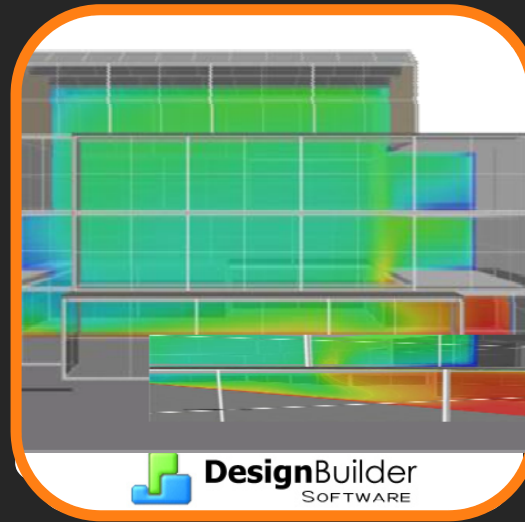




Building Performance Simulation for Designers - Energy  
DesignBuilder // EnergyPlus  
**‘Tutorial #1’**  
Getting Started



GEOMETRY



LOADS



RESULTS



# OVERVIEW

This document is a guide for building energy performance simulation beginners. Its focus audience are designers interested in studying the effect of early design decisions such a orientation, shape and façade layout on the energy efficiency of their projects. Throughout the document we will be using DesignBuilder/ EnergyPlus as our simulation tool. The document will teach you how to:

- Set up DesignBuilder on your WINDOWS™ PC;
- Build and maintain a simple model in DesignBuilder;
- Carry out a heating and cooling load analysis of the model and calculate its annual energy use for heating, lighting and cooling.

# OVERVIEW

## Building Energy Performance Simulation

- A building is a complex thermodynamic object that accommodates constantly changing energy flows between the different thermal zones within the building and the outside.
- The two main components of the building energy simulation model are the building fabric and content (walls, floors, ceilings, occupants and equipment) and the plant components (HAVC equipment and other environmental control systems).
- Due to the complexity of a building model, computer simulations can analyze the effects of different ECMs (Energy Conservation Measures) and their complex interactions more efficiently, comprehensively and accurately than any other available method.<sup>1</sup>

## INFO

<sup>1</sup> M Kaplan and P Caner, *Guidelines for Energy Simulation of Commercial Buildings*. Report for Bonneville Power Administration (DE-FC79-85BP26683). 1992.

# OVERVIEW

## Simulation Engine vs. GUI

- Most building energy simulation programs come with a graphical user interface (GUI) as well as the actual simulation engine. The former is used to prepare simulation input files for the latter and to display simulation results once a simulation is complete.
- The developers of simulation engines and GUIs often work for different companies with the engine being developed at public organizations (government lab & universities) whereas GUIs are more often developed by commercial vendors. As a result there can be several GUIs for the same simulation engine.
- While the choice of GUI determines the ease of use of a simulation program, it is ultimately the engine that determines how reliable simulation results are. **A great GUI with a weak engine cannot yield reliable results!**

# OVERVIEW

We will be using EnergyPlus as the simulation engine

- EnergyPlus is the U.S. Department of Energy's 3<sup>rd</sup> generation dynamic building energy simulation engine for modeling building, heating, cooling, lighting, ventilating and other energy flows.<sup>2</sup>
- The program was developed during the nineties and is an amalgamation of the BLAST and DOE-2 simulation engines. Apart from energy use, the program can be used for load calculations and to model natural ventilation, photovoltaic systems, thermal comfort, water use, green roofs and other ECMs.

## INFO

EnergyPlus can be downloaded from [www.eere.energy.gov/buildings/energyplus/](http://www.eere.energy.gov/buildings/energyplus/). The program comes with ample documentations but without a GUI. EnergyPlus' capabilities are constantly being further expanded so that more recent modules might not be accessible through any GUI. As a result advanced users often start editing their models manually using a text editor. Once any manual changes have been made to a model one usually cannot go back to the GUI.

# OVERVIEW

## Other reasons for using EnergyPlus

- It is a 'Qualified Computer Software' for Calculating Energy Savings for Purposes of the Energy-Efficient Commercial Building Tax Deduction under Internal Revenue Code §179D.
- Expert users can get access to the source code allowing for third-party validation which adds to the software's credibility and long term reliability.
- EnergyPlus has been validated under the comparative Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs BESTEST/ASHARE STD 140.

## INFO

To find a list of qualified computer software for calculating commercial building energy and power cost savings that meet federal tax incentive requirements under Internal Revenue Service (IRS) go to:

[http://www1.eere.energy.gov/buildings/qualified\\_software.html](http://www1.eere.energy.gov/buildings/qualified_software.html)

The BESTEST (Building Energy Simulation TEST) is a comparative set of tests which has become one of the industry's most accepted methods to validate and test the simulation capabilities of the exterior envelope portions of building energy simulation programs. More information at <http://gundog.lbl.gov/dirpubs/rio4.pdf>

# OVERVIEW

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