Building Shell Area:	102.00	m²	Underground:	-	
Ventilated Volume:	129.60	m³	Openings:	-	
Glazing Ratio:	0	%			
			Annual Energy		
Internal Temperature			Heating:	2557.94	kWh
Min. (22:00 Jan. 02):	20.00	°C	Cooling:	658.28	kWh
Annual Mean:	22.65	°C			
Max. (16:00 Apr. 26):	27.00	°C	**Peak**		
			Heating (08:00 Jan. 04):	2.70	kW
Degree Days			Cooling (17:00 Sep. 02):	1.18	kW
Heating (HDD):	5298				
Cooling (CDD):	1322		**Unmet Load Hours**		
			Heating:	0	hrs/a
			Cooling:	0	hrs/a

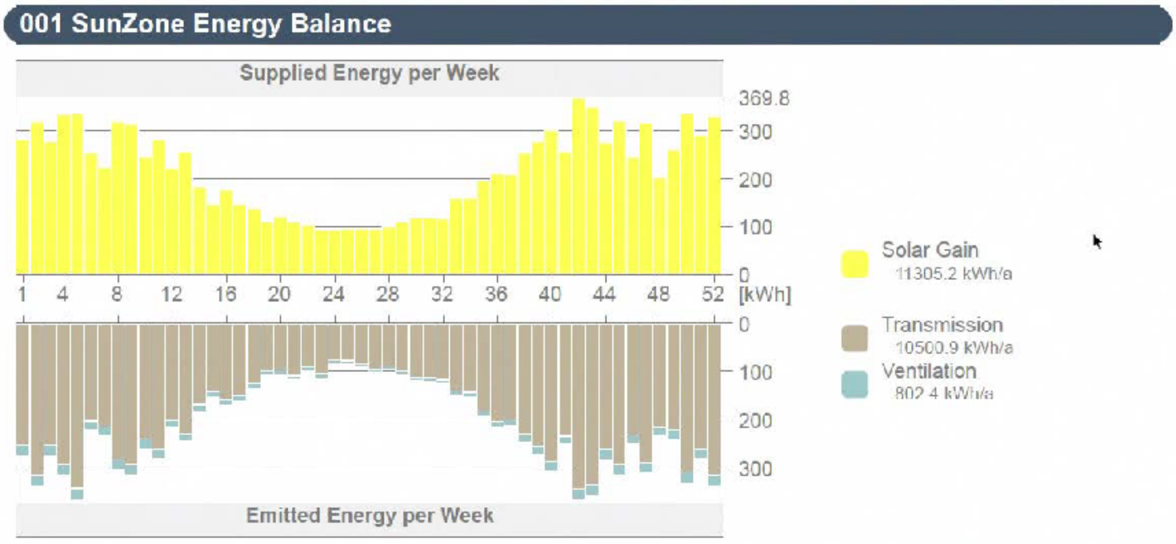
For the Sun-Zone, the internal temperature data on the left of the Sun-Zone Key Values chapter are the most important.

001 SunZone - Key Values

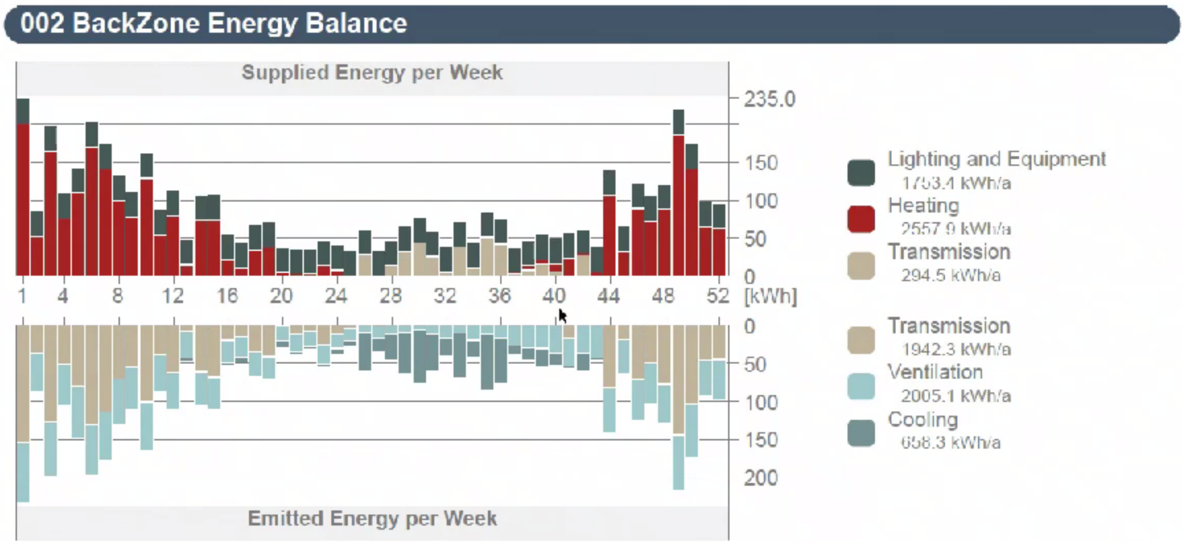
Geometry Data			**Heat Transfer Coefficients**	U value	[W/m²K]
Gross Floor Area:	17.82	m²	Floors:	0.04 - 0.04	
Treated Floor Area:	16.00	m²	External:	0.31 - 0.51	
Building Shell Area:	48.40	m²	Underground:	-	
Ventilated Volume:	43.20	m³	Openings:	3.00 - 3.00	
Glazing Ratio:	25	%			
			Annual Energy		
Internal Temperature			Heating:	0.00	kWh
Min. (07:00 Jan. 04):	-2.12	°C	Cooling:	0.00	kWh
Annual Mean:	25.44	°C			
Max. (15:00 Oct. 17):	51.11	°C	**Peak**		
			Heating (01:00 Jan. 01):	0.00	kW
Degree Days			Cooling (01:00 Jan. 01):	0.00	kW
Heating (HDD):	5298				
Cooling (CDD):	1322		**Unmet Load Hours**		
			Heating:	0	hrs/a
			Cooling:	0	hrs/a

Now view the Thermal Block Energy Balances data.

On the Energy Balance diagram of the unconditioned Sun-Zone, the Solar Gain (yellow) is counterbalanced only by the Transmission and the Air Flow, displayed in blue and brown.



On the Energy Balance of the conditioned Back-Zone, the Heating Demands appear in red on the supply (top) side of the diagram, while the Cooling Demands are shown in greenish-blue as emitted energy, at the bottom of the Energy Balance diagram.



The **HVAC Design Data** table contains a very important demand calculation output: the Annual and Peak Heating and Cooling loads of the conditioned thermal block (Back-Zone). These are the necessary building system sizing data for energy modeling and HVAC design alike.

HVAC Design Data

Thermal Block	Heating Demand Yearly [kWh]	Heating Demand Hourly Peak [kW]	Cooling Demand Yearly [kWh]	Cooling Demand Hourly Peak [kW]	Internal Temperature Min. [°C]	Internal Temperature Max. [°C]
002 BackZone	2557	2.7 08:00 Jan. 04	658	1.2 17:00 Sep. 02	20.0 22:00 Jan. 02	27.0 16:00 Apr. 26
001 SunZone	0	0.0 --	0	0.0 --	-2.1 07:00 Jan. 04	51.1 15:00 Oct. 17
All Thermal Blocks:	**2557**	**2.7** **08:00 Jan. 04**	**658**	**1.2** **17:00 Sep. 02**		

Number of Used Hours in Year:			Unmet Load Hours in Year:		
Heating:	3762	hrs	Heating:	0	hrs
Cooling:	1671	hrs	Cooling:	0	hrs

Review the detailed simulation data presented by the **Excel spreadsheet evaluation reports**. Based on the custom report content specified by the user, a project data Excel spreadsheet is generated alongside the separate spreadsheets dedicated to each thermal block.

The first page of the thermal block result data spreadsheets is the Detailed Inputs page.

Thermal Block:	002 BackZone								
Operation Profile:	ASHRAE								
Gross Floor Area:	50.54	m²							
Building Volume:	129.60	m³							
STRUCTURES									
	Orientation	**Category**	**Type**	**Complexity**	**Name**	**Area [m²]**	**Thickness / Length [mm]**	**U-value [W/m²K]**	**Infiltration [l/sm²]**
	North	External	Lightweight Exterior Wall	Straight	Wall	21.60	87.00	0.51	0.00
	West	External	Lightweight Exterior Wall	Straight	Wall	16.20	87.00	0.51	0.00
	East	External	Lightweight Exterior Wall	Straight	Wall	16.20	87.00	0.51	0.00
	Slab on grade	Floor (at or above grad	Lightweight Floor 0211185	----	Slab	30.00	1028.00	0.04	1.10
	Slab on grade	Floor (at or above grad	Lightweight Floor 0211185	----	Slab	18.00	1028.00	0.04	1.10
	Upward	External	Lightweight Roof 0259058	Extruded	Shell	48.00	140.80	0.31	0.50
	Inner	Internal	ASHARE Case560 commor	Straight	Wall	21.60	200.00	2.55	1.10
OPENINGS									
	Orientation	**Type**	**Glazing Area [m²]**	**Glazing U-value [W/m²K]**	**TST %**	**DST %**	**Opaque Area [m²]**	**Perimeter [mm]**	**Opaque U-value [W/m²K]**
BUILDING SYSTEMS									
	System Type	**System Name**							
	Heating	New Building System 1							
	Cooling	New Building System 2							
	Ventilation	New Building System 3							
ZONES ASSIGNED									
	Zone ID	**Zone Name**	**Zone Category**						
	005	Office	Office						

Detailed Inputs | Detailed Results - Monthly | Detailed Results - Hourly | Thermal Block - Key Values

The second page contains the Detailed Monthly Results. The annual heating and cooling loads are displayed here. In the example project, 2558 kWh is required annually for heating…

Monthly Values Energy flows All numbers are in [kWh]	MEP System type	Target		January	February	March	April	May	June	July	August	September	October	November	December	Annual Total [kW
Infiltration				0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Human heat gain				0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Solar gain				0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Heating				546.81	485.13	335.91	187.14	73.23	22.56	0.00	0.00	11.54	82.22	298.08	515.31	
	Central			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		Boiler		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Space heating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Circulation pump	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		Solar thermal collector		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Space heating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Circulation pump	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		Heat pump		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Space heating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Auxiliary systems	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		District		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Space heating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Circulation pump	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Local			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		Boiler		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Space heating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Circulation pump	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		Solar thermal collector		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Space heating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Circulation pump	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		Heat pump		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Space heating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Auxiliary systems	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		Dx heater		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Space heating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Auxiliary systems	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Not yet specified			546.81	485.13	335.91	187.14	73.23	22.56	0.00	0.00	11.54	82.22	298.08	515.31	
Service hot water heating				0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		Boiler		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

Detailed Inputs | Detailed Results - Monthly | Detailed Results - Hourly | Thermal Block - Key Values

and 658 kWh is required for cooling for the Back-Zone.

Monthly Values Energy flows All numbers are in [kWh]	MEP System type	Target		January	February	March	April	May	June	July	August	September	October	November	December	Annual Total [k
			Auxiliary systems	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		Dx heater		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Space heating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Auxiliary systems	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Not yet specified			546.81	485.13	335.91	187.14	73.23	22.56	0.00	0.00	11.54	82.22	298.08	515.31	
Service hot-water heating				0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		Boiler		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Service hot-water heating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Circulation pump	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		Solar thermal collector		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Service hot-water heating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Circulation pump	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		Heat pump		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Service hot-water heating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Auxiliary systems	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		District		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Service hot-water heating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Circulation pump	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		Sewer recovery		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		Not yet specified		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Cooling				0.00	0.00	-2.27	-6.11	-16.32	-63.28	-209.06	-184.14	-135.59	-41.12	0.00	0.00	
	Central			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		Mechanical		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Cooling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Auxiliary systems	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		District		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Cooling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Circulation pump	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Local			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		Mechanical		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Cooling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
			Auxiliary systems	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		DX Cooling		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

Detailed Inputs | Detailed Results - Monthly | Detailed Results - Hourly | Thermal Block - Key Values

Use the spreadsheet of the ASHRAE 140 Standard that contains the **reference simulation results**. Besides the standard's reference values, this sheet includes the EcoDesigner STAR calculation results for ALL the ASHRAE 140 test cases.

The investigated test case No. 960 is highlighted here:

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	ANNUAL HEATING LOADS [MWH]												
2		ESP	BLAST	DOE2	SRES/SUN	SERIRES	S3PAS	TRNSYS	TASE	VIP-Energy	EDS	SUMMARY	
3		UK-DMU	US/IT	USA	USA	UK-BRE	SPAIN	BEL/UK	FINLAND	SWEDEN	DATA	MIN	MAX
4	CASE	MWh	MWh	MWh	MWh	MWh	MWh	MWh	MWh	MWh	MWh	MWh	MWh
5	600	4.296	4.773	5.709	5.226	5.596	4.882	4.872	5.362	5.095	5.090	4.296	5.709
6	610	4.355	4.806	5.786	5.280	5.620	4.971	4.970	5.383	5.880	5.154	4.355	5.786
7	620	4.613	5.049	5.944	5.554	5.734	5.564	5.073	5.728	5.230	5.349	4.613	5.944
8	630	5.050	5.359	6.469	5.883	6.001	6.095	5.624		6.439	5.414	5.050	6.469
9	640	2.751	2.888	3.543	3.255	3.303	3.065	3.043	3.309	3.243	3.043	2.751	3.803
0	650	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	900	1.170	1.610	1.872	1.897	1.988	1.730	1.655	2.041	1.890	2.000	1.170	2.041
2	910	1.575	1.862	2.254	2.174	2.282	2.063	2.097	2.220	2.326	2.194	1.575	2.282
3	920	3.313	3.752	4.255	4.093	4.058	4.235	3.776	4.300	3.835	4.063	3.313	4.300
4	930	4.143	4.347	5.335	4.755	4.728	5.168	4.740		5.061	4.183	4.143	5.335
5		0.793	1.021	1.239	1.231	1.411	1.179	1.080	1.323	1.163	1.246	0.793	1.411
6		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	960	2.311	2.664	2.928	2.884	2.351	2.943	3.373	2.816	2.721	2.558	2.311	3.373
8	195	4.167								5.153	7.306	4.167	5.153
9	200	5.252								9.133	7.306	5.252	9.133

Our calculated **annual heating load** was 2.56 MWh for the Back-Zone. As you can see, the standard reference result range is between 2.3 and 3.3 MWh. Thus, the calculation performed by EcoDesigner STAR is within the acceptable range defined by the ASHRAE 140 standard.

Now consider the **annual cooling load**. The EcoDesigner calculation result is 0.66 MWh. The acceptable range prescribed by the standard is between 0.41 and 0.8 MWh for Case 960, so the EcoDesigner STAR calculation result meets the ASHRAE 140 standard requirements.

ANNUAL COOLING [MWH]	ESP	BLAST	DOE2	SRES/SUN	SERIRES	S3PAS	TRNSYS	TASE	VIP-Energy	EDS	SUMMARY	
	UK-DMU	US/IT	USA	USA	UK-BRE	SPAIN	BEL/UK	FINLAND	SWEDEN	DATA	MIN	MAX
CASE#	MWh	MWh	MWh	MWh	MWh	MWh	MWh	MWh	MWh	MWh	MWh	MWh
600	6.137	6.433	7.079	7.278	7.964	6.492	6.492	6.778	7.606	6.1745753	6.137	7.964
610	3.915	4.851	4.852	5.448	5.778	4.764	4.601	5.506	5.201	5.40987526	3.915	5.778
620	3.417	4.092	4.334	4.633	5.004	4.011	3.901	4.351	4.658	3.8603901	3.417	5.004
630	2.129	3.108	2.489	3.493	3.701	2.489	2.416		2.043	2.83603599	2.129	3.701
640	5.952	6.183	6.759	7.026	7.811	6.247	6.246	6.508	6.844	5.88110614	5.952	7.811
650	4.816	5.140	5.795	5.894	6.545	5.080	5.119	5.456	6.173	5.43695846	4.816	6.545
900	2.132	2.600	2.455	3.165	3.415	2.572	2.485	2.599	3.328	2.44529496	2.132	3.415
910	0.821	1.533	0.976	1.872	1.854	1.428	1.326	1.767	1.729	1.96746316	0.821	1.872
920	1.840	2.616	2.440	2.943	3.092	2.457	2.418	2.613	3.040	2.41386257	1.840	3.092
930	1.039	1.934	1.266	2.173	2.238	1.439	1.416		1.473	1.56114074	1.039	2.238
940	2.079	2.536	2.340	3.036	3.241	2.489	2.383	2.516	3.117	2.30876878	2.079	3.241
950	0.387	0.526	0.538	0.921	0.589	0.551	0.561	0.771	0.820	0.69649409	0.387	0.921
960	0.488	0.666	0.428	0.803	0.718	0.643	0.411	0.786	0.774	0.6583	0.411	0.803
195	0.414								0.468	0.62103435	0.414	0.468
200	0.570								0.877	0.62103435	0.570	0.877

Now validate the **Peak Cooling Load and Peak Heating Load** calculation results. Display the Thermal Block Key values page for the calculated Annual Hourly Integrated Peak Heating Load, which equals 2.7 kW.

The Annual Integrated Peak Sensible Cooling Load, according to the EcoDesigner energy simulation results, is 1.18 kW.

B	C	D	E	F
			Date	Time
Annual Mean Zone Air Temperature:	22.65	°C		
Annual Hourly Integrated Maximum Zone Air Temperature:	27	°C	**26/4**	**16**
Annual Hourly Integrated Minimum Zone Air Temperature:	20	°C	**2/1**	**22**
Annual Hourly Integrated Peak Heating Load:	2.696	kW	**4/1**	**8**
Annual Hourly Integrated Peak Sensible Cooling Load:	1.178	kW	**2/9**	**17**
Key Values:				
	Gross Area	50.54	m²	
	Conditioned Area	48	m²	
	Building Shell Area	102	m²	
	Ventilated Volume	129.6	m³	
	Glazing Ratio	0	%	
	Air Leakage	0.5	ACH	
U Values:				
	Building Shell Average	42.82	W/m²K	
	Floors	0.04 - 0.04	W/m²K	
	External	0.31 - 0.51	W/m²K	
	Underground	-	W/m²K	
	Opening	-	W/m²K	
Design Loads:				
	Heating Load	2557.9384	kWh/m²a	
	Cooling Load	658.27587	kWh/m²a	
	Unmet Heating Hours	0	h	
	Unmet Cooling Hours	0	h	
	Heating Degree Days	5298.425		

Detailed Inputs | Detailed Results - Monthly | Detailed Results - Hourly | **Thermal Block - Key Values**

Let’s compare these values with the results provided by the standard: the Peak Heating load must be between 2.4 and 2.8 kW.

ANNUAL HOURLY INTEGRATED PEAK HEATING LOADS

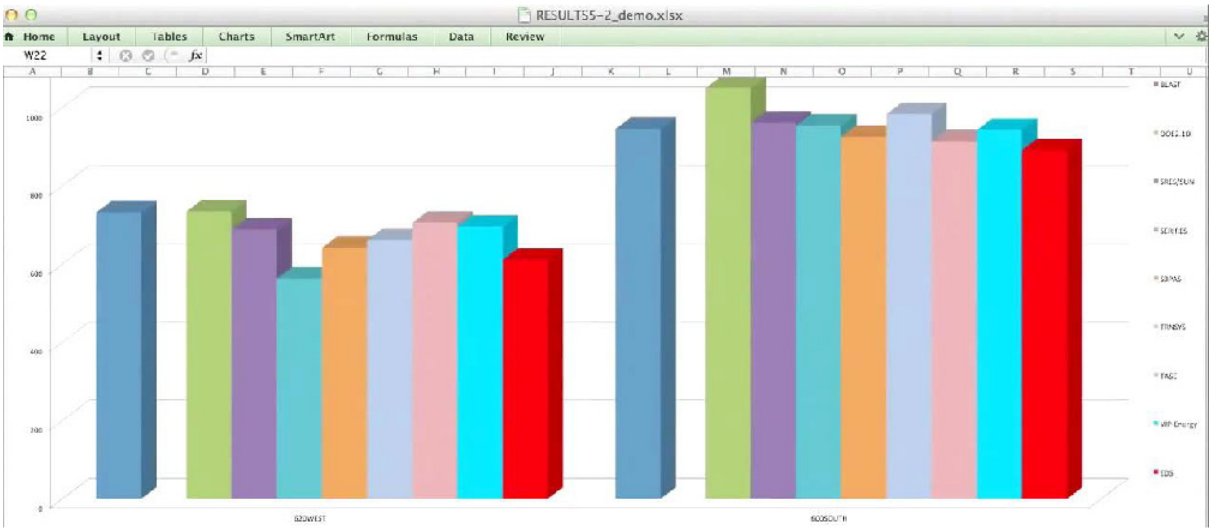
	ESP	BLAST	DOE2	SRES/SUN	SERRES	S3PAS	TRNSYS	TASE	VIP-Energy	EDS	SUMMARY	
	UK-DMJ	US/IT	USA	USA	UK-BRE	SPAIN	BEL/UK	FINLAND	SWEDEN	DATA		
CASE#	KW	KW	KW	KW	KW	KW	KW	KW	KW	KW	MIN	MAX
600	3.437	3.940	4.045	4.258		4.037	3.931	4.354	3.840	4.126	3.437	4.354
610	3.437	3.941	4.034	4.258		4.037	3.922	4.354	4.110	4.126	3.437	4.354
620	3.591	3.941	4.046	4.277		4.277	3.922	4.379	3.830	4.136	3.591	4.379
630	3.592	3.941	4.025	4.280		4.278	3.922		4.120	4.136	3.592	4.280
640	5.232	5.486	5.943	6.530		6.347	5.722	6.954	5.660	4.97	5.232	6.954
650	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0	0.000	0.000
900	2.850	3.453	3.557	3.760		3.608	3.517	3.797	3.550	3.681	2.850	3.797
910	2.858	3.456	3.564	3.764		3.618	3.536	3.801	3.588	3.685	2.858	3.801
920	3.308	3.703	3.805	4.013		4.029	3.708	4.061	3.721	3.896	3.308	4.061
930	3.355	3.732	3.832	4.042		4.064	3.744		3.756	3.899	3.355	4.064
940	3.980	5.028	5.665	6.116		6.117	5.122	6.428	5.758	5.043	3.980	6.428
950	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0	0.000	0.000
960	2.410	2.751	2.727	2.863		2.852	2.522	2.779	2.586	2.7	2.410	2.863
195	2.004									3.425	2.004	2.004
200	2.651									3.425	2.651	2.651

So the EcoDesigner STAR calculation is again in the acceptable range. The same applies for the Peak Cooling load, which must be between 0.9 and 1.4 kW.

ANNUAL HOURLY INTEGRATED PEAK COOLING LOADS

	ESP	BLAST	DOE2	SRES/SUN	SERIRES	S3PAS	TRNSYS	TASE	VIP Energy	EDS	SUMMARY	
	UK-DMU	US/T	USA	USA	UK-BRE	SPAIN	BEL/UK	FINLAND	SWEDEN	DATA		
CASE#	kW	kW	kW	kW	kW	kW	kW	kW	KW	KW	MIN	MAX
600	6.194	5.965	6.656	6.827		6.286	6.486	6.812	5.570	6.525	5.965	6.827
610	5.569	5.824	6.064	6.371		6.170	5.675	6.146	5.790	6.357	5.669	6.371
620	3.634	4.075	4.430	4.593		4.297	4.275	5.096	4.530	4.249	3.634	5.096
630	3.072	3.704	3.588	4.116		3.665	3.608		3.850	3.224	3.072	4.116
640	6.161	5.892	6.576	6.776		6.250	6.442	6.771	5.508	6.464	5.892	6.776
650	6.031	5.831	6.516	6.671		6.143	6.378	6.679	5.544	6.378	5.831	6.679
900	2.388	3.155	3.458	3.871		3.334	3.567	3.457	4.041	3.726	2.888	3.871
910	1.396	2.500	2.336	3.277		2.786	2.792	3.147	3.302	3.519	1.896	3.277
920	2.385	2.933	3.109	3.487		3.071	3.050	3.505	3.543	3.151	2.385	3.505
930	1.373	2.546	2.388	3.080		2.486	2.498		2.865	2.308	1.873	3.080
940	2.388	3.155	3.458	3.871		3.334	3.567	3.457	4.041	3.726	2.888	3.871
950	2.033	2.621	2.664	3.170		2.677	2.686	2.857	3.072	2.702	2.033	3.170
960	0.953	1.144	1.057	1.370		1.179	1.370	1.403	1.384	1.18	0.953	1.403
195	0.651									1.159	0.651	0.651

These graphs show the results of the other ASHRAE 140 building envelope test cases. EcoDesigner STAR – shown in red – is capable of producing results that are just as accurate as the standard reference results generated with other high-end building energy analysis software applications.



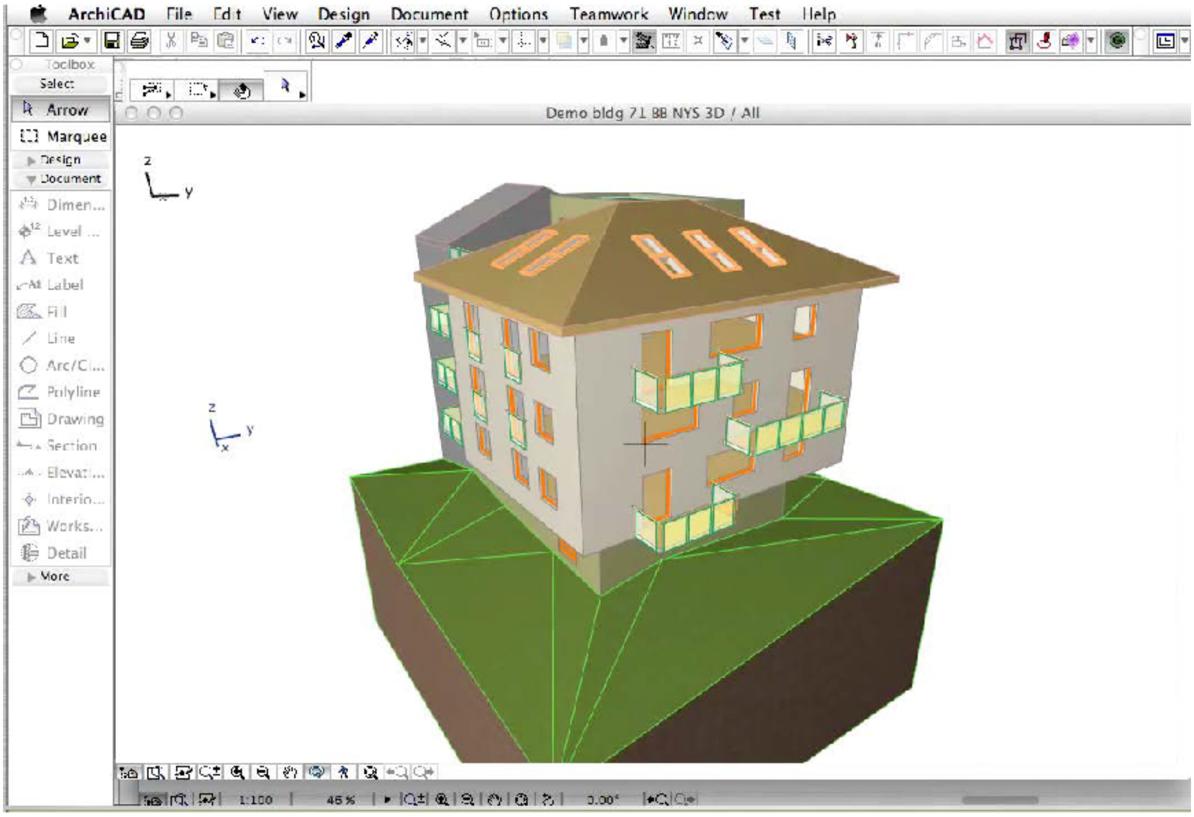
4. Project-Specific Low-Energy Building Solution Set

This chapter presents how to choose the most appropriate low-energy building design strategy for your project.

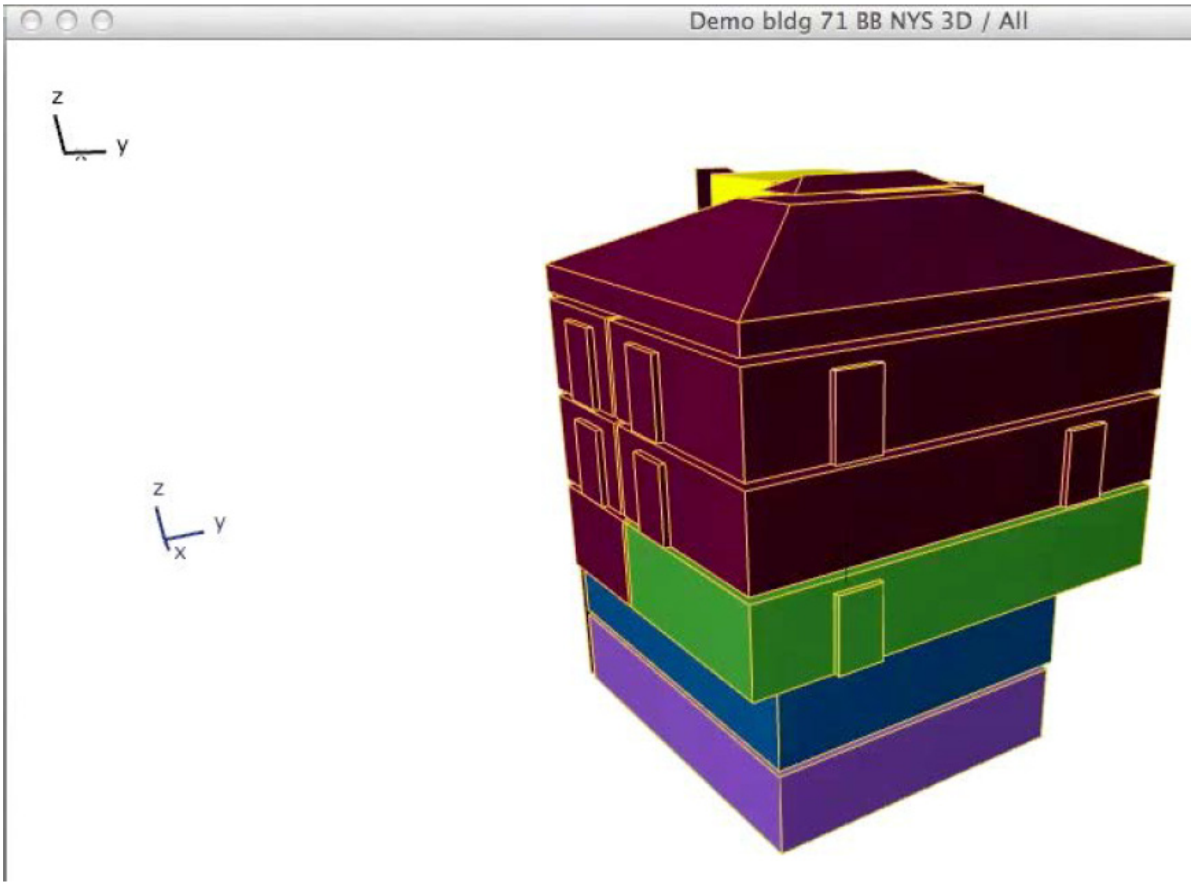
The workflow starts with creating a baseline building for testing the feasibility of each potential low-energy building solution. This method is called sensitivity analysis.

4.1 Create Baseline Building (Without Systems)

Here is our sample building information model (**BIM**) created in GRAPHISOFT ArchiCAD. It is a multistory, multipurpose building built next to an existing apartment block.



Let’s look at this building in 3D view: you can see the 3D ArchiCAD zones that represent the internal spaces.

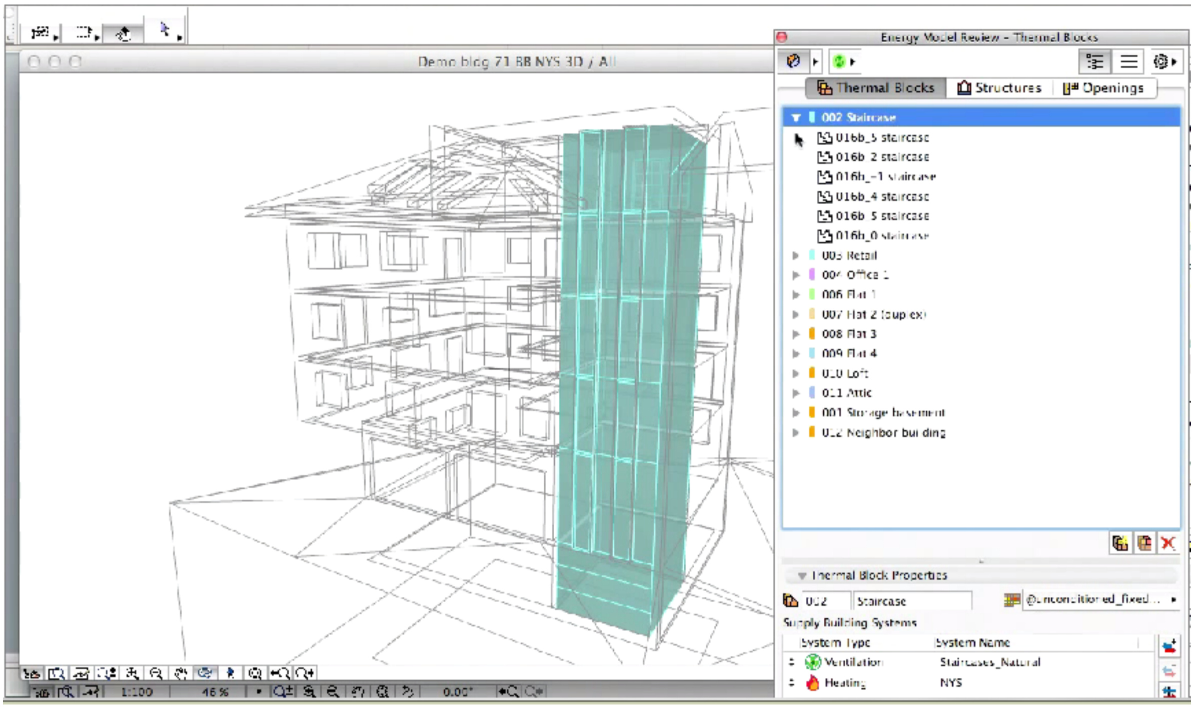


With the help of these zones and the architectural model elements, the building energy model - or BEM for short – is automatically created. Since it originates from the BIM, the EcoDesigner **BEM** automatically contains all the building geometry and material property data required for building energy simulations, without any manual data input.

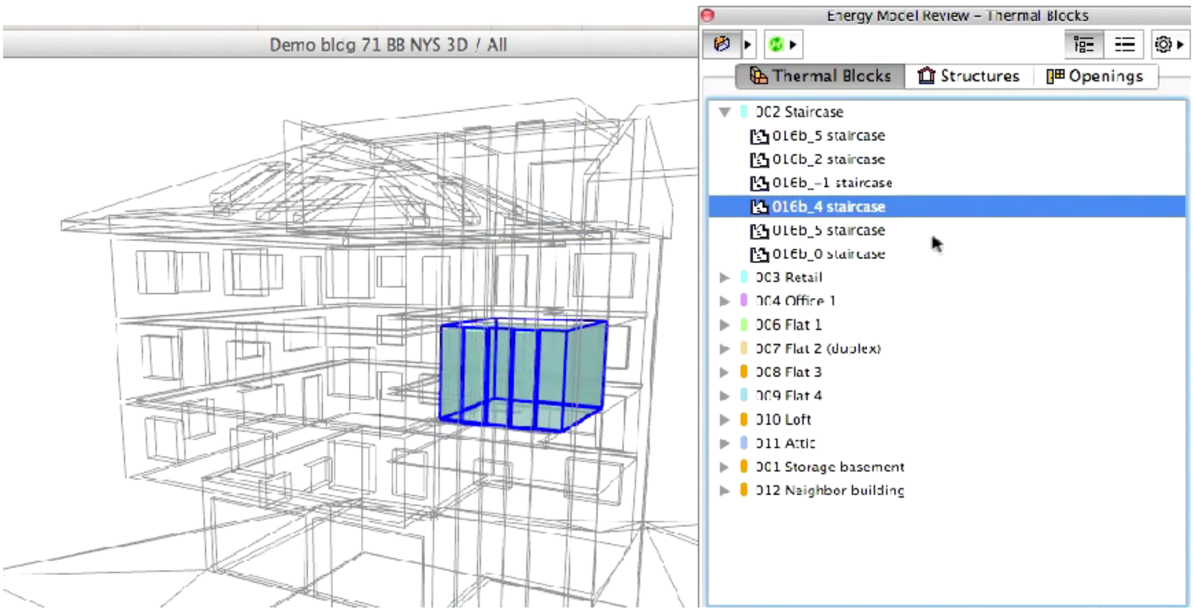
Use the **Energy Model Review palette** to visualize and edit the building energy model.

The **Thermal Blocks page** lists all the thermal blocks in the design. Turn on the energy model view to display any selected thermal block in a particular color in the 3D view, while the rest of the building is shown in wire-frame view.

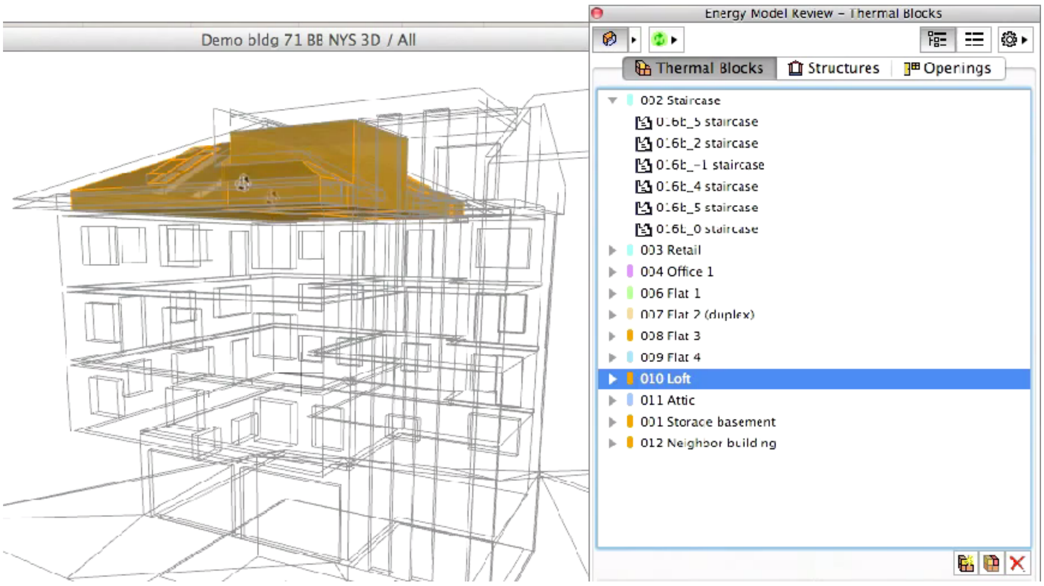
Groups of ArchiCAD zones can be specified as thermal blocks. For example: this is the Staircase thermal block, containing contains several ArchiCAD zones.



The individual zones can also be displayed in the 3D window –simply select them on the list.

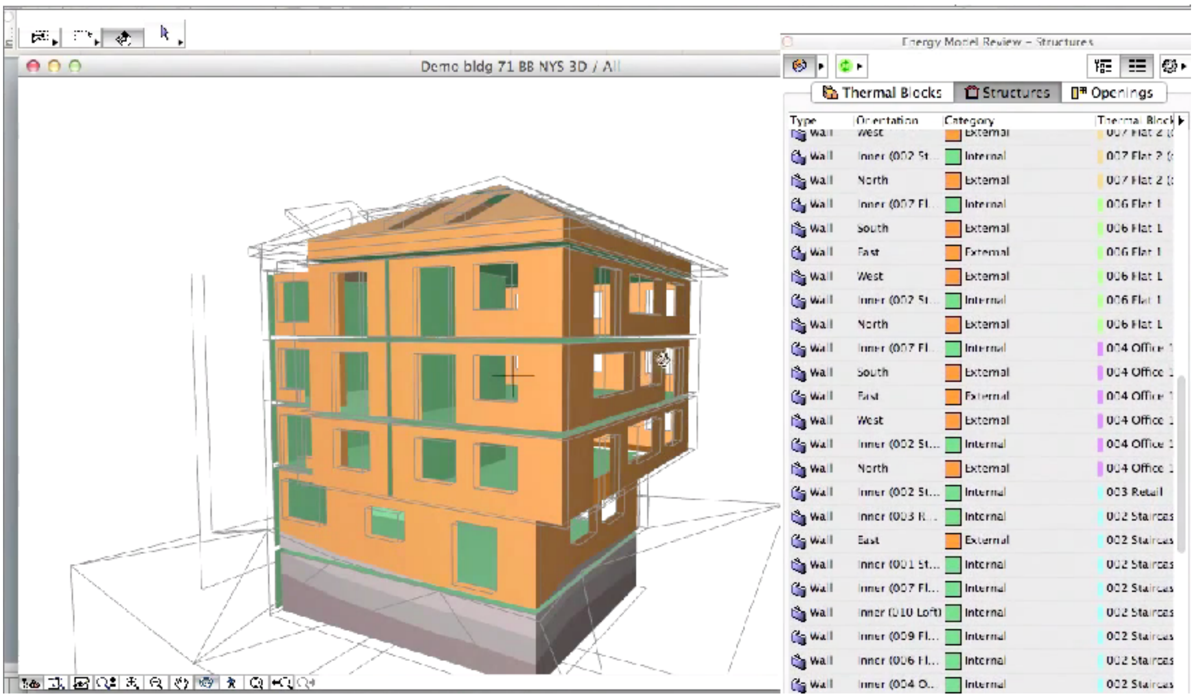


The ground floor contains a retail area, and the floor above is office space. The example building also includes apartments: one is a duplex and another is a loft.



Define Thermal Blocks by drag-and-dropping the 3D ArchiCAD zones into a Thermal Block on the list. New Thermal Blocks can also be created here.

If you select the list entries on the **Structures page** of the Energy Review Palette, then the appearance of the building energy model changes in the 3D view. The colors now represent the Category and Orientation of the building energy model's opaque structures. The Structures list is populated automatically based on the ArchiCAD building information model.

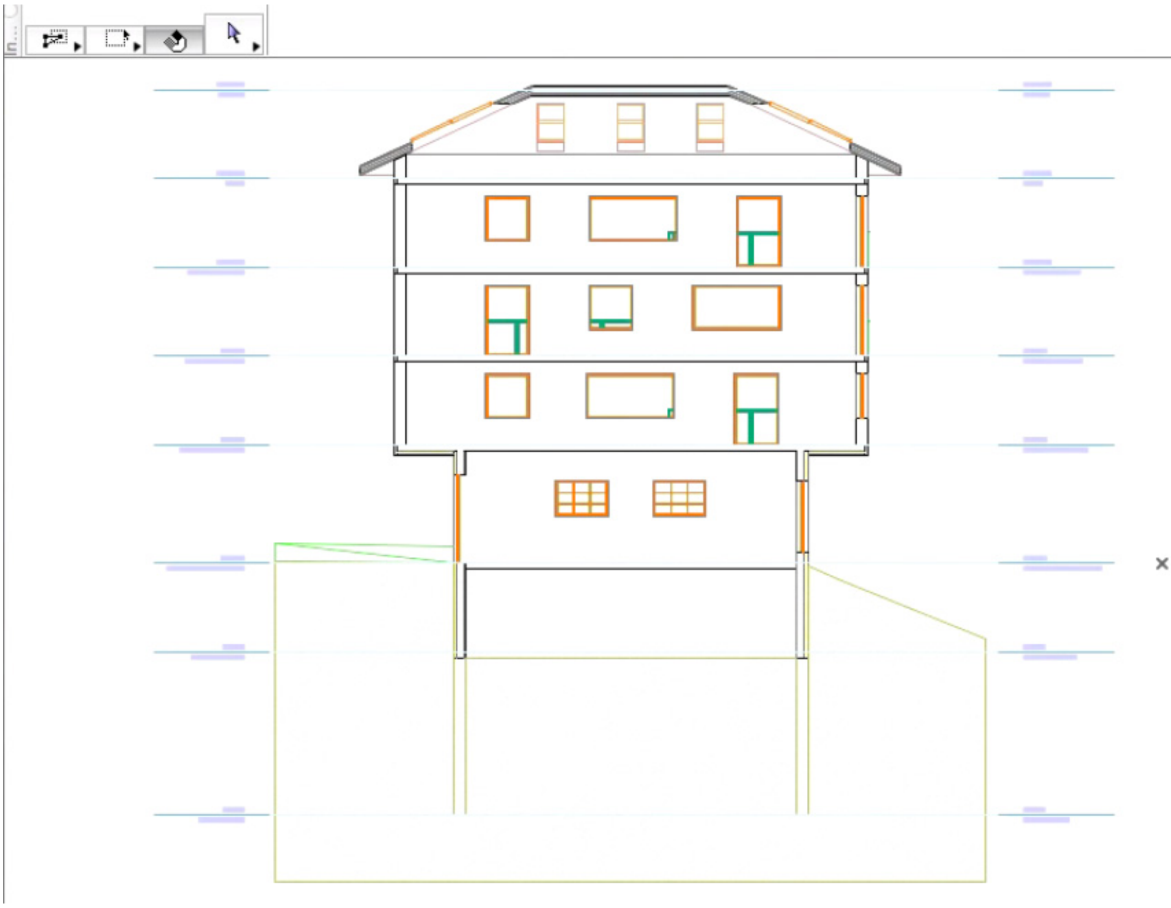


The integration of building energy modeling with the architectural model allows geometry and material property data takeoff with unparalleled accuracy. EcoDesigner STAR performs very detailed, hourly dynamic energy analysis based on this input data to produce energy simulation results.

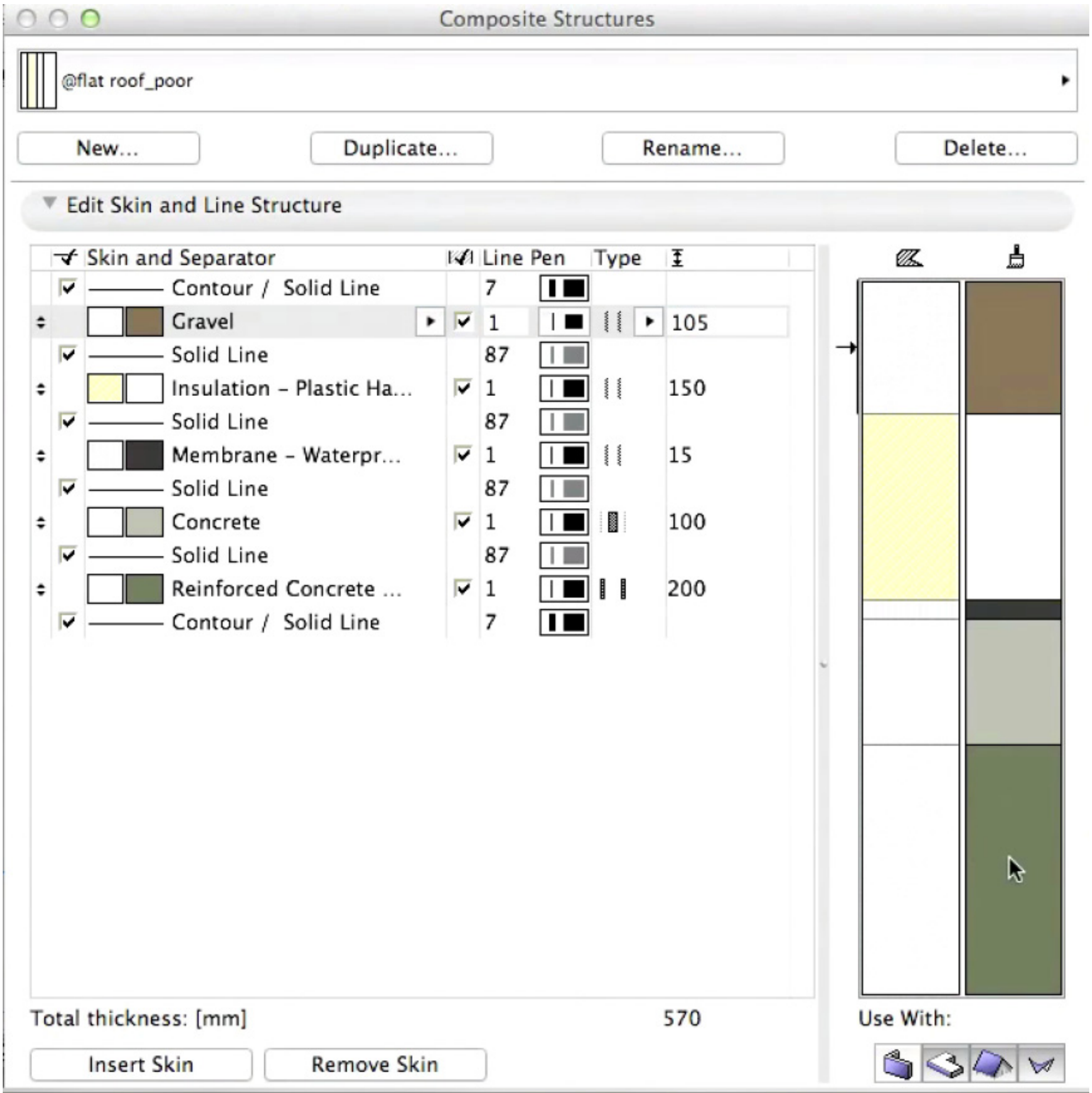
The example project represents a phase in the architectural design process, when **no low-energy** building **solutions** have yet been applied. The shape and zoning are already decided, but the final composites, façade solutions, window placements, shading etc. can still be changed easily. The building systems are not yet defined, either.

In this example, we will use EcoDesigner STAR to optimize the architectural design first, and then to evaluate the effect of different building systems (e.g. natural vs. mechanical ventilation), in order to find the best solutions for the specific project.

As you can see in the cross section, the project at this phase has very **simple construction solutions**: reinforced concrete external walls with minimal thermal insulation on the ground floor, light-weight block walls, a double-ventilated composite roof structure above the loft area and a simple flat roof construction.

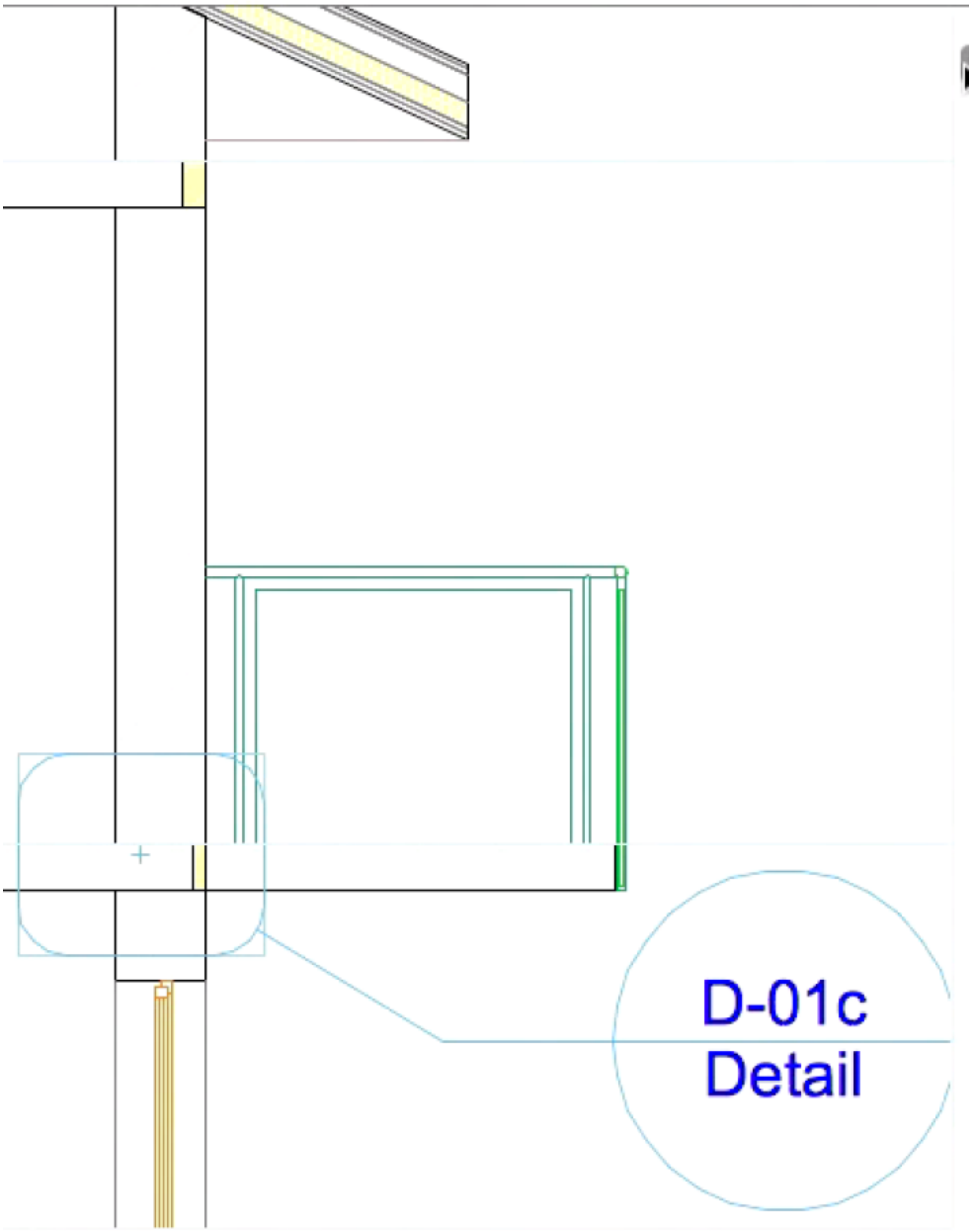


Look at the components of one of the **mediocre composite structures**. Here are all the skins of the simple flat roof with their properties. A load-bearing concrete slab, sloping screed, waterproofing membrane, thermal insulation, and gravel on the top.



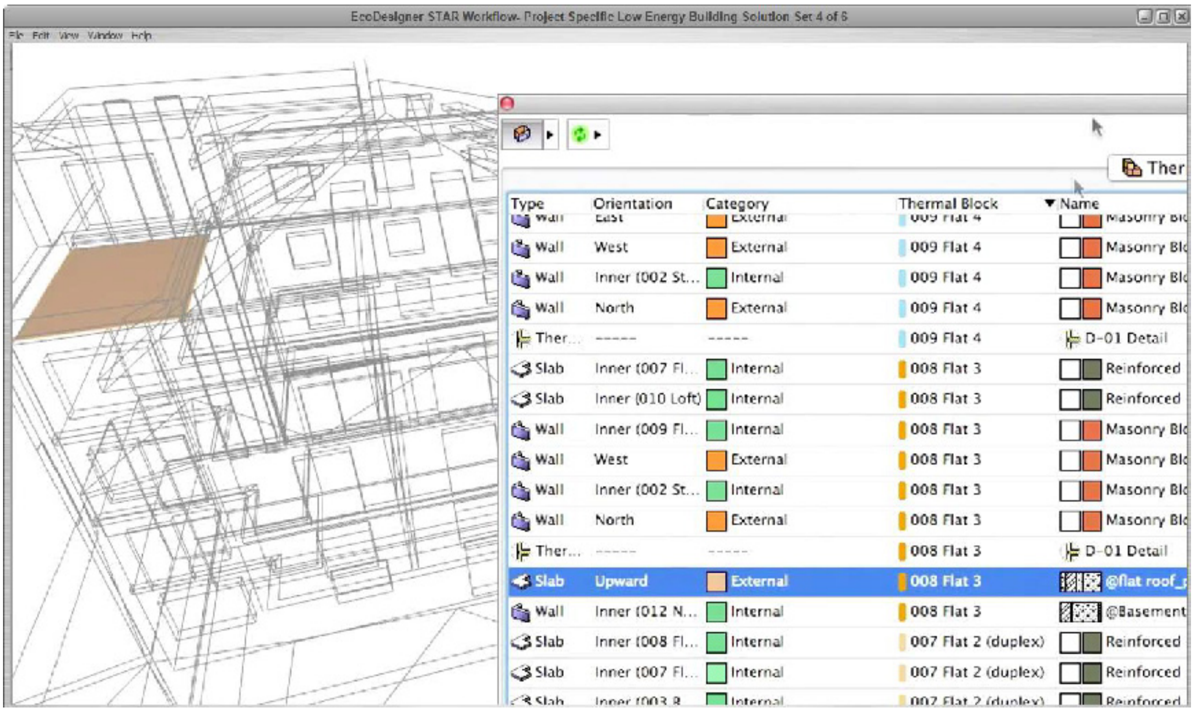
Note: you can modify composites or create new ones using the Composite Structures dialog box from ArchiCAD's Options menu.

Thanks to ArchiCAD's **Priority Based Connections**, all structural details are automatically and accurately connected, in accordance with the intersection priority settings of the skins' materials. The automatically generated details are updated in every BIM view as the model changes.

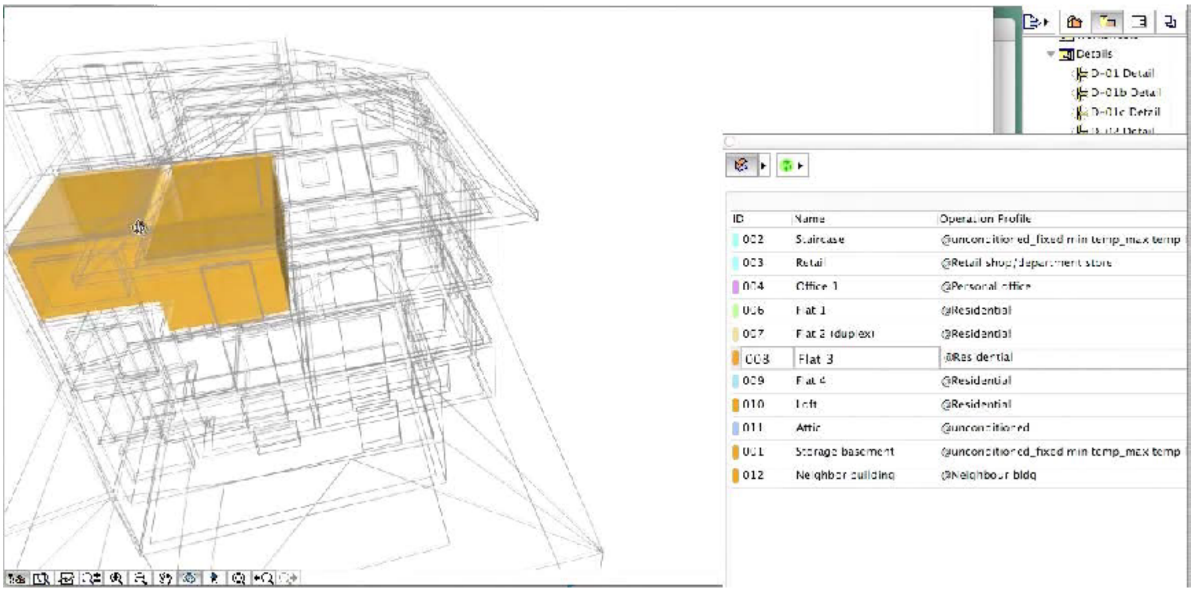


To update the Building Energy Model with the latest changes in the architectural design, press the Update Zones command.

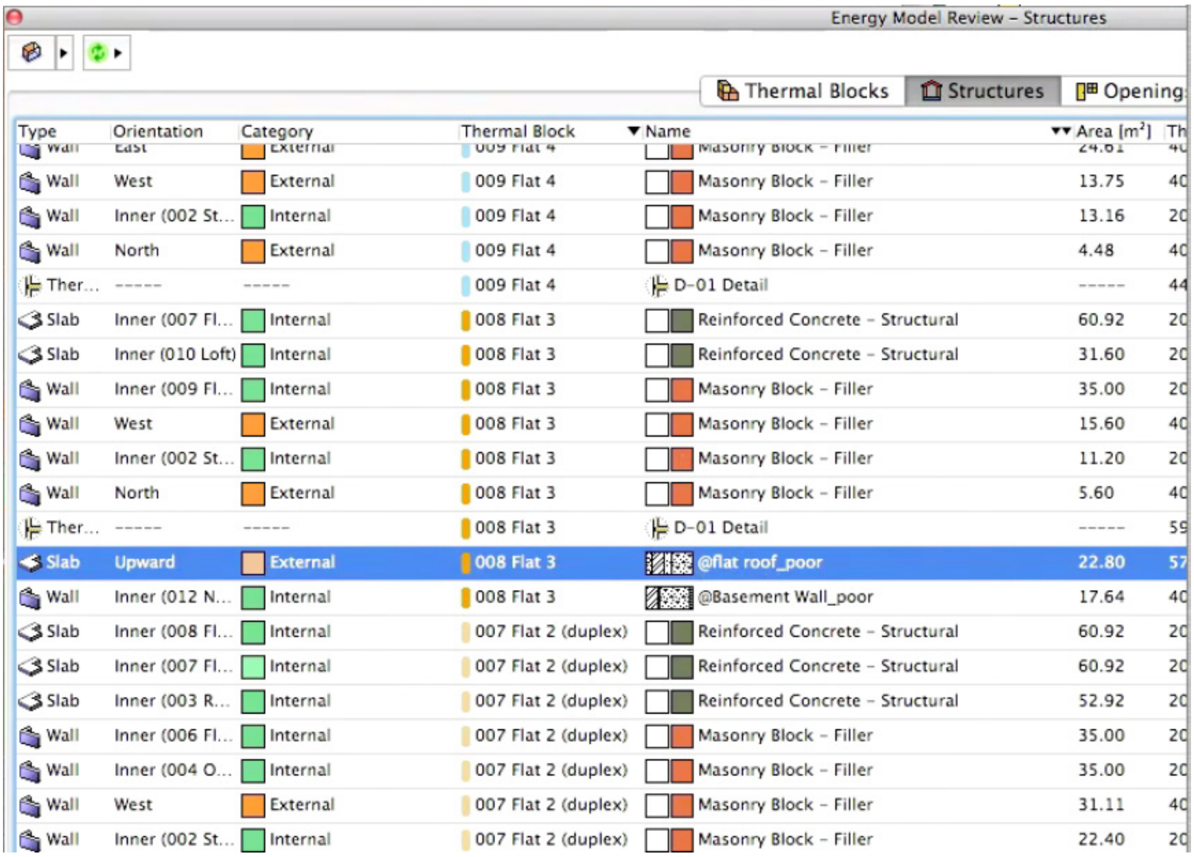
Here is the 3D energy model view of one of the project's flat roofs. It is located above Flat number three.



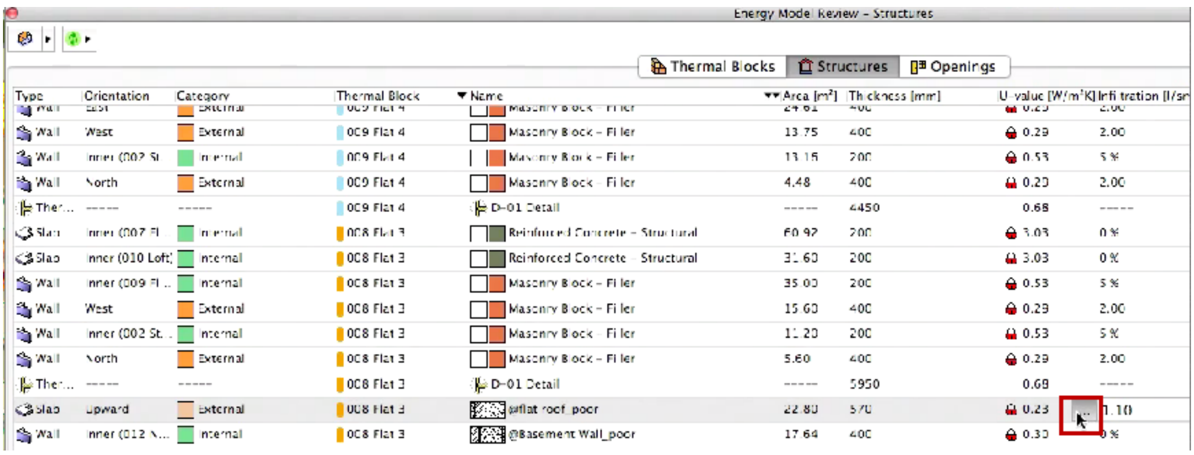
Here's the thermal block representing that Flat, located partially under the pitched roof and the loft ... and partially under the flat roof.



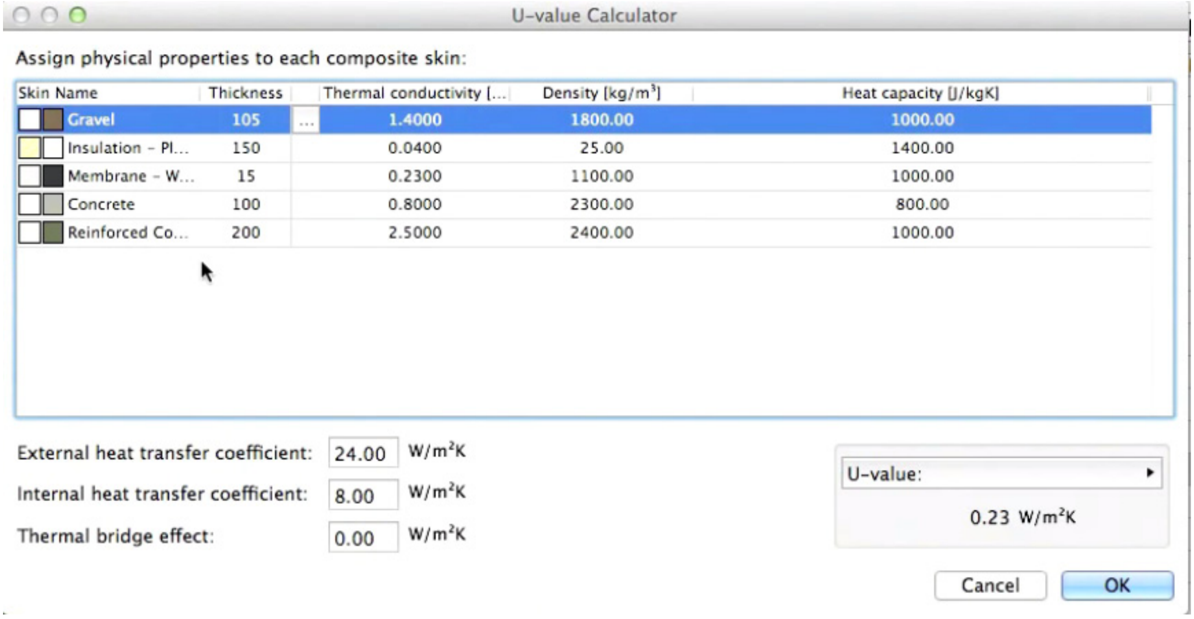
Find this flat roof on the Structures list of the Energy Model Review palette. First, sort the elements to list them by Thermal Blocks. Select the flat roof from the list of structural elements assigned to Flat number three. Note that it is now highlighted in the 3D view.



The Structures list contains the name of the composite used to model the flat roof. Open the **U-Value Calculator** to check the thermal characteristics of this flat roof composite.

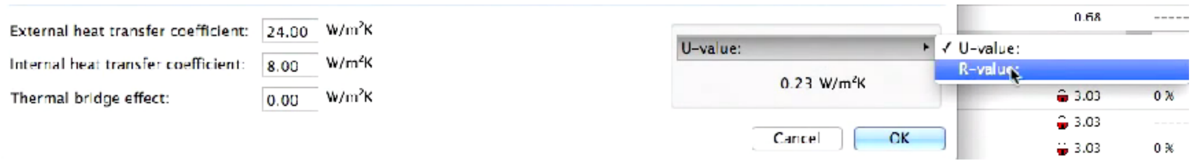


In this dialog, the skins of the composite flat roof slab are listed the same way as in the Composite Structures dialog box, but the U-Value Calculator panel also displays the skins' thermal properties.

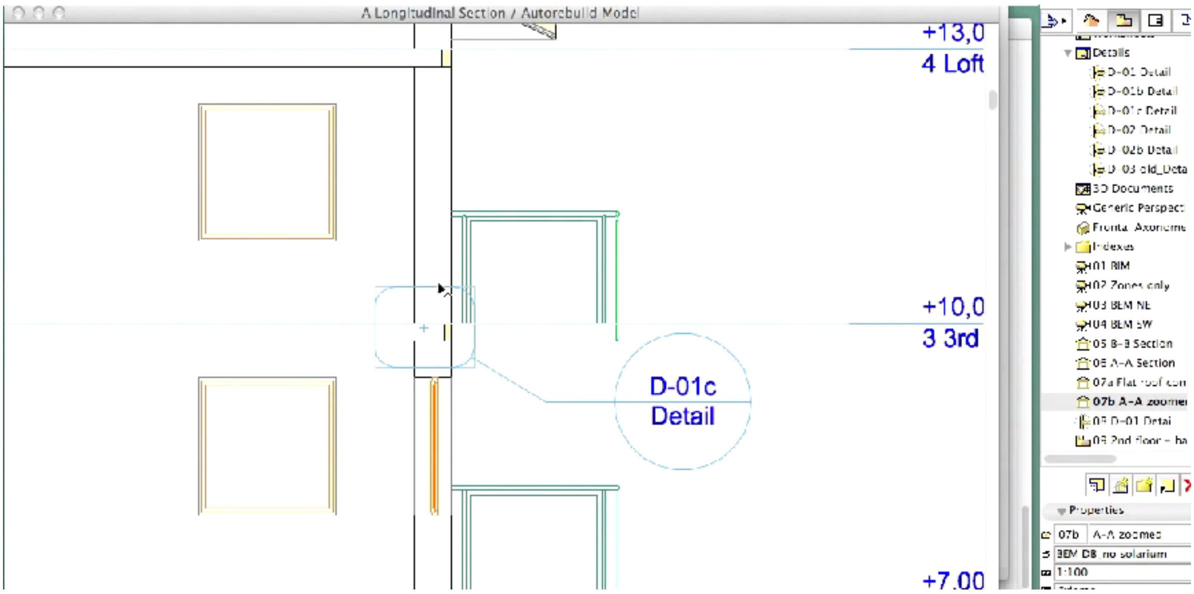


You can fine-tune the default physical properties of the Building Materials used to model these composite skins. Alternatively, the best matching material item from the Material Catalog can be assigned to the skin.

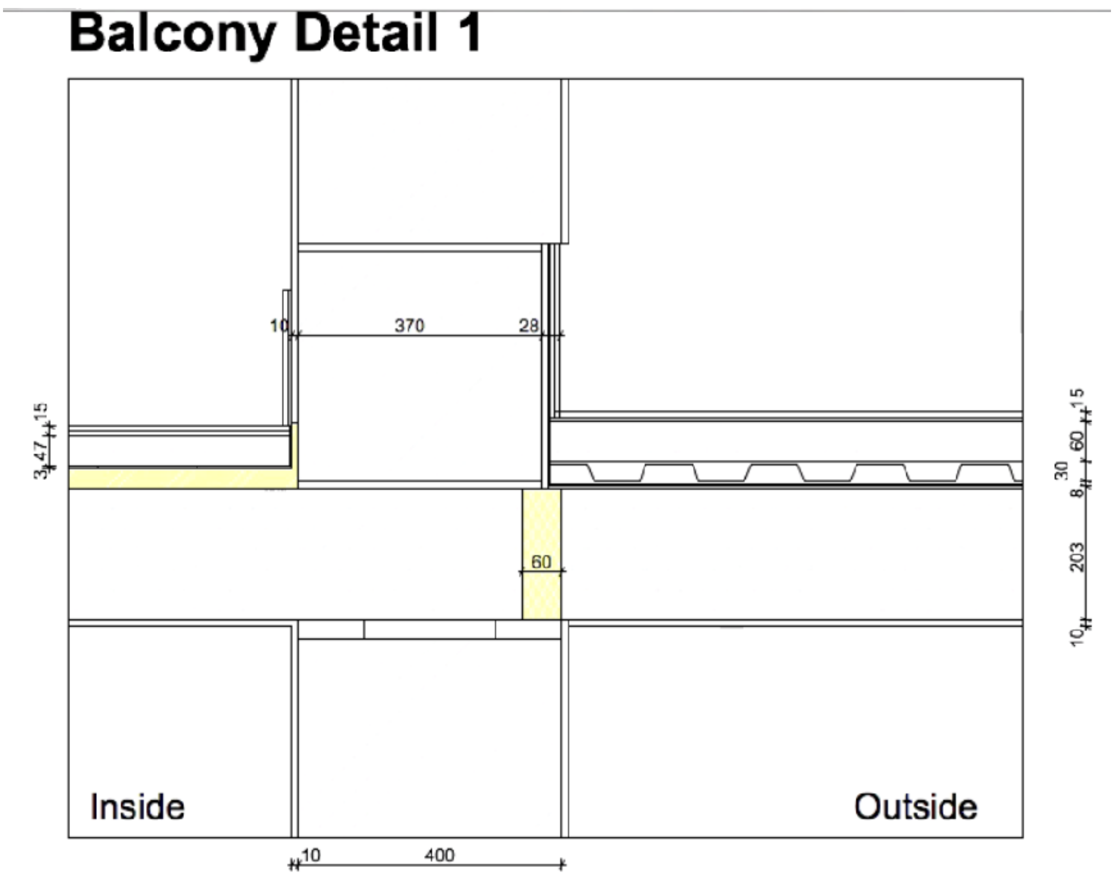
Based on the skin characteristics, the external and internal heat transfer coefficients and the steady-state overall heat transfer coefficient of the composite structure are automatically calculated. Use the switch to decide whether to display this calculation result as U-value or R-value (thermal resistance – the reciprocal of the U-value).



Open a section view of the project to have a closer look at one of the **construction details**. This detail is located at the junction of the external wall, the floor slab and the balcony slab.

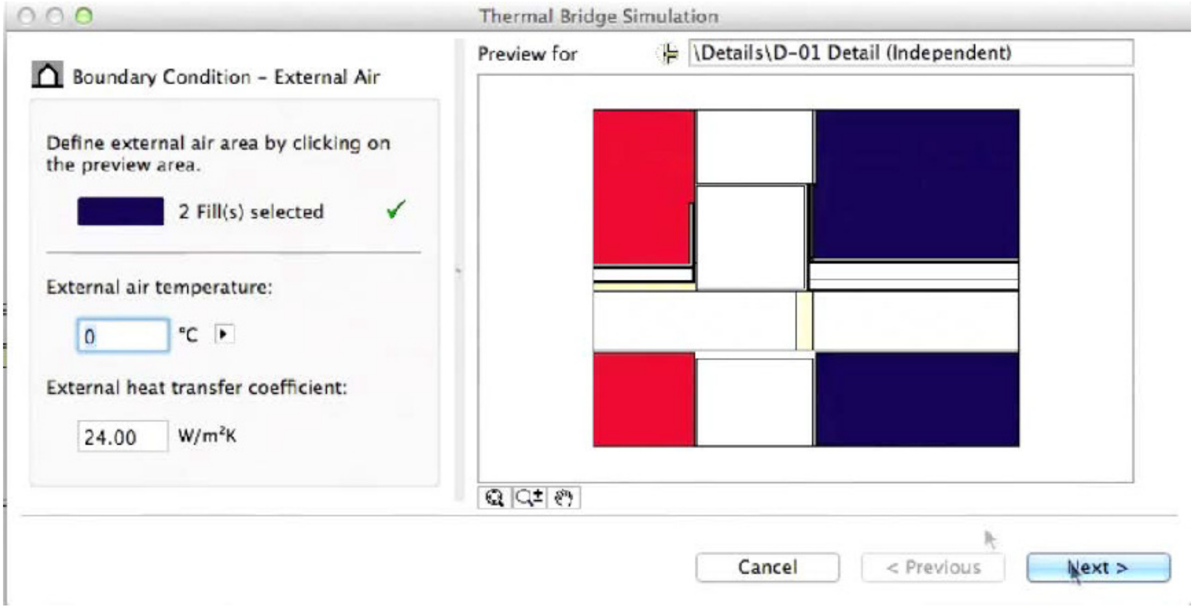


Open the corresponding ArchiCAD detail, where we’ve already added some dimensions and other drawing elements to the 3D model elements.

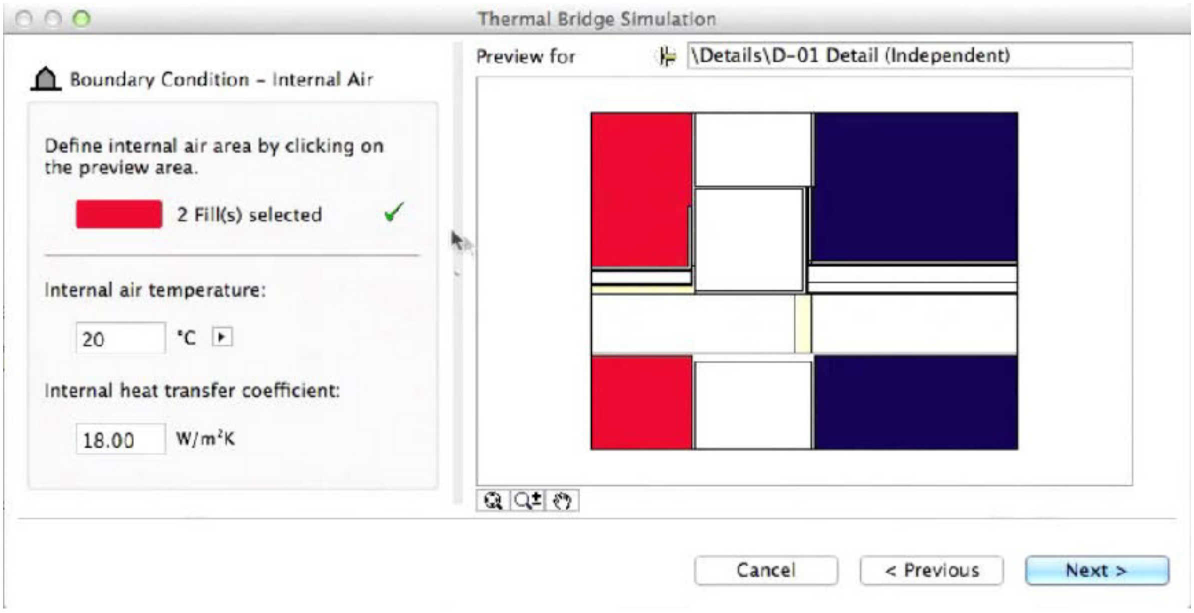


Run a **thermal bridge simulation** on this detail. The easy-to-use wizard guides us through the steps of the thermal bridge simulation.

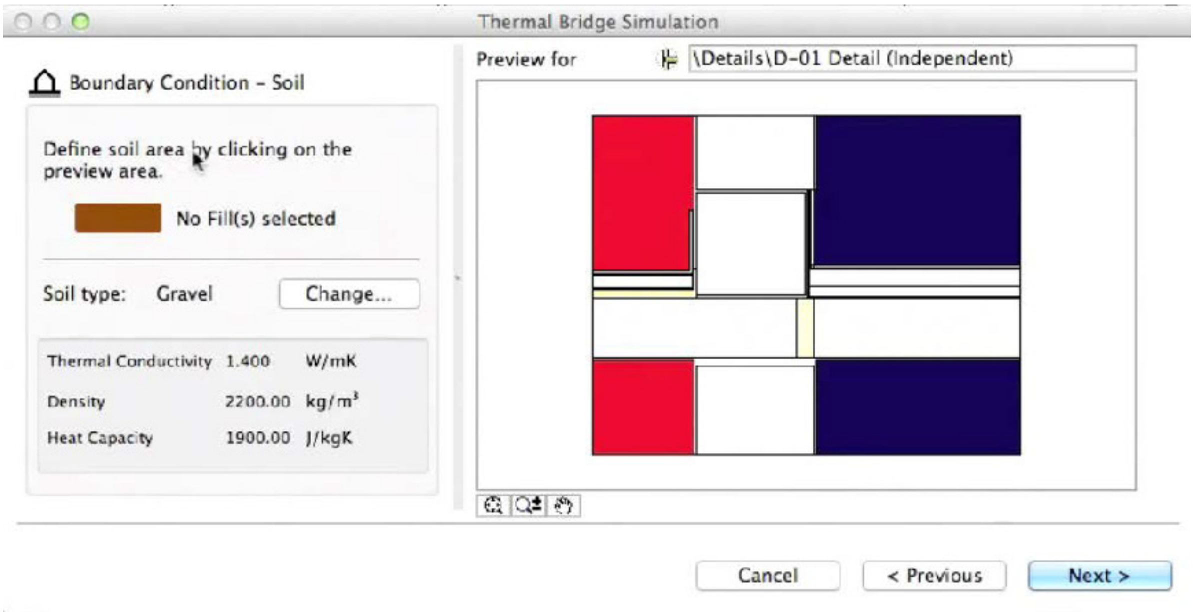
First, define the exterior areas by assigning the dark blue color to them.



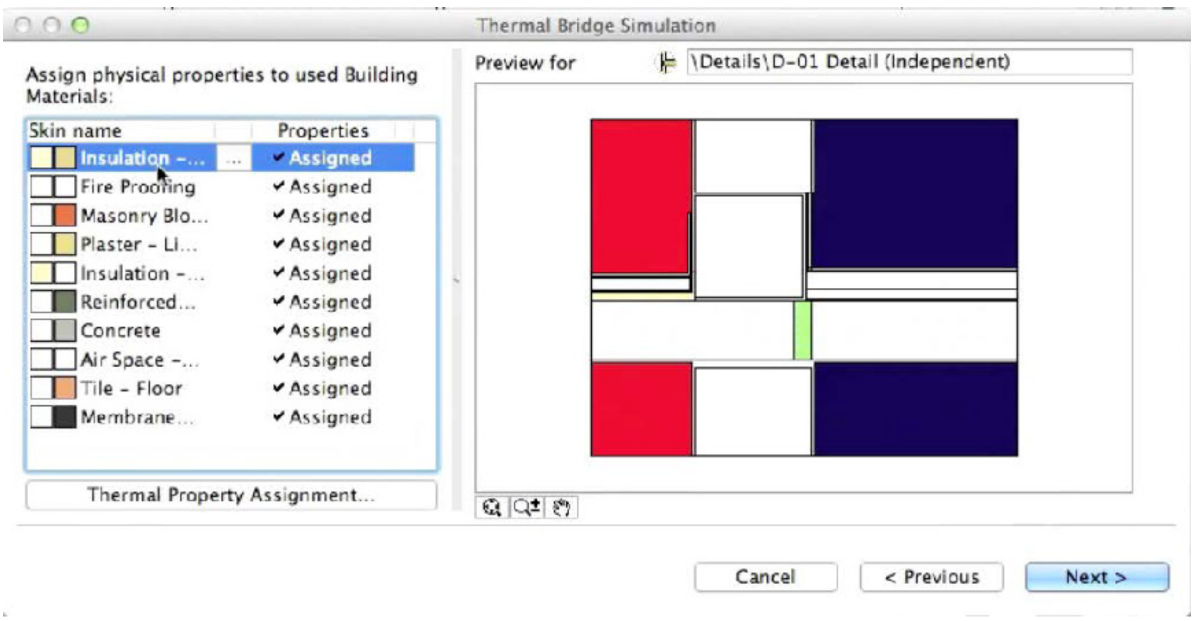
Similarly, define the internal areas, by assigning the red color to them.



This detail has no connection with the ground, so there's no soil area to define.

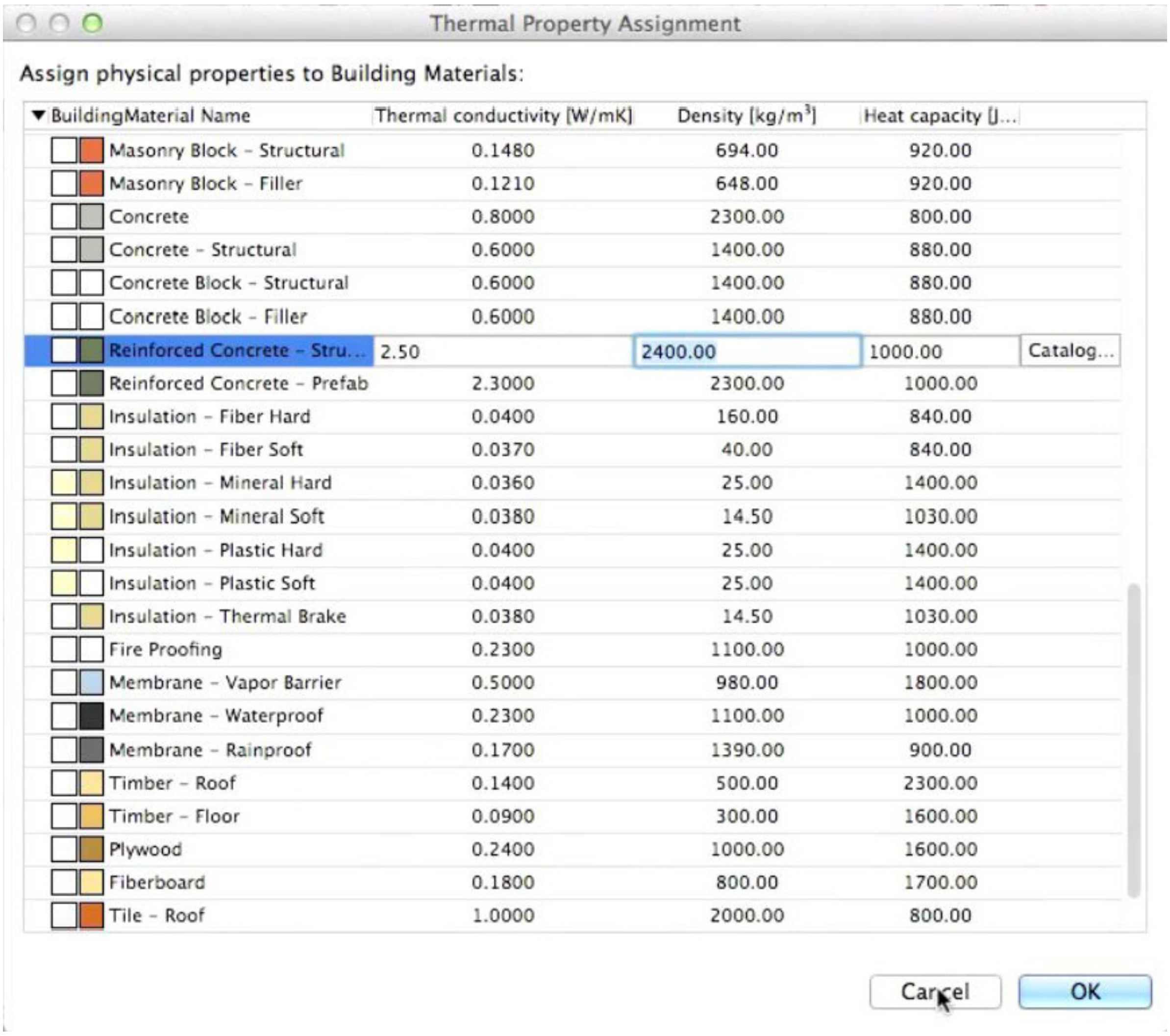


The next step is to make sure that each skin and structural element of the detail has the right building material assigned to it. On the left of the next wizard dialog, the detail's building materials are listed. Most of these materials come directly from the model elements.



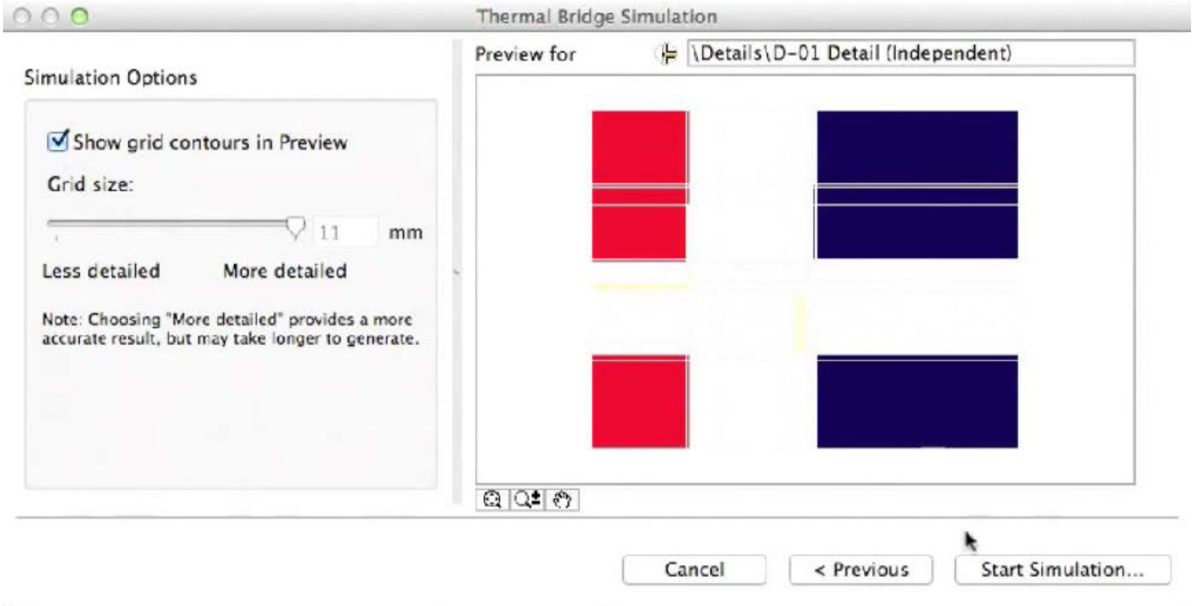
Use the list to highlight the detail components' building material data one by one, and the corresponding graphical representations will be highlighted on the detail preview, on the right.

For this example building, the building materials and thermal properties of the individual skins have already been correctly defined. Besides fine-tuning the building material assignments, you can directly override the thermal characteristics of the individual skins.



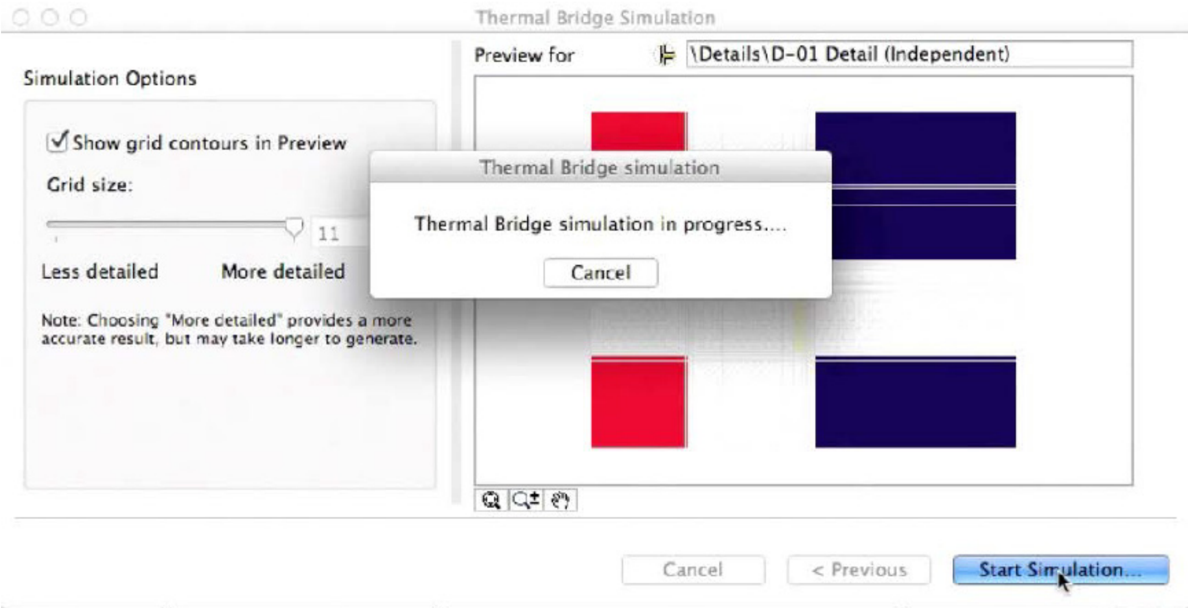
BuildingMaterial Name	Thermal conductivity [W/mK]	Density [kg/m³]	Heat capacity [J...
Masonry Block - Structural	0.1480	694.00	920.00
Masonry Block - Filler	0.1210	648.00	920.00
Concrete	0.8000	2300.00	800.00
Concrete - Structural	0.6000	1400.00	880.00
Concrete Block - Structural	0.6000	1400.00	880.00
Concrete Block - Filler	0.6000	1400.00	880.00
Reinforced Concrete - Stru...	2.50	2400.00	1000.00 Catalog...
Reinforced Concrete - Prefab	2.3000	2300.00	1000.00
Insulation - Fiber Hard	0.0400	160.00	840.00
Insulation - Fiber Soft	0.0370	40.00	840.00
Insulation - Mineral Hard	0.0360	25.00	1400.00
Insulation - Mineral Soft	0.0380	14.50	1030.00
Insulation - Plastic Hard	0.0400	25.00	1400.00
Insulation - Plastic Soft	0.0400	25.00	1400.00
Insulation - Thermal Brake	0.0380	14.50	1030.00
Fire Proofing	0.2300	1100.00	1000.00
Membrane - Vapor Barrier	0.5000	980.00	1800.00
Membrane - Waterproof	0.2300	1100.00	1000.00
Membrane - Rainproof	0.1700	1390.00	900.00
Timber - Roof	0.1400	500.00	2300.00
Timber - Floor	0.0900	300.00	1600.00
Plywood	0.2400	1000.00	1600.00
Fiberboard	0.1800	800.00	1700.00
Tile - Roof	1.0000	2000.00	800.00

Now, examine the simulation options. The adaptive mesh representing the calculation sampling points can be visualized on the preview.

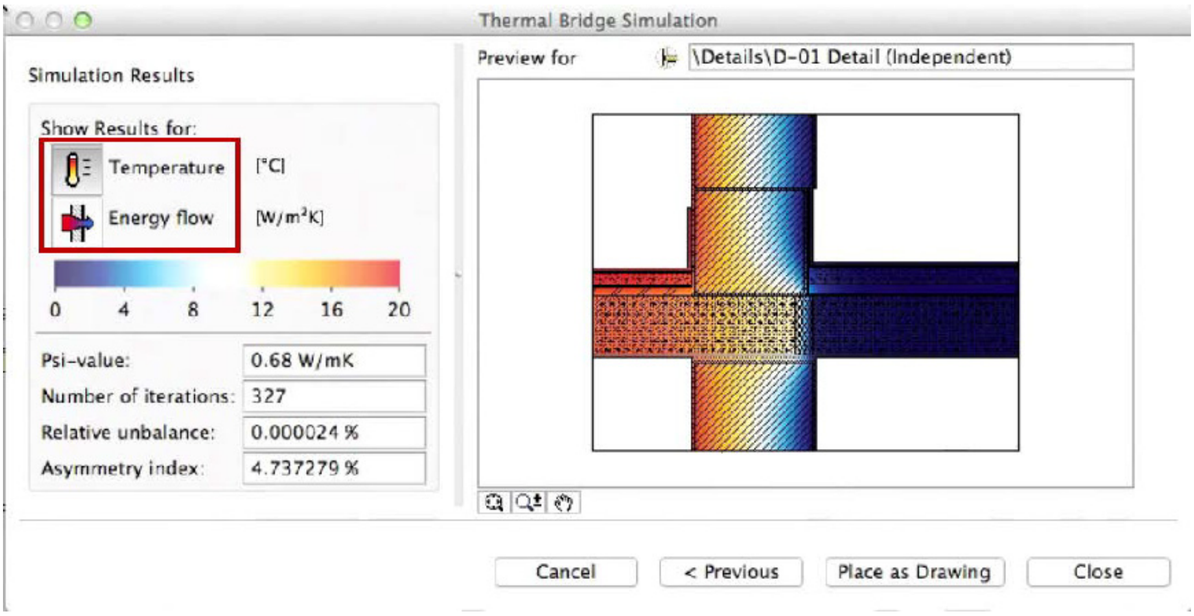


By changing the reference grid size for the calculation we can run more detailed or less detailed thermal bridge simulations.

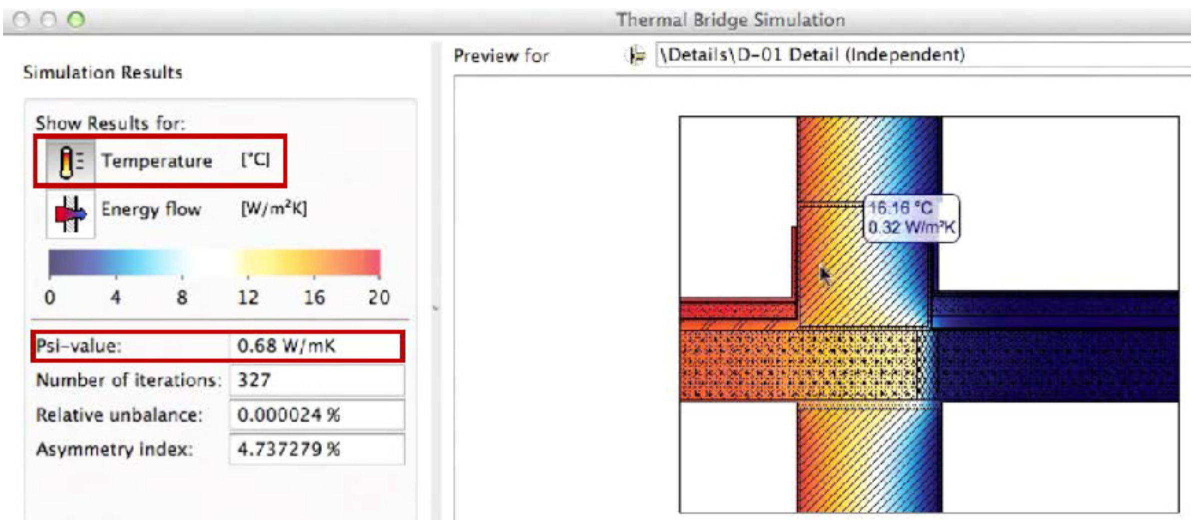
Start the simulation.



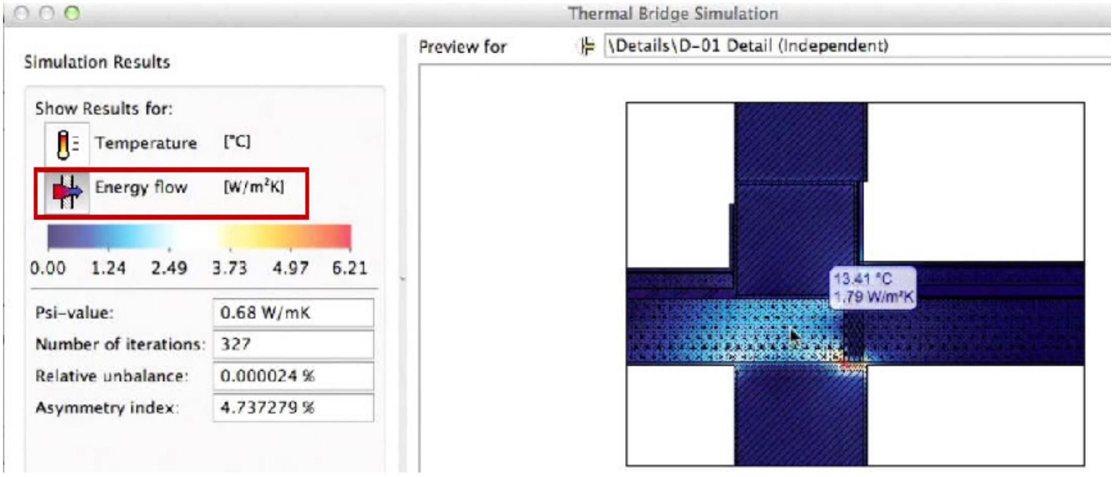
The results appear in seconds, offering two options for visualization: the Temperature view and the Energy Flow view.



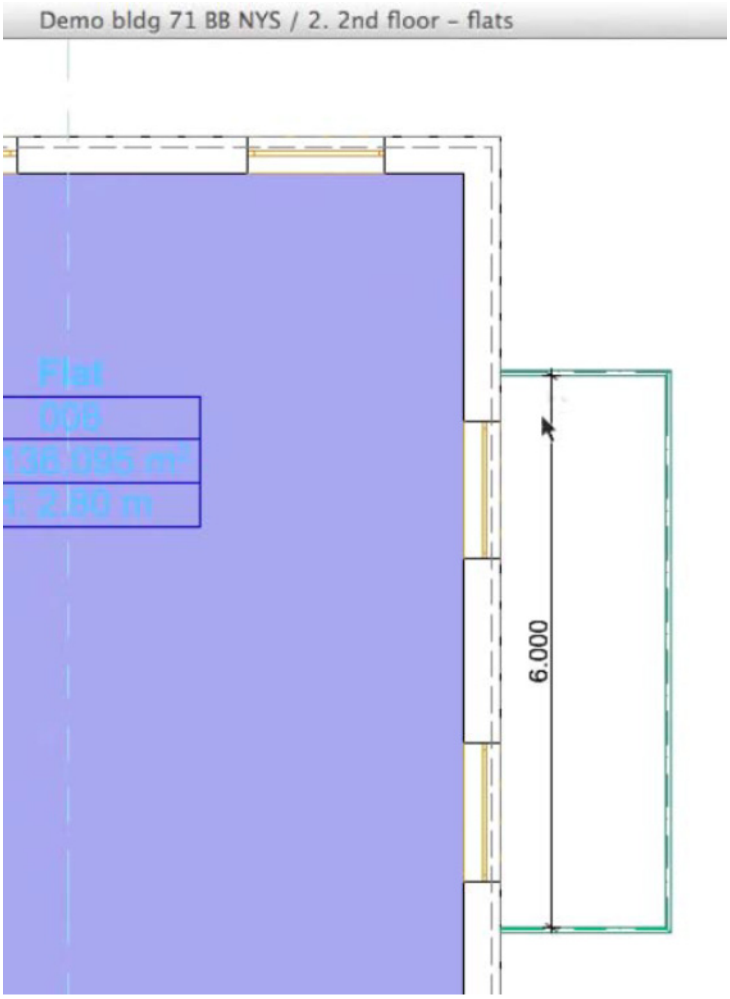
Hover the cursor over the colored Temperature diagram on the left side, to read the calculated thermal characteristics at every point. The **detail's overall thermal performance** is described by the linear heat transfer coefficient (Psi-Value) value. The results show that there is a significant thermal bridge at this balcony detail - even though a thermal brake has been inserted between the balcony slab and the floor slab.



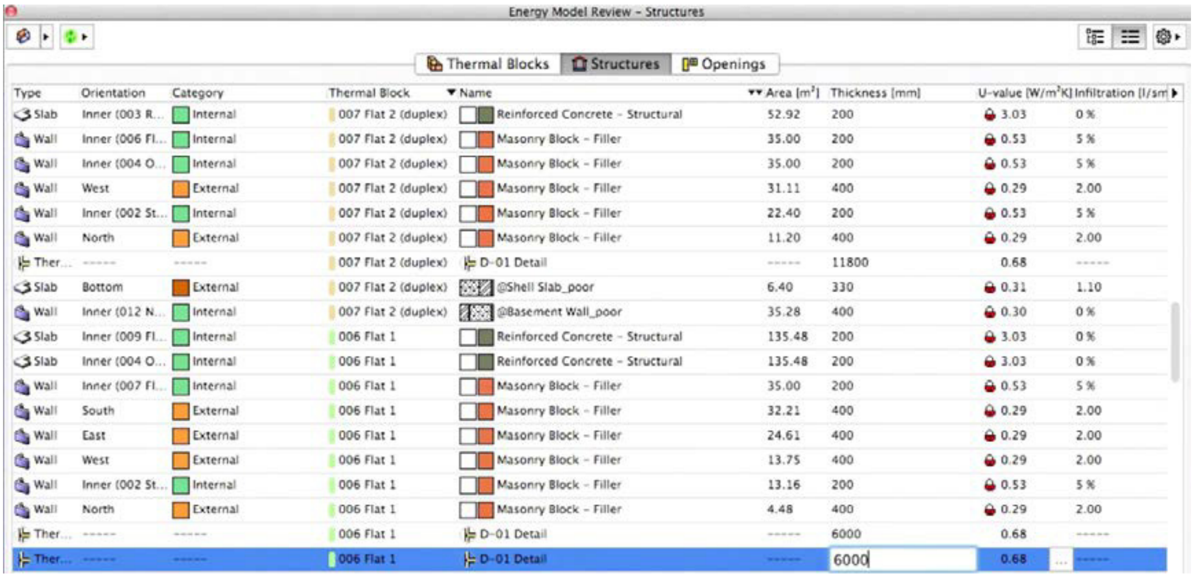
On the other Thermal Bridge Simulation result view, the energy flow is represented by colors. Again, use the cursor to display the simulation results at every point of the detail.



The next step is to apply the results of the thermal bridge simulation in the hourly building energy simulation. First, measure the length of the balcony slab to floor slab joint on the floor plan to determine the length along which the thermal bridge occurs.



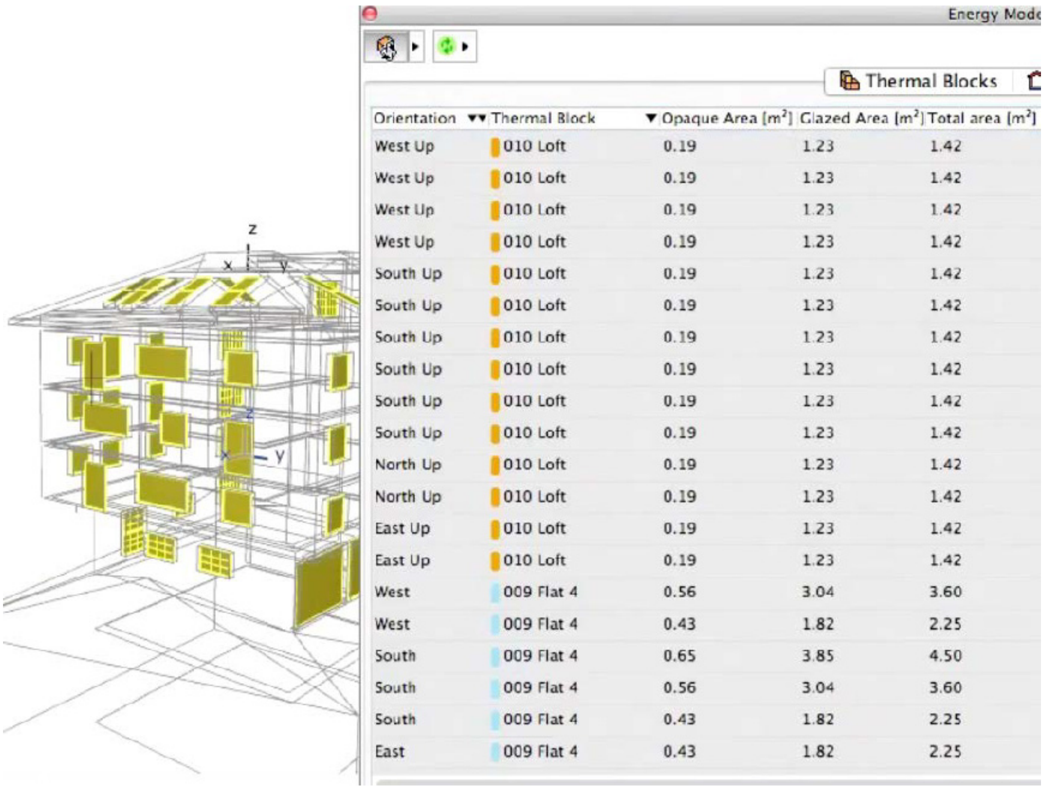
Then use the Structures list of the Energy Model Review palette to add the thermal bridge to the relevant thermal block and to enter the thermal bridge's length.



Type	Orientation	Category	Thermal Block	Name	Area [m²]	Thickness [mm]	U-value [W/m²K]	Infiltration [l/sm
Slab	Inner (003 R...	Internal	007 Flat 2 (duplex)	Reinforced Concrete - Structural	52.92	200	3.03	0 %
Wall	Inner (006 Fl...	Internal	007 Flat 2 (duplex)	Masonry Block - Filler	35.00	200	0.53	5 %
Wall	Inner (004 O...	Internal	007 Flat 2 (duplex)	Masonry Block - Filler	35.00	200	0.53	5 %
Wall	West	External	007 Flat 2 (duplex)	Masonry Block - Filler	31.11	400	0.29	2.00
Wall	Inner (002 St...	Internal	007 Flat 2 (duplex)	Masonry Block - Filler	22.40	200	0.53	5 %
Wall	North	External	007 Flat 2 (duplex)	Masonry Block - Filler	11.20	400	0.29	2.00
Ther...	-----	-----	007 Flat 2 (duplex)	D-01 Detail	-----	11800	0.68	-----
Slab	Bottom	External	007 Flat 2 (duplex)	@Shell Slab_poor	6.40	330	0.31	1.10
Wall	Inner (012 N...	Internal	007 Flat 2 (duplex)	@Basement Wall_poor	35.28	400	0.30	0 %
Slab	Inner (009 Fl...	Internal	006 Flat 1	Reinforced Concrete - Structural	135.48	200	3.03	0 %
Slab	Inner (004 O...	Internal	006 Flat 1	Reinforced Concrete - Structural	135.48	200	3.03	0 %
Wall	Inner (007 Fl...	Internal	006 Flat 1	Masonry Block - Filler	35.00	200	0.53	5 %
Wall	South	External	006 Flat 1	Masonry Block - Filler	32.21	400	0.29	2.00
Wall	East	External	006 Flat 1	Masonry Block - Filler	24.61	400	0.29	2.00
Wall	West	External	006 Flat 1	Masonry Block - Filler	13.75	400	0.29	2.00
Wall	Inner (002 St...	Internal	006 Flat 1	Masonry Block - Filler	13.16	200	0.53	5 %
Wall	North	External	006 Flat 1	Masonry Block - Filler	4.48	400	0.29	2.00
Ther...	-----	-----	006 Flat 1	D-01 Detail	-----	6000	0.68	-----
Ther...	-----	-----	006 Flat 1	D-01 Detail	-----	6000	0.68	-----

As a result, the **thermal bridge** will be **included in the energy balance simulation** and will influence the building's overall energy performance.

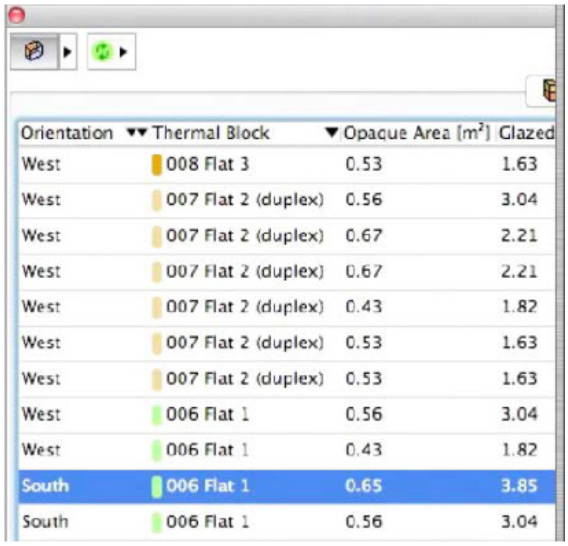
Now, review the characteristics of the transparent surfaces - in other words: the fenestration - of the building envelope. Select all entries on the Openings page of the Energy Model Review palette to highlight all windows in the 3D building energy model view.



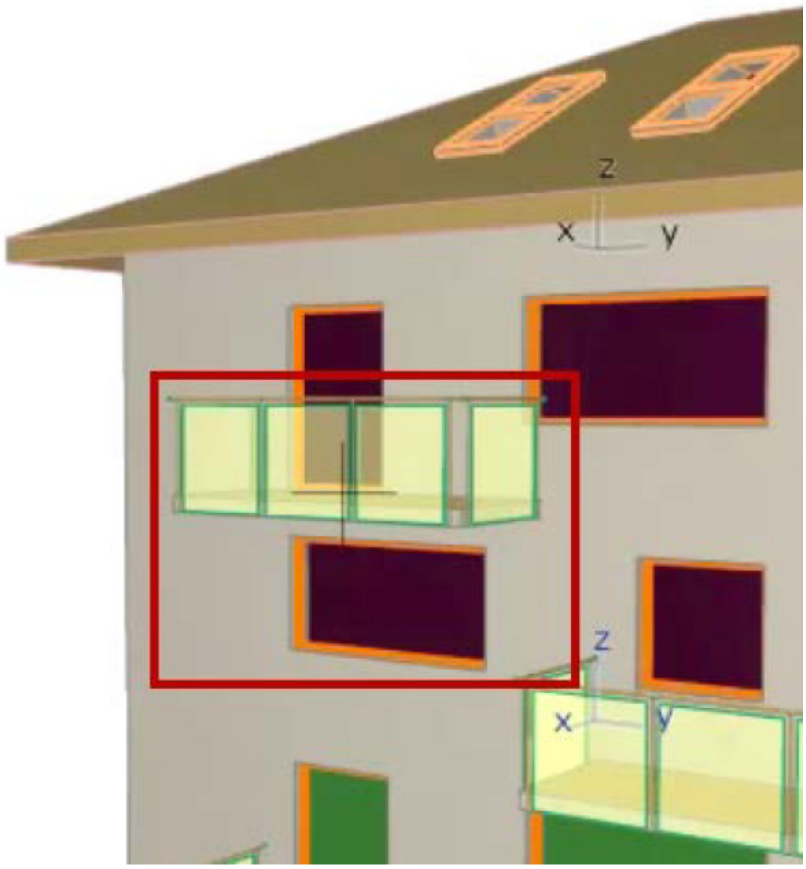
Orientation	Thermal Block	Opaque Area [m²]	Glazed Area [m²]	Total area [m²]
West Up	010 Loft	0.19	1.23	1.42
West Up	010 Loft	0.19	1.23	1.42
West Up	010 Loft	0.19	1.23	1.42
West Up	010 Loft	0.19	1.23	1.42
South Up	010 Loft	0.19	1.23	1.42
South Up	010 Loft	0.19	1.23	1.42
South Up	010 Loft	0.19	1.23	1.42
South Up	010 Loft	0.19	1.23	1.42
South Up	010 Loft	0.19	1.23	1.42
South Up	010 Loft	0.19	1.23	1.42
North Up	010 Loft	0.19	1.23	1.42
North Up	010 Loft	0.19	1.23	1.42
East Up	010 Loft	0.19	1.23	1.42
East Up	010 Loft	0.19	1.23	1.42
West	009 Flat 4	0.56	3.04	3.60
West	009 Flat 4	0.43	1.82	2.25
South	009 Flat 4	0.65	3.85	4.50
South	009 Flat 4	0.56	3.04	3.60
South	009 Flat 4	0.43	1.82	2.25
East	009 Flat 4	0.43	1.82	2.25

ArchiCAD and EcoDesigner STAR can perform model-based solar irradiation studies (**Solar Analysis**) on these transparent building elements.

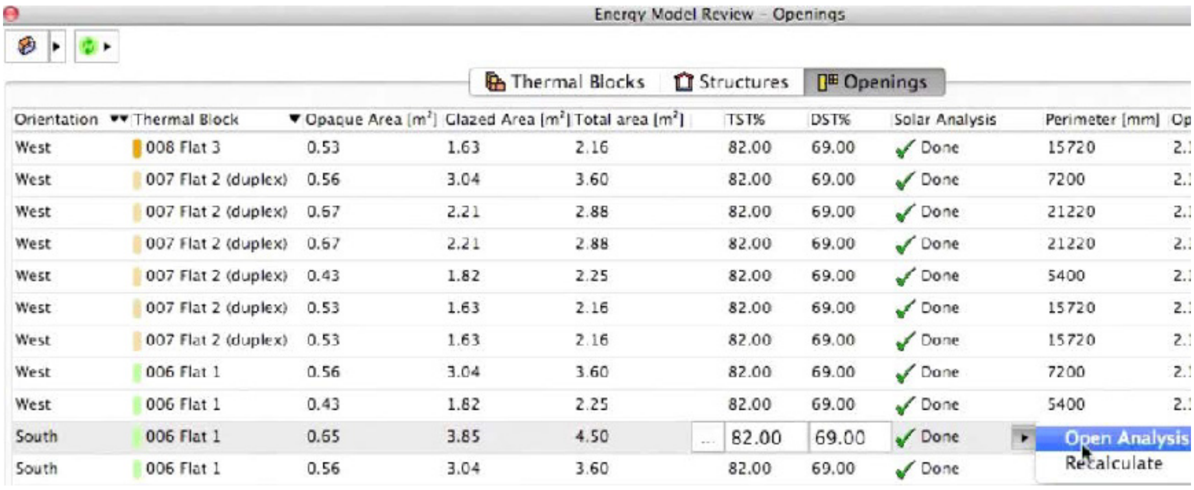
Looking at the building's geometry, we expect the selected window to be partially shaded by the balcony above it.



Orientation	Thermal Block	Opaque Area [m²]	Glazed
West	008 Flat 3	0.53	1.63
West	007 Flat 2 (duplex)	0.56	3.04
West	007 Flat 2 (duplex)	0.67	2.21
West	007 Flat 2 (duplex)	0.67	2.21
West	007 Flat 2 (duplex)	0.43	1.82
West	007 Flat 2 (duplex)	0.53	1.63
West	007 Flat 2 (duplex)	0.53	1.63
West	006 Flat 1	0.56	3.04
West	006 Flat 1	0.43	1.82
South	006 Flat 1	0.65	3.85
South	006 Flat 1	0.56	3.04

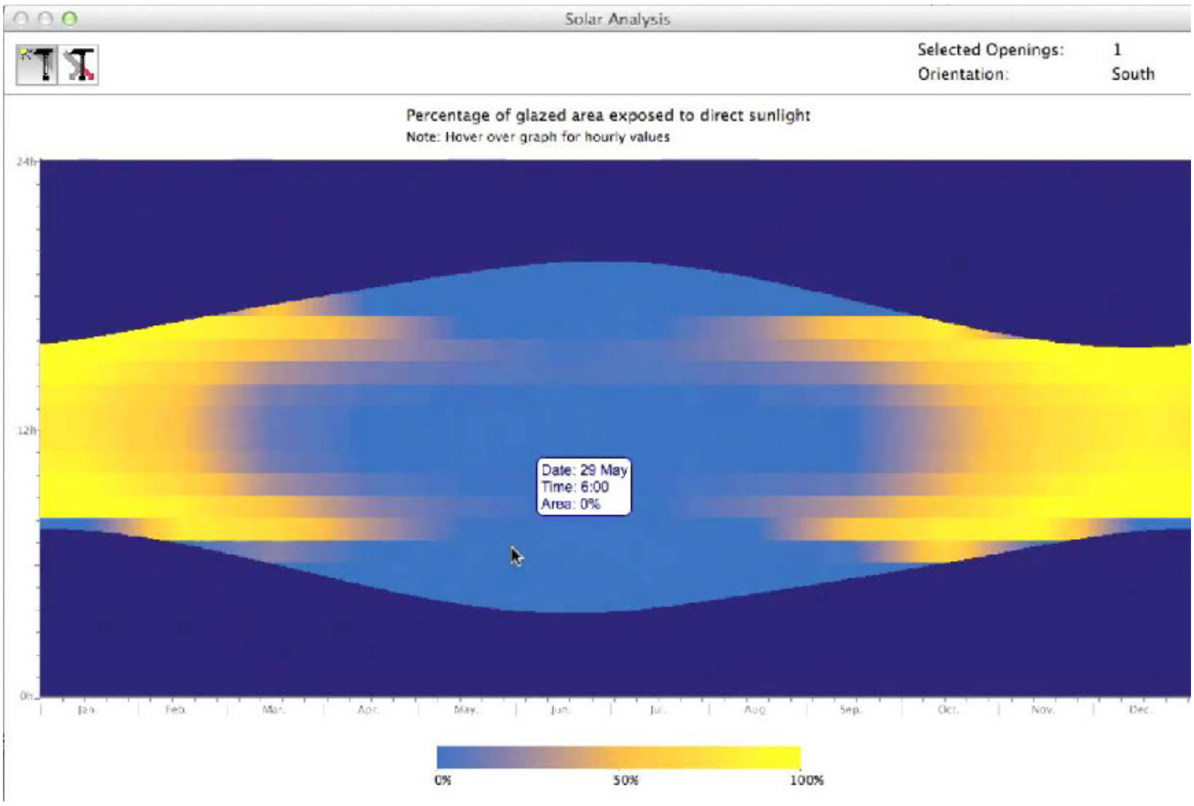


Run the model-based solar irradiation study to determine the annual shadow mask on this window, which has a southern orientation.



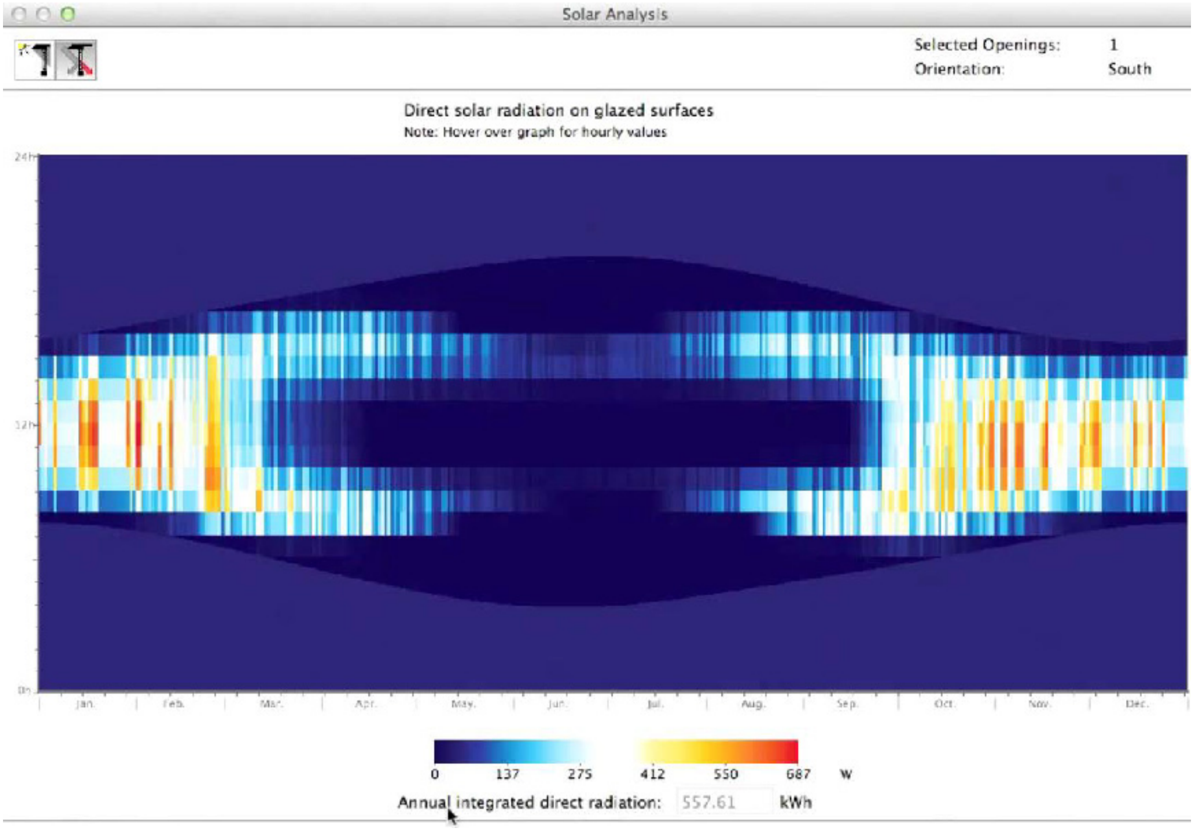
Two diagrams display the results of the Solar Analysis. The horizontal axes show the months of the year, and the vertical axes show the hours of the day.

The yellow color on the **Percentage of glazed area diagram** represents the times of the year when the selected window receives direct sunshine. The blue color represents the times of the year when the window is shaded by the balcony above it. Hover the cursor over the diagram to identify the days and times of the year, and to read the portion of the un-shaded area on that specific date and time.



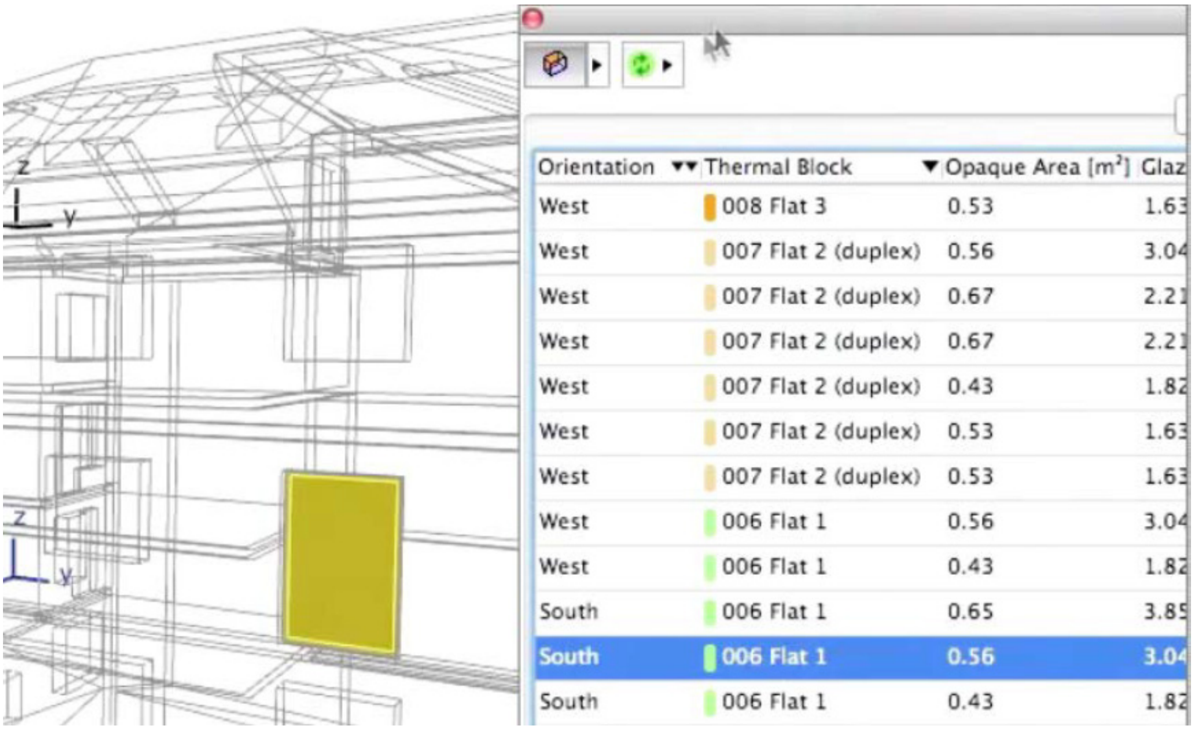
Clearly, during the summer - when the direct solar radiation's angle of incidence is high - the window is shaded by the balcony.

The **Direct solar radiation on glazed surfaces diagram** also considers the effect of cloudy days as defined in the weather file. Based on this input, the program calculates the Annual Integrated Direct Irradiation value, displayed at the bottom of the Solar Analysis dialog.

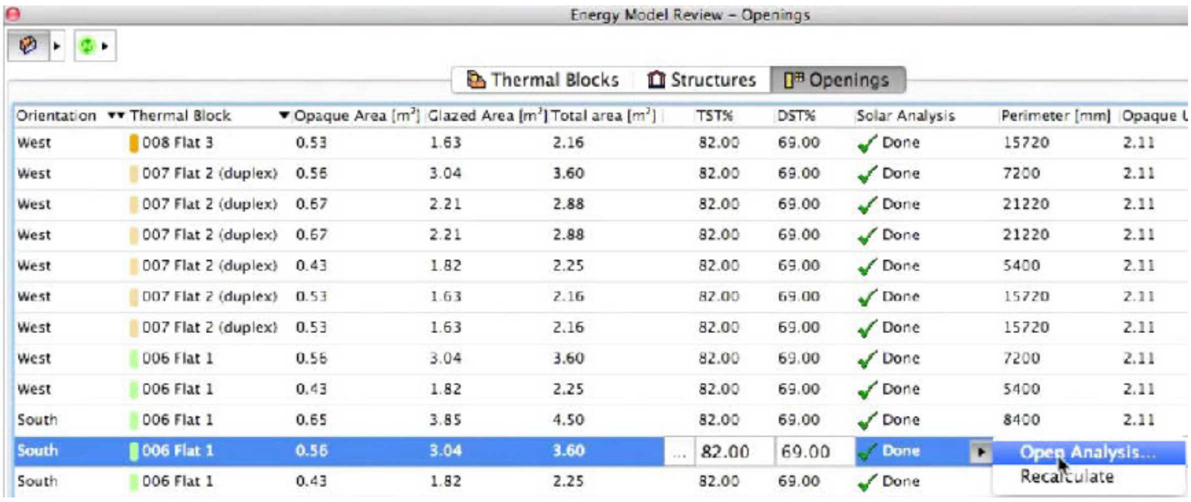


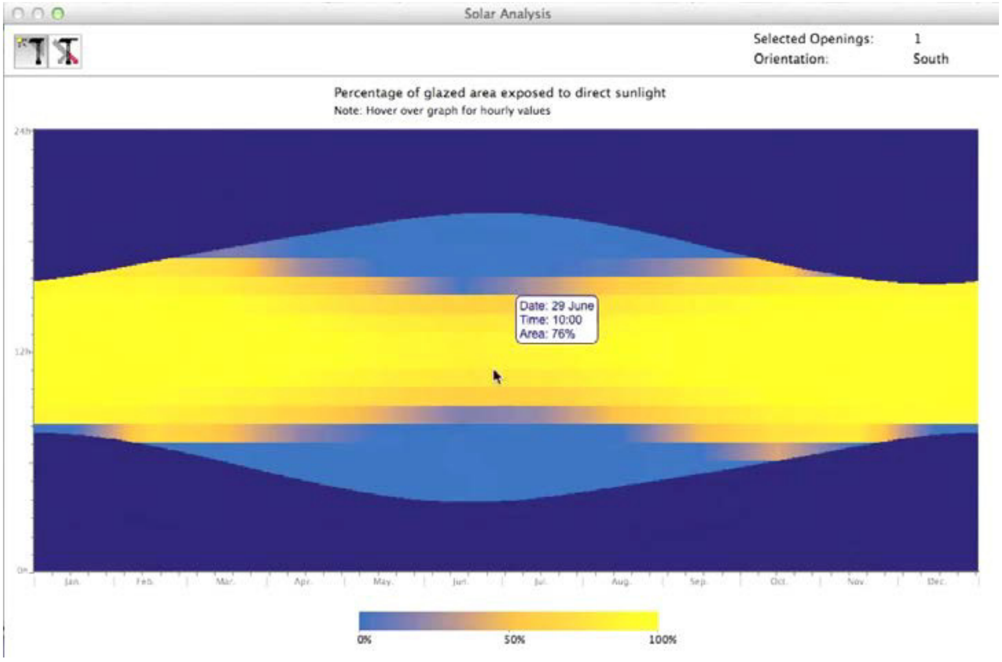
Note that this value is specific to the selected window and depends on its position in the building envelope.

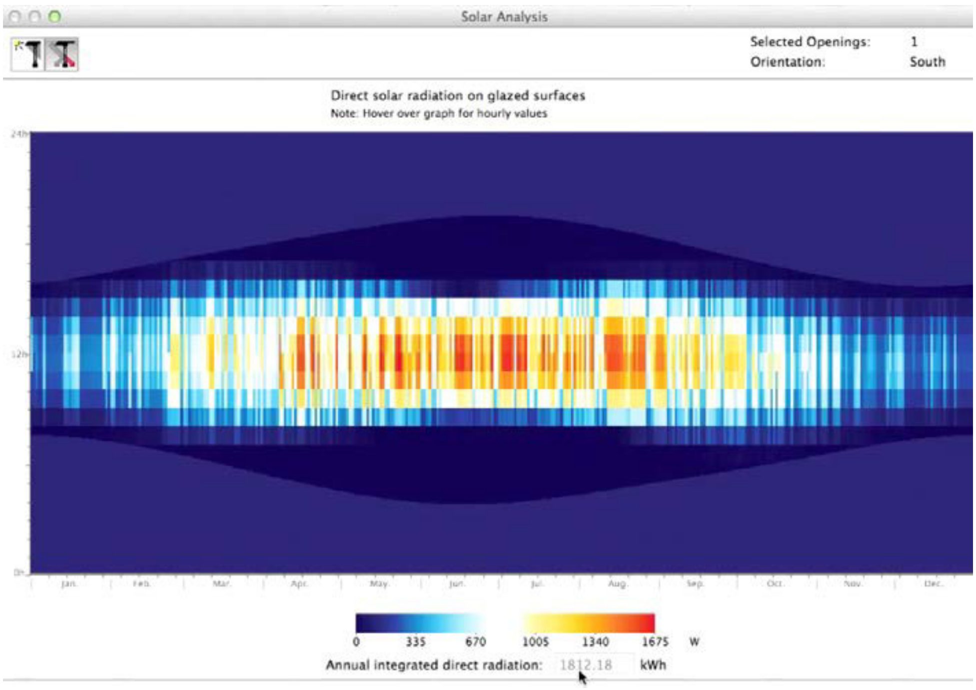
As a second example, select another southern window – this time one that is not shaded by a balcony



- and visualize the corresponding solar irradiation study results.

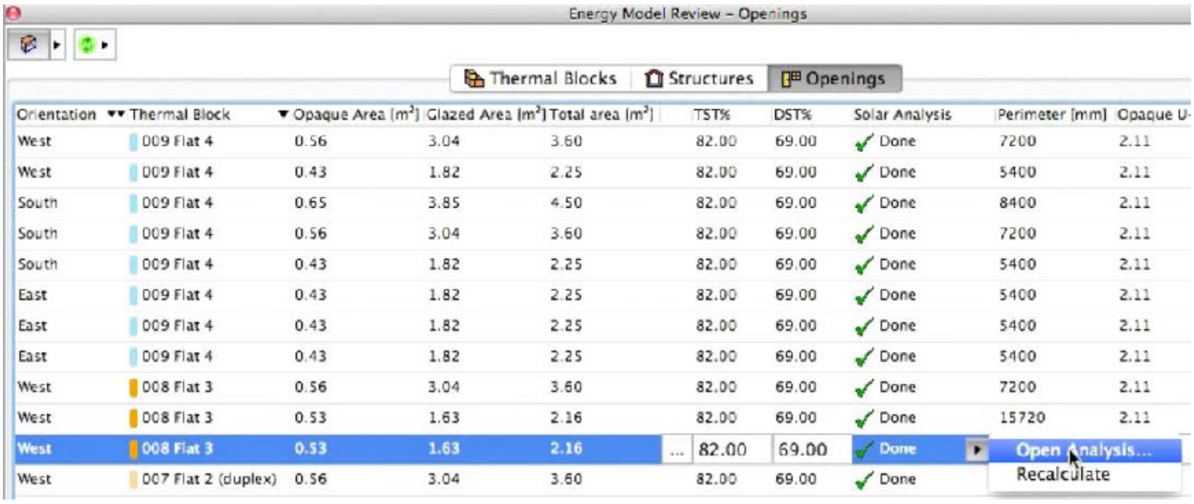


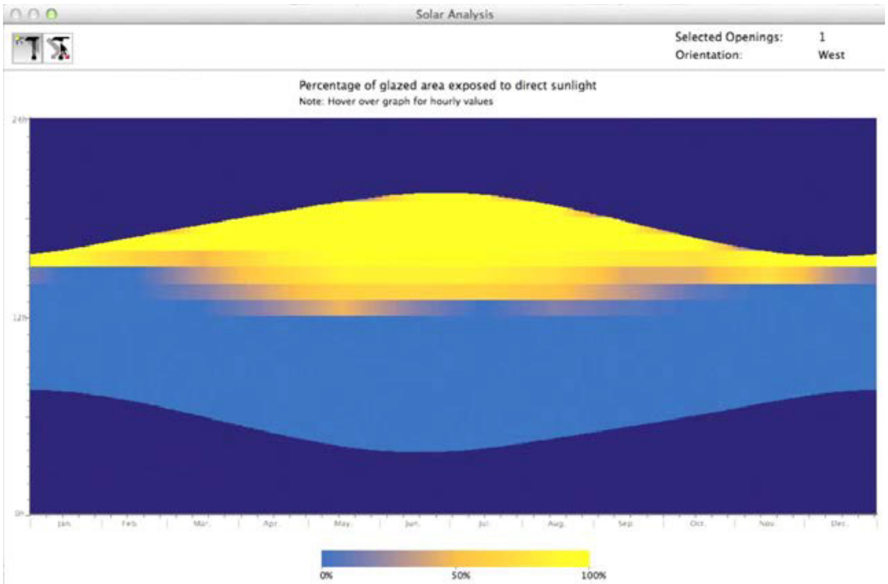




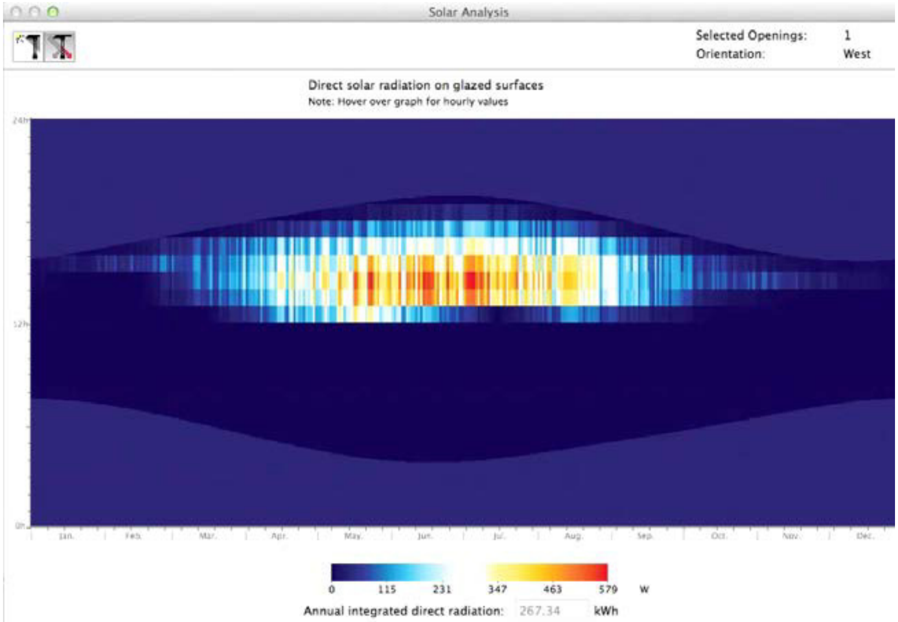
You can see that this window is not shaded during the hot summer months. Consequently, the annual integrated direct solar radiation value, automatically assigned by the Solar Analysis, is much higher.

Now investigate a western window.



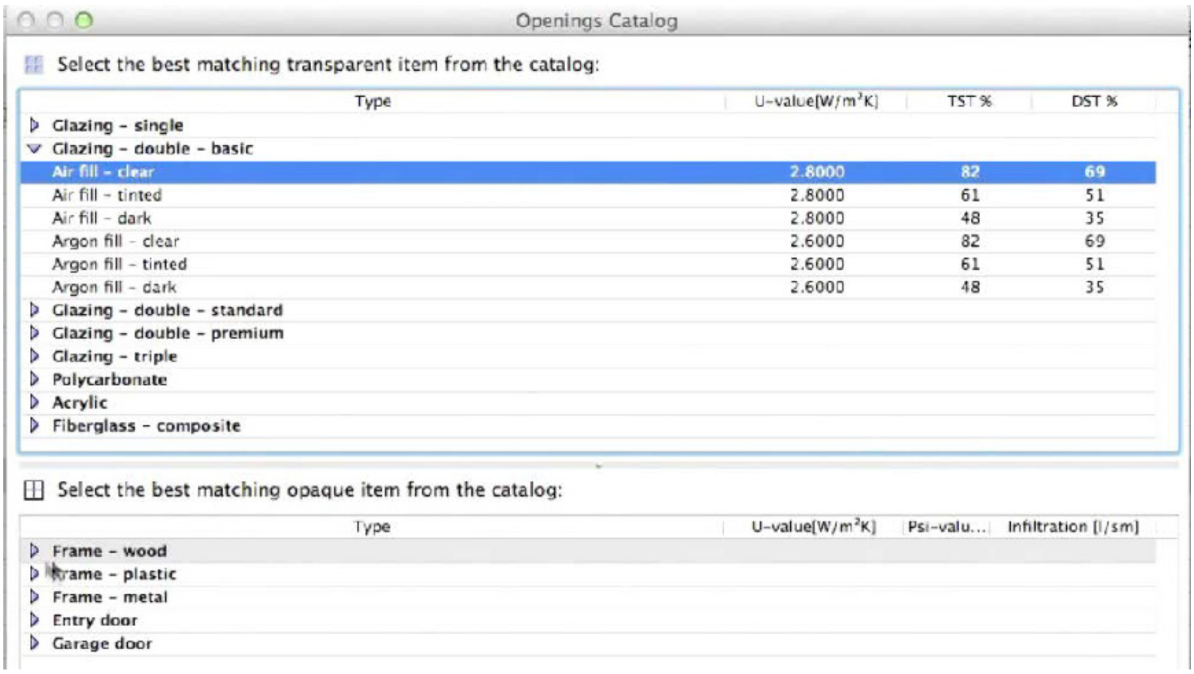


Note that in this case the direct solar irradiation is present only in the afternoons, due to the window’s western orientation.



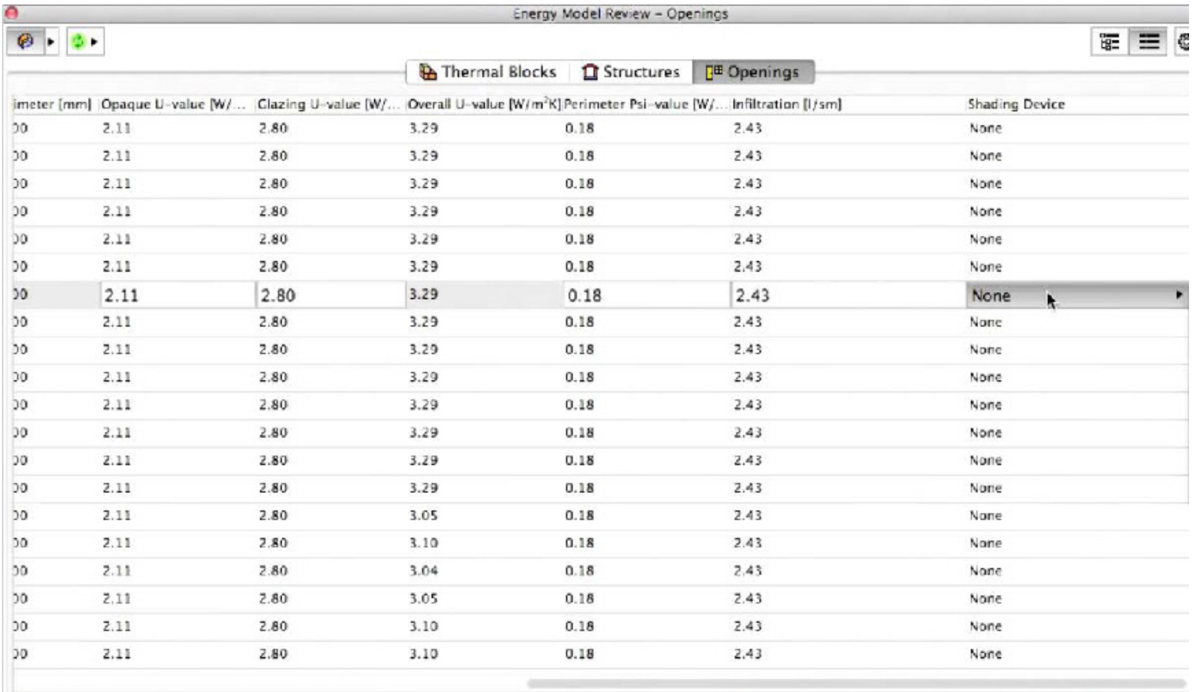
The annual integrated direct solar radiation value is automatically calculated for this window, too.

Edit the **windows' thermal characteristics** using the Openings page of the Energy Model Review palette. Glazing and frame characteristics can be assigned to the ArchiCAD BIM model elements using the Openings Catalog.



You can also provide individual values for each element as needed. In the example building model, we have already assigned some basic glazing and frames from the catalog to the windows.

Note that the Opening list also contains the **infiltration** properties of every window. In the current state of the design – prior to building energy optimization – these are set to rather high values. There are no shading devices assigned to the openings, either.



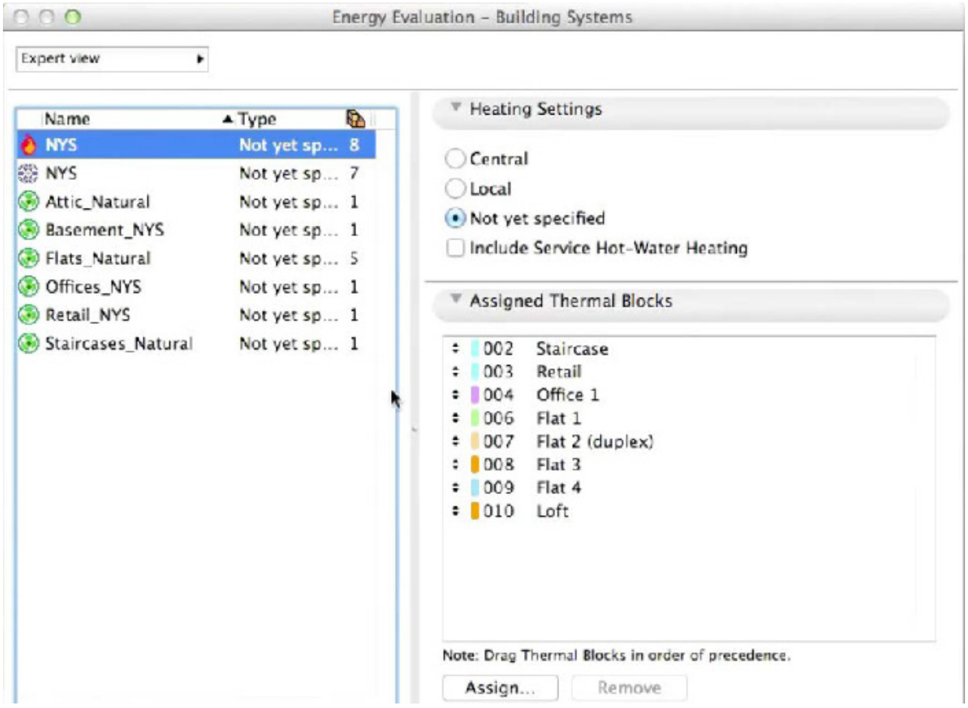
imeter [mm]	Opaque U-value [W/...	Glazing U-value [W/...	Overall U-value [W/m²K]	Perimeter Psi-value [W/...	Infiltration [l/sm]	Shading Device
00	2.11	2.80	3.29	0.18	2.43	None
00	2.11	2.80	3.29	0.18	2.43	None
00	2.11	2.80	3.29	0.18	2.43	None
00	2.11	2.80	3.29	0.18	2.43	None
00	2.11	2.80	3.29	0.18	2.43	None
00	2.11	2.80	3.29	0.18	2.43	None
00	2.11	2.80	3.29	0.18	2.43	None
00	2.11	2.80	3.29	0.18	2.43	None
00	2.11	2.80	3.29	0.18	2.43	None
00	2.11	2.80	3.29	0.18	2.43	None
00	2.11	2.80	3.29	0.18	2.43	None
00	2.11	2.80	3.29	0.18	2.43	None
00	2.11	2.80	3.29	0.18	2.43	None
00	2.11	2.80	3.29	0.18	2.43	None
00	2.11	2.80	3.05	0.18	2.43	None
00	2.11	2.80	3.10	0.18	2.43	None
00	2.11	2.80	3.04	0.18	2.43	None
00	2.11	2.80	3.05	0.18	2.43	None
00	2.11	2.80	3.10	0.18	2.43	None
00	2.11	2.80	3.10	0.18	2.43	None

All these settings will be reflected in the results of the overall energy balance calculations.

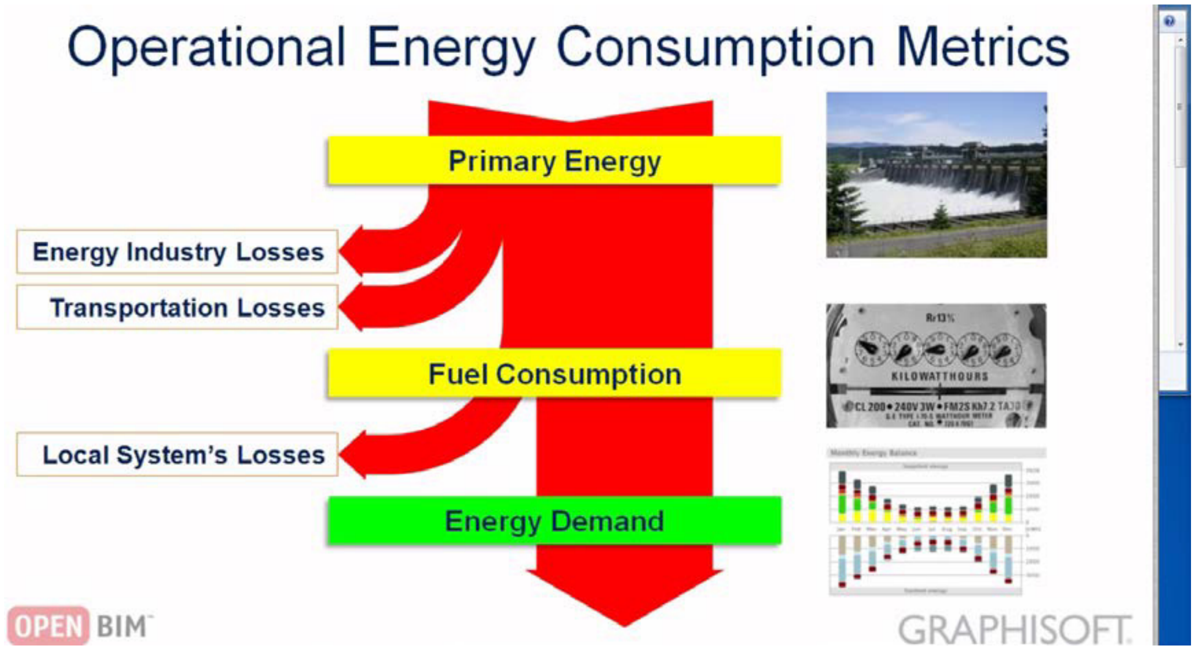
4.2 Run Energy Simulation (Demand Calculation)

So far we have defied the geometry of the building, created 3D zones and thermal blocks based on the zones, and defined the thermal properties of the building structures and the openings.

Note: we have not yet defined any actual building systems. In the Building Systems dialog, the list of building systems - used for heating, cooling and for ventilation - is displayed. Every system assigned to the project at this stage is set to “Not Yet Specified”. This is the setting used in EcoDesigner STAR for **energy demand calculation**.



Take a closer look at operational **energy consumption metrics** to fully understand the different terms that describe energy usage.



The energy balance simulation is used to calculate the building's **Energy Demand**, indicated by the green color at the bottom of the diagram. Energy Demand represents the amount of energy needed to heat up or to cool down the building in order to provide appropriate internal thermal comfort throughout the year. No additional information is need about the building systems if we are interested only in the building's energy demand. We only need to specify whether the systems exist or not.

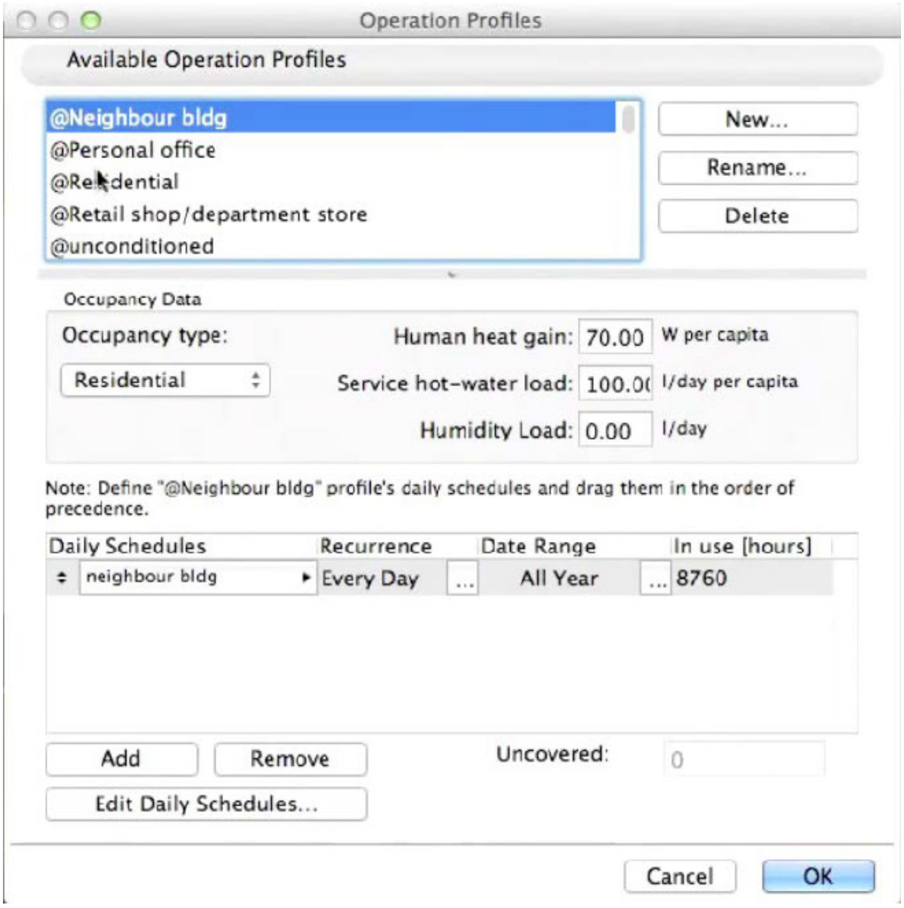
However, if we are also interested in the **Fuel Consumption** of the building, then the building system characteristics must be entered. In this case, the simulation considers system efficiencies in order to determine building system-related energy losses. Not every system is able to satisfy all demands, and machines are not equally efficient under different loads, either. Yet all these factors influence fuel consumption, so proper building systems data input is inevitable at this stage.

Based on Fuel Consumption, EcoDesigner STAR also calculates the **Primary Energy** consumption of the building. The calculation method is similar to that used by the program to obtain the Fuel Cost or the Carbon Footprint results: the fuel consumption data is multiplied with the relevant coefficient in each case.

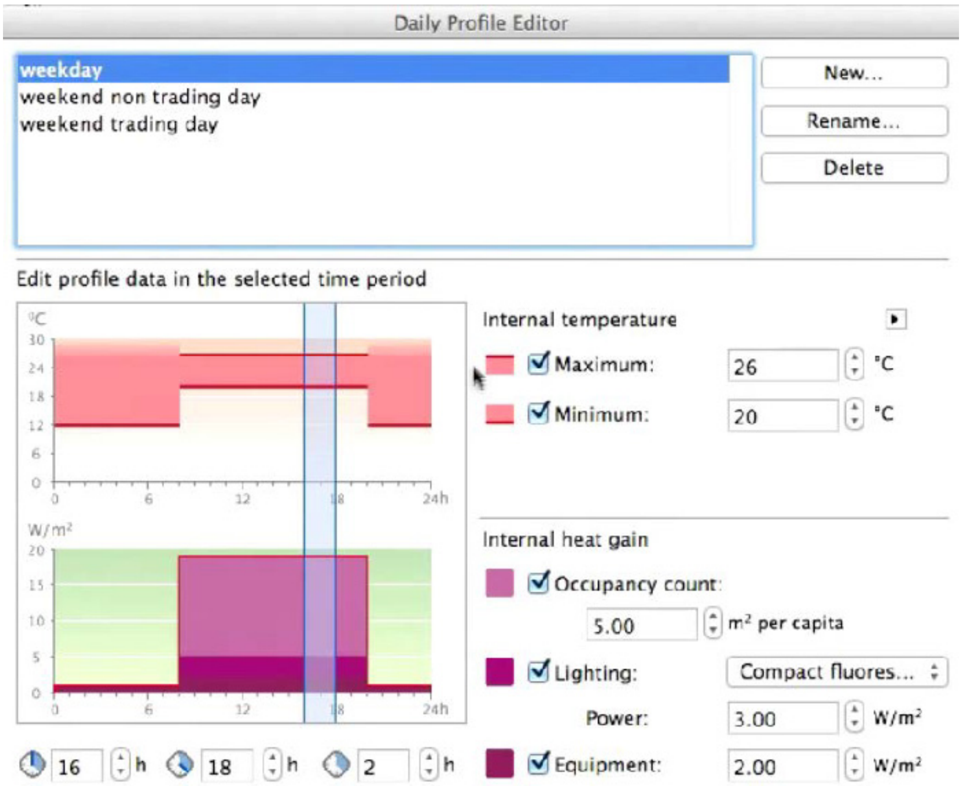
At this phase, however, we are only interested in calculating the Energy Demand of the building project. This building energy performance metric is strictly proportional to the architectural design, so it is an excellent indicator of the success of our low-energy building design efforts.

No building system characteristics are input for this round of calculations yet: heating, cooling and ventilation are all defined as "**Not Yet Specified**" **building systems**. (Later we will configure these systems for the Fuel Consumption calculations.)

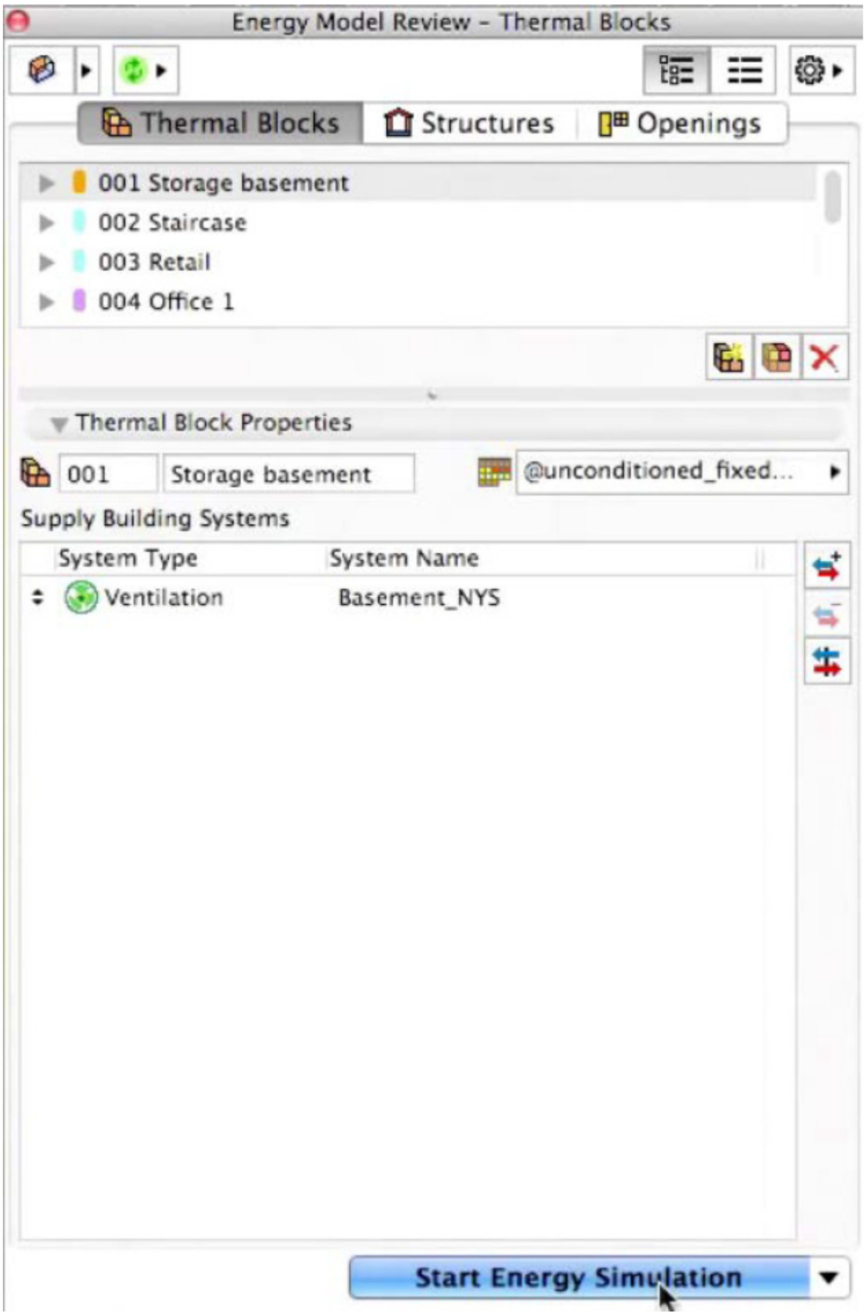
Operation Profiles for the building are also required for the calculations. Each thermal block must be assigned an operation profile (profiles can be modified and new ones created).



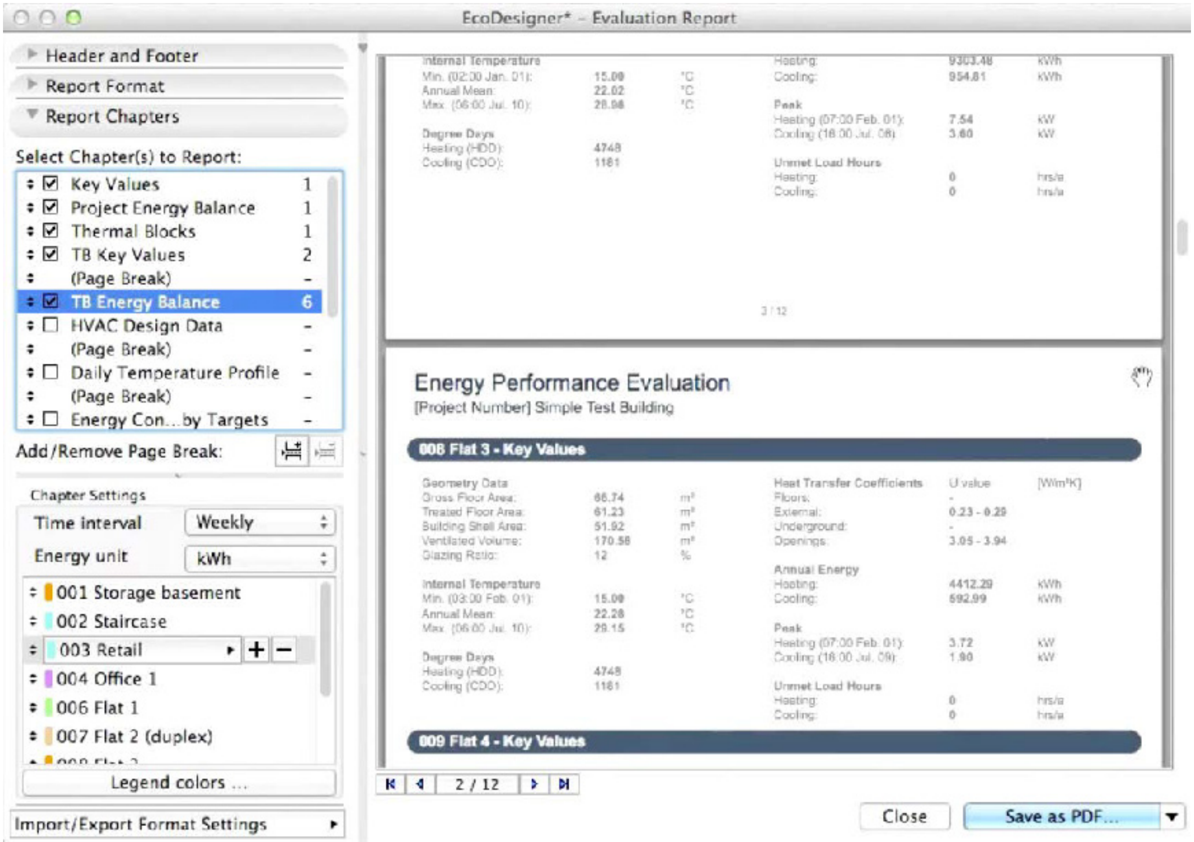
The Daily Profile Editor dialog displays the editable profile data for the selected reference day. Here, you can set the required internal maximum and minimum temperatures for each thermal block and specify the characteristics of internal heat gains. Multiple reference days can be created and scheduled to cover the entire calculation year.



We are now ready to run the first round of simulations. Click the **“Start Energy Simulation”** button. The dynamic energy analysis is executed by EcoDesigner STAR for the entire year, on an hourly basis. This will take a couple of minutes.



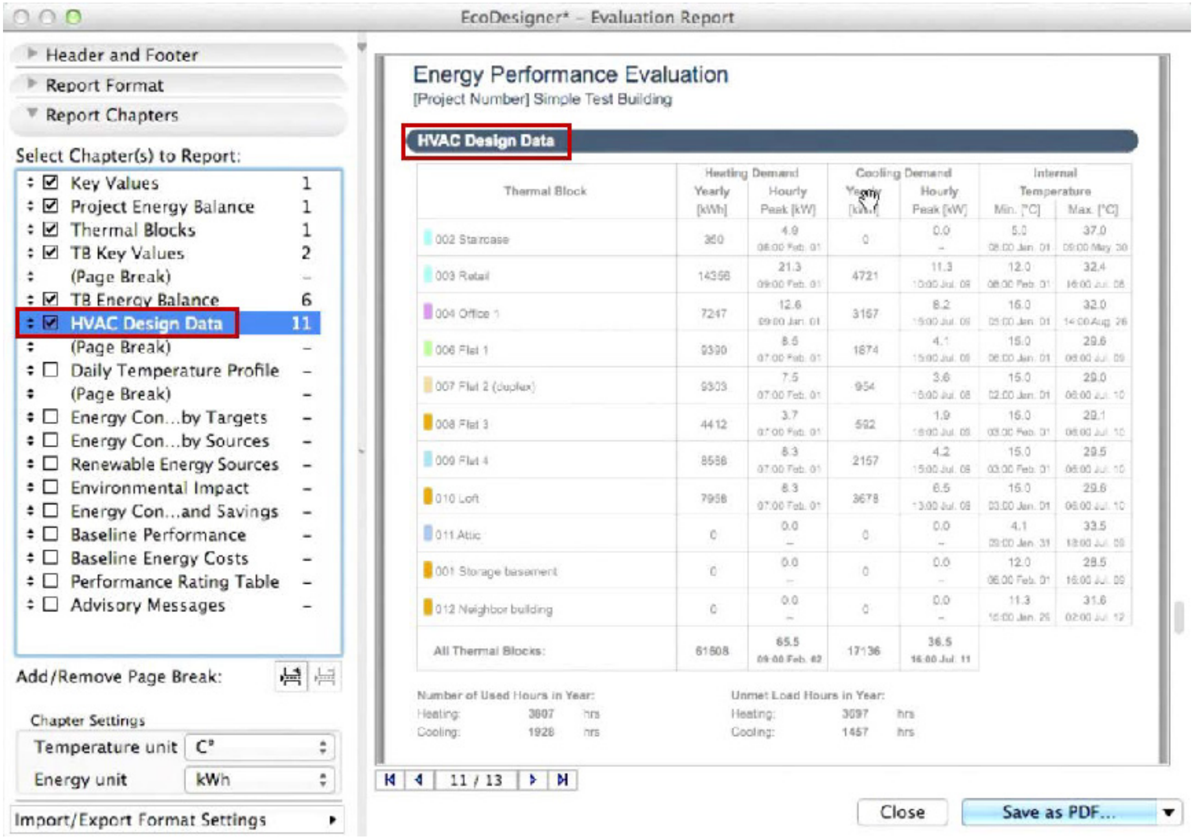
When the energy simulation is complete, the **Energy Performance Evaluation report** is displayed. The content of the report can be customized by selecting the required chapters from the list on the left.



In this case, we wish to include the chapters relevant for the energy demand calculation: the Project Key Values, the Project Energy Balance, Thermal Block geometry information, the Key Values of each individual thermal block, and the Energy Balance diagrams of the thermal blocks. You can see the Thermal Block Energy Balances one by one - note how different they are!

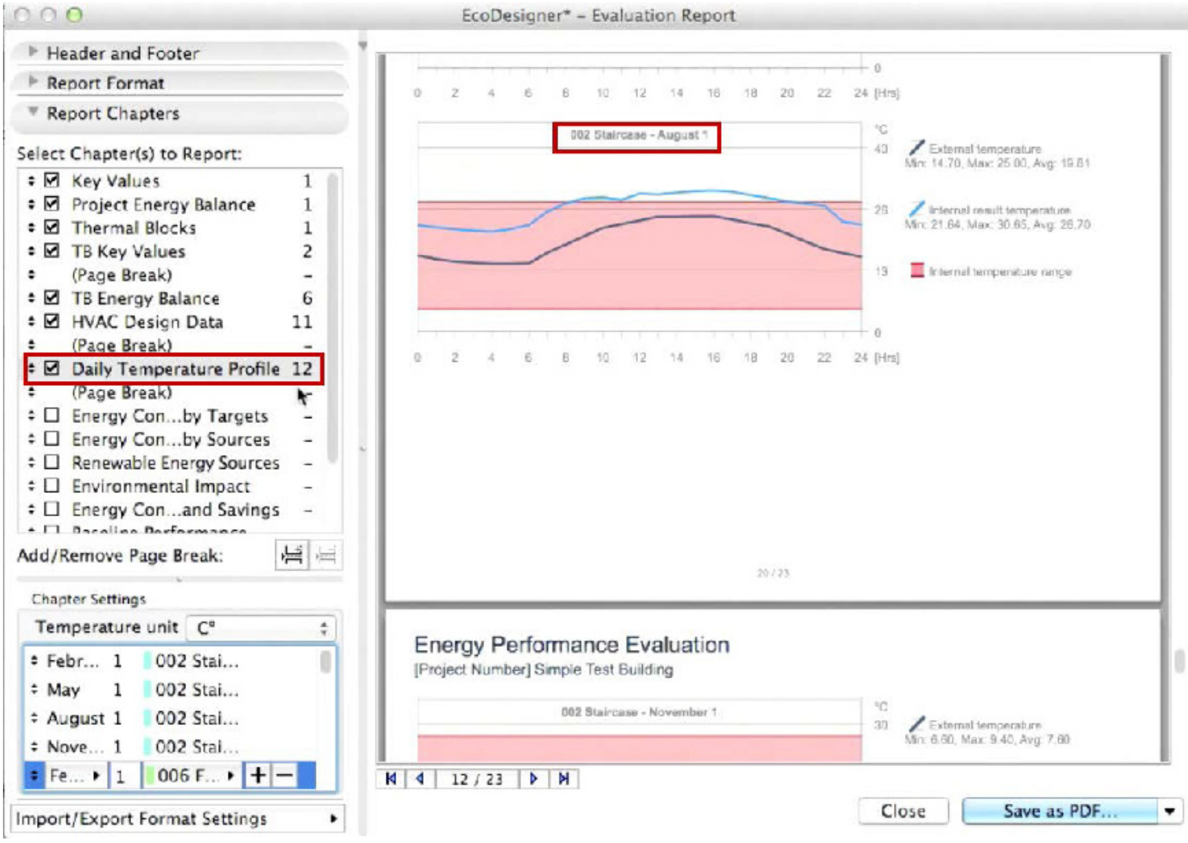
EcoDesigner STAR allows you to study and fine-tune the energy performance of each thermal block, individually. In contrast, the built-in Energy Evaluation feature of ArchiCAD only displays the project’s energy balance, but does not provide Energy Balance Diagrams of the individual thermal blocks. The availability of **thermal block energy performance output** is a major feature difference between ArchiCAD’s standard Energy Evaluation function and EcoDesigner STAR. EcoDesigner STAR provides far more details about the project’s energy characteristics.

The HVAC Design Data chapter of the report contains the most important output of the calculation: peak loads, annual loads and annual unmet load hours.

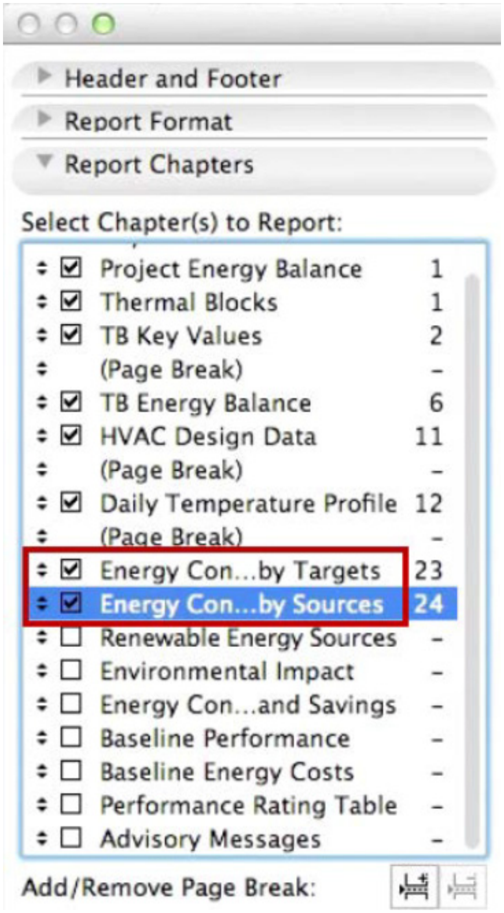


Include Daily Temperature Profiles in the Energy Performance Evaluation PDF document to display temperature values for specific days of the year. Such days can be the coldest and the hottest day, and/or the days when peak loads occur.

We can also specify days representing the typical spring, summer, autumn and winter conditions. Daily Temperature Profiles for any of the thermal blocks can be selected for documentation.



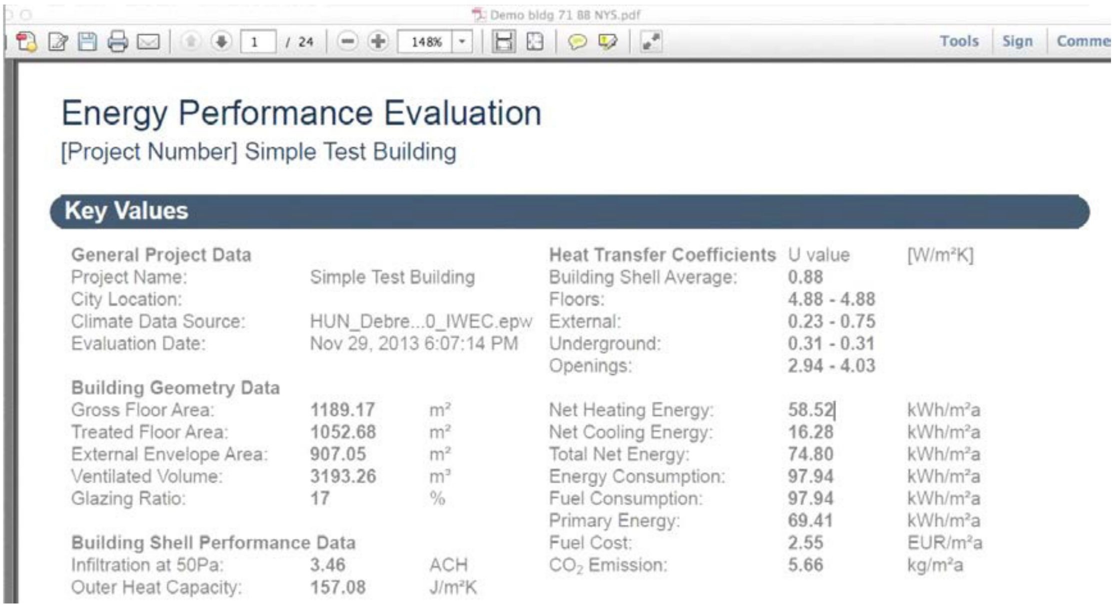
Also select the Energy Consumption by Targets and Energy Consumption by Sources chapters. These are less relevant for now, since no building systems have been defined yet, but are good for validating the demand calculation.



Finally, click **"Save as PDF**" to save the Energy Performance Evaluation report as a PDF document.

4.3 Review Baseline Building's Energy Performance

Open the previously created Energy Performance Evaluation report. This represents the project in its so called "**baseline**" design state, before any low-energy building solution is applied.



Energy Performance Evaluation

[Project Number] Simple Test Building

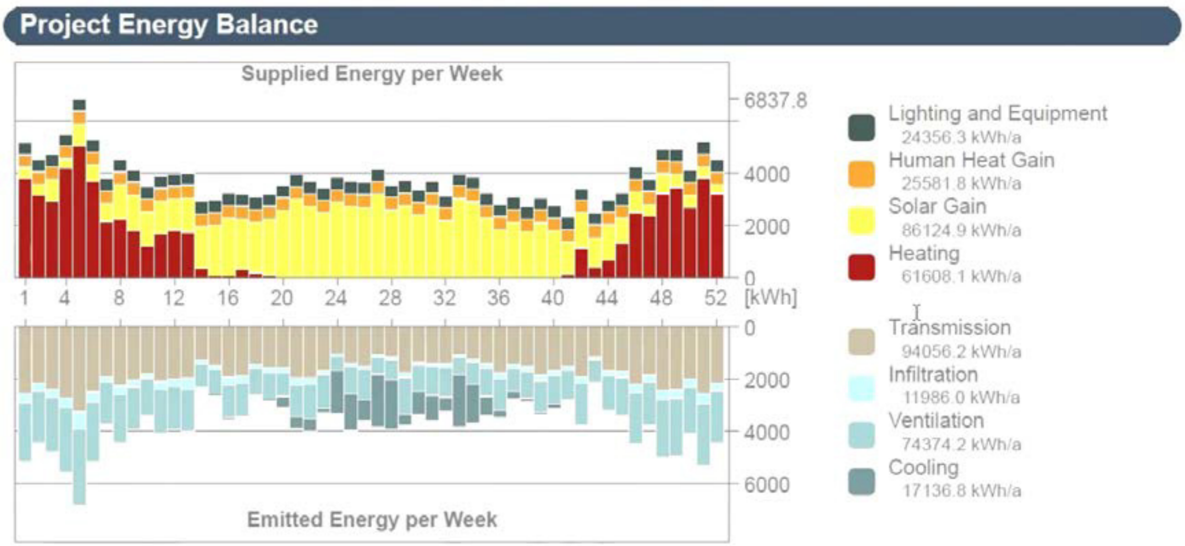
Key Values

General Project Data			Heat Transfer Coefficients	U value	[W/m²K]
Project Name:	Simple Test Building		Building Shell Average:	0.88	
City Location:			Floors:	4.88 - 4.88	
Climate Data Source:	HUN_Debre...0_IWEC.epw		External:	0.23 - 0.75	
Evaluation Date:	Nov 29, 2013 6:07:14 PM		Underground:	0.31 - 0.31	
			Openings:	2.94 - 4.03	
Building Geometry Data					
Gross Floor Area:	1189.17	m²	Net Heating Energy:	58.52	kWh/m²a
Treated Floor Area:	1052.68	m²	Net Cooling Energy:	16.28	kWh/m²a
External Envelope Area:	907.05	m²	Total Net Energy:	74.80	kWh/m²a
Ventilated Volume:	3193.26	m³	Energy Consumption:	97.94	kWh/m²a
Glazing Ratio:	17	%	Fuel Consumption:	97.94	kWh/m²a
			Primary Energy:	69.41	kWh/m²a
Building Shell Performance Data			Fuel Cost:	2.55	EUR/m²a
Infiltration at 50Pa:	3.46	ACH	CO_2 Emission:	5.66	kg/m²a
Outer Heat Capacity:	157.08	J/m²K			

The next step is to use this baseline energy evaluation report to determine the most appropriate, low-energy design strategy for our project.

Remember: we've specified mediocre building structures and openings for the baseline design. Therefore, the building shell's average heat transfer coefficient, for example, is rather high.

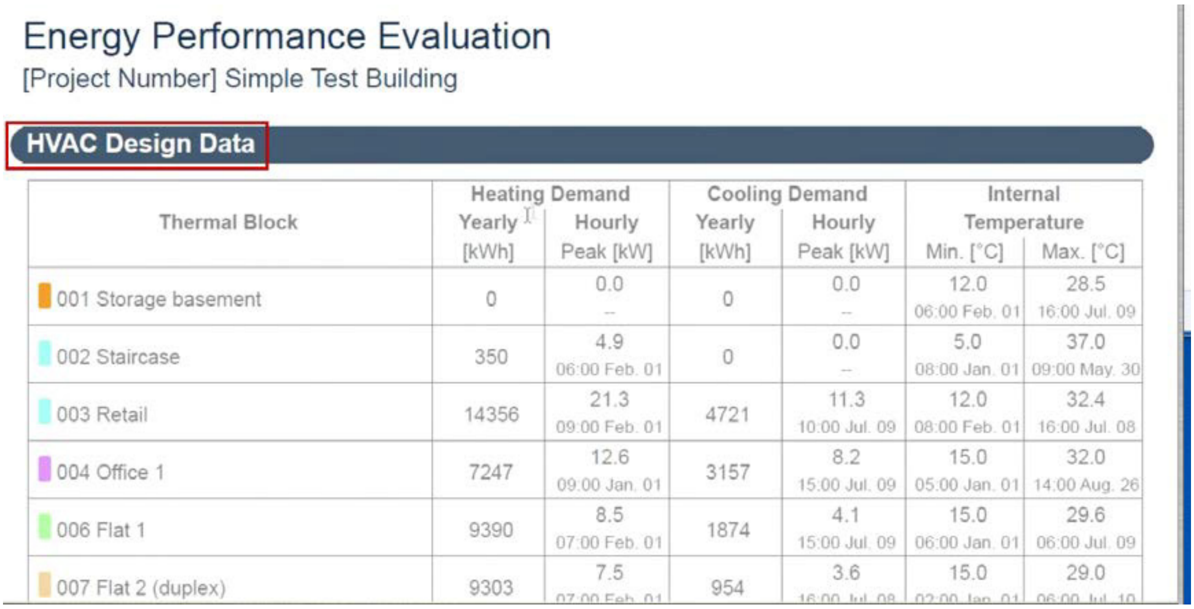
Take a look at the **Project Energy Balance**. Heat loss via transmission is significant throughout the year.



Earlier, we specified a fairly high infiltration rate for the openings, so it is not surprising that the building shell's overall infiltration at 50 Pa (Pascal) pressure is 3 air changes per hour - a high value. In contrast, the passive house standard requires this value to be below 0.5! Still, the effect of the infiltration (represented in light blue on the energy balance diagram) is not as significant as the transmission (represented in light brown in the lower part of the diagram).

The upper part of the diagram uses red to show the **heating demand** during the cold months of the year. The heating demand is really high for the baseline building. This is no surprise: we have already run climate analysis on this site (as presented in the "Climate Analysis" chapter), so we know that winter is cold at our project location. Therefore, the baseline building with its poor envelope characteristics will undoubtedly require a lot of heating.

In the **HVAC Design Data** chapter of the Energy Performance Evaluation report, you can see a thermal block-level breakdown of all the yearly and hourly heating and cooling demands. Use these calculation results to determine the characteristics of the building systems.



Energy Performance Evaluation

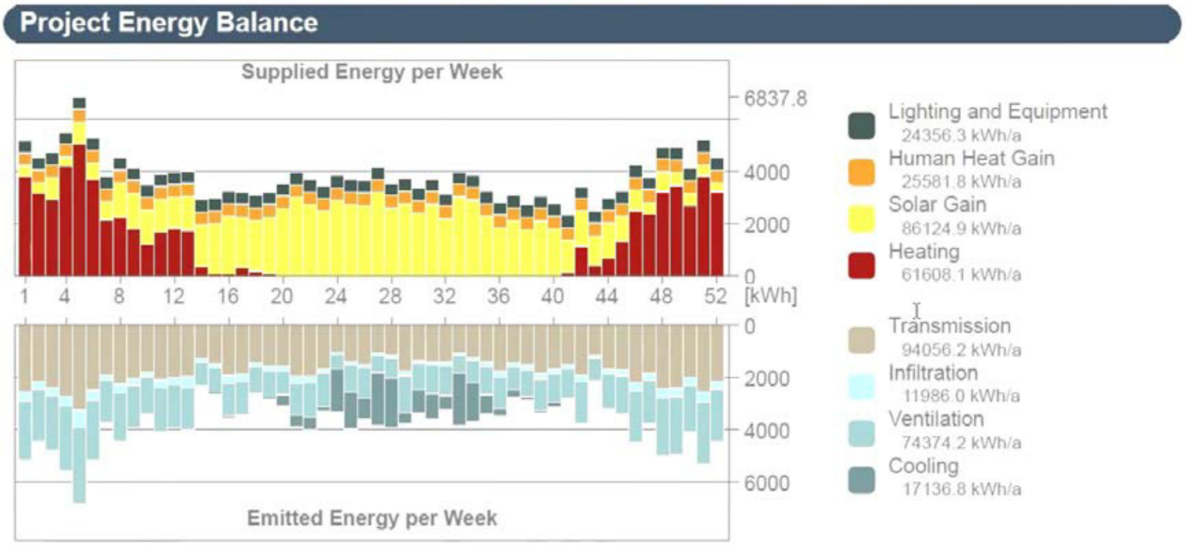
[Project Number] Simple Test Building

HVAC Design Data

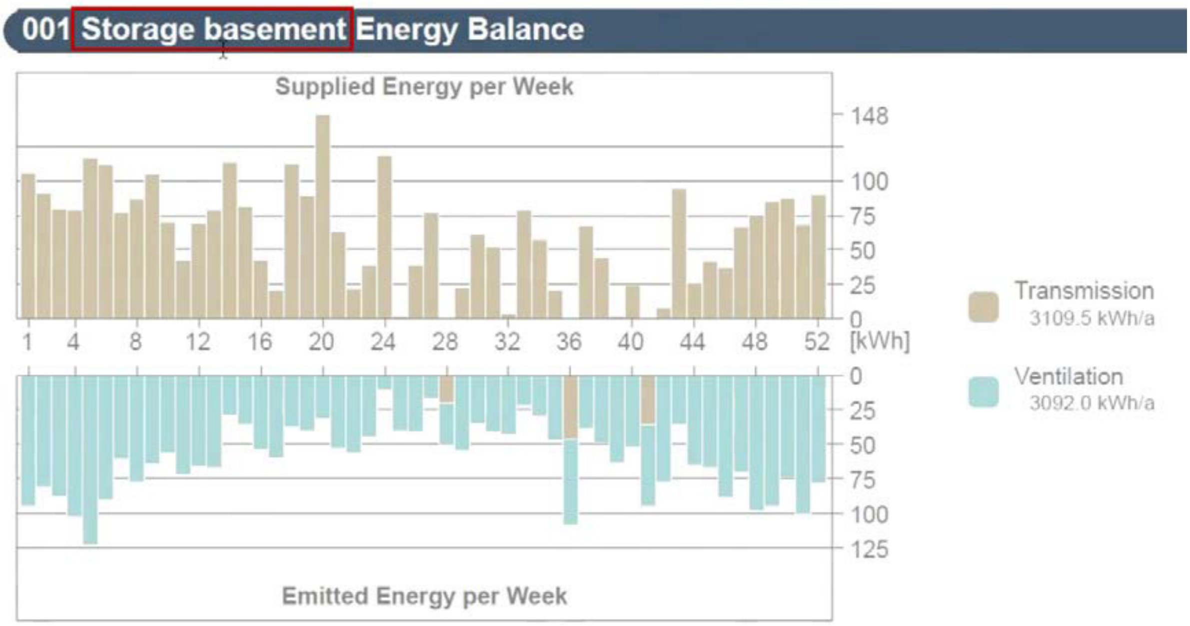
Thermal Block	Heating Demand Yearly [kWh]	Heating Demand Hourly Peak [kW]	Cooling Demand Yearly [kWh]	Cooling Demand Hourly Peak [kW]	Internal Temperature Min. [°C]	Internal Temperature Max. [°C]
001 Storage basement	0	0.0 --	0	0.0 --	12.0 06:00 Feb. 01	28.5 16:00 Jul. 09
002 Staircase	350	4.9 06:00 Feb. 01	0	0.0 --	5.0 08:00 Jan. 01	37.0 09:00 May. 30
003 Retail	14356	21.3 09:00 Feb. 01	4721	11.3 10:00 Jul. 09	12.0 08:00 Feb. 01	32.4 16:00 Jul. 08
004 Office 1	7247	12.6 09:00 Jan. 01	3157	8.2 15:00 Jul. 09	15.0 05:00 Jan. 01	32.0 14:00 Aug. 26
006 Flat 1	9390	8.5 07:00 Feb. 01	1874	4.1 15:00 Jul. 09	15.0 06:00 Jan. 01	29.6 06:00 Jul. 09
007 Flat 2 (duplex)	9303	7.5 07:00 Feb. 01	954	3.6 16:00 Jul. 08	15.0 02:00 Jan. 01	29.0 06:00 Jul. 10

We did not specify any shading devices for the baseline building's openings, so the **cooling demand** during the hot season is quite significant. Still, it is not as dominant as the heating demand, due to the project-specific climate conditions.

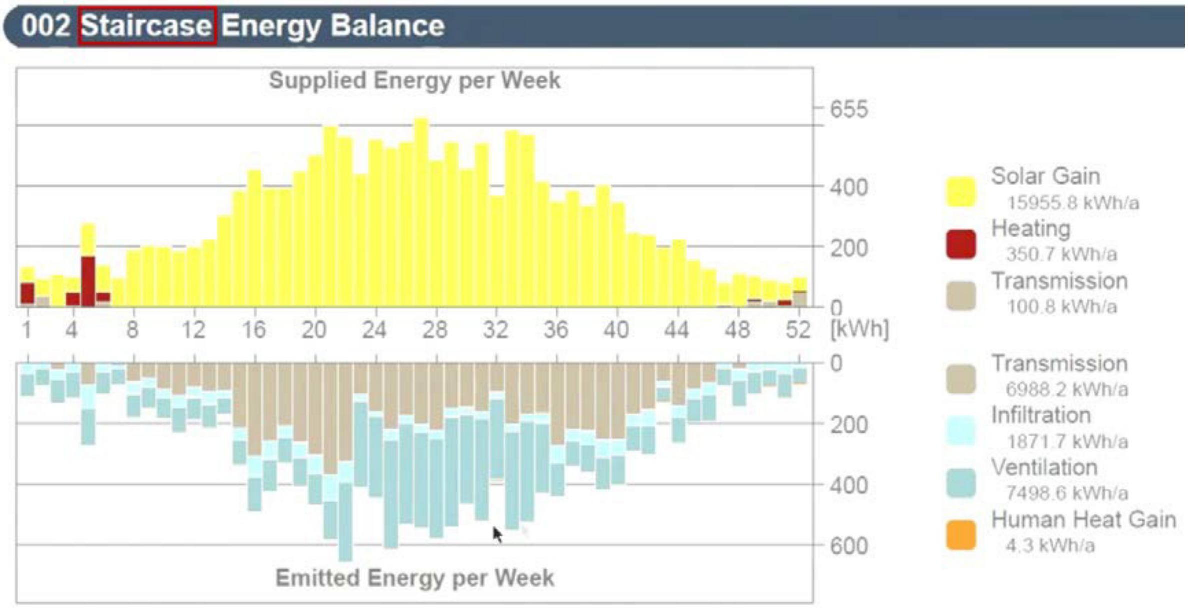
Under Project Energy Balance, you can see that the solar gain - represented in yellow on the top diagram - is compensated by the cooling demand - represented in dark green on the lower diagram.



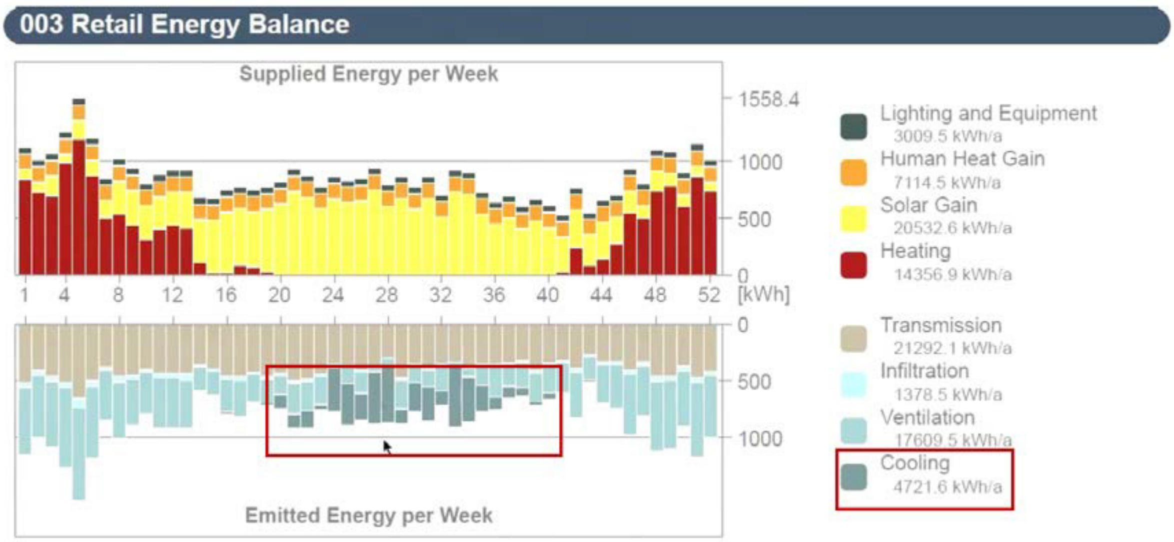
Use the **Thermal Block Energy Balances** to compare the energy performances of the thermal blocks. For example: there is certainly no solar gain in the underground storage area.



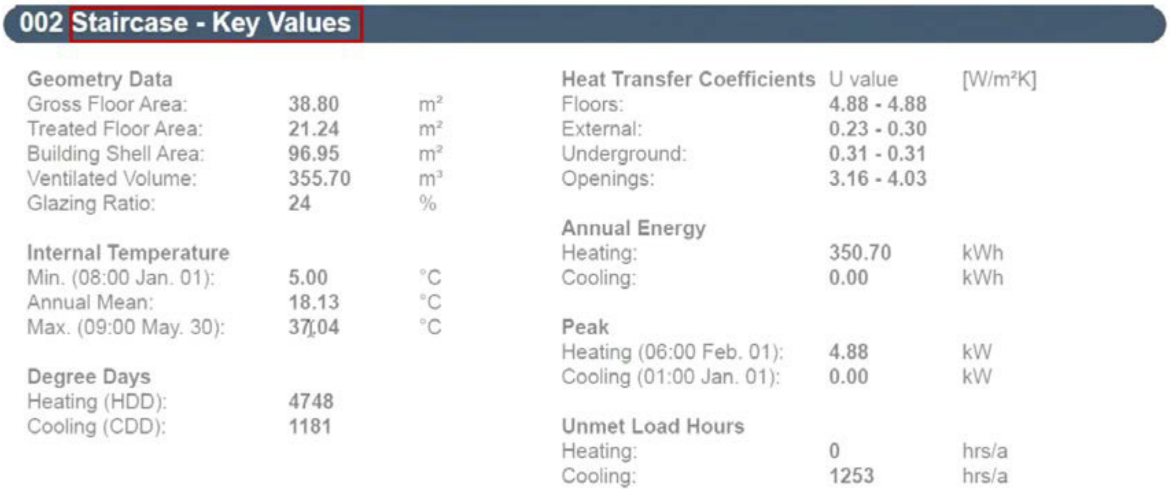
But there is a huge solar gain in the staircase! There is no cooling demand in the staircase block, because there is no system (not even “Not Yet Specified”) assigned to it.



Cooling demand, however, does appear for all the rest of the conditioned spaces (e.g. Retail) to which “Not Yet Specified” coolers were assigned.



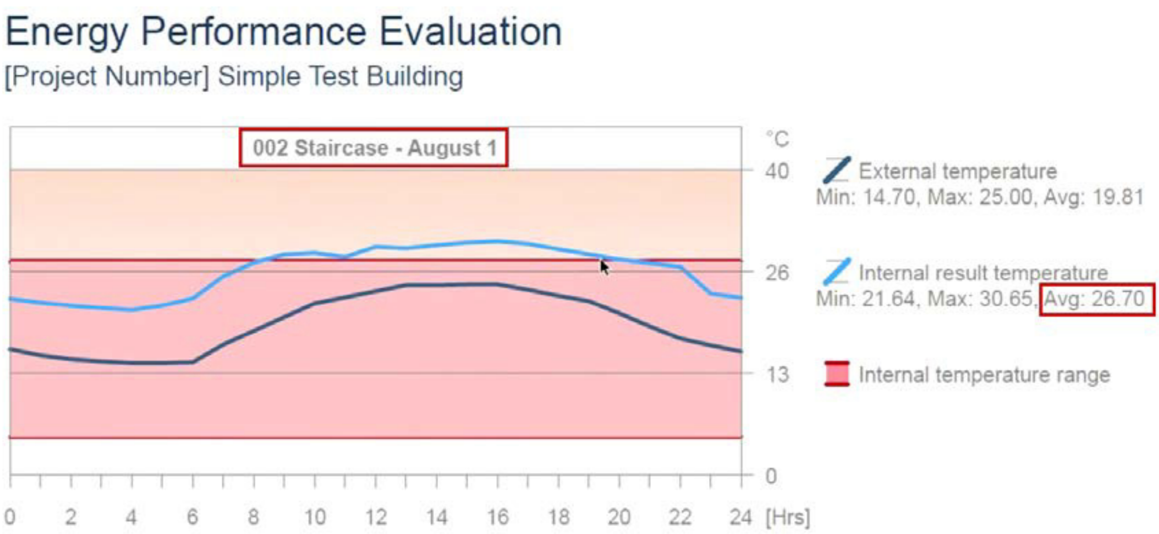
Use the **Thermal Block Key Values** chapter of the report to examine the internal temperature values in the staircase during the hottest summer day.


002 Staircase - Key Values

Geometry Data		
Gross Floor Area:	38.80	m²
Treated Floor Area:	21.24	m²
Building Shell Area:	96.95	m²
Ventilated Volume:	355.70	m³
Glazing Ratio:	24	%
Internal Temperature		
Min. (08:00 Jan. 01):	5.00	°C
Annual Mean:	18.13	°C
Max. (09:00 May. 30):	37.04	°C
Degree Days		
Heating (HDD):	4748	
Cooling (CDD):	1181	

Heat Transfer Coefficients	U value	[W/m²K]
Floors:	4.88 - 4.88	
External:	0.23 - 0.30	
Underground:	0.31 - 0.31	
Openings:	3.16 - 4.03	
Annual Energy		
Heating:	350.70	kWh
Cooling:	0.00	kWh
Peak		
Heating (06:00 Feb. 01):	4.88	kW
Cooling (01:00 Jan. 01):	0.00	kW
Unmet Load Hours		
Heating:	0	hrs/a
Cooling:	1253	hrs/a

The average internal temperature is 26 degrees centigrade, while the maximum internal temperature is 37 degrees centigrade. The hourly internal temperatures that are higher than the maximum allowable limit (defined for the staircase in the Operation Profile) appear on the report as Unmet Cooling Hours. There is no cooling system in the staircase of the baseline building, and it does not have any shading devices either, so the internal temperature is often unbearably hot in the summer months.

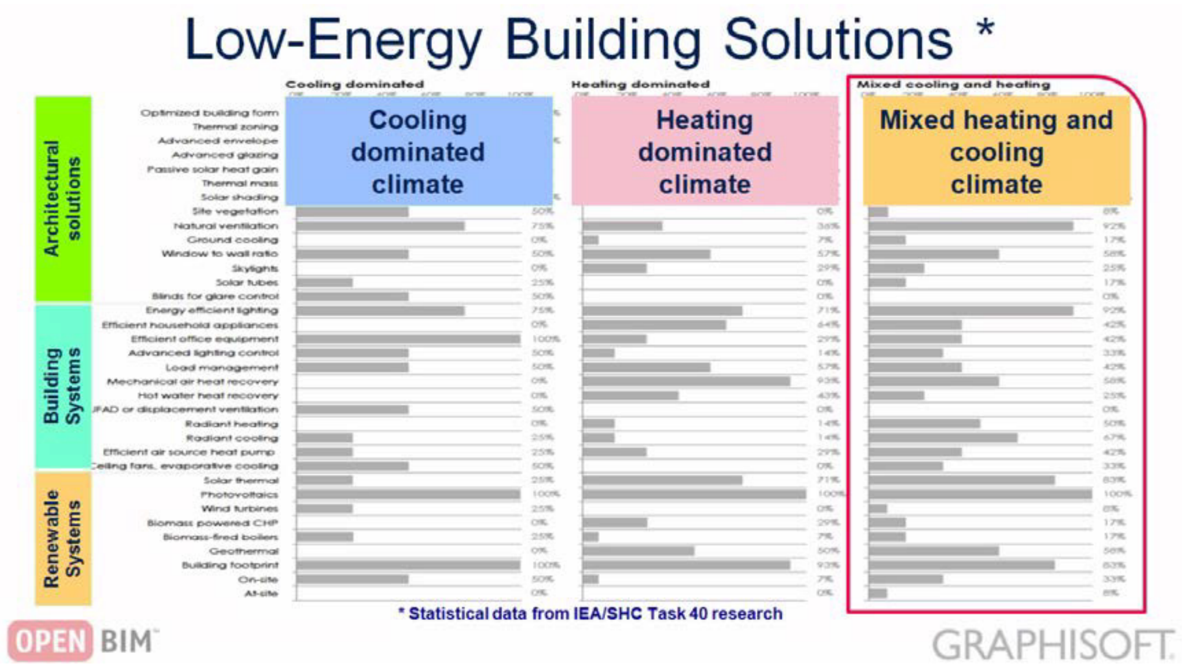


4.4 Investigate Building Energy Optimization Options

The designer can choose from several solutions to optimize the energy demand of a building. This example presents the so-called **"Low-energy Building Solution Set**". This concept is the result of research carried out by the "Solar Heating and Cooling" chapter of the "International Energy Agency - Task 40" research group. It categorizes low-energy building solutions in an easy-to-understand way, so that they can be applied effectively and successfully during the design process.

The "Low-energy Building Solution Set" concept defines groups based on **low-energy building solution types**. There are three solution types: "architectural solutions", "building system solutions" and "renewable energy solutions".

The research group evaluated a large number of low-energy buildings in different climates to determine the relevance of each solution with respect to the weather conditions. This chart shows the results of this study.



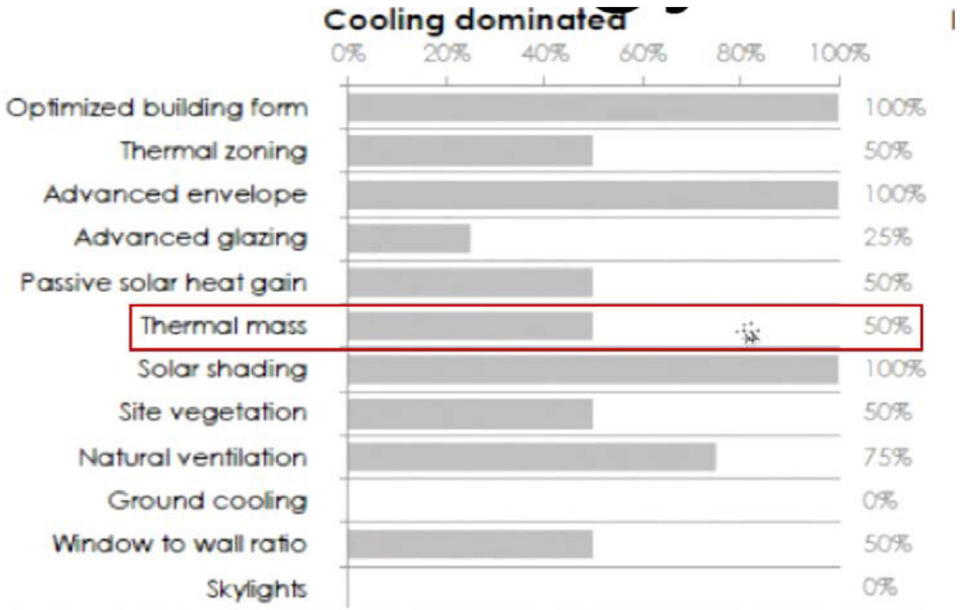
The three columns represent three different climates. The first column represents the so called “heating dominated” climates, the second column represents “cooling dominated” climates and the third column represents “mixed heating and cooling” climates.

Each row of the table represents a low-energy building solution. The top group contains the “architectural solutions”, such as solar shading, orientation, building materials and structures, openings and natural ventilation. The second group lists the “building system solutions”, such as mechanical ventilation, heating and cooling systems. The third group of solutions represents the “renewable energy solutions” such as photovoltaic panels, sun-collectors and wind turbines.

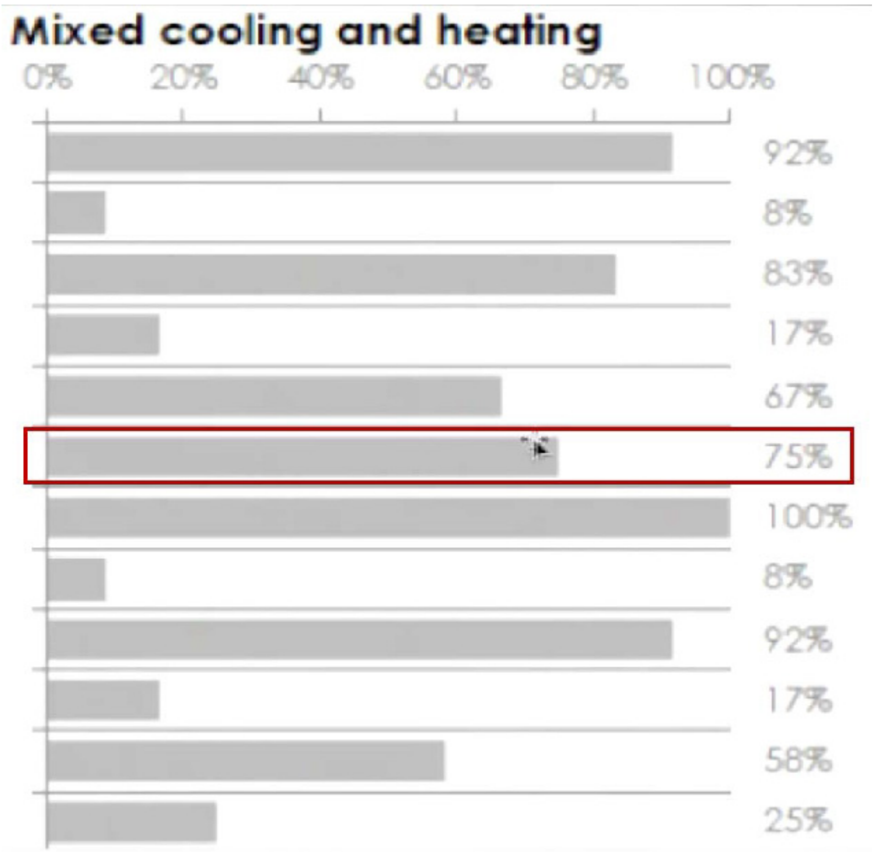
Our example project is located in a climate that requires mixed heating and cooling. Please refer to the “Climate Analysis” chapter to find out more about how to determine the climate characteristics of your project location.

The gray bars represent statistical results about the relevance of the different low-energy building solutions in the different climates. Several net-zero heating energy buildings were considered throughout the research project, when this chart was created.

Take a closer look at one of the low-energy building solutions presented on the chart. The "Thermal Mass" option is less relevant in "cooling dominated" climates, while in "heating dominated" climates it is really important: 9 out of ten investigated buildings used this low-energy strategy.

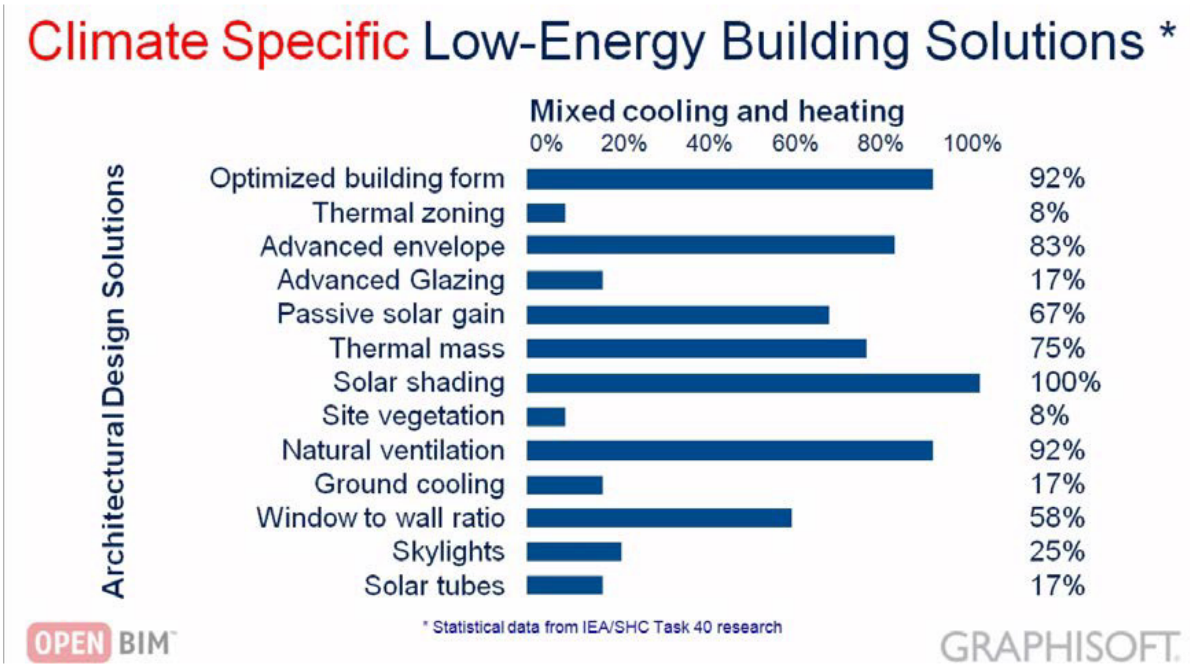


In "mixed cooling and heating" climates its relevance falls in between the two other cases.



The research data validates the concept that groups low-energy solutions into "**Climate-Specific Solution Sets**", since the relevance of each low-energy building solution greatly depends on the weather conditions.

Now look at the relevance of the different **low-energy architectural solutions** for the "mixed cooling and heating" climate of our example building.



Only the architectural solutions are displayed - the building system and renewable energy solutions are not - because at this stage of the design process, we are only evaluating the efficiency of the architectural solutions. To analyze the effect of these architectural solutions in an isolated manner, no building systems or renewable energy strategies are added to the project at this point.

4.5 Execute Sensitivity Analysis

When selecting an architectural low-energy building solution, we should consider not only its relevance to a given climate, but also other, project-specific aspects, such as site characteristics, availability of construction methods and materials, and budget. The most important task of sustainable building design is to find the optimal combination of low-energy building solutions for each individual project: that is, "**Project-Specific Solution Sets**".

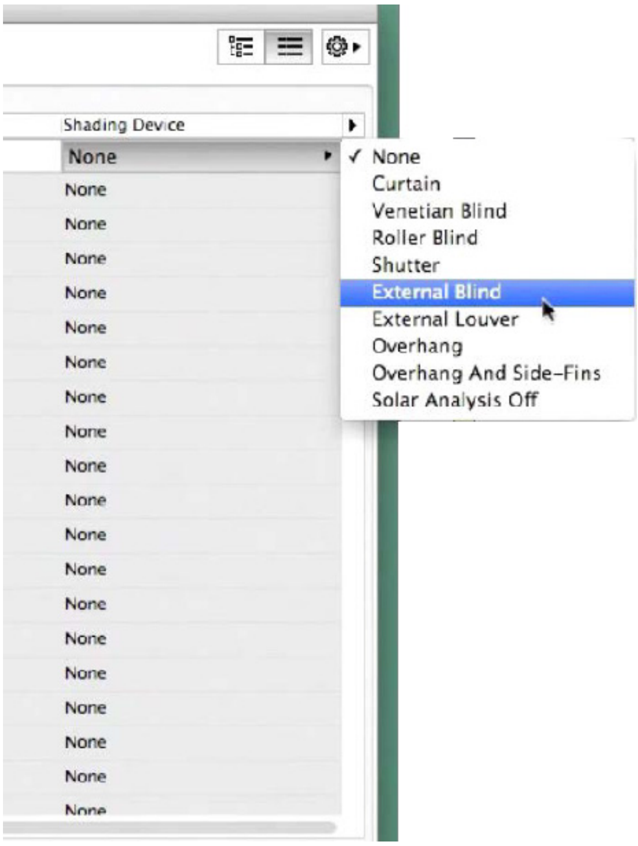
Let's investigate the effect of the highlighted four solutions (advanced opaque building envelope, good details, advanced fenestration and solar shading) on our example project. We will execute the so-called "sensitivity analysis" on the example building to measure the exact impact of these solutions on the project's energy performance.

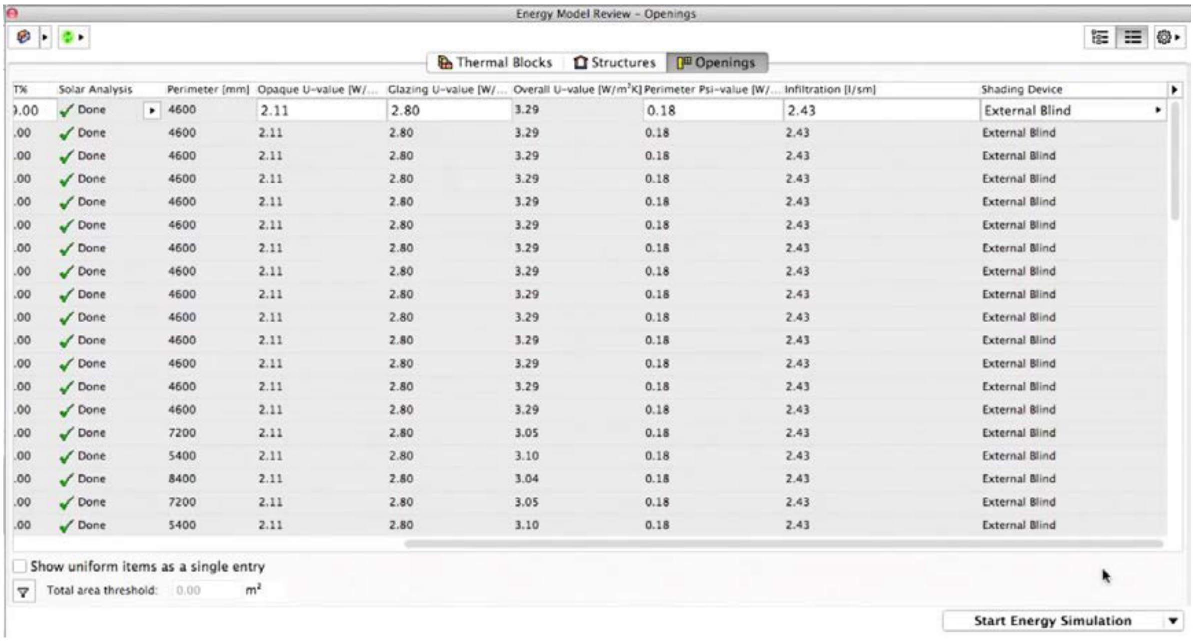
The EcoDesigner STAR **sensitivity analysis workflow** consists of the following steps:

1. Run an energy simulation on the building in the early design phase, when only its shape, zoning and overall appearance is decided. In this chapter, we have already completed this step and documented the calculation results (baseline result).

2. For the next step, apply the low-energy building solutions that we wish to evaluate one-by-one, run the building energy simulation, then document these results, too.
3. Finally, compare these results with the baseline result for each tested low-energy building solution, to study their impact on the building's energy performance.

To illustrate this workflow, let's test the effect of solar irradiation. On the Openings page of Energy Model Review palette, select all the openings on the building shell, and apply an "External Blind" shading device to all of them.

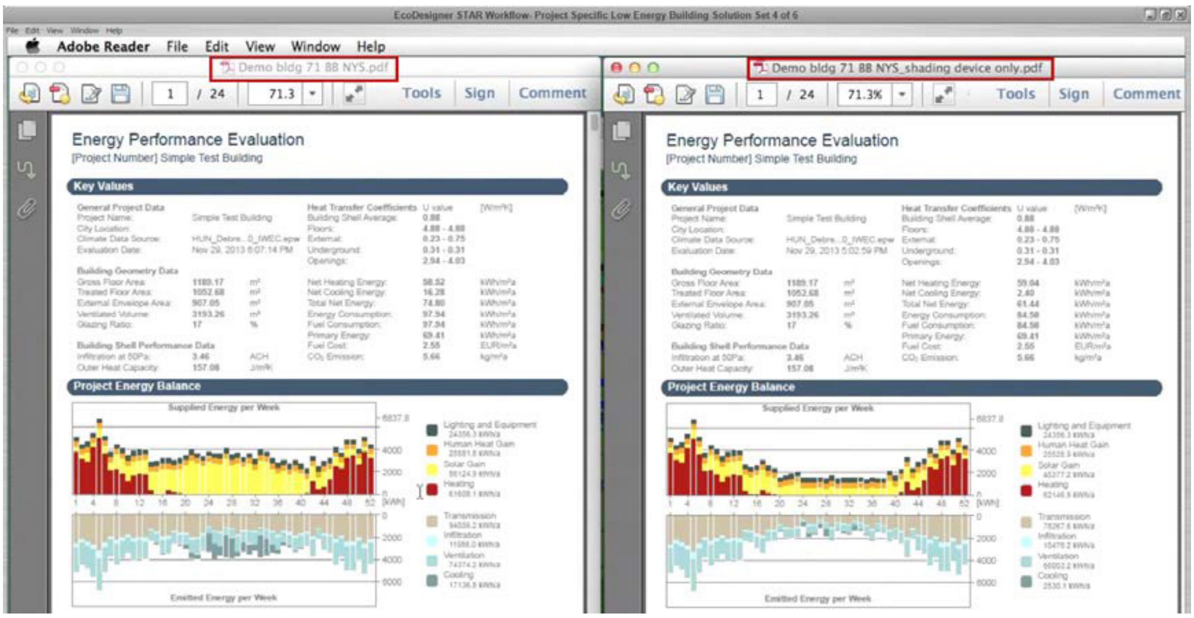




Note that EcoDesigner STAR's External Blind is an "intelligent," adjustable shading device that is activated only when the internal temperature of the thermal block behind its window exceeds 22 degrees centigrade.

Click "Start Energy Simulation," then view the Building Energy Performance report. Compare these results with the "baseline" results.

The baseline results are shown on the left side, and the energy evaluation report, including the effect of the shading devices, is shown on the right.



Note that the yellow bars - representing solar gain - are considerably lower in the hot seasons, thanks to the shading devices. This means that less energy is required to cool the interior spaces in the summer. Consequently, the dark green bars representing cooling energy are also much lower.

Using the method described above for the solar shading, the relevance of other low-energy building solutions (e.g. advanced opaque building envelope, good details, advanced fenestration) can be tested as well. The most important results of the isolated solution tests are displayed on this **sensitivity analysis summary spreadsheet**, and each is compared with the corresponding baseline result.

SENSITIVITY ANALYSIS	Heating demand				Cooling demand			
	Yearl	Savings	Hourly	Savings	Yearl		Hourly	Savings
	[kWh]	[%]	[kWh]	[%]	[kWh]	[%]	[kWh]	[%]
Baseline	61608		65.5		17136		36.5	
Advanced envelope	52744	-14.39	59.6	-9.01	19100	11.46	36.4	-0.27
Good details	61387	-0.36	65.4	-0.15	17352	1.26	36.7	0.55
Advanced fenestration	41870	-32.04	51.8	-20.92	13908	-18.84	28	-23.29
Solar shading	62146	0.87	65.5	0.00	2530	-85.24	17.8	-51.23

Savings [%] color coding - legend

Extra investment	75-100%
	50-75%
	25-50%
	0-25%
Savings	0-25%
	25-50%
	50-75%
	75-100%

The heating and cooling yearly demands, plus hourly maximum demands, are listed on the summary spreadsheet (these values also appear on the HVAC Design Data table of the Building Energy Performance evaluation report). The sensitivity analysis summary spreadsheet displays the energy savings in percentages for each of the individual low-energy solutions, compared to the baseline results. The energy savings are also color-coded: the amount of the extra investments are indicated by different shades of red, while savings are indicated in shades of blue.

Note that there was practically no change in heating costs as a result of installing the shading devices. However, there was a huge reduction in cooling demand – and in related cooling costs - thanks to the shading devices, in both the annual and hourly values. This allows us to install cooling systems of lower capacity.

SENSITIVITY ANALYSIS	Heating demand				Cooling demand			
	Yearl	Savings	Hourly	Savings	Yearl		Hourly	Savings
	[kWh]	[%]	[kWh]	[%]	[kWh]	[%]	[kWh]	[%]
Baseline	61608		65.5		17136		36.5	
Advanced envelope	52744	-14.39	59.6	-9.01	19100	11.46	36.4	-0.27
Good details	61387	-0.36	65.4	-0.15	17352	1.26	36.7	0.55
Advanced fenestration	41870	-32.04	51.8	-20.92	13908	-18.84	28	-23.29
Solar shading	62146	0.87	65.5	0.00	2530	-85.24	17.8	-51.23

Savings [%] color coding - legend		
	Extra investment	75-100%
		50-75%
		25-50%
		0-25%
	Savings	0-25%
		25-50%
		50-75%
		75-100%

The advantage of the "**intelligent**" **shading devices** of EcoDesigner STAR is that they do not shade the windows in the cold seasons, when solar heat gain helps to reduce the heating demand.

Now look at the summary spreadsheet again to evaluate the potential benefits of the other low-energy architectural solutions considered for this example project.

Using an **advanced envelope,** we can achieve a huge reduction in heating demand in the cold seasons. This solution does not help to reduce the cooling demand, though. In fact, well insulated buildings tend to overheat more often.

SENSITIVITY ANALYSIS	Heating demand				Cooling demand			
	Yearl	Savings	Hourly	Savings	Yearl		Hourly	Savings
	[kWh]	[%]	[kWh]	[%]	[kWh]	[%]	[kWh]	[%]
Baseline	61608		65.5		17136		36.5	
Advanced envelope	52744	-14.39	59.6	-9.01	19100	11.46	36.4	-0.27
Good details	61387	-0.36	65.4	-0.15	17352	1.26	36.7	0.55
Advanced fenestration	41870	-32.04	51.8	-20.92	13908	-18.84	28	-23.29
Solar shading	62146	0.87	65.5	0.00	2530	-85.24	17.8	-51.23

Savings [%] color coding - legend		
	Extra investment	75-100%
		50-75%
		25-50%
		0-25%
	Savings	0-25%
		25-50%
		50-75%
		75-100%

High-end constructional details also have an impact on the overall energy balance.

SENSITIVITY ANALYSIS	Heating demand				Cooling demand			
	Yearl	Savings	Hourly	Savings	Yearl		Hourly	Savings
	[kWh]	[%]	[kWh]	[%]	[kWh]	[%]	[kWh]	[%]
Baseline	61608		65.5		17136		36.5	
Advanced envelope	52744	-14.39	59.6	-9.01	19100	11.46	36.4	-0.27
Good details	61387	-0.36	65.4	-0.15	17352	1.26	36.7	0.55
Advanced fenestration	41870	-32.04	51.8	-20.92	13908	-18.84	28	-23.29
Solar shading	62146	0.87	65.5	0.00	2530	-85.24	17.8	-51.23

Savings [%] color coding - legend

Extra investment	75-100%
	50-75%
	25-50%
	0-25%
Savings	0-25%
	25-50%
	50-75%
	75-100%

Advanced fenestration, however, makes an even bigger difference to the project's building energy balance. Using top-of-the-line windows reduces the annual heating demand by over 30%, and also reduces the annual cooling demand by 18%.

SENSITIVITY ANALYSIS	Heating demand				Cooling demand			
	Yearl	Savings	Hourly	Savings	Yearl		Hourly	Savings
	[kWh]	[%]	[kWh]	[%]	[kWh]	[%]	[kWh]	[%]
Baseline	61608		65.5		17136		36.5	
Advanced envelope	52744	-14.39	59.6	-9.01	19100	11.46	36.4	-0.27
Good details	61387	-0.36	65.4	-0.15	17352	1.26	36.7	0.55
Advanced fenestration	41870	-32.04	51.8	-20.92	13908	-18.84	28	-23.29
Solar shading	62146	0.87	65.5	0.00	2530	-85.24	17.8	-51.23

Savings [%] color coding - legend

Extra investment	75-100%
	50-75%
	25-50%
	0-25%
Savings	0-25%
	25-50%
	50-75%
	75-100%

4.6 Determine Project-Specific Low Energy Building Solution Set

The sensitivity analysis executed for this project and climate shows that we can efficiently apply the low-energy architectural solution set containing the following solutions:

- advanced building envelope
- upgraded constructional details
- advanced fenestration and openings
- solar shading

Refer to the chapter on “Low-energy Demand Architectural Design” for further details about how to apply these solutions.

Note: Besides the sensitivity analysis presented in this chapter, **other factors** also influence the efficacy of low-energy architectural solutions, such as site conditions, local resources and availabilities, and budget. All these characteristics should be investigated and considered when making decisions about the low-energy building solution set.

5. Low-Energy Demand Architectural Design

This chapter shows you how to optimize the building project so that the conditions inside meet internal comfort requirements as often as possible, without the help of any building systems.

We proceed according to the following workflow:

- Start by creating the Baseline Building reference file
- Apply the project-specific low-energy architectural design solution set
- Run demand calculation that contains performance rating
- Review the energy efficiency benefits of architectural optimization

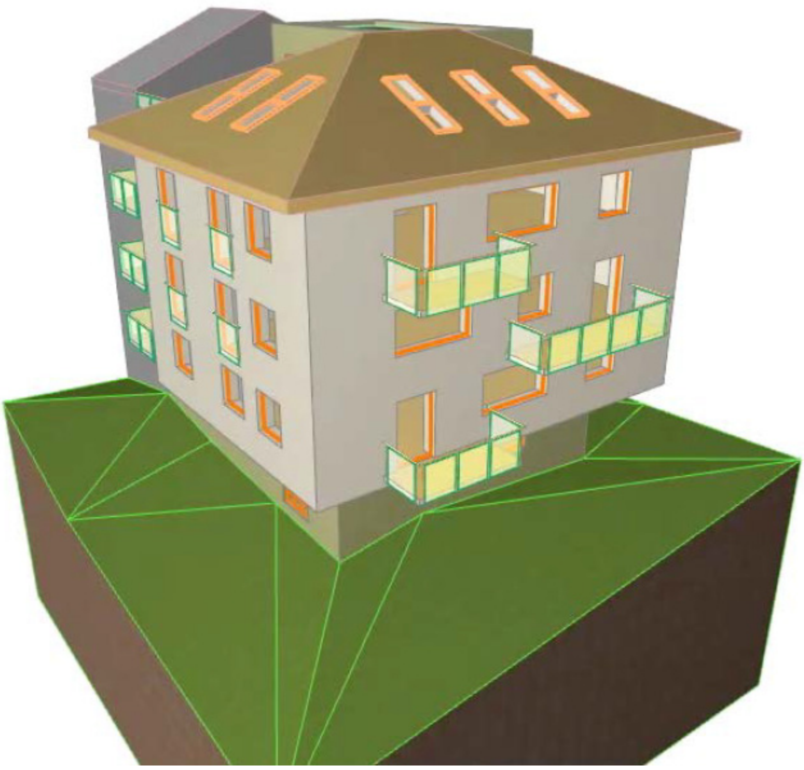
5.1 Create Baseline Building Reference File

To **enable comparative evaluation** of a building project, you must first document its "baseline building" design state.

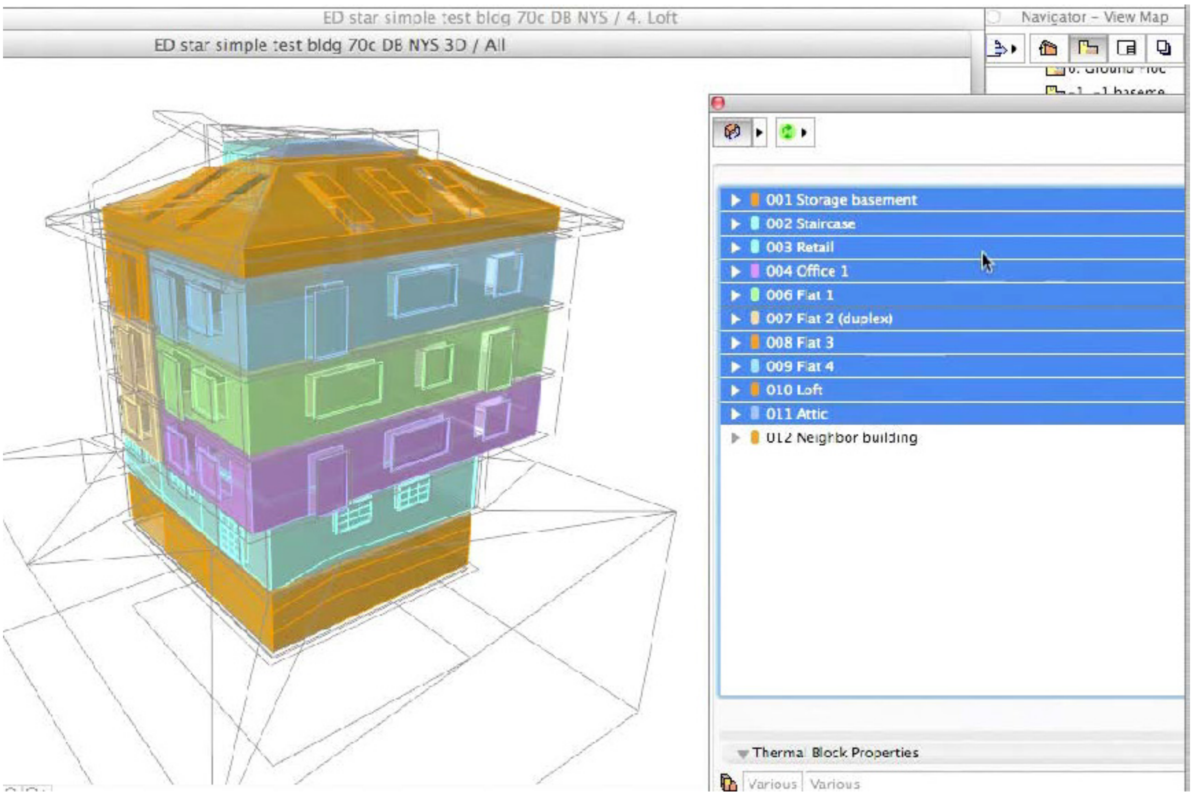
See "Project-Specific Low-Energy Building Solution Set" for more information about the "baseline building" concept.

Here is the 3D view of the Baseline Building model in ArchiCAD.

Its energy model is detailed in the chapter.

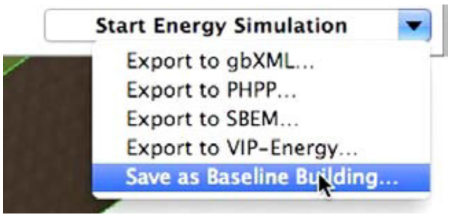


Its thermal blocks are listed with their relevant properties on the Energy Review Palette and can be visualized in the 3D view.



The thermal characteristics of the structures and openings are also defined.

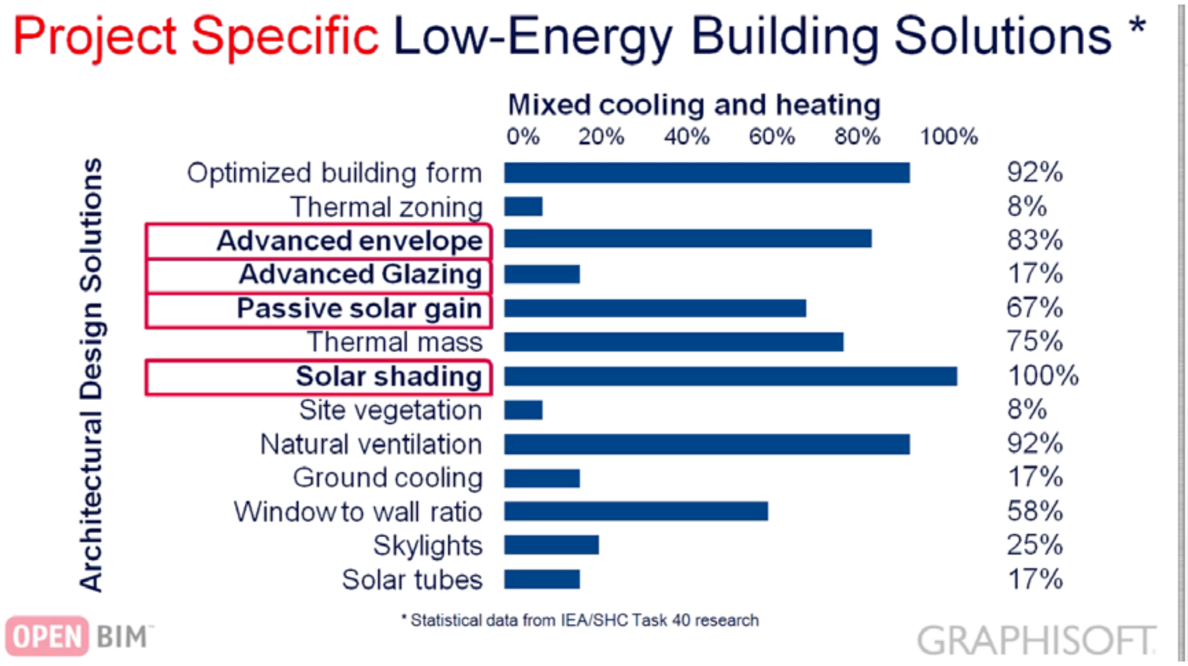
With all the inputs ready for demand calculation, it would be possible to execute a successful energy analysis on this project using EcoDesigner STAR, but let's save it in **Baseline Building file format** instead.



The next step is to apply certain sustainable design solutions to the project. The Baseline Building energy performance is used as a **reference point** that helps place the building's energy performance into perspective.

5.2 Apply Project-Specific Low-energy Architectural Design Solution Set

In the chapter on "Project Specific Low-Energy Building Solution Set", we determined the most appropriate low-energy design strategy for our example project. Now, the next step is to implement this strategy for the ArchiCAD virtual building.

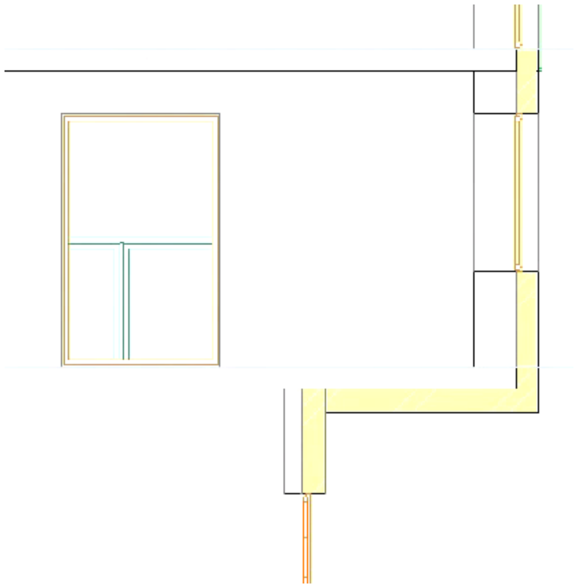


The following solutions will be applied:

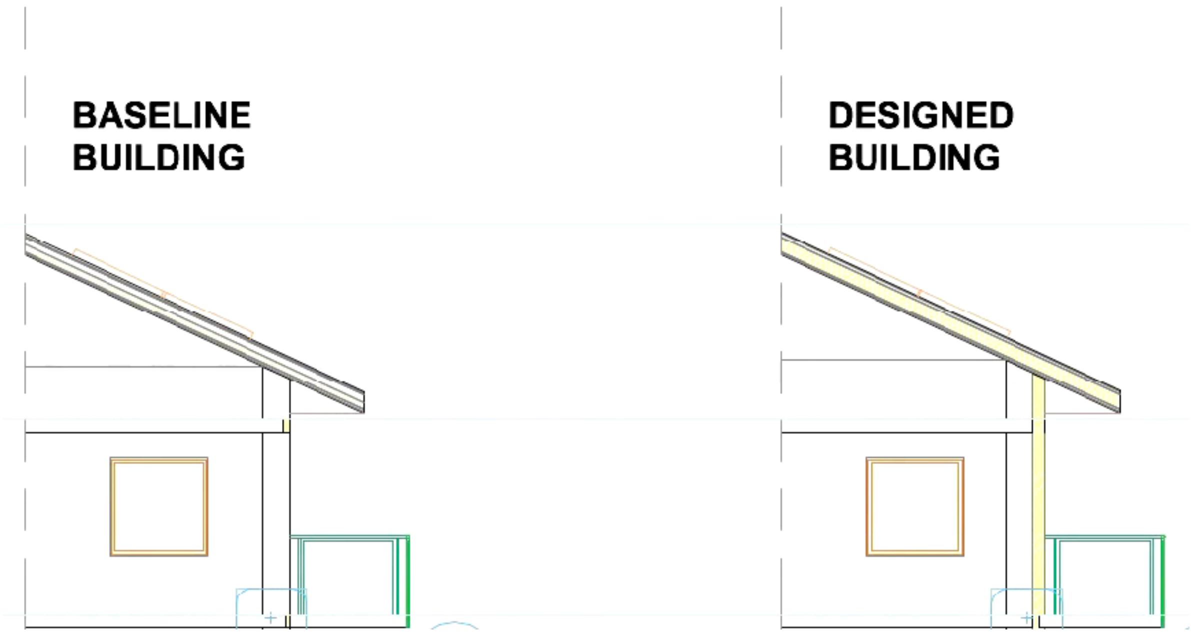
- advanced building envelope
- upgraded construction details
- advanced fenestration
- solar shading

Let's start by **upgrading the building envelope** of the Baseline Building: this entails using more advanced composite structures to optimize the thermal properties.

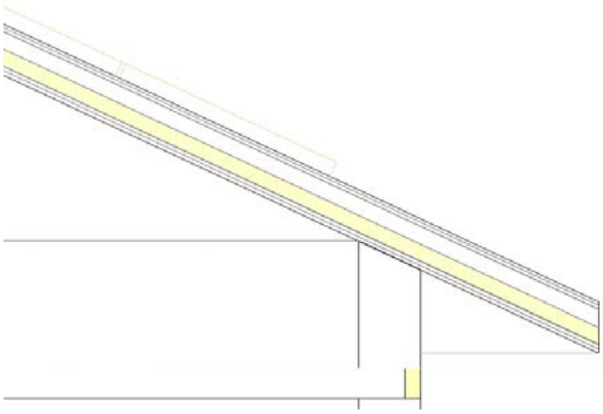
On the cross section of the building, thermal insulation is shown in yellow.



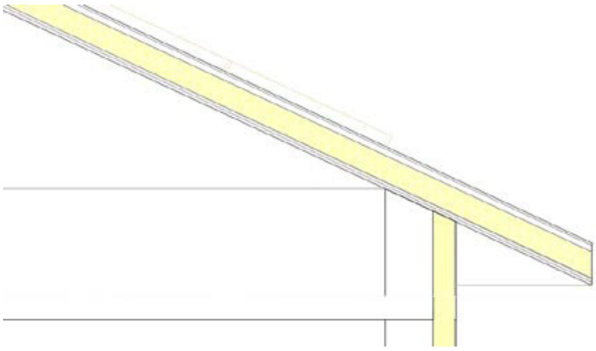
The Designed Building's thermal insulation is continuous on all parts of the building shell and is considerably thicker than the Baseline Building's. The entire building envelope is insulated. Here you can study the cross section of the baseline building vs. the section of the building with the upgraded shell.



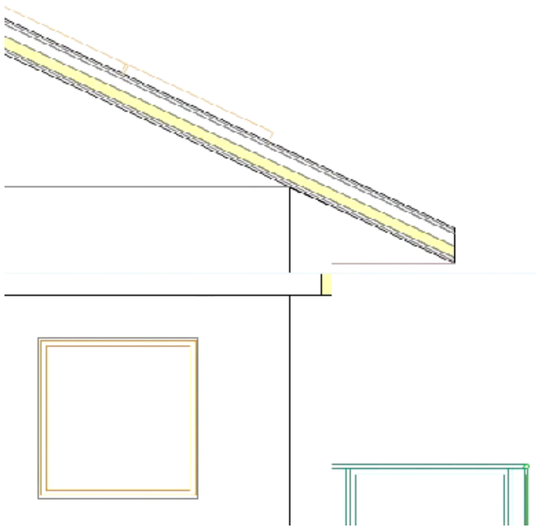
The pitched roof composite on the Baseline Building is a double - ventilated construction with a relatively thin thermal insulation skin that is interrupted by the rafters.



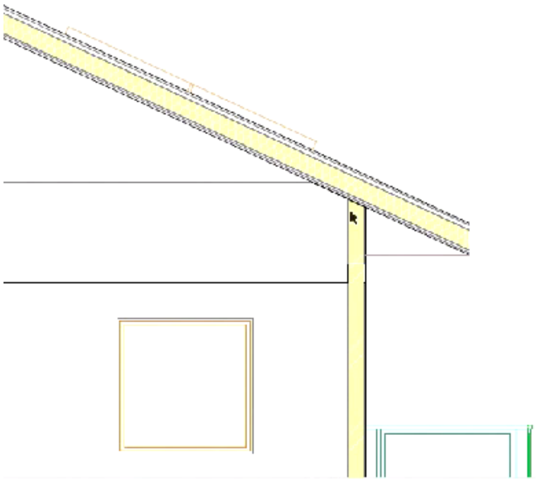
In contrast, the upgraded building design features a more advanced, single-ventilated composite structure with much thicker, mostly uninterrupted thermal insulation.



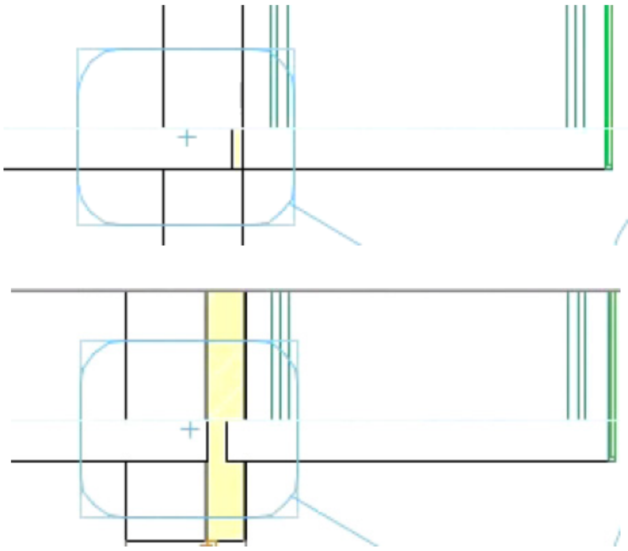
The Baseline Building has external walls made of 400 mm thick burnt clay blocks,



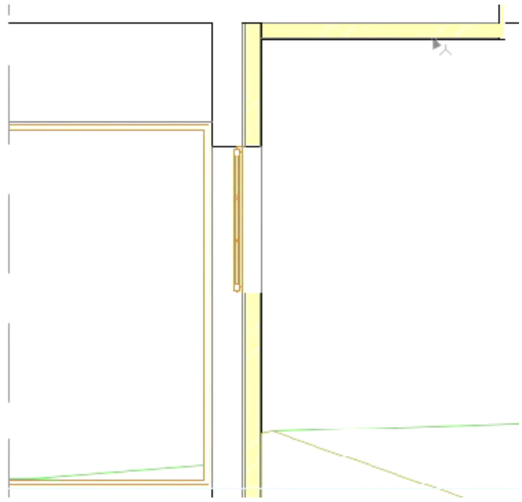
while the upgraded building also has a significant external thermal insulation on the outer surface of the burnt clay block walls.

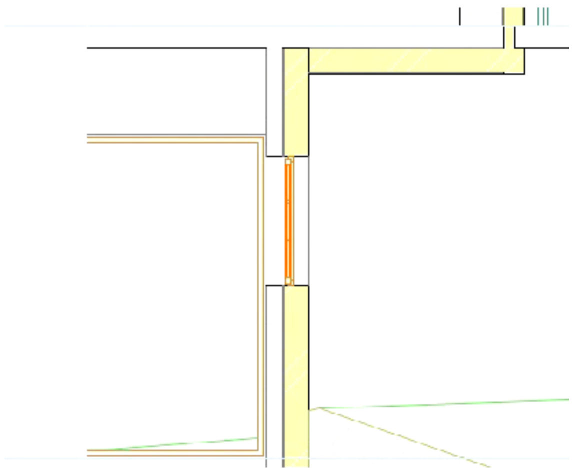


The thickness of the thermal brakes at the balconies are increased for the Designed Building.



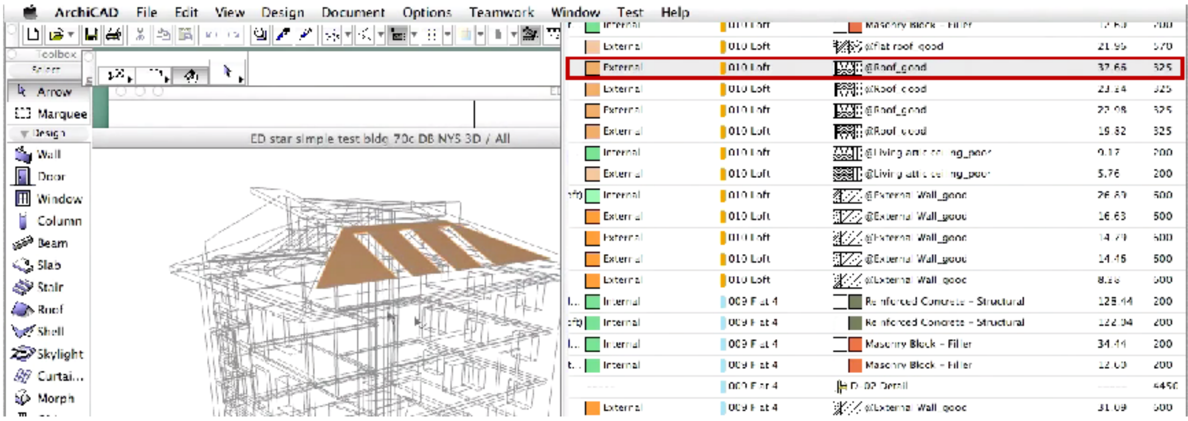
Similarly, thermal insulation on the reinforced concrete external structures at the ground floor level are also increased. In contrast, the Baseline Building used a much thinner layer of thermal insulation.





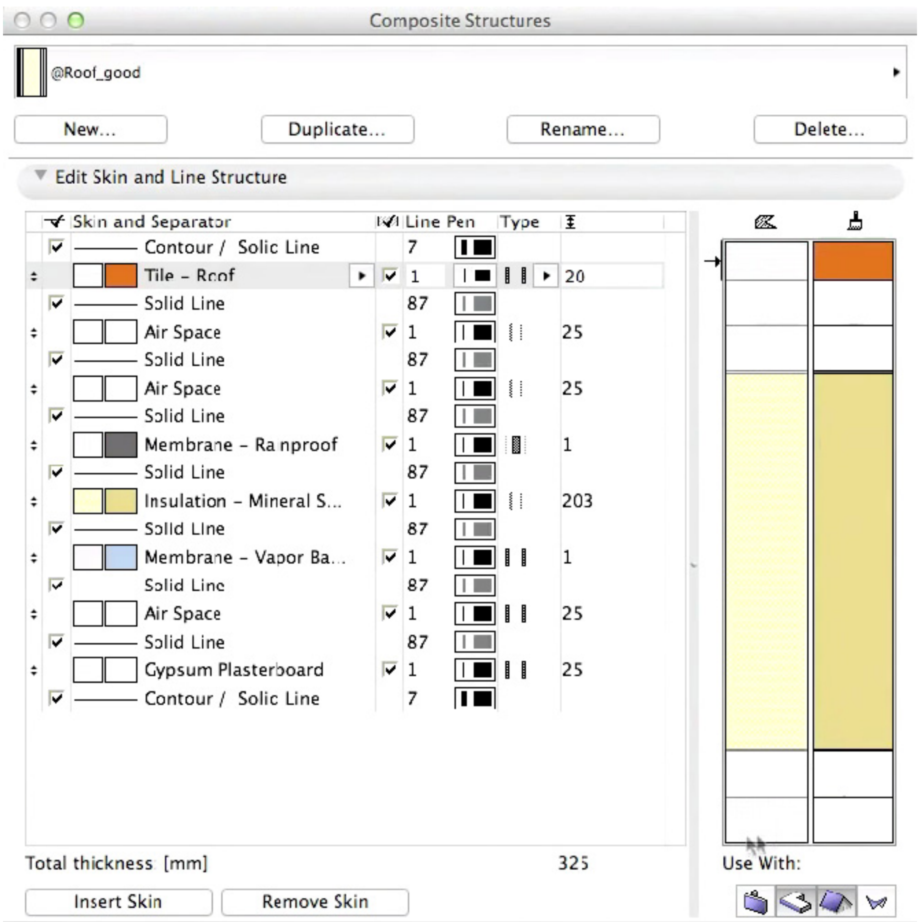
Let’s display the **Energy Model Review** palette and open the Structures page to see how these architectural changes affect the Building Energy Model.

Select an opaque building structure – for example an external roof element - on the Structures list to see its 3D representation instantly highlighted in the 3D view of the Building Energy Model.

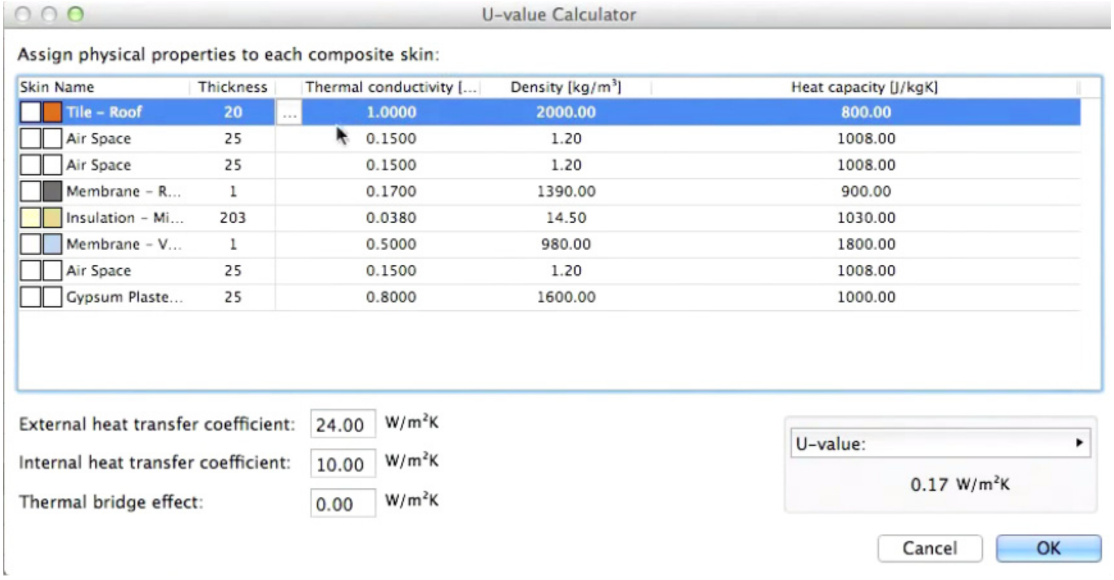


In our project, the **envelope's thermal performance** must be much better for the Designed Building than for the Baseline Building. This requires that the designed pitched roof composite must have better thermal resistance than the baseline flat roof composite.

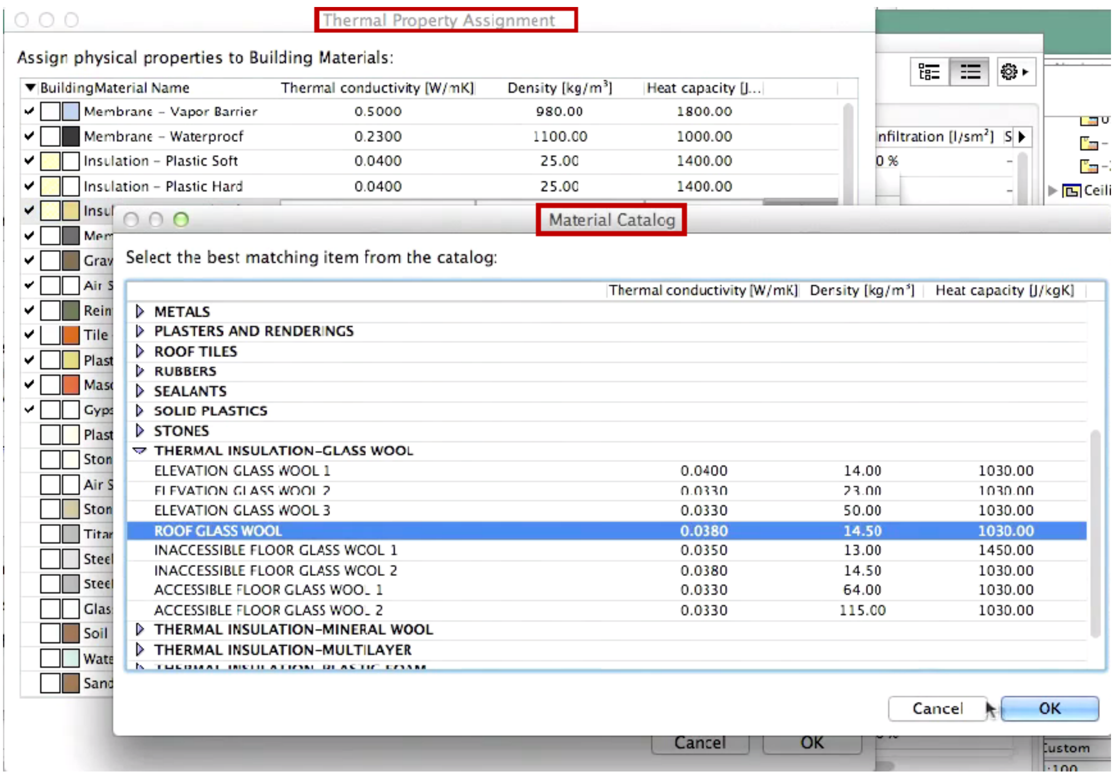
Go to the **Composite Attributes dialog** under the ArchiCAD Options menu to review the structural characteristics of the improved pitched roof composite. Each skin can be individually edited in this dialog to optimize the composite's performance.



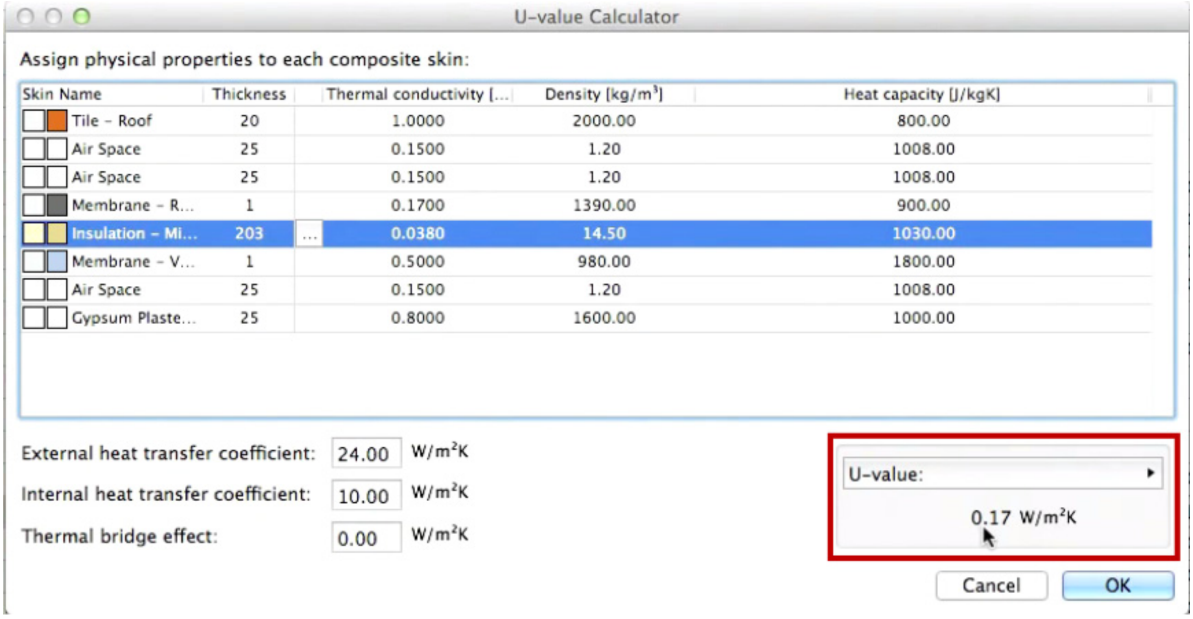
Also, review the thermal performance of the upgraded roof composite using the **U-Value Calculator**. In this dialog the thermal properties are automatically assigned to the composite skins, and the overall heat transfer coefficient of the composite is automatically calculated.



If needed, these properties can be modified via the U-Value Calculator to change the composite's overall thermal performance. The built-in Material Catalog can be used to assign different thermal properties to the skins or to fine-tune the assigned values based on exact building material information (e.g. manufacturer's data). This further enhances simulation accuracy, which is especially useful in the final phases of the design.



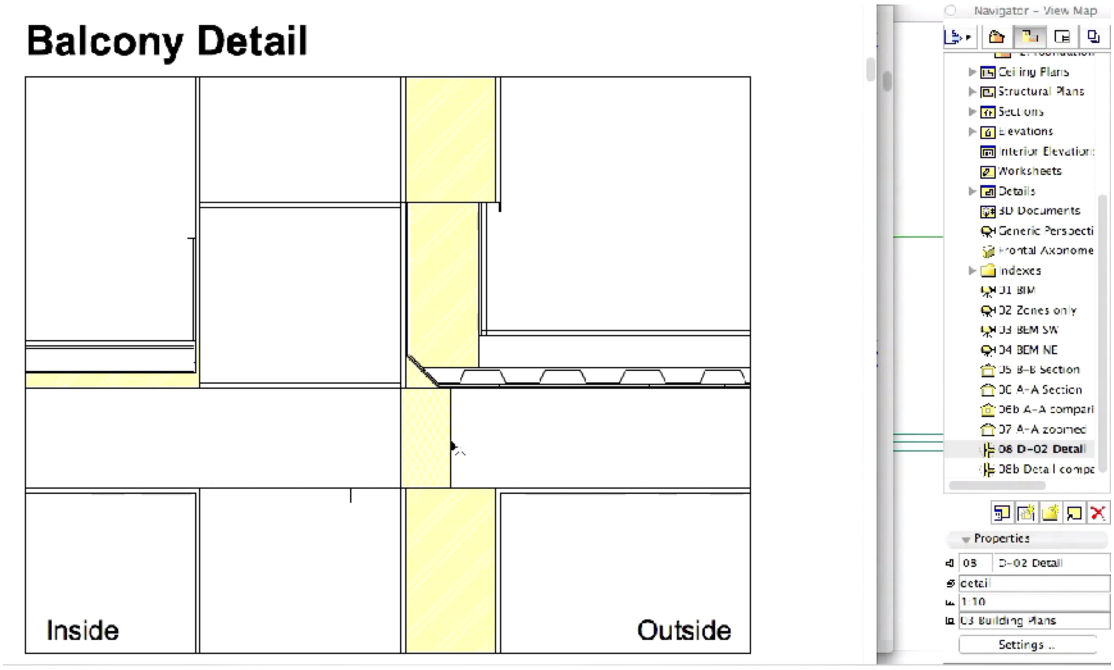
As the result of the **composite structure enhancement**, the Designed Building's pitched roof has a relatively low overall heat transfer coefficient (or "U value"), which translates to a relatively high thermal resistance or "R value".



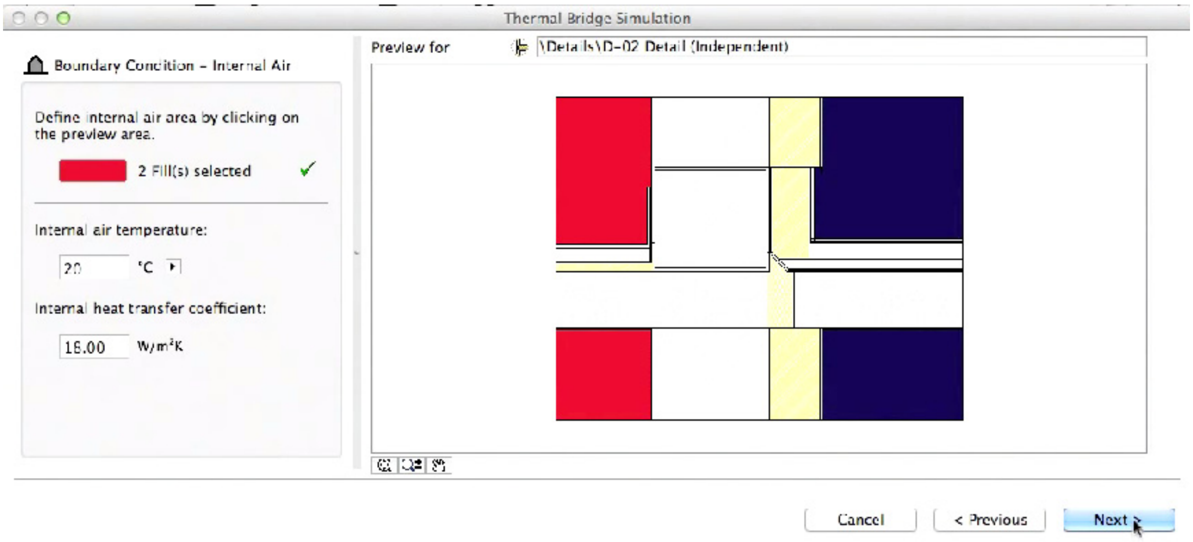
The next solution to apply in ArchiCAD is to **improve the construction details**. In this presentation, the balcony detail with the thermal brake is used as an example.

> **Note** that we have already run the thermal bridge simulation on the baseline version of this detail in the previous chapter.

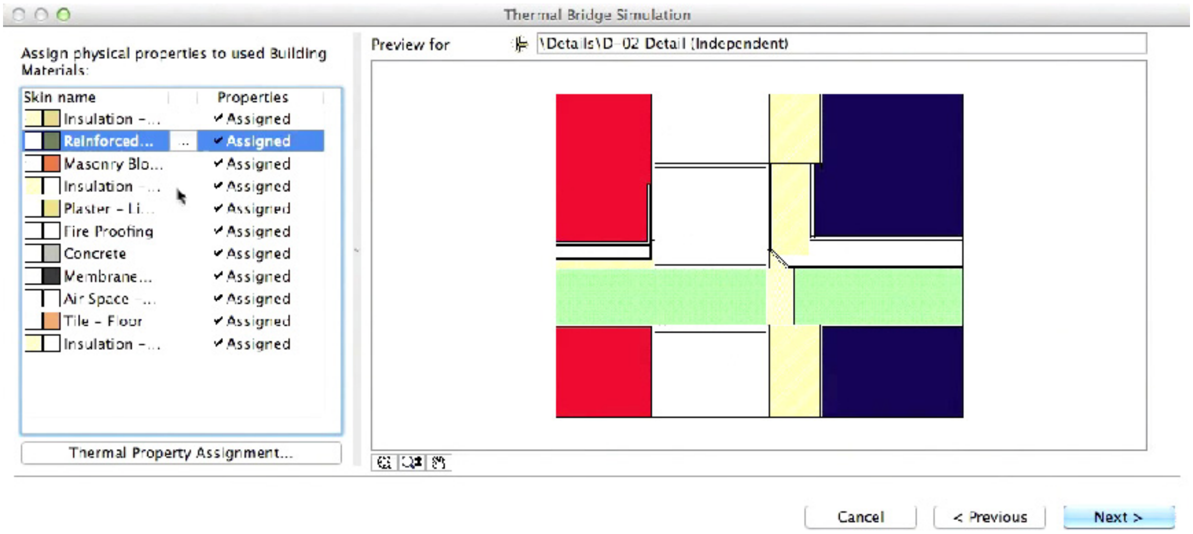
The advanced balcony detail features a much thicker thermal brake at the balcony slab and additional thermal insulation on the external wall surface.



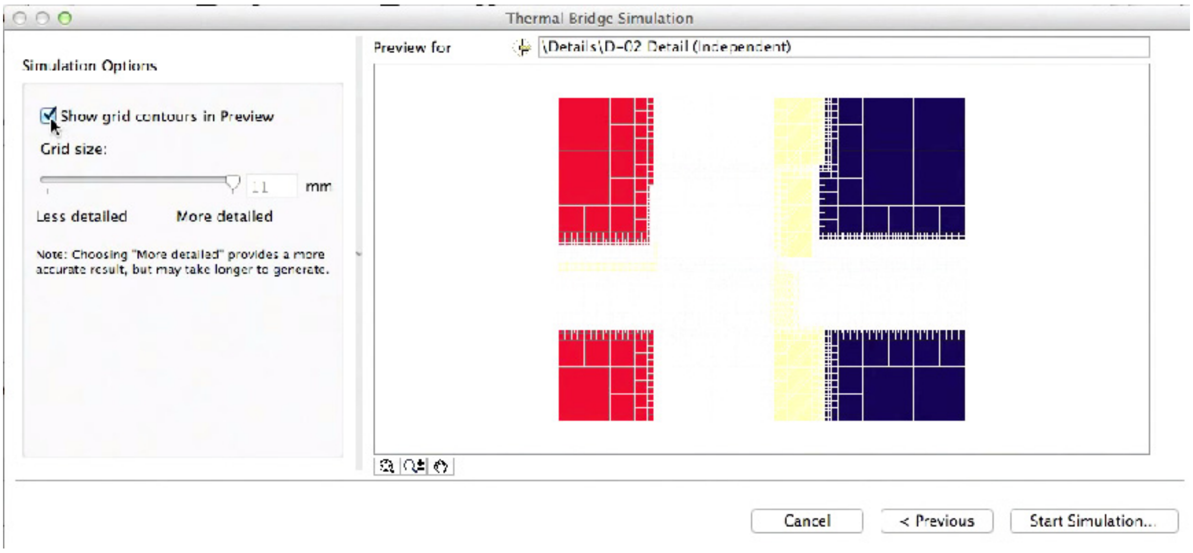
Let's run the **thermal bridge simulation** on this improved detail using the wizard.
First, identify the external and internal spaces, using the blue and red colors, respectively.



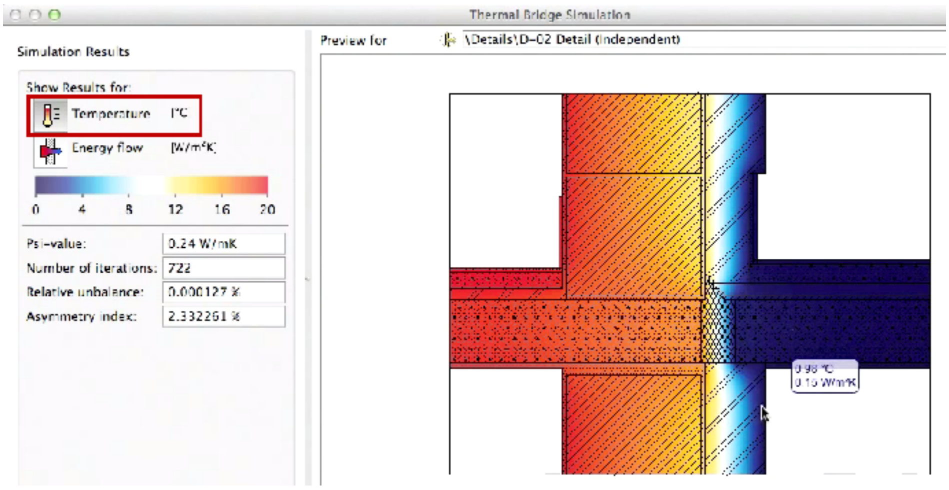
All elements of this construction detail are listed with their building materials on the left side of the dialog. Select the items on the list to highlight them in the preview window. If needed, assign or adjust the thermal properties of individual detail components.



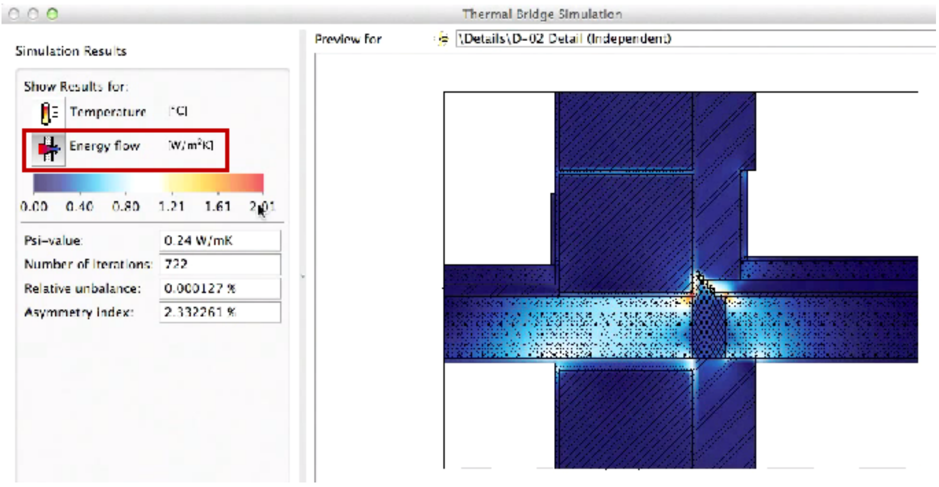
EcoDesigner STAR uses a so called "**adaptive mesh technology**" for the thermal bridge simulation. This means that the grid layout of the calculation sample points is automatically denser at the composite junctions than at other parts of the detail. It is also possible to adjust the calculation grid's reference density to the thermal bridge simulation faster.



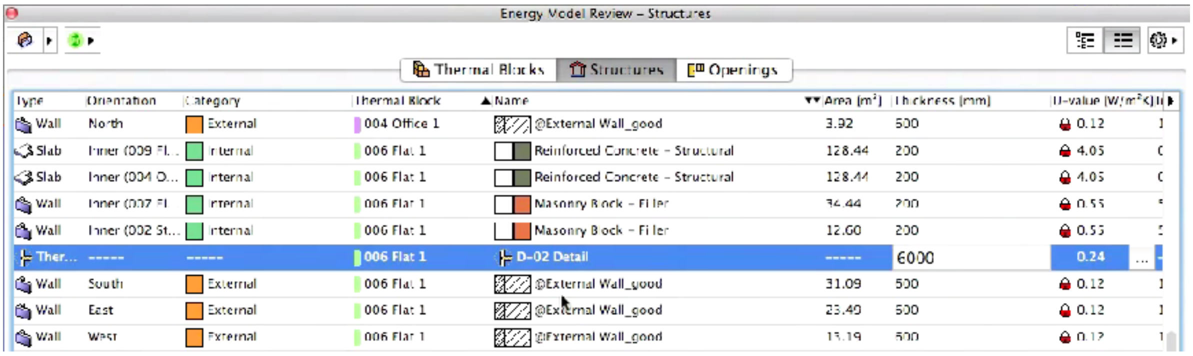
Now run the thermal bridge simulation for the improved detail to obtain the corresponding linear heat transfer coefficient and result diagrams. The color-coded Temperature Diagram shows more consistent temperatures for the designed detail than for the baseline detail.



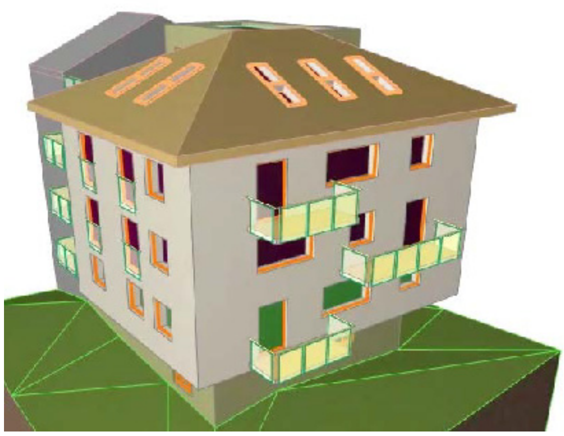
The Energy Flow Diagram only shows minor energy flow (represented by shades of red) at the top and the bottom of the thermal brake.

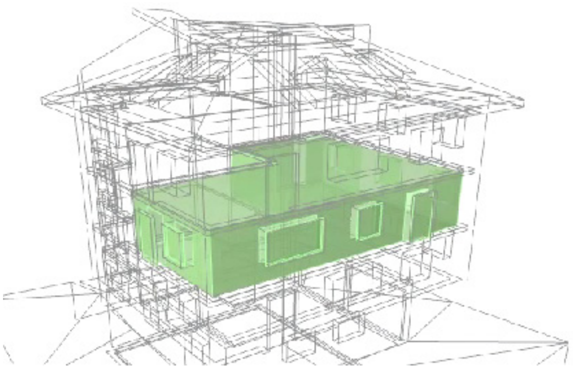


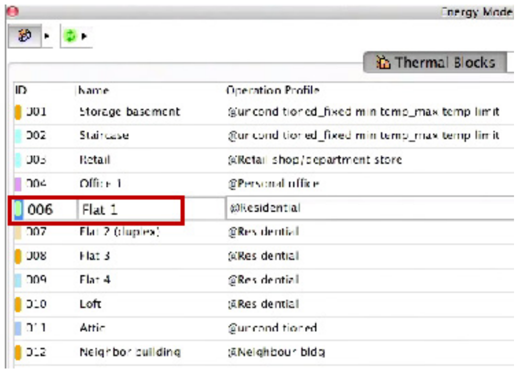
To affect the overall energy balance calculation, attach the thermal bridge to the thermal block where it occurs.



On the Thermal Blocks page of the Energy Review palette you can see that the example balcony detail belongs to the thermal block that represents flat number 1.

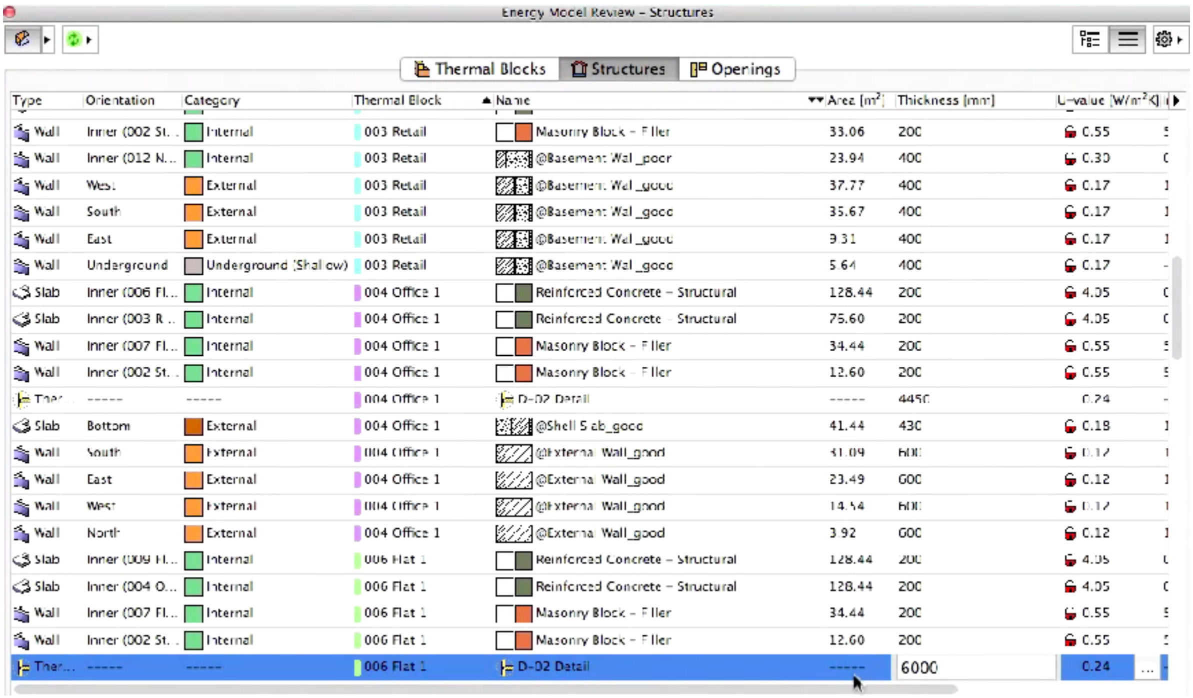






Use the Structures page

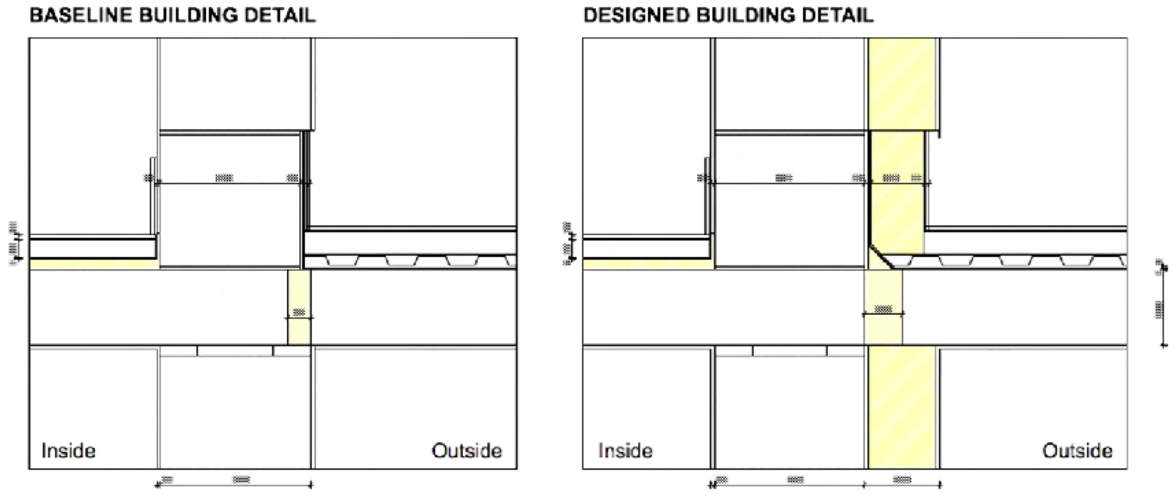
- to assign the previously completed thermal bridge simulation results to this thermal block; and
- to specify the length along which this thermal bridge occurs.



This way, EcoDesigner STAR incorporates the effects of this thermal bridge when performing the energy simulation for the building.

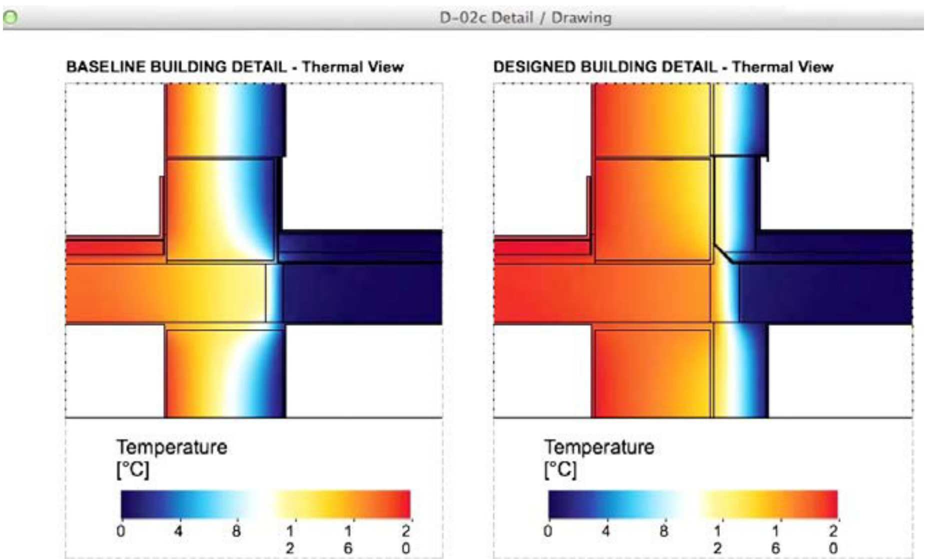
The thermal bridge simulation results can be used to **compare detail solutions**. Let’s compare the baseline detail version with the improved version.

Here are the two **architectural detail drawings** side by side.



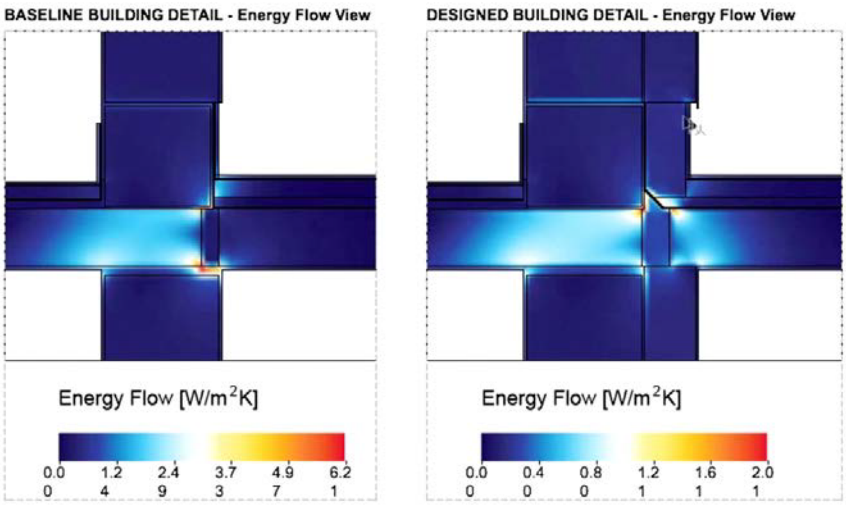
The baseline version is on the left: it has no external insulation and has only a thin thermal brake at the balcony. The improved detail solution on the right has a thicker thermal brake, with a thermal insulation skin added on the external wall.

If the **thermal views** of the two details are placed side by side, the energy efficiency benefits can be clearly identified.



In the improved detail, the masonry block wall is protected from the dynamic effects of the external environment by the additional layer of insulation. The thick thermal brake at the balcony slab forms a continuous protective skin that envelops the building. The masonry wall's external surface is less protected from the temperature changes and the thermal brake at the slab connection is not thick enough to prevent the thermal bridge effect.

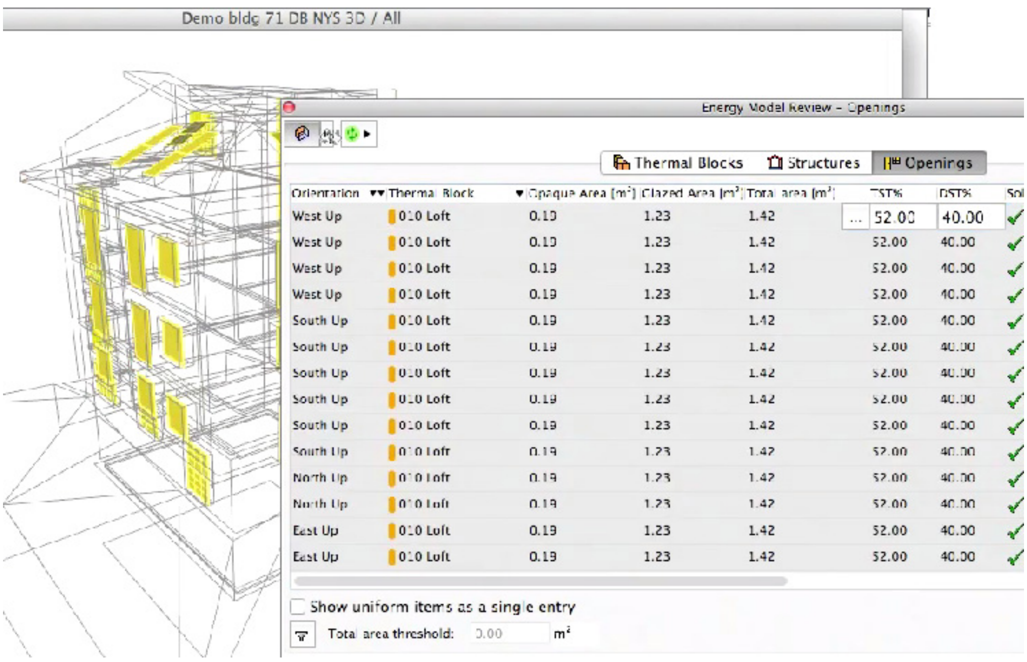
Below, the **energy flow views** display the linear heat transfer coefficients. These describe the details' thermal performance. For the baseline detail, the linear heat transfer coefficient is 3 times larger than that of the improved detail. In other words: the baseline solution's thermal resistance is 3 times poorer than the improved solution's.



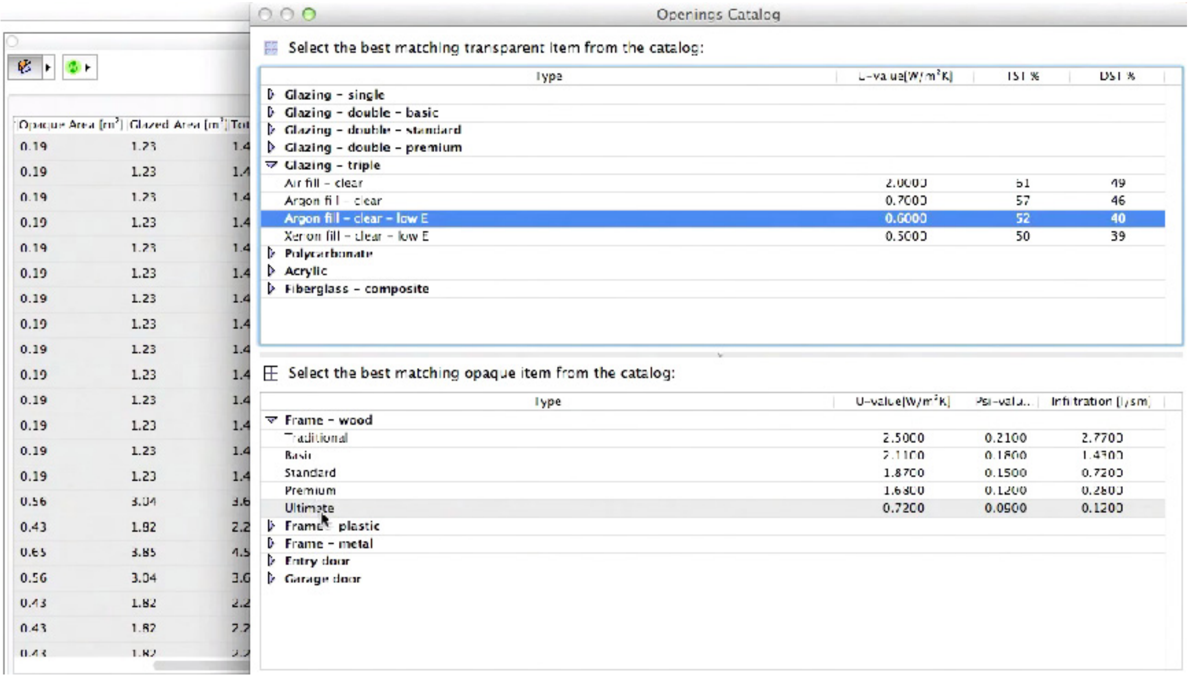
It is recommended to perform thermal bridge analysis **on all critical details** of the building project. Then incorporate the results in the overall building energy calculations. This will also help avoid local thermal comfort issues and condensation problems.

After upgrading the building envelope and designing more advanced details, let's see how to **improve the thermal characteristics of the fenestration**.

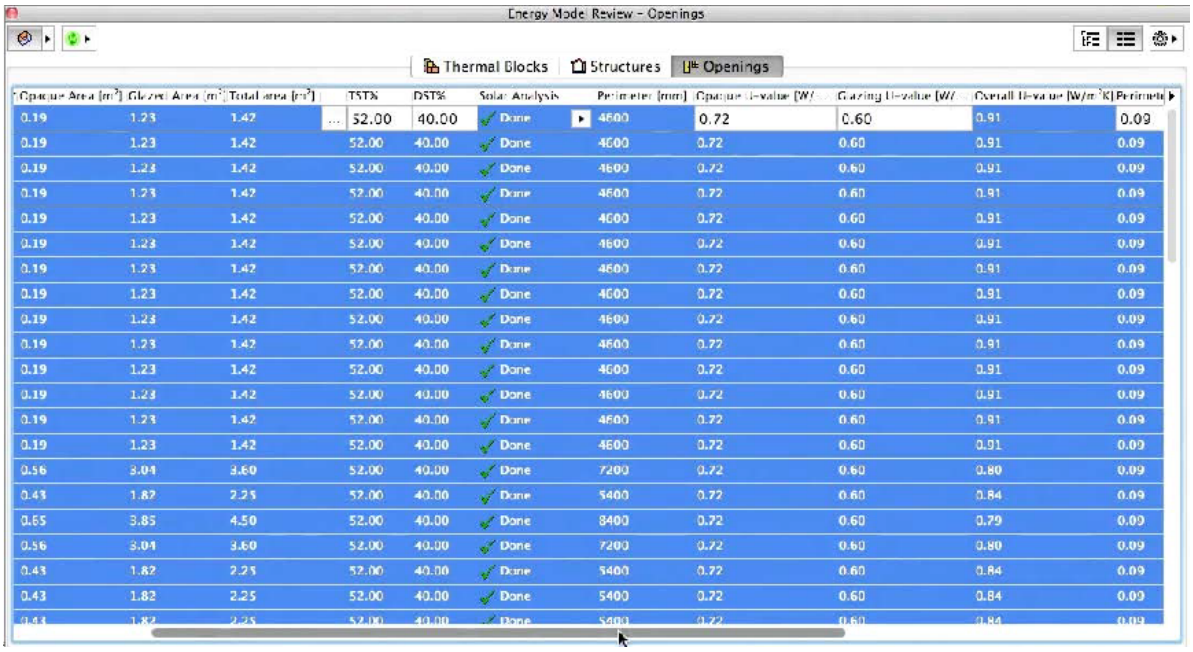
Let's select all windows on the Openings page of the Energy Model Review palette. All windows are instantly highlighted in the 3D view.



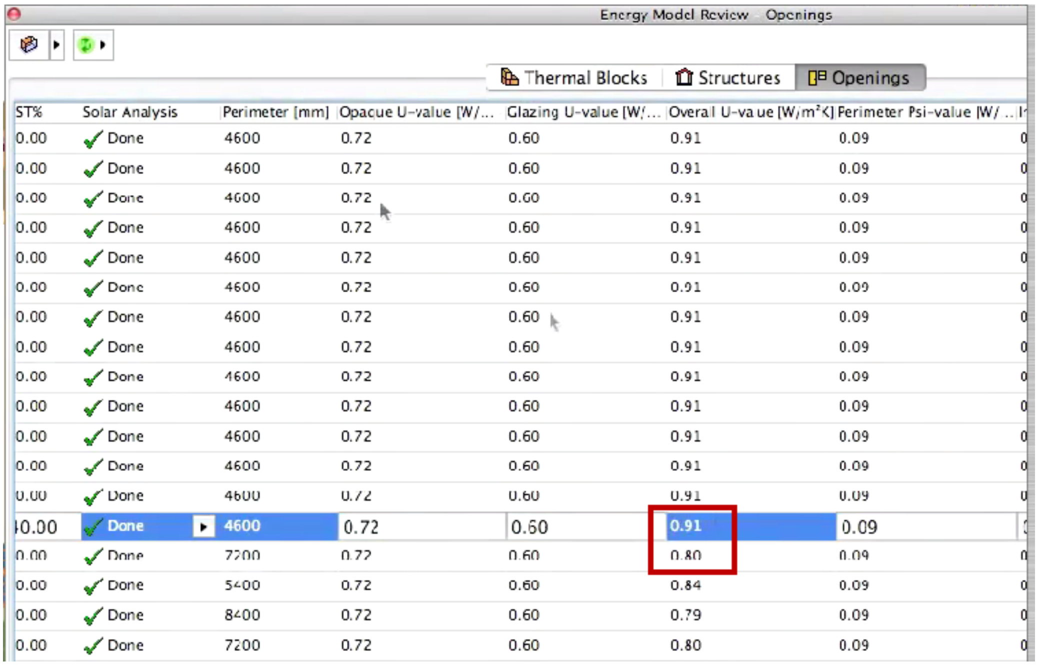
Use the Openings Catalog to assign different performance data to all windows of the project in one step. For this example building, we specify advanced triple glazing with high-end frames for all windows and glazed doors.



ArchiCAD calculates the **overall heat transmission** value and the infiltration around the frame perimeter for each opening individually, based on the individual ratio of the transparent area and the opaque frame of the opening.



As a result of this **model-based geometry data takeoff**, the automatically generated input of the openings' thermal and infiltration characteristics for energy simulation is very accurate in EcoDesigner STAR. For instance, the overall U value of a balcony door is slightly different from the overall U value of a window, because their glazed area to frame area ratios are different.

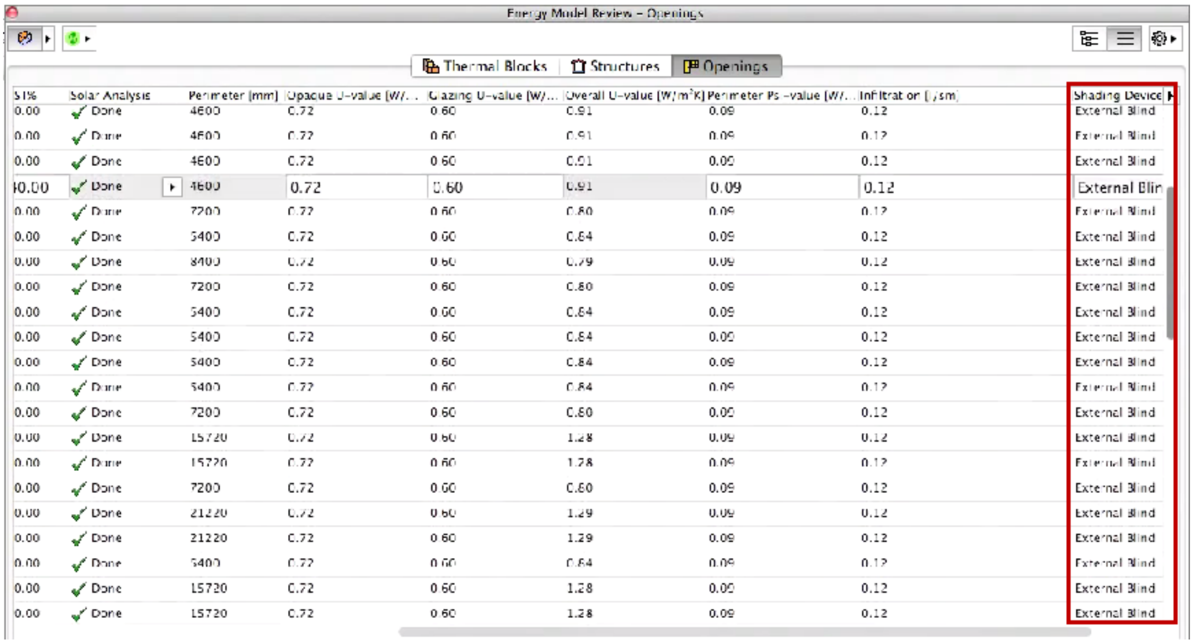

Energy Model Review Openings

Thermal Blocks | Structures | Openings

ST%	Solar Analysis	Perimeter [mm]	Opaque U-value [W/...	Glazing U-value [W/...	Overall U-value [W/m²K]	Perimeter Psi-value [W/...
0.00	Done	4600	0.72	0.60	0.91	0.09
0.00	Done	4600	0.72	0.60	0.91	0.09
0.00	Done	4600	0.72	0.60	0.91	0.09
0.00	Done	4600	0.72	0.60	0.91	0.09
0.00	Done	4600	0.72	0.60	0.91	0.09
0.00	Done	4600	0.72	0.60	0.91	0.09
0.00	Done	4600	0.72	0.60	0.91	0.09
0.00	Done	4600	0.72	0.60	0.91	0.09
0.00	Done	4600	0.72	0.60	0.91	0.09
0.00	Done	4600	0.72	0.60	0.91	0.09
0.00	Done	4600	0.72	0.60	0.91	0.09
0.00	Done	4600	0.72	0.60	0.91	0.09
0.00	Done	4600	0.72	0.60	0.91	0.09
0.00	Done	4600	0.72	0.60	0.91	0.09
0.00	Done	7200	0.72	0.60	0.80	0.09
0.00	Done	5400	0.72	0.60	0.84	0.09
0.00	Done	8400	0.72	0.60	0.79	0.09
0.00	Done	7200	0.72	0.60	0.80	0.09

The **infiltration** around the advanced window's perimeter is also reduced: this reflects improved technology of the more expensive high-performance windows and glazed doors.

We also applied external blinds for all openings of the building shell.

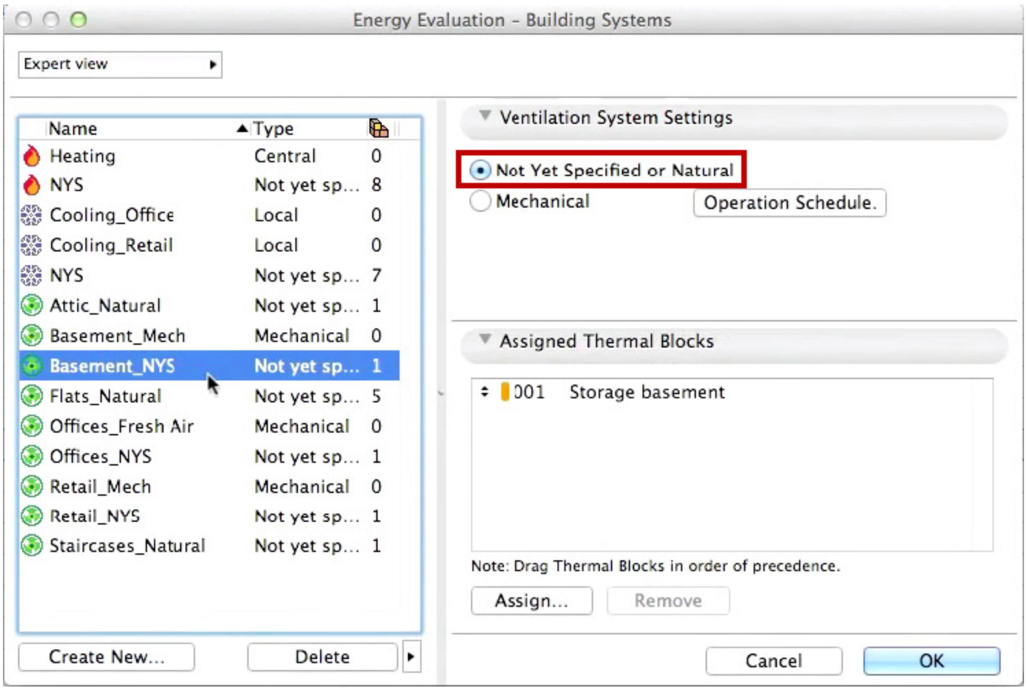

Energy Model Review – Openings

Thermal Blocks | Structures | Openings

ST%	Solar Analysis	Perimeter [mm]	Opaque U-value [W/...	Glazing U-value [W/...	Overall U-value [W/m²K]	Perimeter Psi-value [W/...	Infiltration [l/sm]	Shading Device
0.00	Done	4600	0.72	0.60	0.91	0.09	0.12	External Blind
0.00	Done	4600	0.72	0.60	0.91	0.09	0.12	External Blind
0.00	Done	4600	0.72	0.60	0.91	0.09	0.12	External Blind
0.00	Done	4600	0.72	0.60	0.91	0.09	0.12	External Blin
0.00	Done	7200	0.72	0.60	0.80	0.09	0.12	External Blind
0.00	Done	5400	0.72	0.60	0.84	0.09	0.12	External Blind
0.00	Done	8400	0.72	0.60	0.79	0.09	0.12	External Blind
0.00	Done	7200	0.72	0.60	0.80	0.09	0.12	External Blind
0.00	Done	5400	0.72	0.60	0.84	0.09	0.12	External Blind
0.00	Done	5400	0.72	0.60	0.84	0.09	0.12	External Blind
0.00	Done	5400	0.72	0.60	0.84	0.09	0.12	External Blind
0.00	Done	5400	0.72	0.60	0.84	0.09	0.12	External Blind
0.00	Done	7200	0.72	0.60	0.80	0.09	0.12	External Blind
0.00	Done	15720	0.72	0.60	1.28	0.09	0.12	External Blind
0.00	Done	15720	0.72	0.60	1.28	0.09	0.12	External Blind
0.00	Done	7200	0.72	0.60	0.80	0.09	0.12	External Blind
0.00	Done	21220	0.72	0.60	1.29	0.09	0.12	External Blind
0.00	Done	21220	0.72	0.60	1.29	0.09	0.12	External Blind
0.00	Done	5400	0.72	0.60	0.84	0.09	0.12	External Blind
0.00	Done	15720	0.72	0.60	1.28	0.09	0.12	External Blind
0.00	Done	15720	0.72	0.60	1.28	0.09	0.12	External Blind

This "intelligent" external **solar shading** device is only activated during the periods of the hourly energy simulation when the internal temperature of the thermal block adjacent to the opening exceeds 22 degrees centigrade. Thus, the shading device helps to minimize overheating in the cooling season, yet does not block heat gain that is welcome during the heating season.

Before running the building simulation that executes the demand calculation, display the **Building Systems** dialog box. Make sure that all heating, cooling and ventilation systems assigned to the project's thermal blocks are set to "**Not Yet Specified**".



5.3 Run Energy Simulation (Demand Calculation)

The goal of energy demand calculation is to determine the necessary **heating and cooling loads**. If these loads are small, then the thermal conditions inside the thermal blocks are within the comfort range defined by the operation profiles. In other words: the building does its job well and provides shelter and comfort to its users without the help of the heating and cooling systems. Since building systems consume fuel, the less often they need to operate, the more energy efficient the project becomes.

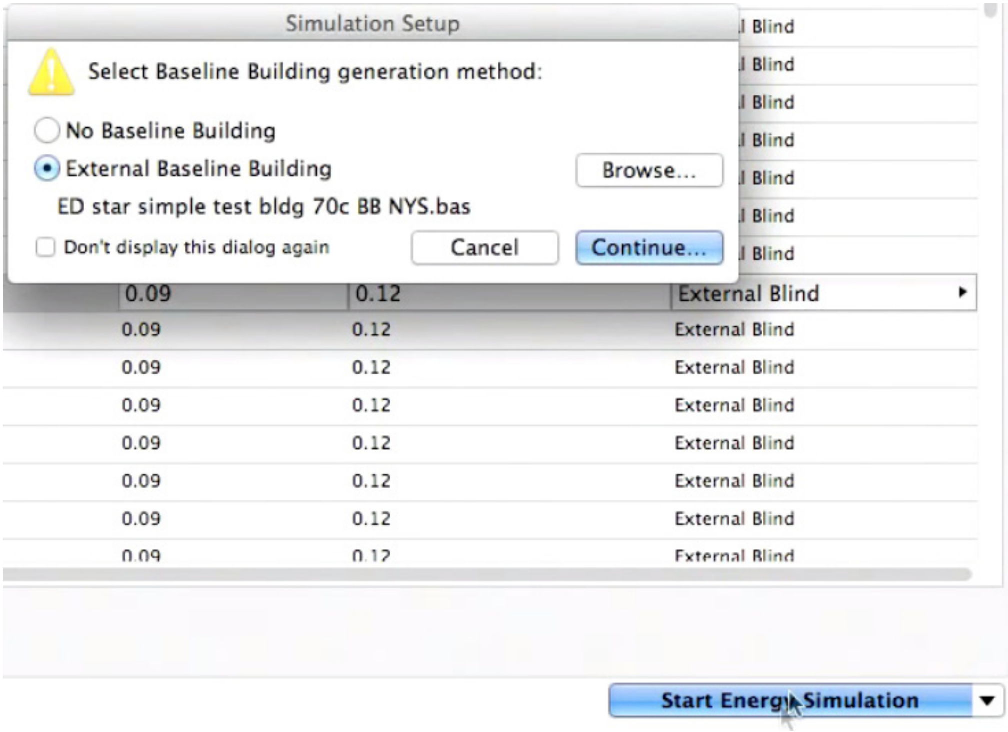
The Designed Building model - with upgraded characteristics - is ready for energy evaluation. Before starting the simulation, let's **create the Baseline Building reference file** to enable the direct comparison of the improved design's performance with the baseline model's performance.

To create the aforementioned reference file, the project archive, with baseline parameters, must be opened in a **separate instance of ArchiCAD**. The appearance of the Baseline Building is the same as the Designed Building, but certain architectural solutions (the structures, details, openings and the solar shading) are far inferior compared to the improved design model.

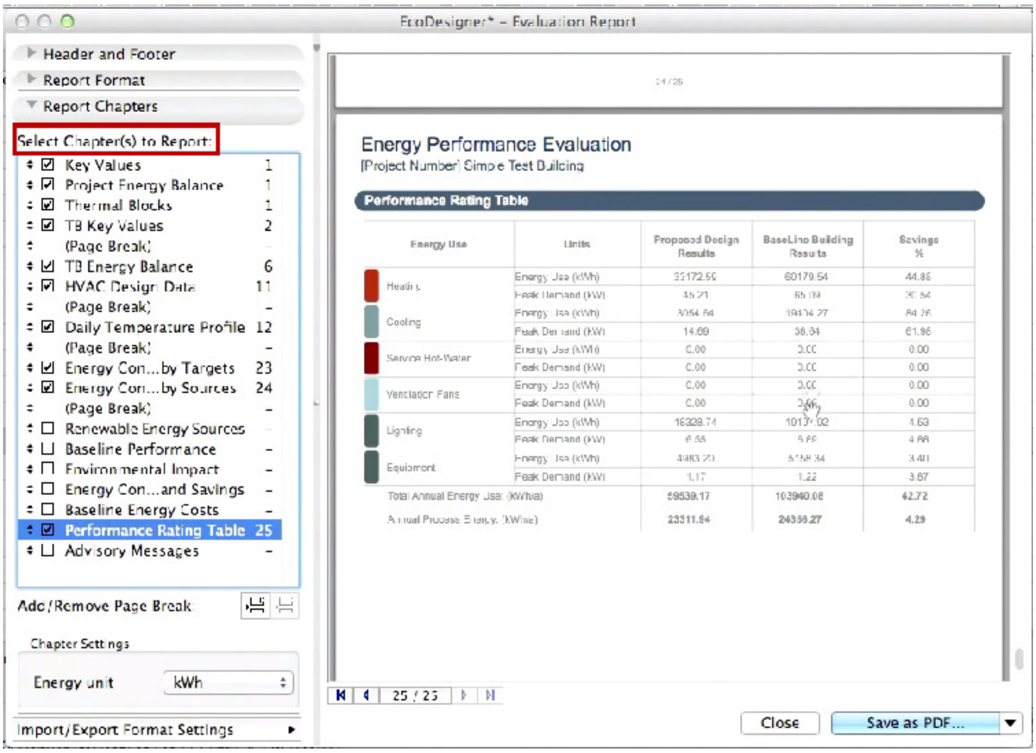
Save the baseline design in "baseline building format" (.BAS) for comparison purposes. This option is available next to the "Start Energy Simulation" button of the Energy Model Review palette.

Now, return to the improved project. After clicking the "Start Energy Simulation" button, the "Simulation Setup" dialog appears.

Import the Baseline Building reference file. Use the browser to locate the previously created "External Baseline Building" BAS file. Then click Continue.



After the energy simulation is completed, the Energy Evaluation report dialog opens. Before saving it as a PDF document, **specify the Energy Performance Evaluation report's content,** .by checking the desired report chapters on the dedicated panel.



- The Project Key Values chapter is important because it contains the high level overview of the calculation results.
- Also, include the Project Energy Balance chapter. We can toggle between monthly and weekly energy balance time interval display.
- The Thermal Blocks chapter provides general information about the building energy model's geometry and operational profiles.
- The Thermal Block Key Values chapter displays the most important energy efficiency data about each thermal block.
- The Thermal Block Energy Balance chapter includes colored diagrams showing the supplied and emitted energy flows of the individual thermal blocks. You can define which thermal blocks to include in the PDF.

The **thermal block level output** makes EcoDesigner STAR a very powerful tool. The Thermal Block Energy Balances provide an excellent way to visualize how each part of the building contributes to the overall building energy model. By controlling each thermal block's performance individually, the architectural design can be optimized to the point where the project can meet even the most ambitious energy performance targets (e.g. LEED Platinum rating, net Zero Energy Building operation etc.)

- The HVAC Design Data chapter provides very important information about the **annual and hourly heating and cooling demands** of the thermal blocks. This data can be used for **building system sizing**. The internal thermal condition data (maximum and minimum temperature values and unmet load hours) of the thermal block also appear at the bottom of this chapter.
- Daily Temperature Profiles
- for the thermal blocks can be shown for specific days of the reference year, with corresponding **internal and external temperature profile diagrams**. Generally, the specific days are the days of maximum heating and cooling loads, as well as one typical day for each season (e.g. typical summer day).
- The Energy Consumption by Sources and by Targets chapters display information about the fuels consumed by the building systems to maintain required internal comfort conditions. Currently, fuel consumption other than electricity appear as “Not Yet Specified” since building systems are also set to “Not Yet Specified” for the energy demand calculation.
- Finally, select the “Performance Rating Table” chapter. This table compares the energy performance of the Designed Building with the Baseline Building. The **energy use savings** caused by the implementation of the Project-Specific Low-energy Building Solution Set also appear in this chapter.

The energy use savings data can be used as input for **return of investment** calculations. Architects can now easily execute these ROI calculations and use the results to answer one of their clients’ most commonly asked questions: “How long does it take until a certain solution pays for itself and starts generating profit?”

Save the customized Energy Evaluation Report as a PDF document.

Before proceeding to study the energy efficiency benefits of architectural optimization, let’s review the Energy Evaluation Report document content for demand calculation, at the design development phase.

These are the relevant **project level results**:

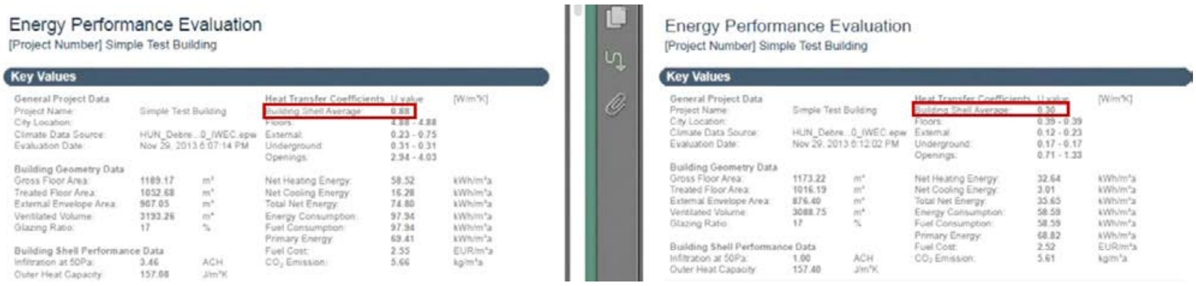
- Project Key Values,
- Project Energy Balance,
- Thermal Blocks list
- Performance Rating Table
- Fuel Consumption by Targets and by Sources tables

The following chapters contain the **thermal block level results** of the energy demand calculation:

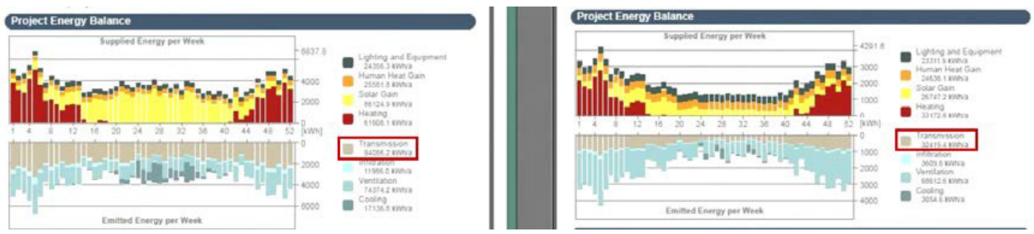
- Thermal Block Key Values,
- Thermal Block Energy Balances,
- Daily Temperature Profiles for the most important days of the reference year
- HVAC Design Data

5.4 Review Energy Efficiency Benefits of Architectural Optimization

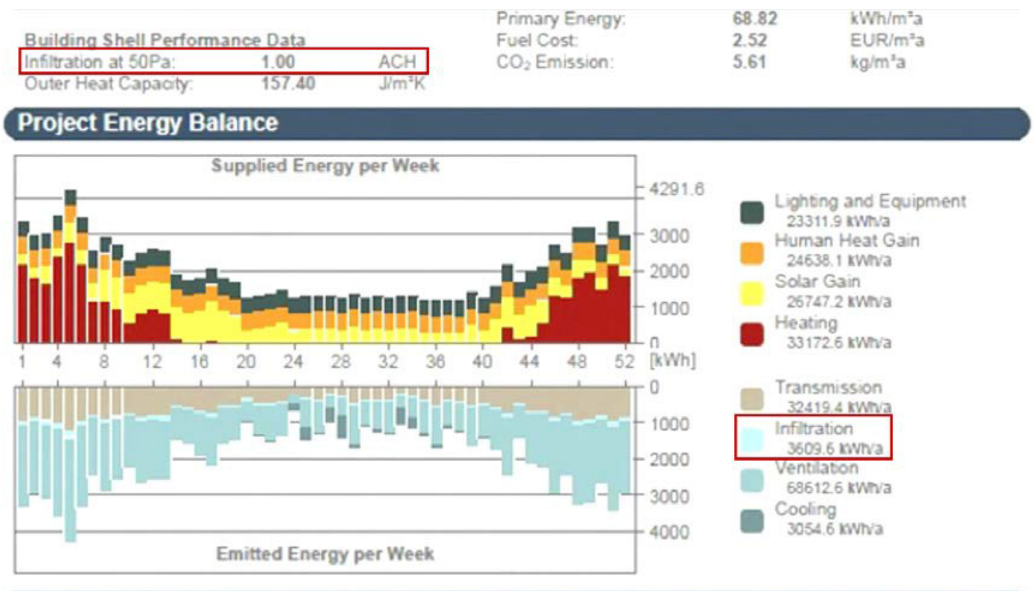
Now compare the energy performance of the improved project (on the right) with the baseline project (on the left).



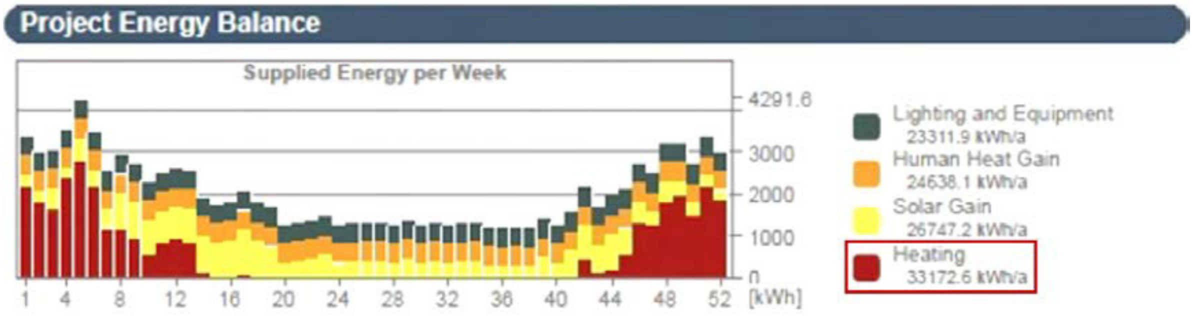
The Project Key Values chapters show that – due to the improved building envelope – the building shell's overall heat transfer coefficient is significantly (about 60%) lower for the improved project. As a result of the building envelope's higher **thermal resistance**, energy transmission (represented by light brown bars on the Projects' Week Energy Balance diagrams) is dramatically reduced, and this in turn decreases heating demand.



Next, compare the **airtightness** of the buildings. The overall infiltration at 50Pa (Pascal) pressure difference dropped dramatically, from 3.46 to 1.0 ACH. Consequently, the infiltration bars - represented in light blue on the Project Energy Balance diagram - are proportionally smaller.

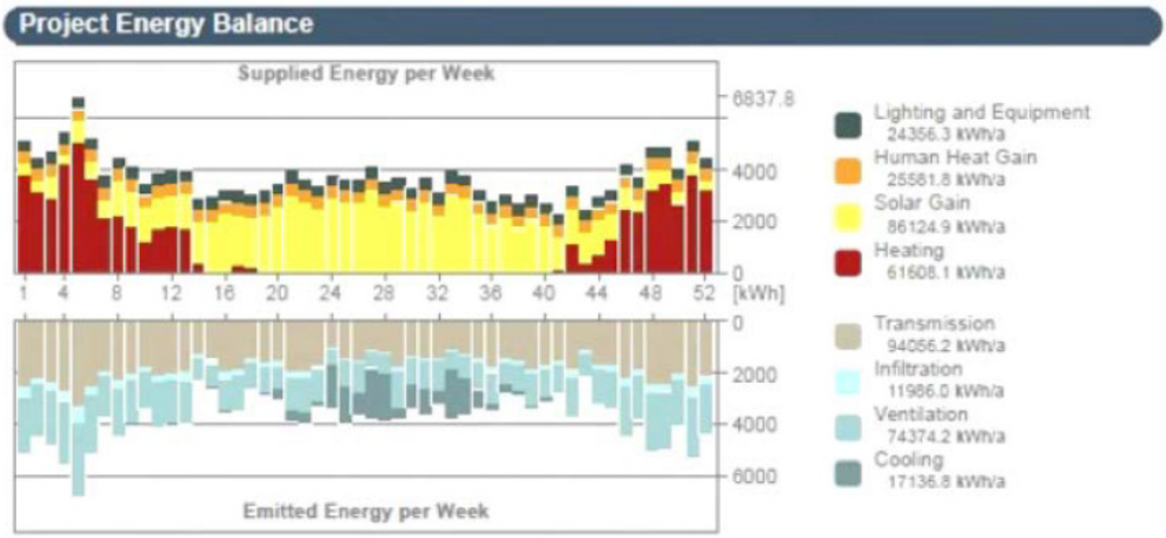


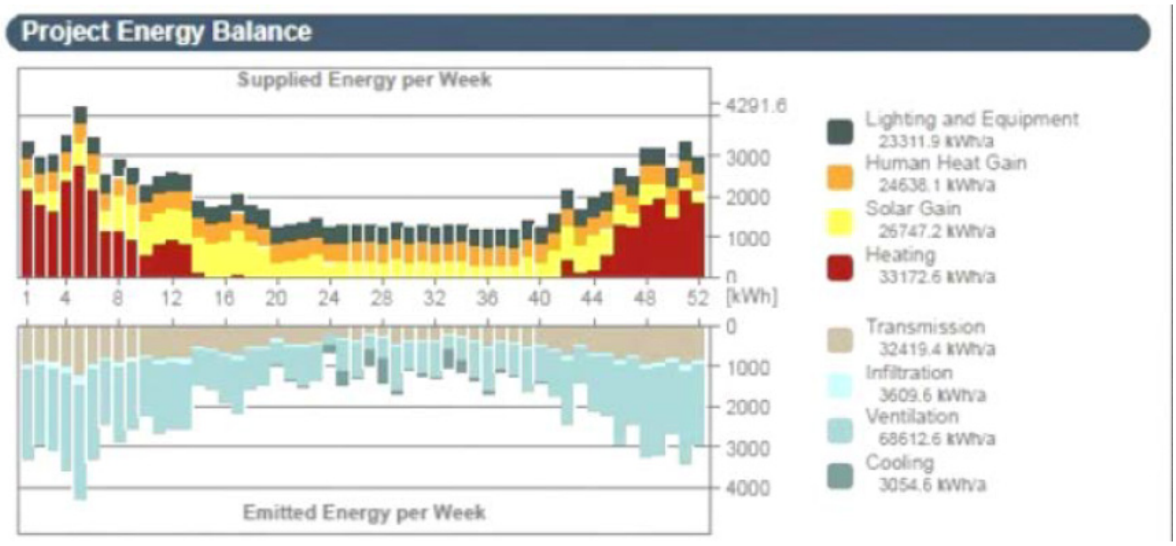
There is a significant - around 50% - **heating demand reduction** in the improved design.



Please note that the scales of the Energy Balance Diagrams are not identical. If you re-scaled one of the diagrams to match the other you would notice that the heating bars - represented in red - are significantly shorter in the improved design. The annual heating demands (shown next to Energy Balance Diagrams) and the specific net heating energy values (displayed under the Project Key Values chapter) document the dramatic reduction in heating which results from the improved building envelope.

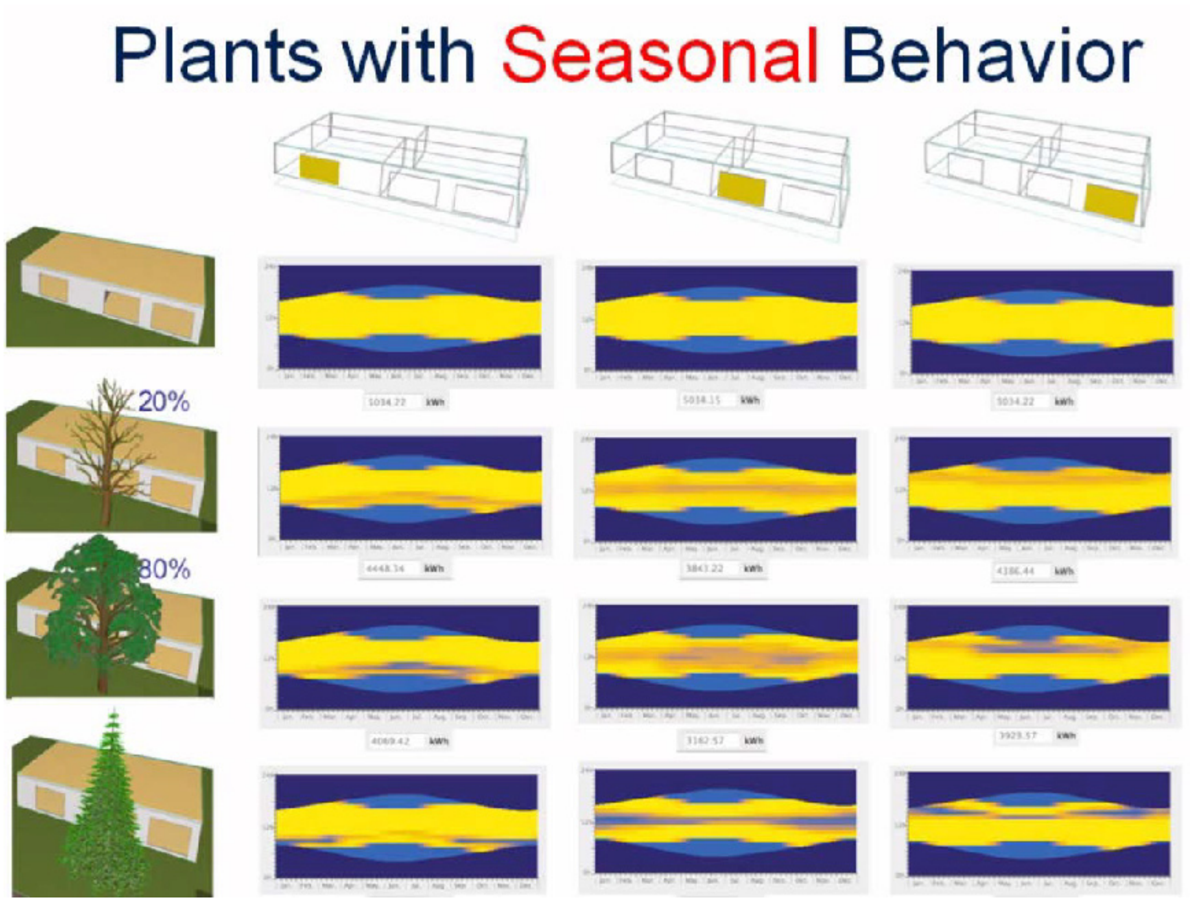
Next, review the benefits of the **solar shading**. Thanks to the smart shading devices, the unnecessary heat gain throughout the hot season is dramatically reduced (as represented by the yellow bars of the Energy Balance Diagram). Consequently, **less cooling energy** is required during the hot periods of the year.





The ArchiCAD Object Library contains plants with seasonal behavior. Since the program's **model-based Solar Analysis** function determines the shadow mask on each opening in every hour of the reference year, these dynamic tree object models can also be used in any design project as smart, seasonal shading devices.

This simple diagram illustrates the seasonal shading effect of deciduous and coniferous trees on the solar irradiation of openings.



This very simple building has three large South-facing windows, with different types of trees in front.

The solar irradiation charts demonstrate that deciduous trees with denser crowns (more leaves) cast larger shadows on the openings throughout the year.

Crown densities of deciduous trees vary during the seasons; they shade windows more effectively during the summer. In winter, however, they lose their leaves and provide less shading, which allows more heat gain through the transparent surfaces in the cold seasons.

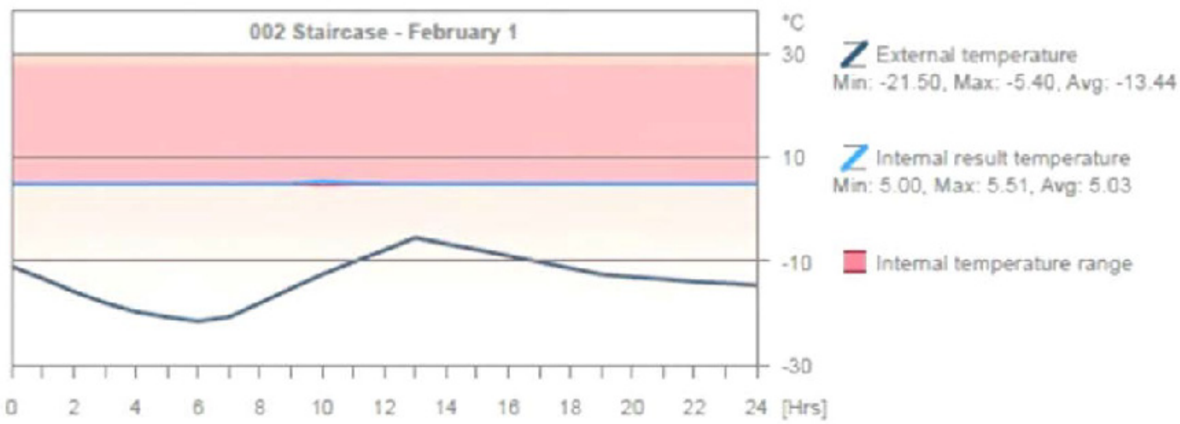
ArchiCAD’s model-based Solar Analysis also considers the tree’s position relative to the window.

> **Note** the difference in the solar irradiation charts for the different windows: the tree on the right side of the South-facing window provides shade in the morning; while the tree on the left provides shade in the afternoon.
>
> **Note** that the tree in the lowest row is an evergreen. Evergreens do not lose their leaves in the winter, and this fact is reflected in corresponding solar irradiation charts!

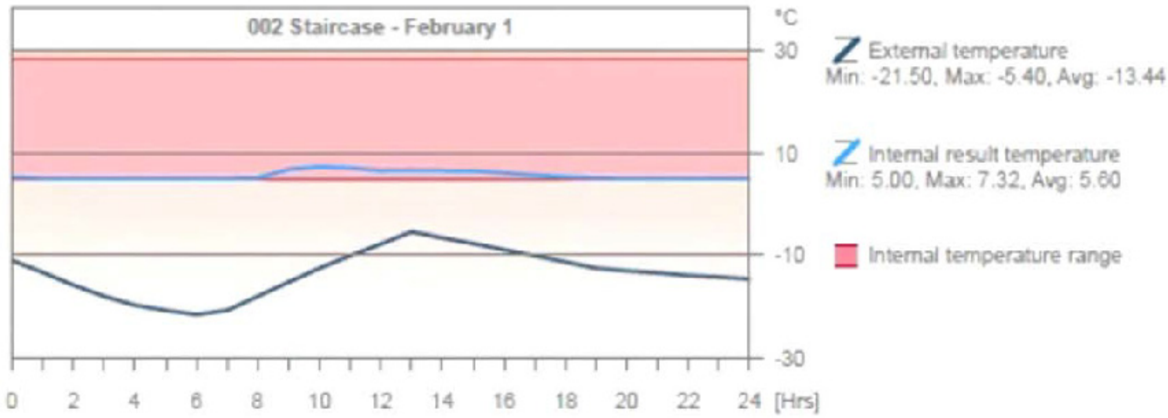
Besides reducing heating and cooling demands, our architectural design solutions also **improve the internal thermal comfort conditions**.

For example, let’s examine the thermal block of the staircase.

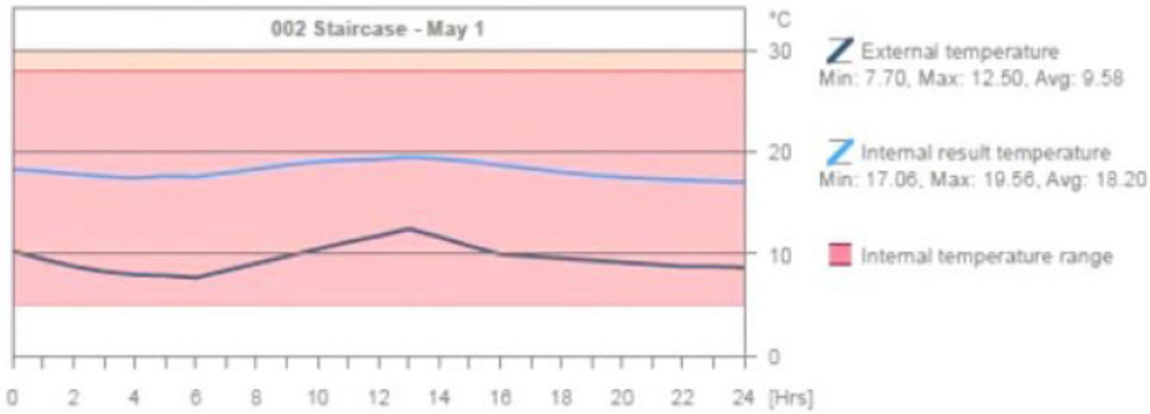
In the baseline building, the staircase block must be heated throughout the entire day of February 1st.

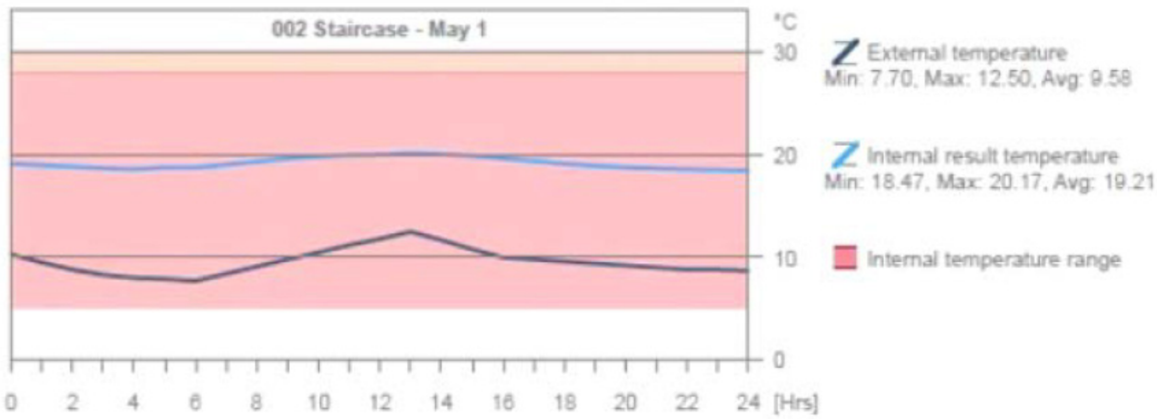


In the improved building, however, there is no need for heating from 8 AM in the morning till 6 PM in the afternoon. The **internal temperature** - displayed in light blue on the Daily Temperature Profile diagram - **remains within the comfort zone** (the red color on the diagram) without any additional energy input.



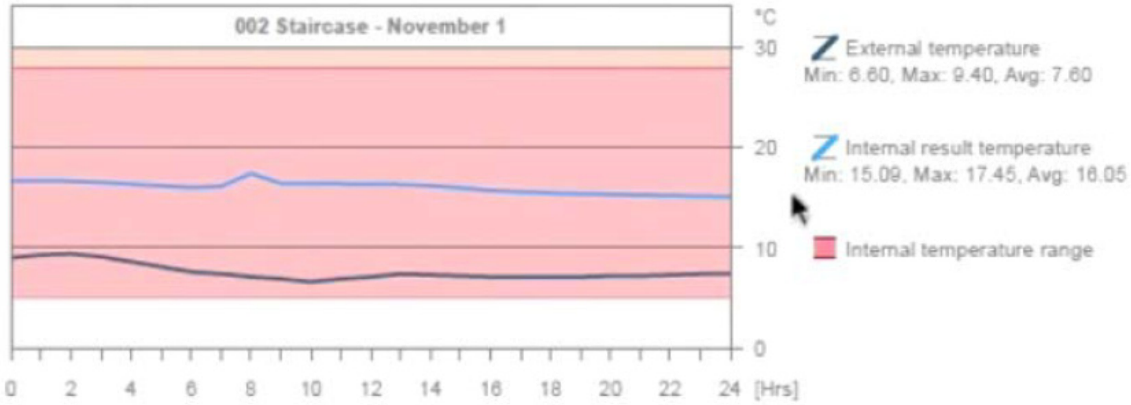
Now compare the **Daily Temperature Profile diagrams** on May 1 - a typical spring day at the project's location.





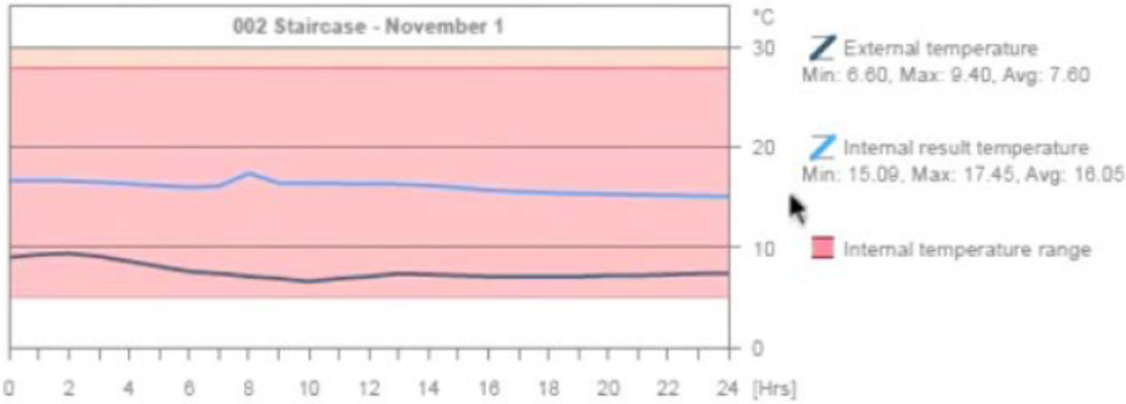
The temperatures inside the staircase block of both buildings are within the comfort zone on this day. In the improved building, however, the internal temperature is slightly higher and thus closer to the optimal comfort temperature.

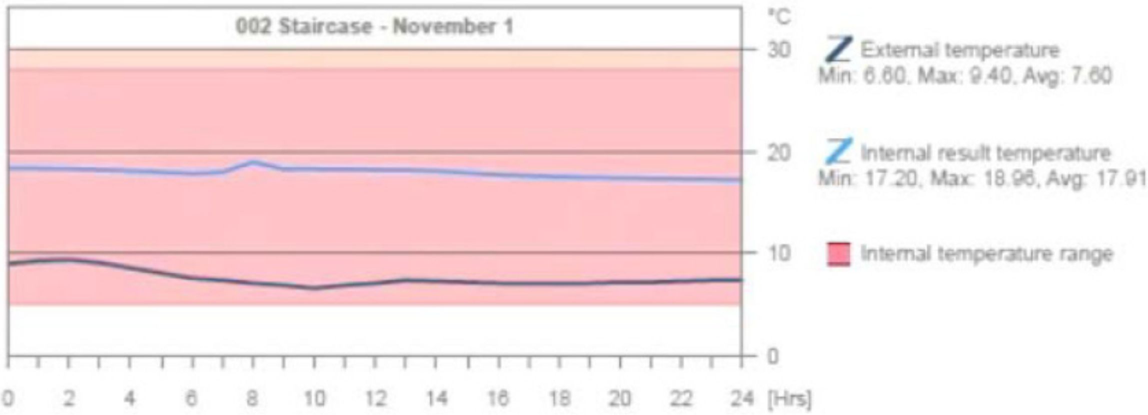
In contrast, on a typical summer day, the baseline design's staircase block is unbearably hot all day long.



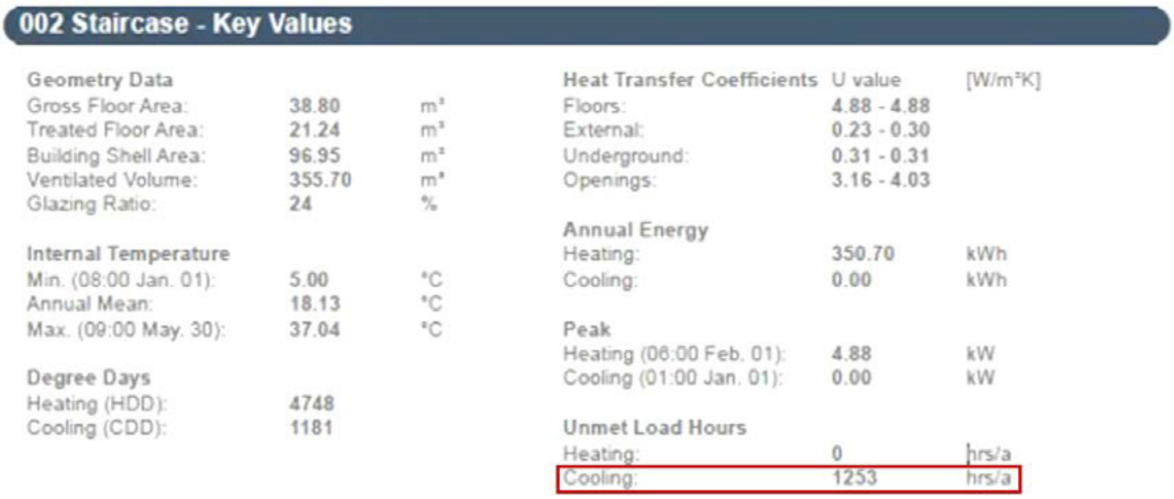
Yet in the improved building, the internal temperature of the same thermal block remains comfortable - and steady – even in the summer.

In the fall - similarly to the spring scenario – both designs provide sufficient thermal comfort, although the temperature in the improved building's staircase block is slightly higher.





Finally, examine the Staircase Block Key Values. In the baseline building, cooling is required throughout 20% of the entire year for this thermal block.


002 Staircase - Key Values

Geometry Data			Heat Transfer Coefficients	U value	[W/m²K]
Gross Floor Area:	38.80	m²	Floors:	4.88 - 4.88	
Treated Floor Area:	21.24	m²	External:	0.23 - 0.30	
Building Shell Area:	96.95	m²	Underground:	0.31 - 0.31	
Ventilated Volume:	355.70	m³	Openings:	3.16 - 4.03	
Glazing Ratio:	24	%			
Internal Temperature			**Annual Energy**		
Min. (08:00 Jan. 01):	5.00	°C	Heating:	350.70	kWh
Annual Mean:	18.13	°C	Cooling:	0.00	kWh
Max. (09:00 May. 30):	37.04	°C			
Degree Days			**Peak**		
Heating (HDD):	4748		Heating (06:00 Feb. 01):	4.88	kW
Cooling (CDD):	1181		Cooling (01:00 Jan. 01):	0.00	kW
			Unmet Load Hours		
			Heating:	0	hrs/a
			Cooling:	1253	hrs/a

In the improved building, there is no need for any cooling in the Staircase Block.

002 Staircase - Key Values

Geometry Data		
Gross Floor Area:	41.22	m²
Treated Floor Area:	21.72	m²
Building Shell Area:	95.03	m²
Ventilated Volume:	344.02	m³
Glazing Ratio:	24	%
Internal Temperature		
Min. (01:00 Jan. 01):	5.00	°C
Annual Mean:	17.14	°C
Max. (11:00 Jul. 09):	28.40	°C
Degree Days		
Heating (HDD):	4748	
Cooling (CDD):	1181	

Heat Transfer Coefficients	U value	[W/m²K]
Floors:	0.39 - 0.39	
External:	0.12 - 0.17	
Underground:	0.17 - 0.17	
Openings:	0.88 - 1.33	
Annual Energy		
Heating:	28.15	kWh
Cooling:	0.00	kWh
Peak		
Heating (06:00 Feb. 01):	1.25	kW
Cooling (01:00 Jan. 01):	0.00	kW
Unmet Load Hours		
Heating:	0	hrs/a
Cooling:	0	hrs/a

After reviewing the energy performance consequences of our architectural design solutions, we can conclude that the enhancements have been successful in the example project.

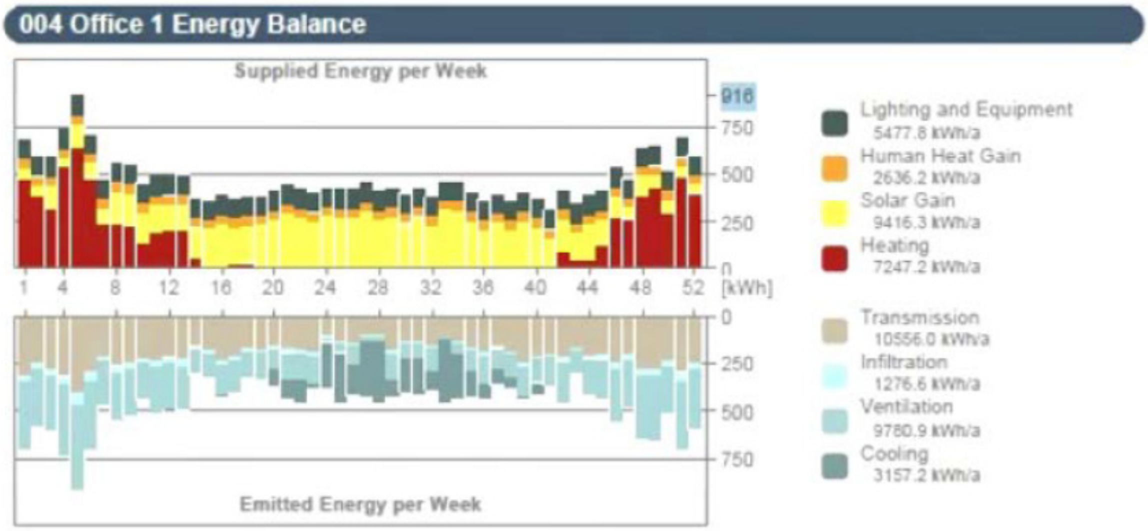
The most significant benefits come from the **lower annual and peak heating and cooling loads**. The Performance Rating Table lists this data for every thermal block of both design versions, together with the energy savings achieved in the improved building.

The numbers speak for themselves: 45% reduction in the annual heating and nearly 85% reduction in the annual cooling demand.

Performance Rating Table

Energy Use	Units	Proposed Design Results	BaseLine Building Results	Savings %
Heating	Energy Use (kWh)	33172.59	60179.54	44.88
	Peak Demand (kW)	45.21	65.09	30.54
Cooling	Energy Use (kWh)	3054.64	19404.27	84.26
	Peak Demand (kW)	14.69	38.64	61.98
Service Hot-Water	Energy Use (kWh)	0.00	0.00	0.00
	Peak Demand (kW)	0.00	0.00	0.00
Ventilation Fans	Energy Use (kWh)	0.00	0.00	0.00
	Peak Demand (kW)	0.00	0.00	0.00
Lighting	Energy Use (kWh)	18328.74	19197.92	4.53
	Peak Demand (kW)	6.55	6.89	4.88
Equipment	Energy Use (kWh)	4983.20	5158.34	3.40
	Peak Demand (kW)	1.17	1.22	3.87
Total Annual Energy Use: (kWh/a)		**59539.17**	**103940.08**	**42.72**
Annual Process Energy: (kWh/a)		**23311.94**	**24356.27**	**4.29**

The Office thermal block’s Energy Balance Diagram is a good illustration of the **reduction of annual total energy flows**. The result is an office with **better thermal comfort** conditions and reduced energy consumption.



When you view the HVAC Design Data table of the improved design, as compared to that of the baseline building, you will notice a significant reduction in energy demands on the thermal block level, as well.

Due to the implemented architectural solutions, **smaller building systems** will be sufficient to maintain the required internal thermal conditions in the improved building.

Energy Performance Evaluation

[Project Number] Simple Test Building

HVAC Design Data

Thermal Block	Heating Demand		Cooling Demand		Internal Temperature	
	Yearly [kWh]	Hourly Peak [kW]	Yearly [kWh]	Hourly Peak [kW]	Min. [°C]	Max. [°C]
001 Storage basement	0	0.0 –	0	0.0 –	13.2 06:00 Feb. 01	26.4 16:00 Jul. 11
002 Staircase	28	1.3 06:00 Feb. 01	0	0.0 –	5.0 01:00 Jan. 01	28.4 11:00 Jul. 09
003 Retail	9438	16.8 09:00 Feb. 01	1328	6.0 16:00 Jul. 11	12.0 08:00 Jan. 02	28.9 16:00 Jul. 08
004 Office 1	4352	9.6 09:00 Feb. 01	982	4.5 16:00 Jul. 09	15.0 06:00 Jan. 01	28.1 16:00 Jul. 08
006 Flat 1	4594	5.2 07:00 Feb. 01	92	1.0 19:00 Jul. 09	15.0 06:00 Jan. 01	28.0 19:00 Jun. 15
007 Flat 2 (duplex)	5019	4.6 07:00 Feb. 01	36	0.8 19:00 Jul. 09	15.0 02:00 Jan. 01	28.0 19:00 Jun. 16
008 Flat 3	2454	2.4 07:00 Feb. 01	37	0.5 19:00 Jul. 10	15.0 05:00 Jan. 01	28.0 19:00 Jun. 15
009 Flat 4	4080	5.0 07:00 Feb. 01	183	1.2 19:00 Jul. 10	15.0 06:00 Jan. 01	28.1 06:00 Jul. 10
010 Loft	3204	4.4 07:00 Feb. 01	392	1.6 19:00 Jul. 09	15.0 04:00 Jan. 01	28.4 24:00 Jul. 10
011 Attic	0	0.0 –	0	0.0 –	3.8 09:00 Feb. 02	32.5 18:00 Jul. 11
012 Neighbor building	0	0.0 –	0	0.0 –	11.9 15:00 Jan. 01	26.9 04:00 Jul. 12
All Thermal Blocks:	**33172**	**45.2 09:00 Feb. 01**	**3054**	**14.7 16:00 Jul. 11**		

Number of Used Hours in Year:			Unmet Load Hours in Year:		
Heating:	**3043**	hrs	Heating:	**3280**	hrs
Cooling:	**993**	hrs	Cooling:	**0**	hrs

6. Whole Building Energy Efficiency Optimization

This chapter presents how to define building systems to enable calculation of fuel consumption, fuel cost, carbon footprint, primary energy and performance rating.

- Add building systems to the baseline project.
- Apply the project-specific low-energy building systems solution set and the project-specific renewable energy solution set to the project.
- Run the energy simulation in performance rating mode to compare the designed project's energy performance with the baseline building's energy performance.

6.1 Add Building Systems to Baseline Building

First, determine system sizes for the baseline building.

Here is the Evaluation Report we produced previously for the baseline building's Energy Performance. This report was created for the purpose of **building system sizing**, therefore all systems were set to Not Yet Specified for this simulation run.

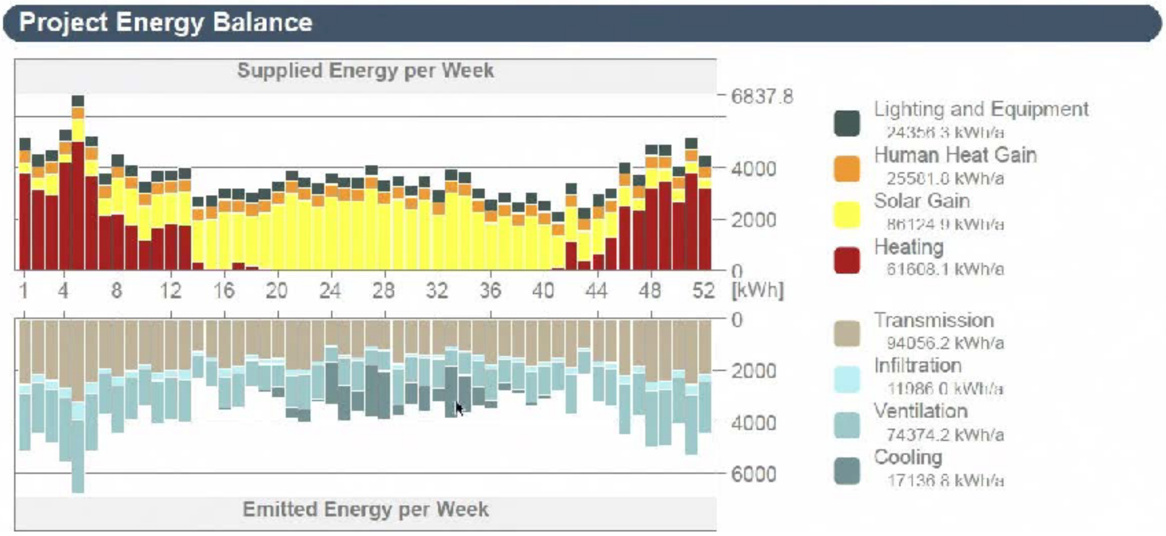
Energy Performance Evaluation

[Project Number] Simple Test Building

Key Values

General Project Data			**Heat Transfer Coefficients**	U value	[W/m²K]
Project Name:	Simple Test Building		Building Shell Average:	0.88	
City Location:			Floors:	4.88 - 4.88	
Climate Data Source:	HUN_Debre...0_IWEC.epw		External:	0.23 - 0.75	
Evaluation Date:	Nov 29, 2013 6:07:14 PM		Underground:	0.31 - 0.31	
			Openings:	2.94 - 4.03	
Building Geometry Data					
Gross Floor Area:	1189.17	m²	Net Heating Energy:	58.52	kWh/m²a
Treated Floor Area:	1052.68	m²	Net Cooling Energy:	16.28	kWh/m²a
External Envelope Area:	907.05	m²	Total Net Energy:	74.80	kWh/m²a
Ventilated Volume:	3193.26	m³	Energy Consumption:	97.94	kWh/m²a
Glazing Ratio:	17	%	Fuel Consumption:	97.94	kWh/m²a
			Primary Energy:	69.41	kWh/m²a
Building Shell Performance Data			Fuel Cost:	2.55	EUR/m²a
Infiltration at 50Pa:	3.46	ACH	CO_2 Emission:	5.66	kg/m²a
Outer Heat Capacity:	157.08	J/m²K			

Please remember that a **mediocre quality building** shell (thermal insulation, structural details, transparent surfaces, etc.) is specified for the baseline project. Consequently, the baseline building's energy evaluation shows that the heat transfer coefficients are not particularly good, and a large heat loss via transmission has a strong negative impact on overall energy consumption.



Furthermore, the baseline design's windows have no shading devices, which results in huge solar gains in the hot season. This must be counter-balanced by cooling, which further increases the baseline building's energy consumption.

The **HVAC Design Data chapter** of the baseline design's Energy Performance Evaluation Report provides information about the building's annual and hourly peak heating- and cooling demands. The hourly **peak heating and cooling load data** is the most important for determining the right size of the building systems for each thermal block.

HVAC Design Data

Thermal Block	Heating Demand Yearly [kWh]	Heating Demand Hourly Peak [kW]	Cooling Demand Yearly [kWh]	Cooling Demand Hourly Peak [kW]	Internal Temperature Min. [°C]	Internal Temperature Max. [°C]
001 Storage basement	0	0.0 –	0	0.0 –	12.0 06:00 Feb. 01	28.5 16:00 Jul. 09
002 Staircase	350	4.9 06:00 Feb. 01	0	0.0 –	5.0 08:00 Jan. 01	37.0 09:00 May. 30
003 Retail	14356	21.3 09:00 Feb. 01	4721	11.3 10:00 Jul. 09	12.0 08:00 Feb. 01	32.4 16:00 Jul. 08
004 Office 1	7247	12.6 09:00 Jan. 01	3157	8.2 15:00 Jul. 09	15.0 05:00 Jan. 01	32.0 14:00 Aug. 26
006 Flat 1	9390	8.5 07:00 Feb. 01	1874	4.1 15:00 Jul. 09	15.0 06:00 Jan. 01	29.6 06:00 Jul. 09
007 Flat 2 (duplex)	9303	7.5 07:00 Feb. 01	954	3.6 16:00 Jul. 08	15.0 02:00 Jan. 01	29.0 06:00 Jul. 10
008 Flat 3	4412	3.7 07:00 Feb. 01	592	1.9 16:00 Jul. 09	15.0 03:00 Feb. 01	29.1 06:00 Jul. 10
009 Flat 4	8588	8.3 07:00 Feb. 01	2157	4.2 15:00 Jul. 09	15.0 03:00 Feb. 01	29.5 06:00 Jul. 10
010 Loft	7958	8.3 07:00 Feb. 01	3678	6.5 13:00 Jul. 09	15.0 03:00 Jan. 01	29.6 06:00 Jul. 10
011 Attic	0	0.0 –	0	0.0 –	4.1 09:00 Jan. 31	33.5 18:00 Jul. 09
012 Neighbor building	0	0.0 –	0	0.0 –	11.3 15:00 Jan. 29	31.6 02:00 Jul. 12
All Thermal Blocks:	61608	65.5 09:00 Feb. 02	17136	36.5 16:00 Jul. 11		

The HVAC Design Data section also displays minimum and maximum internal temperatures for each thermal block. This information shows the times when the internal temperatures do not meet the thermal comfort requirements.

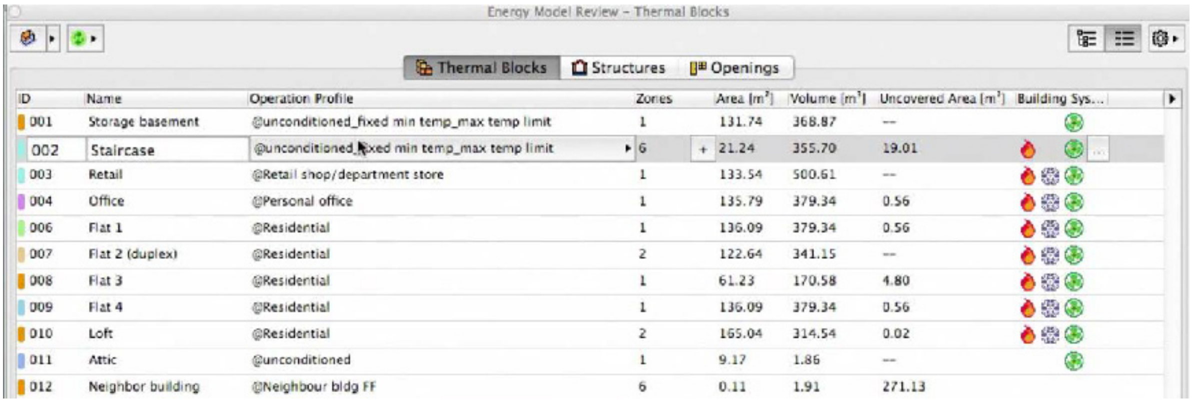
Let's continue by adding building systems to the baseline building!

Similarly to its building envelope, the baseline building's systems also represent **mediocre solutions** typically used in the region where the project is located. District heating, conventional "incandescent lighting", average quality water taps, natural and mechanical ventilation without heat-recovery option.

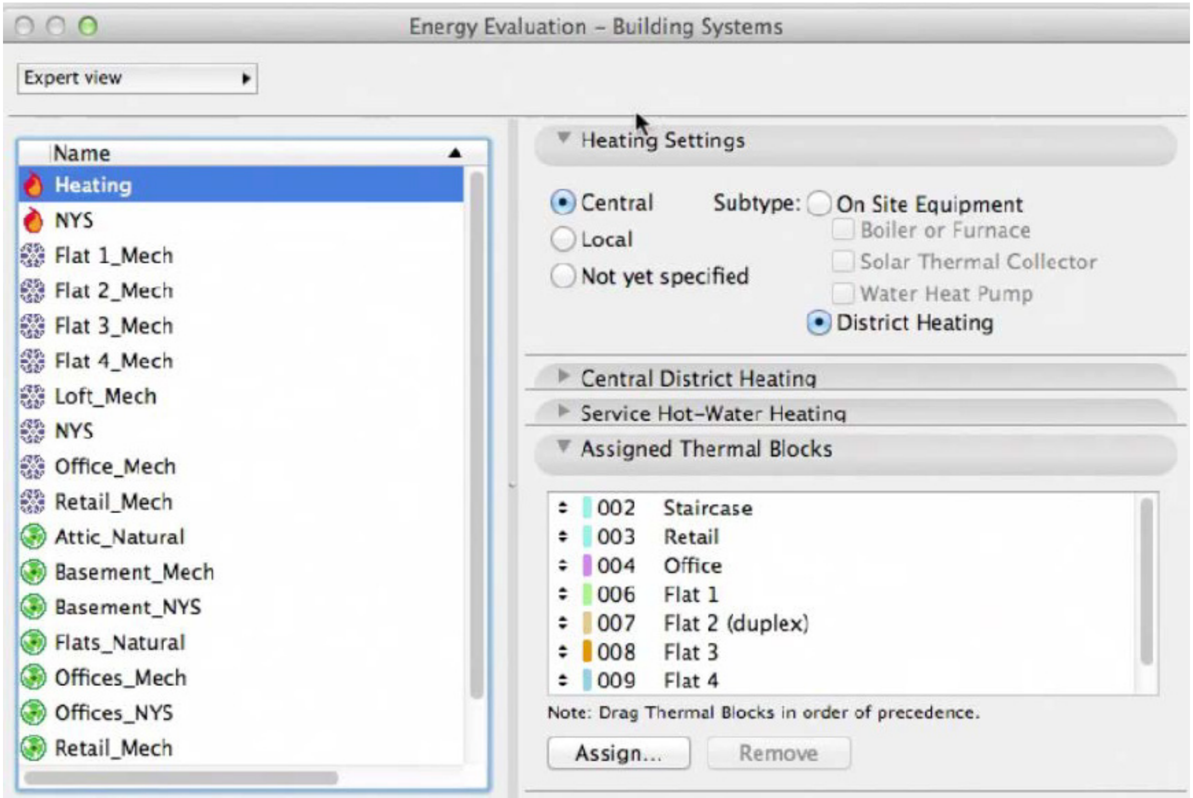
Electricity is supplied from the grid; no on-site renewable energy systems are defined.

Switch to ArchiCAD to access the baseline project. Display the Thermal Blocks page of the Energy Model Review palette to see the **building system types assigned to the thermal blocks**.

> **Note** that the colored icons on the right represent heating, cooling and ventilation systems assigned.



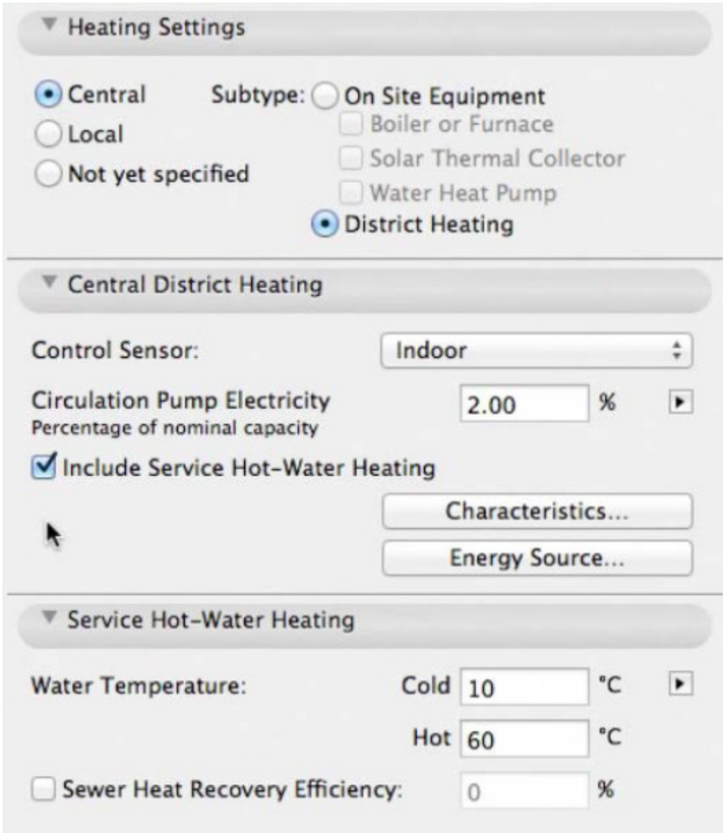
Display the Building Systems dialog to see the heating- and service hot water systems to be assigned to the thermal blocks– in other words: to **define baseline building system parameters**.



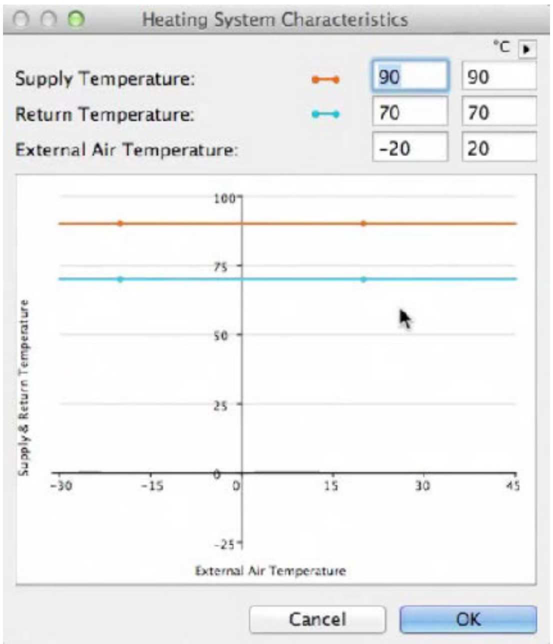
Please note: to define and assign building systems to thermal blocks, you do not need in-depth knowledge about building systems to effectively use EcoDesigner STAR. You just need to know the very basics about the building systems (most importantly their size and their type), using the **Building Systems dialog's Basic View**.

In the final design phase or when producing building energy performance rating for official approval, however, it is advisable to consult your building system engineer. The simulation input data regarding system parameters can be validated and fine-tuned via the **Expert View** of the Building Systems dialog.

Various **heating** types can be assigned to one thermal block or to a number of thermal blocks simultaneously. Select Central District Heating for the baseline design.

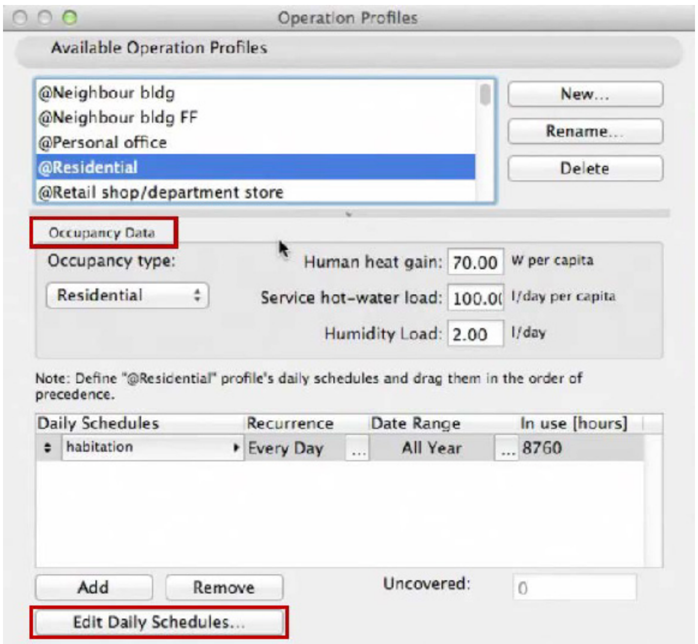


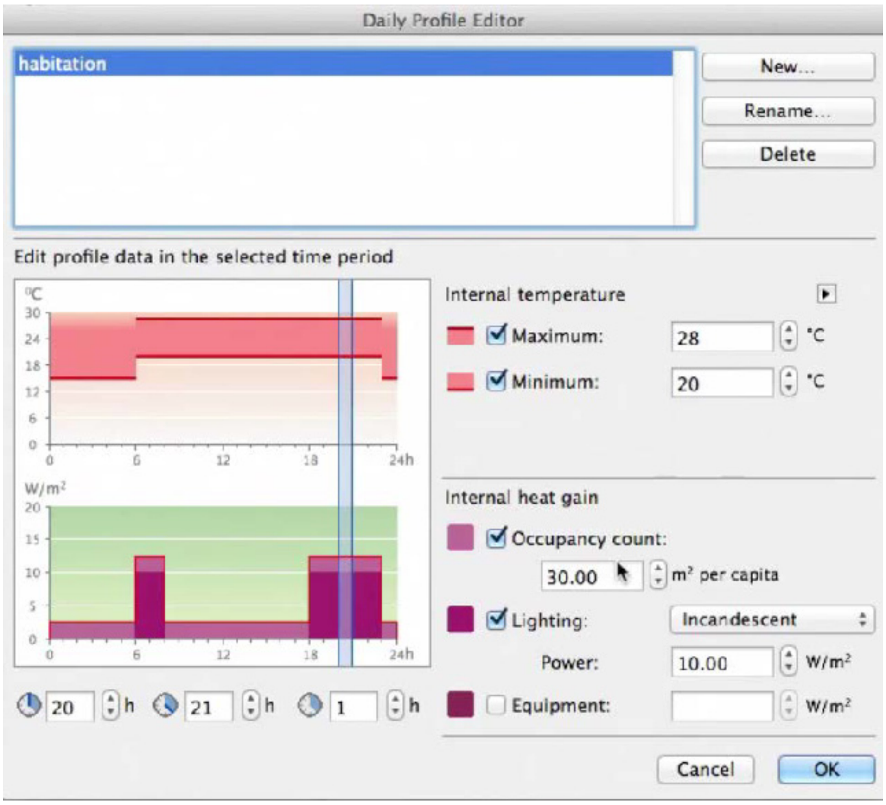
Use the Heating System Characteristics dialog to visualize or edit the default Central District Heating system profile offered by EcoDesigner STAR.



We can also specify specific temperature values for the service hot water.

The thermal blocks having the “Residential” profile consume the majority of the **service hot water** (this is necessary for washing, cooking and cleaning in the households). Use the Occupancy panel on the Operation Profiles dialog to review and edit the service hot water load specified for the residential profile. In this example, a relatively high amount is specified: 100 liters daily per capita.

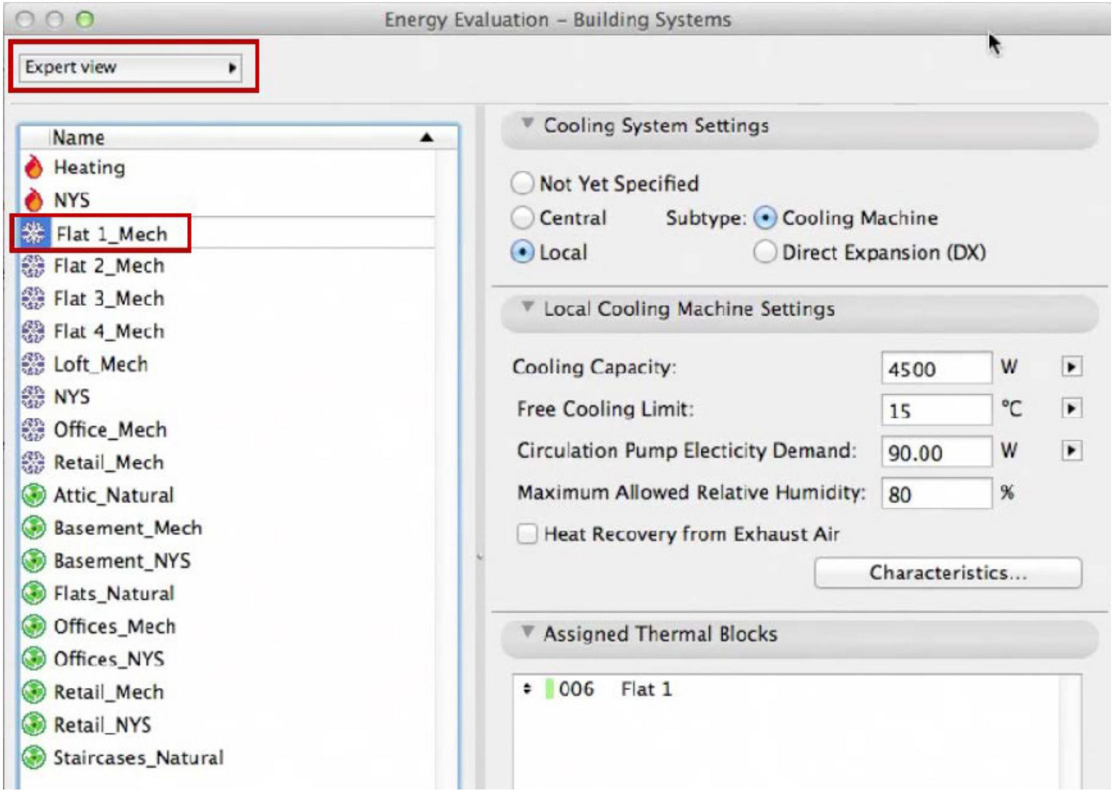




High service water consumption increases waste-water production, as well.

Now review the **cooling** systems. Local cooling machines are assigned to most thermal blocks. Like the heating systems, these Cooling Systems can be set up very simply, using the Building Systems dialog's Basic View.

The settings discussed below - other than the Cooling System Capacity and Characteristics – are advanced settings, accessible only via the Building Systems dialog's Expert View. They are discussed in this document to show that even the expert-level settings of EcoDesigner STAR are easy to understand for architects.



- The required cooling capacities are copied from the previously presented HVAC Design Data table of the Baseline Building's energy demand calculation report.

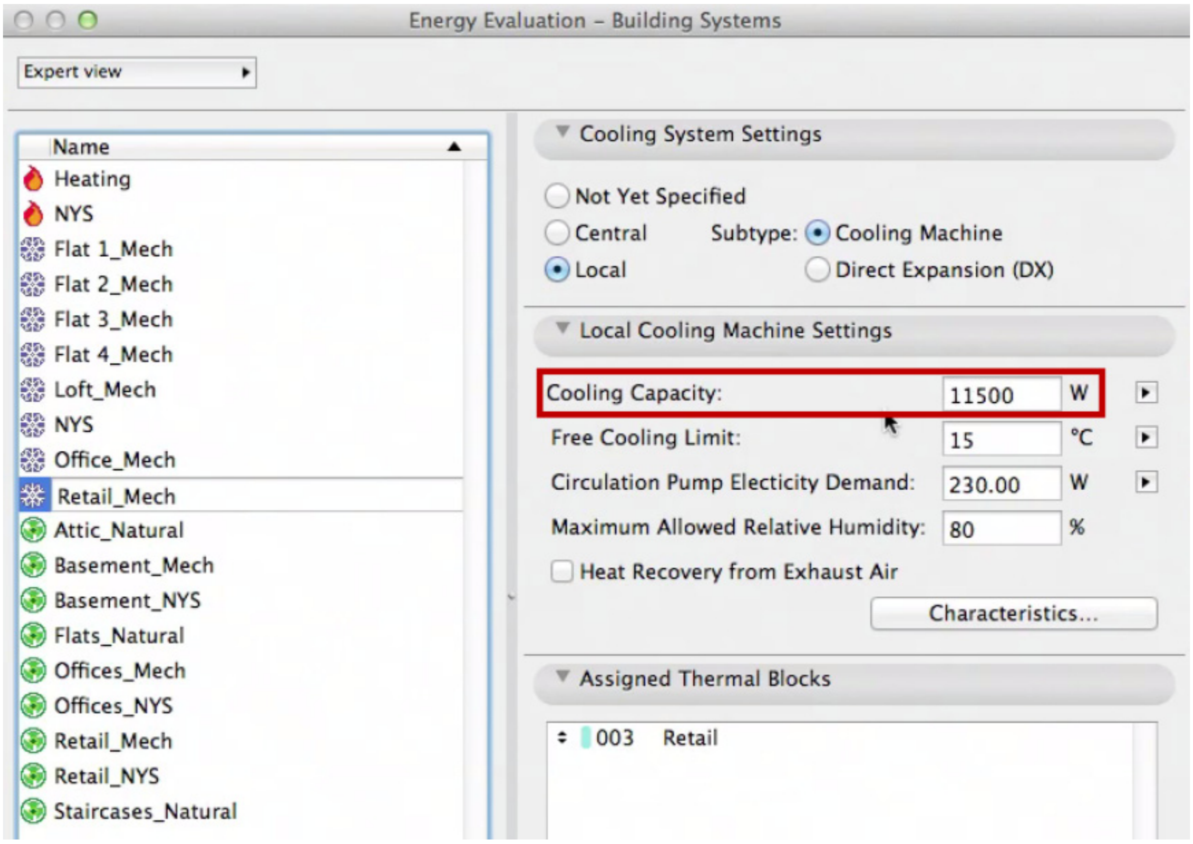
HVAC Design Data

Thermal Block	Heating Demand Yearly [kWh]	Heating Demand Hourly Peak [kW]	Cooling Demand Yearly [kWh]	Cooling Demand Hourly Peak [kW]	Internal Temperature Min. [°C]	Internal Temperature Max. [°C]
001 Storage basement	0	0.0 –	0	0.0 –	12.0 06:00 Feb. 01	28.5 16:00 Jul. 09
002 Staircase	350	4.9 06:00 Feb. 01	0	0.0 –	5.0 08:00 Jan. 01	37.0 09:00 May. 30
003 Retail	14356	21.3 09:00 Feb. 01	4721	11.3 10:00 Jul. 09	12.0 08:00 Feb. 01	32.4 16:00 Jul. 08
004 Office 1	7247	12.6 09:00 Jan. 01	3157	8.2 15:00 Jul. 09	15.0 05:00 Jan. 01	32.0 14:00 Aug. 26
006 Flat 1	9390	8.5 07:00 Feb. 01	1874	4.1 15:00 Jul. 09	15.0 06:00 Jan. 01	29.6 08:00 Jul. 09
007 Flat 2 (duplex)	9303	7.5 07:00 Feb. 01	954	3.6 16:00 Jul. 08	15.0 02:00 Jan. 01	29.0 06:00 Jul. 10
008 Flat 3	4412	3.7 07:00 Feb. 01	592	1.9 16:00 Jul. 09	15.0 03:00 Feb. 01	29.1 06:00 Jul. 10
009 Flat 4	8588	8.3 07:00 Feb. 01	2157	4.2 15:00 Jul. 09	15.0 03:00 Feb. 01	29.5 06:00 Jul. 10

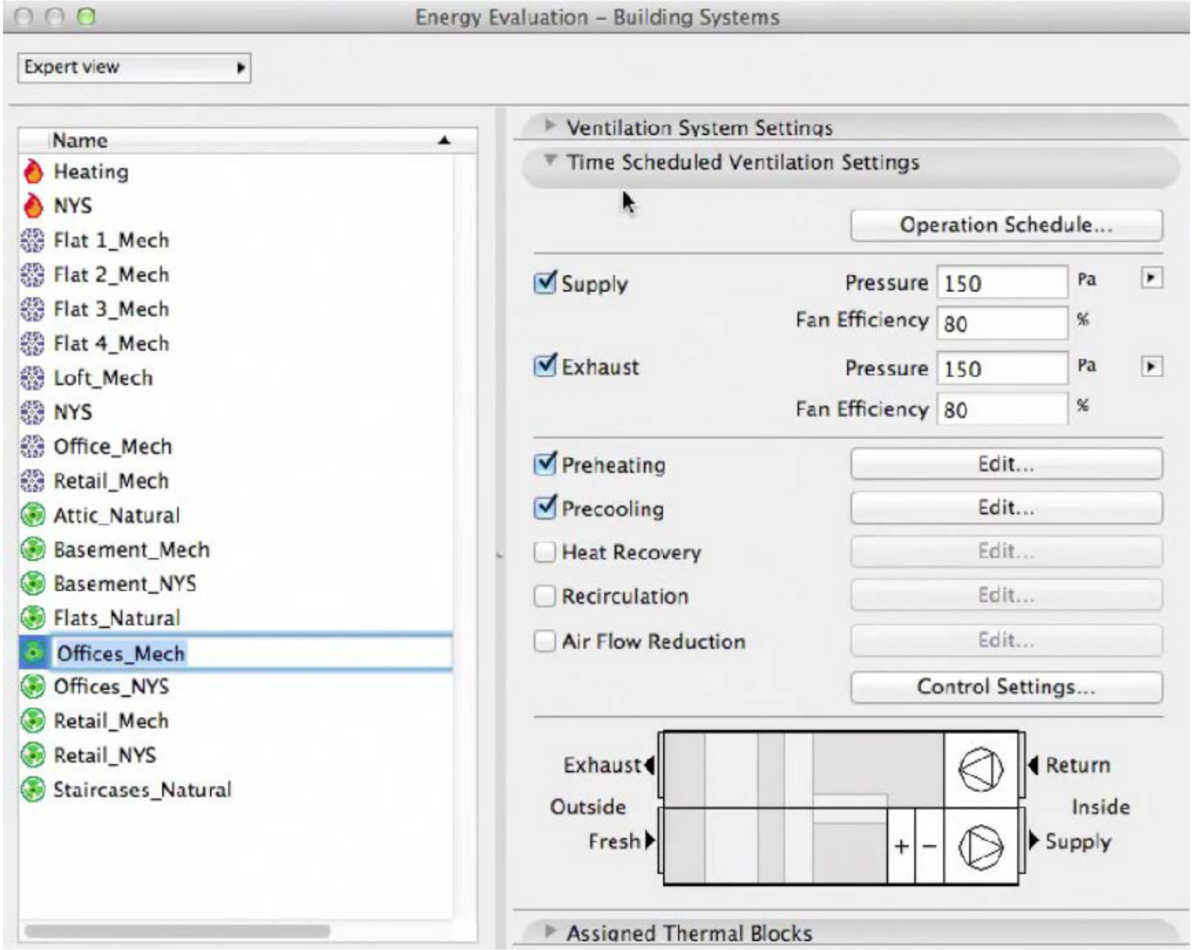
- The Free Cooling Limit is an external air temperature limit. If the external air temperature drops below this limit value, then the external air is used directly to cool the building - no cooling mechanism is applied to alter the temperature of the external air. These are the times of the year when natural ventilation can also be effectively used for cooling.
- Circulation Pump Electricity Demand is the peak energy demand of the pump that circulates the refrigerant in the cooling circuit.
- The maximum allowed relative humidity is a limit value that is used as a setpoint during the hourly Energy simulation. If the indoor air's relative humidity increases beyond this threshold, then the cooling machine turns off to avoid condensation.
- Use the Cooling System Characteristics dialog to visualize or edit the default Local Cooling system profile offered by EcoDesigner STAR.

As an example, open the Cooling Systems settings of the "Retail" operation profile.

Note that this thermal block requires the largest cooling capacity.



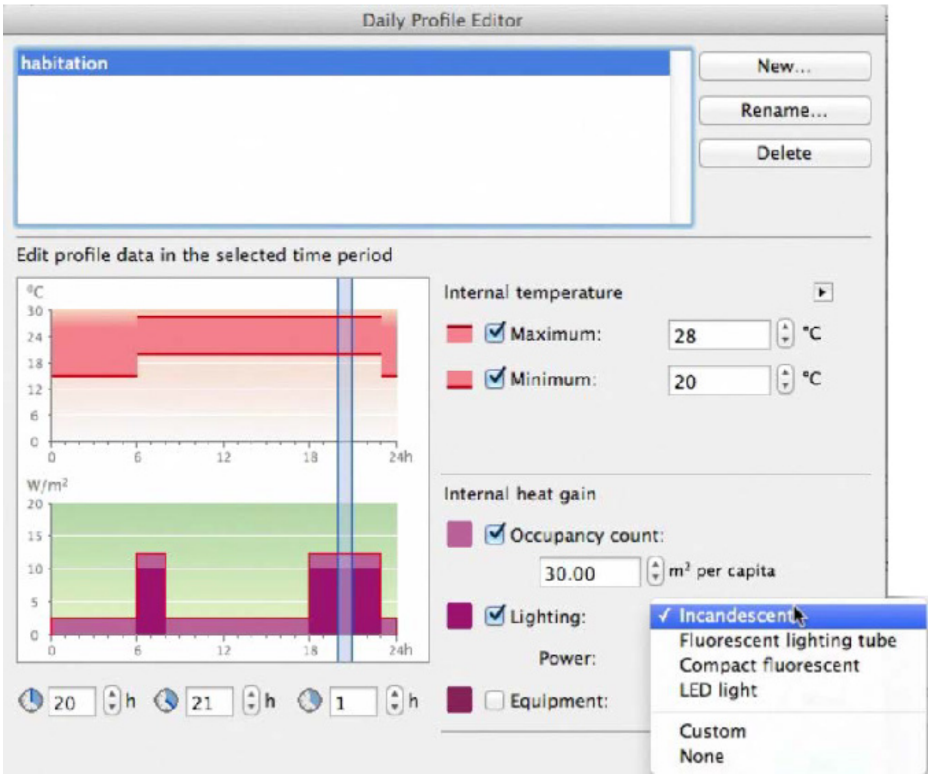
Review the settings of the **ventilation** system assigned to the thermal block, which uses the Office operation profile.



Use the Time Scheduled Ventilation Settings panel of the Building Systems dialog in Expert View if you wish to modify the default Time Scheduled Mechanical Ventilation system's parameters. Details such as Supply and Exhaust fan pressures and efficiencies can be altered; preheating and precooling parameters can be specified.

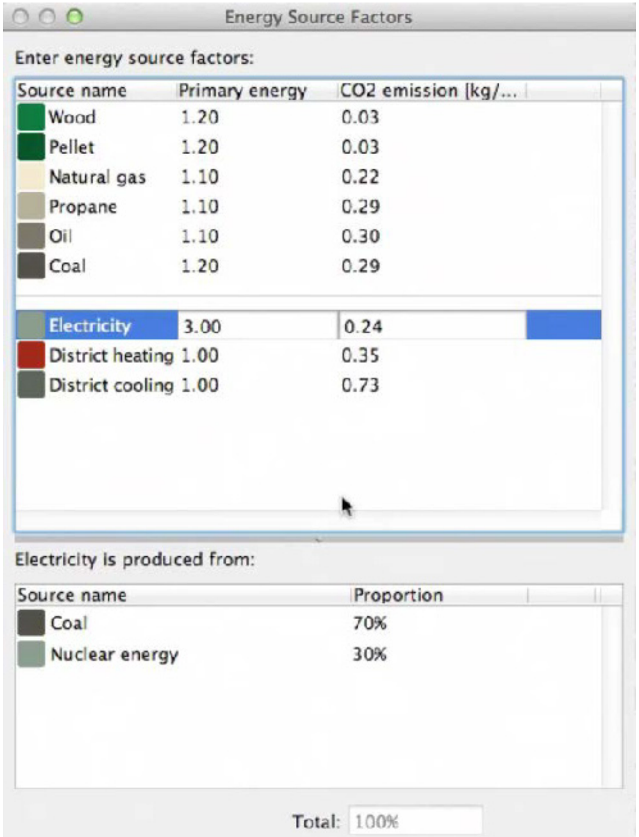
Note that it is also possible to model more advanced ventilation systems than the ones used in this baseline building example. Use the Heat Recovery, Recirculation or Air Flow Reduction dialogs to specify more advanced mechanical ventilation units.

Let's see how to specify the schedule and characteristics of **artificial lighting**. Lighting is a component of the internal heat gain defined on the Daily Profile Editor panel of the Operation Profiles dialog. Here, select the light fixture type used to illuminate the thermal block. Alternatively, define the Lighting Power Density (LPD) numerically.



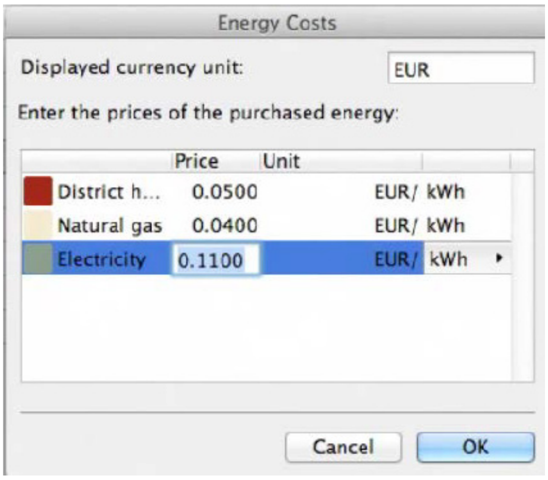
Conventional "Incandescent" light fixtures are selected for the baseline building. This lamp type is the least efficient; its operation produces significant heat in addition to visible light.

Finally, examine the Energy Source Factors dialog, which defines primary **energy and CO2 emission factors**. These values are used in primary energy and carbon dioxide emission calculations.

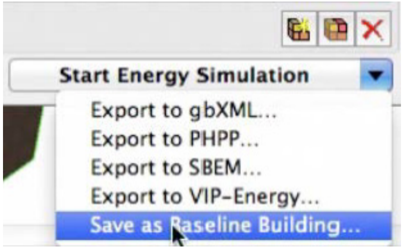


For example, electrical power is produced from 70% coal and 30% from a nuclear facility in the region where the example project is located. This defines the carbon footprint and primary energy associated with electricity consumption.

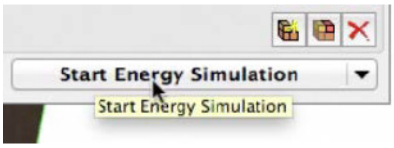
Energy sources (a.k.a. fuel types) are defined for each building system individually via the dedicated dialogs of the Building Systems panel. **Fuel prices** - as well as the currency - are specified on the Energy Costs dialog.



After specifying all baseline systems for the baseline design, we save the building energy model as a **baseline building reference file,** with “BAS” file-name extension. We will use this baseline building reference file later, for the performance rating.



Start the Energy Simulation of the baseline building with all systems included, then save the Energy Performance Evaluation report as a PDF file.



6.2 Apply Project-Specific Low-energy Building Systems and Renewable Energy Systems Solution Set to Designed Building

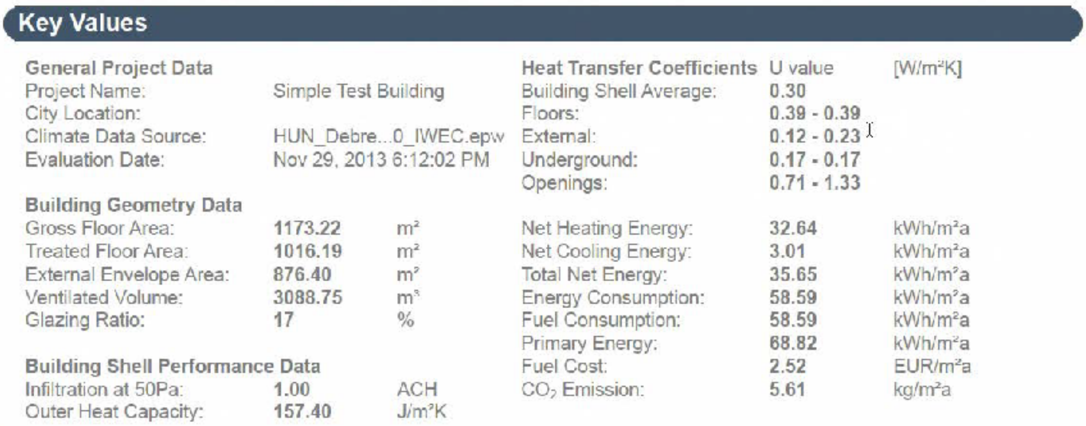
The next step of the energy optimization process is to apply the project-specific, low-energy building systems and renewable energy systems.

We start by reviewing the **system sizing** calculations carried out on the project version referenced as the “designed building”.

Note that this project version is different from the baseline building project version.

Please see the “Low-Energy Demand Architectural Design” chapter to find out more about the differences between the designed building and the baseline building project versions.

The designed building’s energy **demand calculation results** are displayed. The lower heat transfer coefficient values on the energy evaluation report reflect the benefits of the energy efficient architectural solutions, such as the advanced envelope, improved detail construction, and advanced windows.


Key Values

General Project Data			**Heat Transfer Coefficients**	U value	[W/m^{2}K]
Project Name:	Simple Test Building		Building Shell Average:	0.30	
City Location:			Floors:	0.39 - 0.39	
Climate Data Source:	HUN_Debre...0_IWEC.epw		External:	0.12 - 0.23	
Evaluation Date:	Nov 29, 2013 6:12:02 PM		Underground:	0.17 - 0.17	
			Openings:	0.71 - 1.33	
Building Geometry Data					
Gross Floor Area:	1173.22	m^2	Net Heating Energy:	32.64	kWh/m^{2}a
Treated Floor Area:	1016.19	m^2	Net Cooling Energy:	3.01	kWh/m^{2}a
External Envelope Area:	876.40	m^2	Total Net Energy:	35.65	kWh/m^{2}a
Ventilated Volume:	3088.75	m^3	Energy Consumption:	58.59	kWh/m^{2}a
Glazing Ratio:	17	%	Fuel Consumption:	58.59	kWh/m^{2}a
			Primary Energy:	68.82	kWh/m^{2}a
Building Shell Performance Data			Fuel Cost:	2.52	EUR/m^{2}a
Infiltration at 50Pa:	1.00	ACH	CO_2 Emission:	5.61	kg/m^{2}a
Outer Heat Capacity:	157.40	J/m^{2}K			

Due to solar shading, the solar heat gain is significantly less during the hot season and therefore the cooling demand is also less, as compared to the baseline building.

The HVAC Design Data chapter of the Energy Performance Evaluation report contains the initial input information necessary for sizing the building systems: the annual and hourly peak heating and cooling demands.

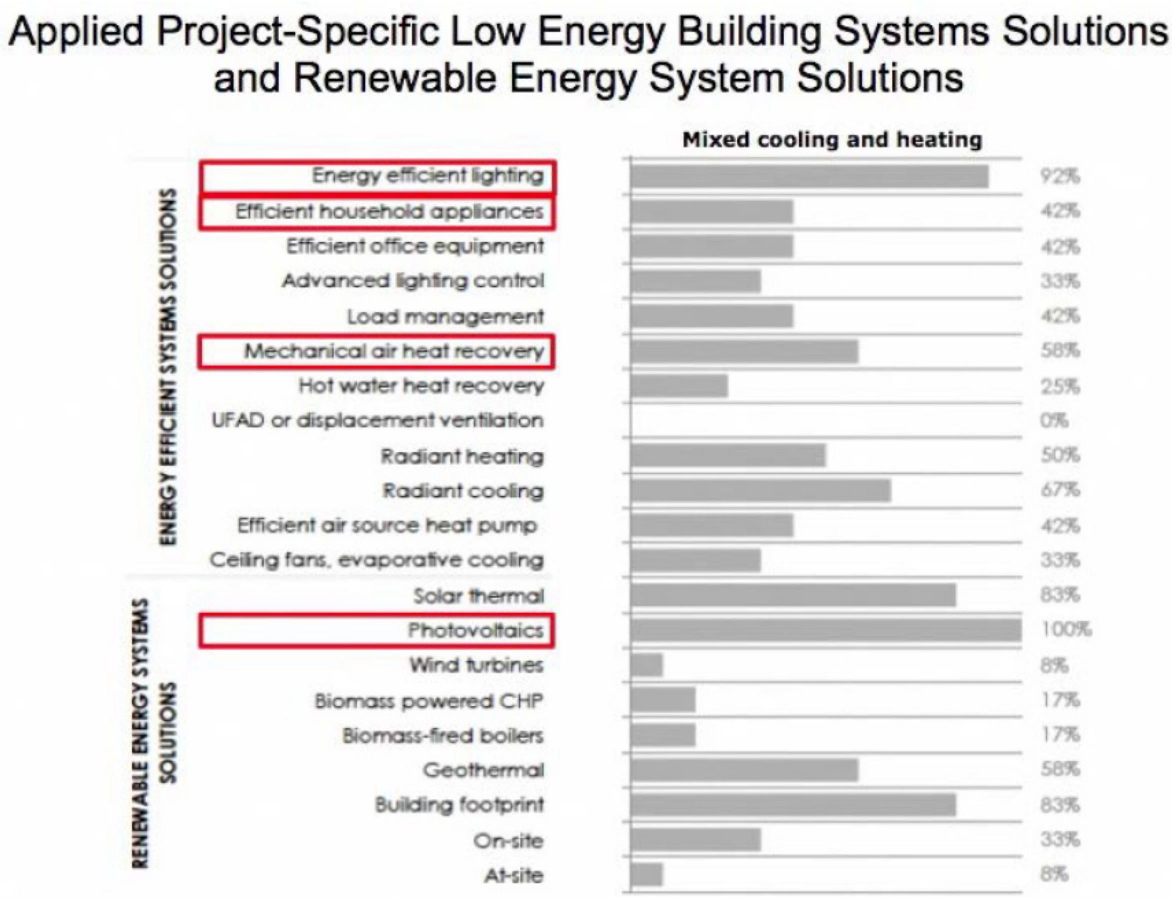
HVAC Design Data

Thermal Block	Heating Demand		Cooling Demand		Internal Temperature	
	Yearly [kWh]	Hourly Peak [kW]	Yearly [kWh]	Hourly Peak [kW]	Min. [°C]	Max. [°C]
001 Storage basement	0	0.0 --	0	0.0 --	13.2 06:00 Feb. 01	26.4 16:00 Jul. 11
002 Staircase	28	1.3 06:00 Feb. 01	0	0.0 --	5.0 01:00 Jan. 01	28.4 11:00 Jul. 09
003 Retail	9438	16.8 09:00 Feb. 01	1328	6.0 16:00 Jul. 11	12.0 08:00 Jan. 02	28.9 16:00 Jul. 08
004 Office 1	4352	9.6 09:00 Feb. 01	982	4.5 16:00 Jul. 09	15.0 06:00 Jan. 01	28.1 16:00 Jul. 08
006 Flat 1	4594	5.2 07:00 Feb. 01	92	1.0 19:00 Jul. 09	15.0 06:00 Jan. 01	28.0 19:00 Jun. 15
007 Flat 2 (duplex)	5019	4.6 07:00 Feb. 01	36	0.8 19:00 Jul. 09	15.0 02:00 Jan. 01	28.0 19:00 Jun. 16
008 Flat 3	2454	2.4 07:00 Feb. 01	37	0.5 19:00 Jul. 10	15.0 05:00 Jan. 01	28.0 19:00 Jun. 15
009 Flat 4	4080	5.0 07:00 Feb. 01	183	1.2 19:00 Jul. 10	15.0 06:00 Jan. 01	28.1 06:00 Jul. 10
010 Loft	3204	4.4 07:00 Feb. 01	392	1.6 19:00 Jul. 09	15.0 04:00 Jan. 01	28.4 24:00 Jul. 10
011 Attic	0	0.0 --	0	0.0 --	3.8 09:00 Feb. 02	32.5 18:00 Jul. 11
012 Neighbor building	0	0.0 --	0	0.0 --	11.9 15:00 Jan. 01	26.9 04:00 Jul. 12

The next step is to define the building systems for the designed building. The recommended workflow:

- Review the designed building's energy demands
- Investigate building energy optimization options
- Execute sensitivity analysis
- Determine the project-specific solution set

This table summarizes the results of an extensive study carried out by the International Energy Agency Solar Heating and Cooling Program Task 40 Research Group. It presents the statistical data about the relevance of applied “Energy Efficient Building System Solutions” and “Renewable Energy Systems Solutions” for the “Mixed Cooling and Heating” climate, where our example project is located. Based on these statistics (or on similar research data), the solutions that are potentially suitable for the example project can be selected. Whether it’s worthwhile to apply them can then be decided by sensitivity analysis.



Based on the sensitivity analysis’ results, the following **project-specific low-energy building systems and renewable energy systems solutions** are applied to the example project:

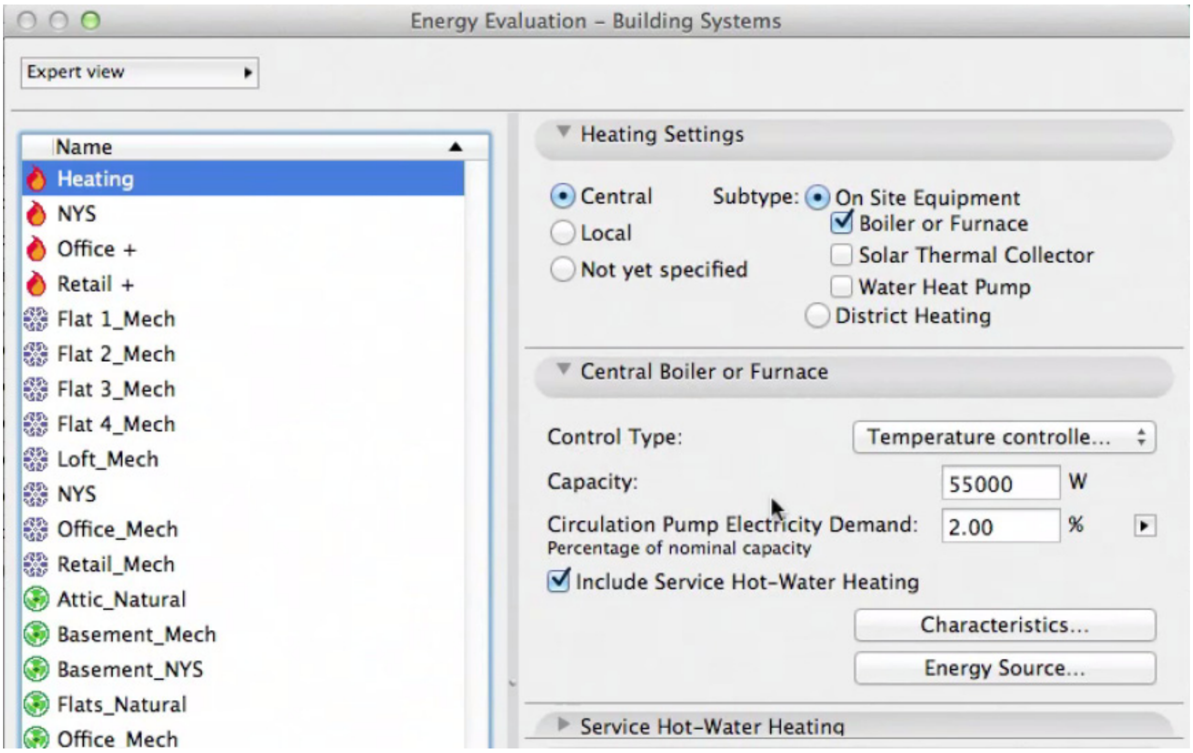
- Energy efficient lighting
- Water-saving taps
- Mechanical air heat recovery for the mechanical ventilation systems
- Photovoltaic system to produce electricity on-site

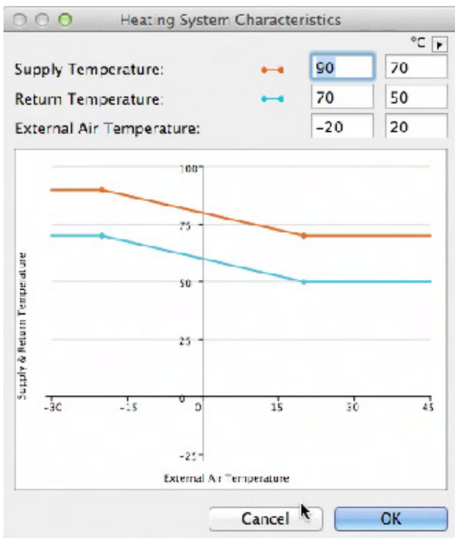
  Note that - due to the previously applied low-energy architectural design solutions – the designed building requires much lower-capacity heating and cooling systems than the baseline building.

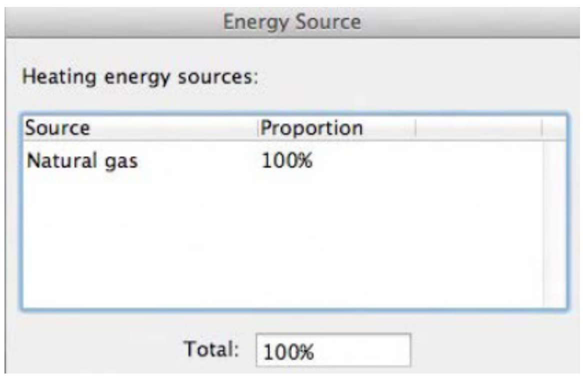
Let’s return to EcoDesigner STAR and see how to implement the building system solutions. In this example file, the low-energy building systems and renewable energy systems are already set up, as detailed below:

Use the Thermal Blocks page of the Energy Model Review Palette to create and configure building systems and to add them to the thermal blocks.

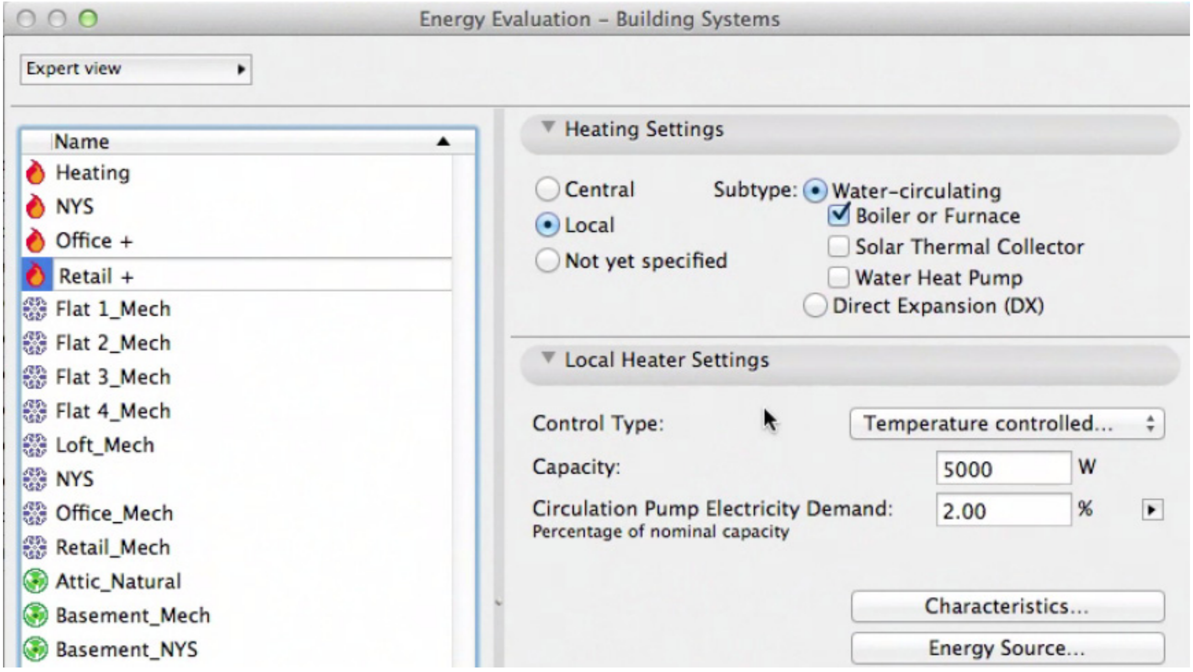
- A Central, On-Site **heating** system is specified for all thermal blocks that require heating. Here you can see its characteristics and the energy source (natural gas) that it consumes.



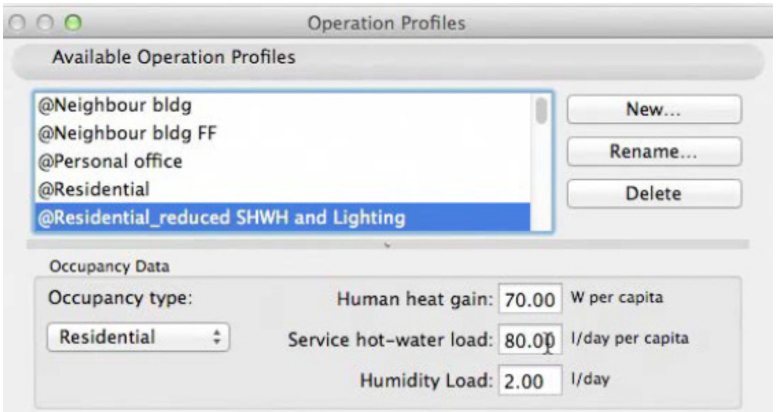




We provided two additional smaller, local back-up gas boilers: one for the office and one for the retail thermal blocks.

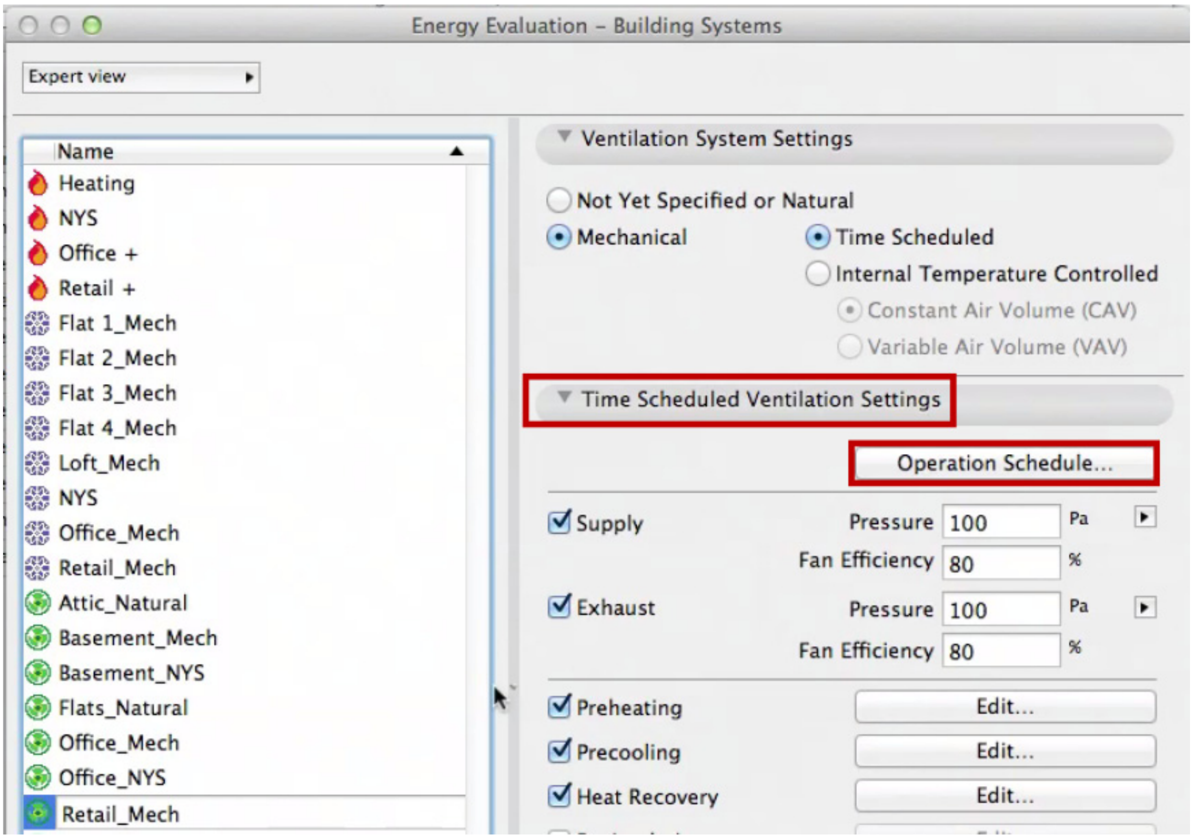


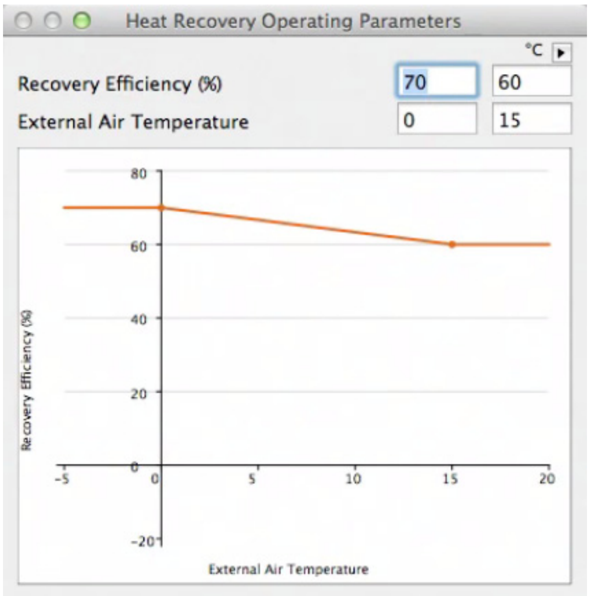
- By using more advanced taps and household appliances, it is possible to reduce the **service hot-water** load by 20% compared to the baseline building. Use the Operation Profiles dialog to set the service hot-water load of the residential operational profile.



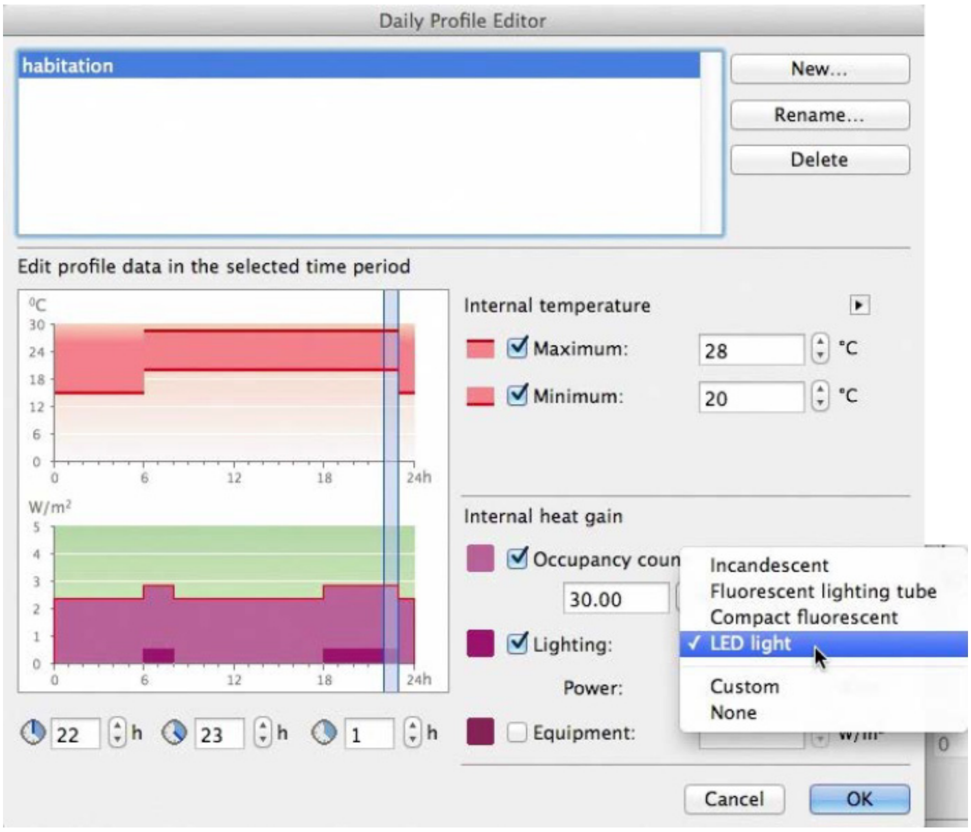
- Please note that the designed building's energy model contains fewer **cooling** machines than the baseline building, because some of the apartments do not require mechanical cooling due to the effective solar shading discussed earlier. For the thermal blocks that do require mechanical cooling – e.g. the Office - cooling systems with less capacity than the baseline project's are suitable.

- The mechanical **ventilation** systems – e.g. the Retail thermal zones - are time-scheduled and equipped with modern air-to-air heat recovery modules. This means that the heat of the exhaust air is used to pre-heat the fresh air.

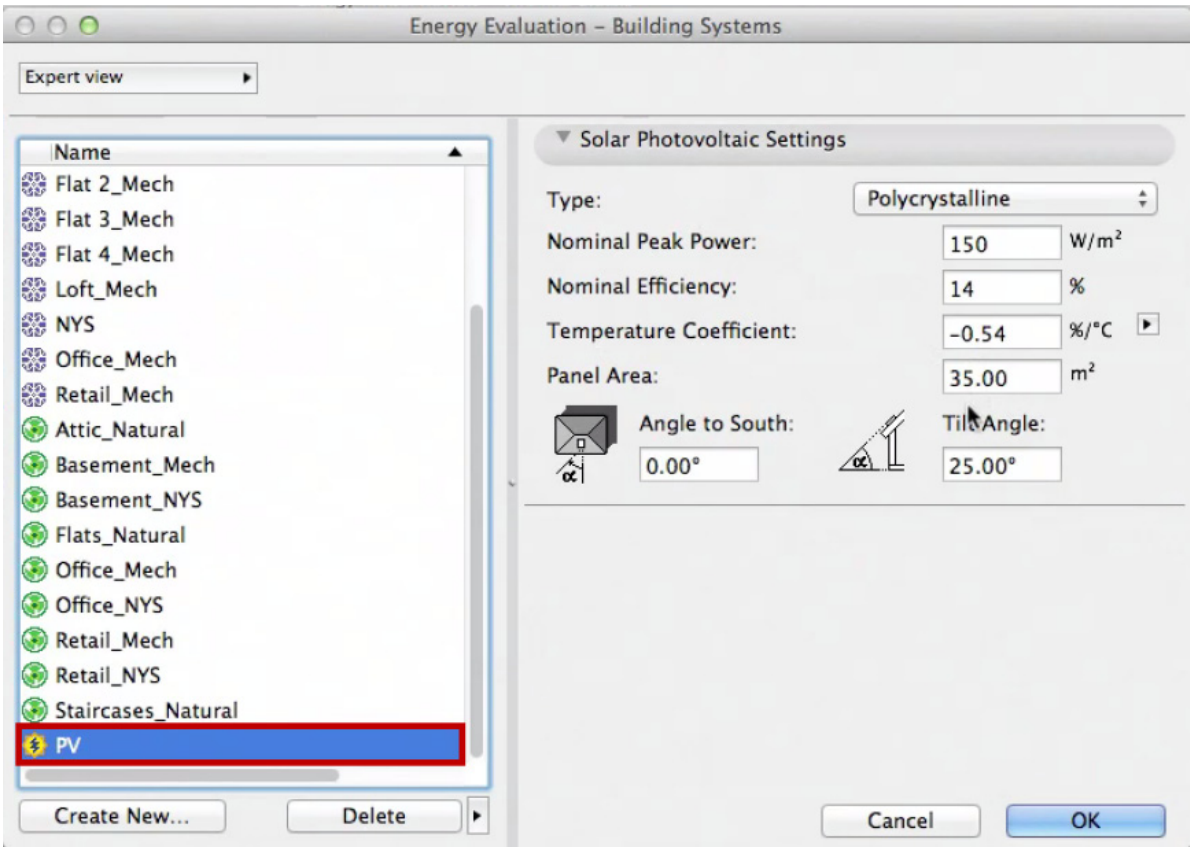




- Next, display the Residential Operation Profile and note that modern, energy-efficient LED **lighting** fixtures are used in the residential thermal blocks instead of the incandescent lamps. LED lights use less energy to provide the required level of artificial illumination, since they produce much less heat than the incandescent lamps used in the baseline building.

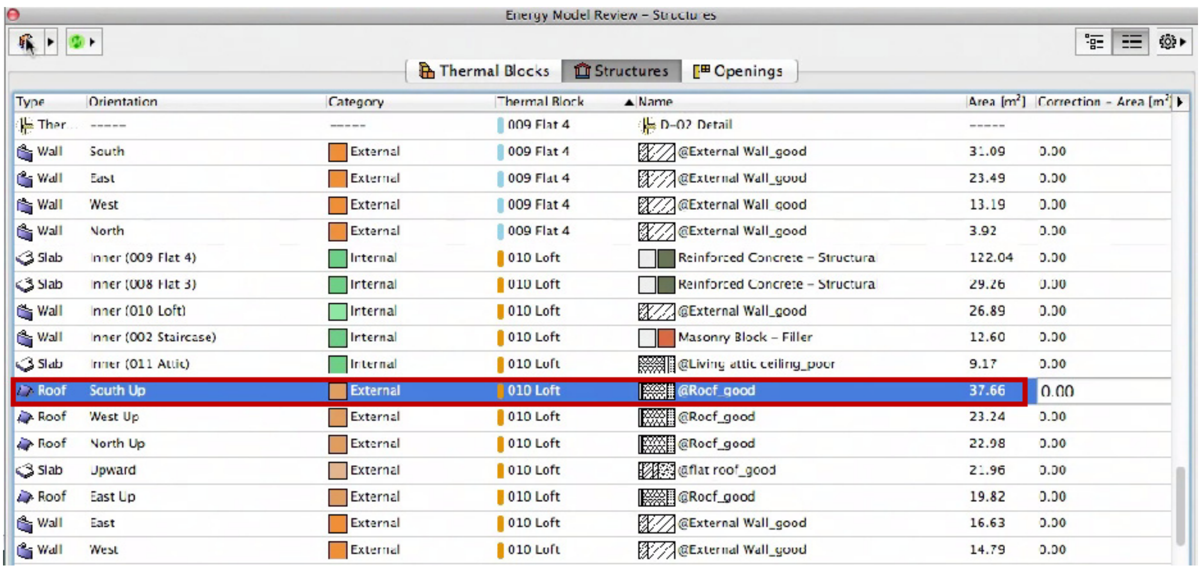


- To produce **electricity from a renewable source on site**, a photovoltaic system is defined for the designed building.



The panels are located on the pitched roof surfaces facing the equator.

Display the Structures page of the Energy Model Review Palette and select the Southern, pitched roof in the list to determine the available space for the PV panels.



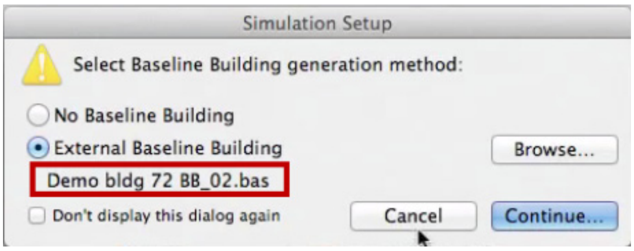
You can see that its area is a bit more than 35 square meters (or 375 square feet). The area and inclination of the installed “polycrystalline” photovoltaic panels correspond to the area and inclination of the equator-facing pitched roof.

6.3 Run Energy Simulation (Performance Rating)

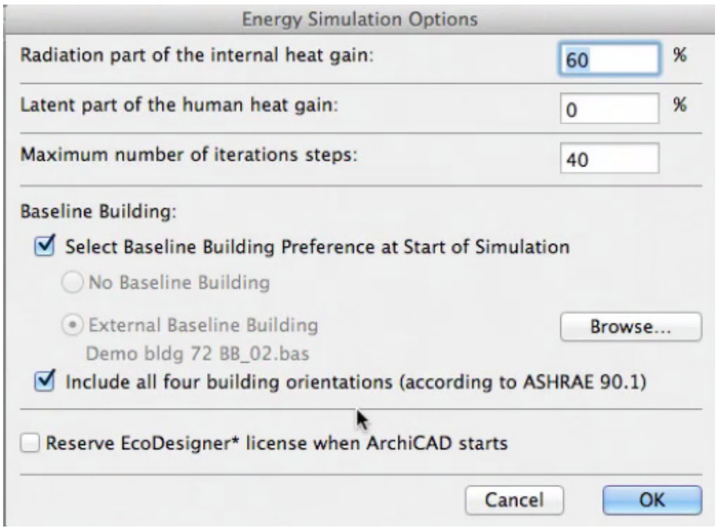
After setting the properties of the designed building’s systems, start the energy simulation.

Since the building energy model now contains every input parameter, it is possible to execute a **complete building energy performance analysis,** including hourly energy-balance, fuel-consumption, energy-cost, carbon-footprint, primary energy usage, on-site renewables and performance rating.

To enable performance analysis, we must use the previously created external baseline building reference file.



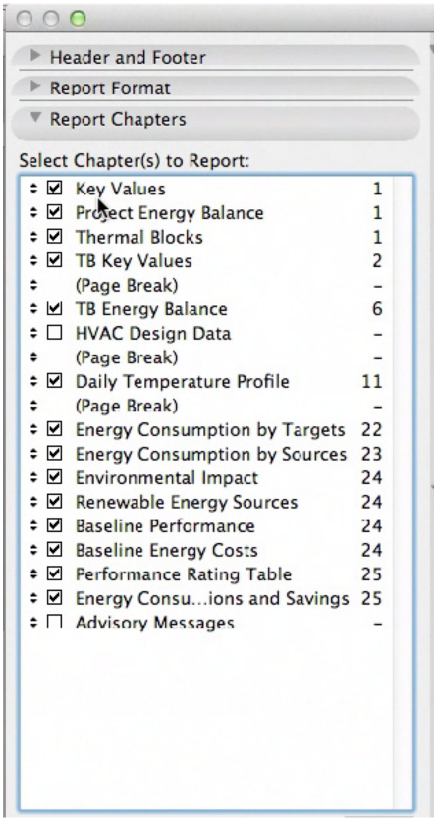
EcoDesigner STAR can use the baseline building reference file in two ways:



- Straight-up performance comparison with the designed building’s performance
- The baseline building reference data is first automatically processed by the program according to the ASHRAE 90.1 Standard (LEED Energy) and the resultant data is then used for energy performance comparison.

Let’s start the energy evaluation!

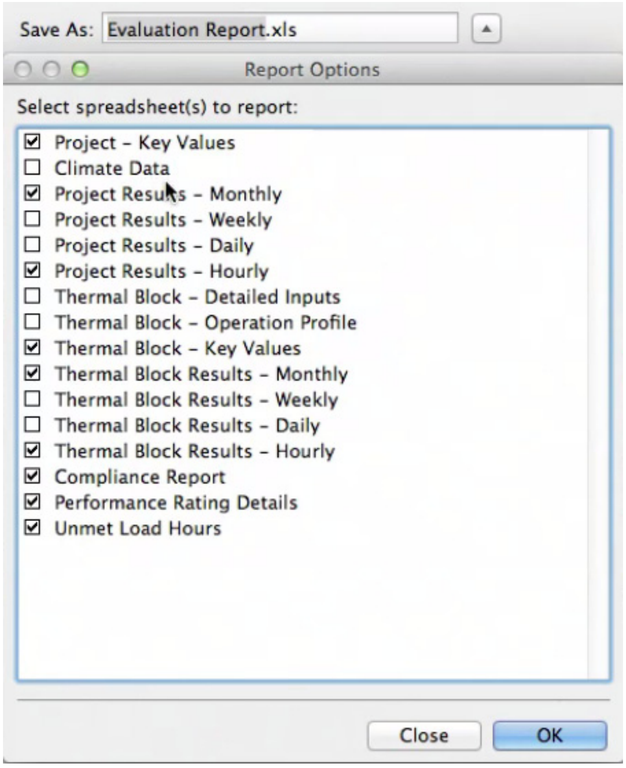
Once the analysis is completed, the Energy Performance Evaluation Report dialog appears. Here, select the **report chapters to be included** in the Energy Performance Rating PDF document.



Unlike with energy calculations carried out in the earlier design phases, select all but one of the report chapters this time. Exclude only the “HVAC Design Data” chapter from the documentation, because the example energy model’s building systems are already defined.

The Energy Performance Rating **PDF document** should include the energy balance diagram of every thermal block and also all the internal temperature profiles for each thermal block for a typical day of each season. This evaluation report should also include the “Environmental Impact” and “Renewable Energy Sources” chapters, and also all the performance rating chapters.

Save the Evaluation Report as a PDF document, and also as an **Excel spreadsheet**.



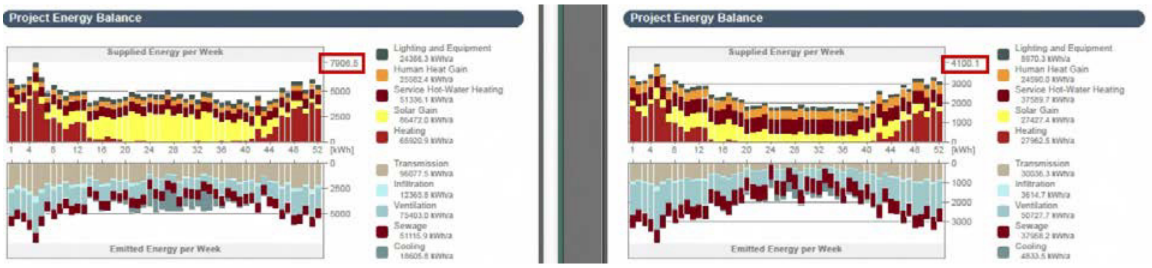
Even though processing the data takes a few minutes, it is worthwhile to document hourly calculation output files as well as thermal block level analysis results at this phase.

6.4 Review Results of Low-energy Building Design

The baseline project's energy evaluation report is displayed on the left. The designed building's report is on the right. Let's compare them, and draw conclusions by **rating the energy efficiency of the designed building relative to the baseline building**.

The **Project Key Values** display high-level information about the buildings' energy performance.

> **Note** the huge reduction in the cooling and heating energy needs of the designed building. Both primary energy consumption and fuel cost are reduced to half compared to the baseline project.



What is the reason behind the reduction of heating and cooling energy? Due to the low-energy building solutions (e.g. better thermal insulation and airtightness), the **Project Energy Balance** displays a massive reduction in energy flows. The maximum Supplied energy per week in the baseline project was over 7900 kWh, while in the improved project it is less than 4100 kWh.

The benefits of smaller building systems, heat recovery and on-site electricity production is reflected in the reduced carbon footprint.

Display the **Energy Consumption by Targets** diagrams for both design scenarios.

> **Note** that total required energy is reduced. In the baseline building, the heating is provided by district heating.

Energy Performance Evaluation
[Project Number] Simple Test Building

Energy Consumption by Targets

Target Name	Energy Quantity kWh/a	Primary kWh/a	Cost EUR/a	CO_2 Emission kg/a
Heating	65920	67260	3336	22949
Cooling	18606	47561	796	1769
Service Hot-Water	51336	51776	2580	17903
Ventilation Fans	669	2008	73	163
Lighting & Appliances	24356	73068	2679	5953
Total:	160888	241676	9465	48739

Energy Performance Evaluation
[Project Number] Simple Test Building

Energy Consumption by Targets

Target Name	Energy Quantity kWh/a	Primary kWh/a	Cost EUR/a	CO_2 Emission kg/a
Heating	27962	31423	1141	6042
Cooling	4833	10706	117	266
Service Hot-Water	37589	41657	1510	8119
Ventilation Fans	655	1633	48	107
Lighting & Appliances	8970	22302	733	1628
Total:	80011	107523	3551	16159

The designed building uses a more efficient and sensitive, reduced-capacity heating system. The On-site central heating boiler is the main heat supplier, with local backup systems installed where necessary. The result is reduced energy consumption and reduced carbon footprint.

The **Energy Consumption by Sources** diagrams show a massive reduction in electricity demand.

Energy Consumption by Sources

Source Type	Source Name	Energy Quantity kWh/a	Primary kWh/a	Cost EUR/a	CO_2 Emission kg/a
Renewable	External Air	25844	25844	NA	0
Secondary	Electricity	33154	99464	3647	8104
	District Heating	116367	116367	5818	40635
	Total:	175366	241676	9465	48739

In the designed building, 40 percent of this demand can be satisfied with electricity produced by the PV panels, on site.

Energy Consumption by Sources

Source Type	Energy Source Name	Energy Quantity kWh/a	Primary kWh/a	Cost EUR/a	CO_2 Emission kg/a
Renewable	Solar (Thermal & PV)	3374	3374	NA	0
	External Air	6704	6704		0
Fossil	Natural Gas	65040	71544	2601	14048
Secondary	Electricity	8633	25899	949	2110
	Total:	83752	107523	3551	16159

The **Environmental Impact** and **Renewable Building Systems Summary** evaluation report chapters highlight the benefits of the air-to-air heat recovery systems, the shading devices, the apartments' natural cooling, and the photovoltaic panels that use renewable solar energy to produce electricity. The project-specific combination of these strategies greatly reduce fossil energy consumption and operation costs.

The following chapters of the designed building's Energy Evaluation Report can be called **performance rating chapters** because they contain data that evaluate the energy efficiency of the designed building relative to the baseline building:

- Baseline Performance
- Baseline Energy Costs
- Performance Rating Table
- Energy Consumptions and Savings

Use these chapters to compare the enhanced energy performance of the designed building with the mediocre energy performance of the baseline building and to document the benefits of low-energy building design.

The baseline building reference file concept is discussed in an earlier part of this chapter. To understand the Baseline Performance chapter, we must revisit the baseline building reference file concept and the two ways how EcoDesigner STAR can process such a file: besides directly comparing the baseline building's energy performance with the designed buildings, the program is also capable of **automatic ASHRAE 90.1 (LEED Energy) baseline building reference data processing**. This simply means that the program automatically rotates the baseline building by 90 degrees three times, re-analyzing the project after each rotation. Eventually, the four baseline building variations' energy performance is averaged and the resultant data set is used for the performance rating of the designed building.

According to ASHRAE, the baseline building performance data generated this way represents the average design solution better, because it disregards differences in orientation caused by specific architectural solutions.

EcoDesigner STAR's automatic baseline building processing function is also a great tool for **checking the designed building's orientation** - whether it is truly optimized, or whether a rotated layout with thermal blocks having different orientations might be more energy efficient.

On the other hand, automatic ASHRAE 90.1 (LEED Energy) baseline building reference data processing requires five simulations (designed building plus four baseline building versions) versus the single (un-rotated) baseline building method that only requires two simulations (one for the designed building and another for the baseline building). Carrying out a performance rating analysis using the single baseline building method is much faster.

The **Baseline Performance** chapter's "zero degrees" column display the original (un-rotated) baseline building's performance data, while the 3 additional columns contain the performance data of the rotated baseline building versions. The last column displays the calculated average values.

The **Baseline Energy Costs** chapter list the operation costs of each baseline building variation.

Baseline Performance

Energy Type	Annual Energy & Peak Demand	Baseline Design				
		0°	90°	180°	270°	Average
External Air	Energy Use (kWh)	29079	18686	23961	25515	24310
	Peak Demand (kW)	50	43	45	45	45
Electricity	Energy Use (kWh)	34049	31138	32699	33042	32732
	Peak Demand (kW)	17	15	18	17	17
District Heating	Energy Use (kWh)	115069	117378	119910	115092	116862
	Peak Demand (kW)	74	78	78	76	76
Total Energy Use: (kWh/a)		178197	167202	176570	173649	173904

Baseline Energy Costs

Energy Type	Baseline Cost				Baseline Building Performance
	0° EUR/a	90° EUR/a	180° EUR/a	270° EUR/a	EUR/a (average)
Electricity	3745	3425	3596	3634	3600
District Heating	5753	5868	5995	5754	5843
Sum:	9498	9293	9591	9388	9443

The **Performance Rating Table** displays and compares the Proposed and Baseline project's energy performance. The final column presents the achieved savings.

Note that the total annual energy use of the designed building is about the half that of the baseline design, and would result in 50% savings.

Performance Rating Table

Energy Use	Units	Proposed Design Results	BaseLine Building Results	Savings %
Heating	Energy Use (kWh)	27962.54	66422.01	57.90
	Peak Demand (kW)	31.34	70.23	55.37
Cooling	Energy Use (kWh)	4833.46	17504.09	72.39
	Peak Demand (kW)	12.52	33.67	62.82
Service Hot-Water	Energy Use (kWh)	37589.68	51340.66	26.78
	Peak Demand (kW)	5.77	7.33	21.20
Ventilation Fans	Energy Use (kWh)	655.14	669.65	2.17
	Peak Demand (kW)	0.18	0.18	2.24
Lighting	Energy Use (kWh)	3987.08	19197.92	79.23
	Peak Demand (kW)	1.05	6.89	84.82
Equipment	Energy Use (kWh)	4983.20	5158.34	3.40
	Peak Demand (kW)	1.17	1.22	3.87
Total Annual Energy Use: (kWh/a)		**80011.11**	**160292.67**	**50.08**
Annual Process Energy: (kWh/a)		**8970.28**	**24356.27**	**63.17**

Let's see the components of this massive difference in energy consumption! Almost 60% less energy is needed to heat the designed building. The cooling-related energy consumption difference is even more significant. Some of the flats do not require cooling systems at all, thanks to solar shading devices. Water-sawing taps reduce the amount of energy consumed by the service hot water heating system by over 25%.

The designed building consumes much less electricity due to efficient artificial lighting and the smaller auxiliary electricity demands of the proposed building's systems, which are much smaller than the baseline building's.

Finally, look at the **Energy Consumptions and Savings** table. Electricity-related cost savings in the proposed building design is almost 75%, compared to a mediocre solution represented by the baseline building. The designed building's overall energy use is 51% less and its energy costs are 60% less than the baseline building's.

Energy Consumptions and Savings

Purchased Energy	Proposed Design		Baseline Building		Saving	
	Energy Use	Cost EUR/a	Energy Use	Cost EUR/a	Energy Use %	Cost %
Natural Gas (kWh)	65040	2601				
Electricity (kWh)	8633	949	32732	3600	74	74
District Heating (kWh)	0	0	116862	5843	100	100
Subtotal: (kWh)	73673	3551	149595	9443	51	62

On Site Renewable Energy	Energy Generated kWh/a	Energy Cost EUR/a
Photovoltaic system	3374	0
Subtotal:	3374	0

	Proposed Design		Baseline Building		Saving	
	Energy Use kWh/a	Cost EUR/a	Energy Use kWh/a	Cost EUR/a	Energy Use %	Cost %
Total:	77048	3551	149595	9443	48	62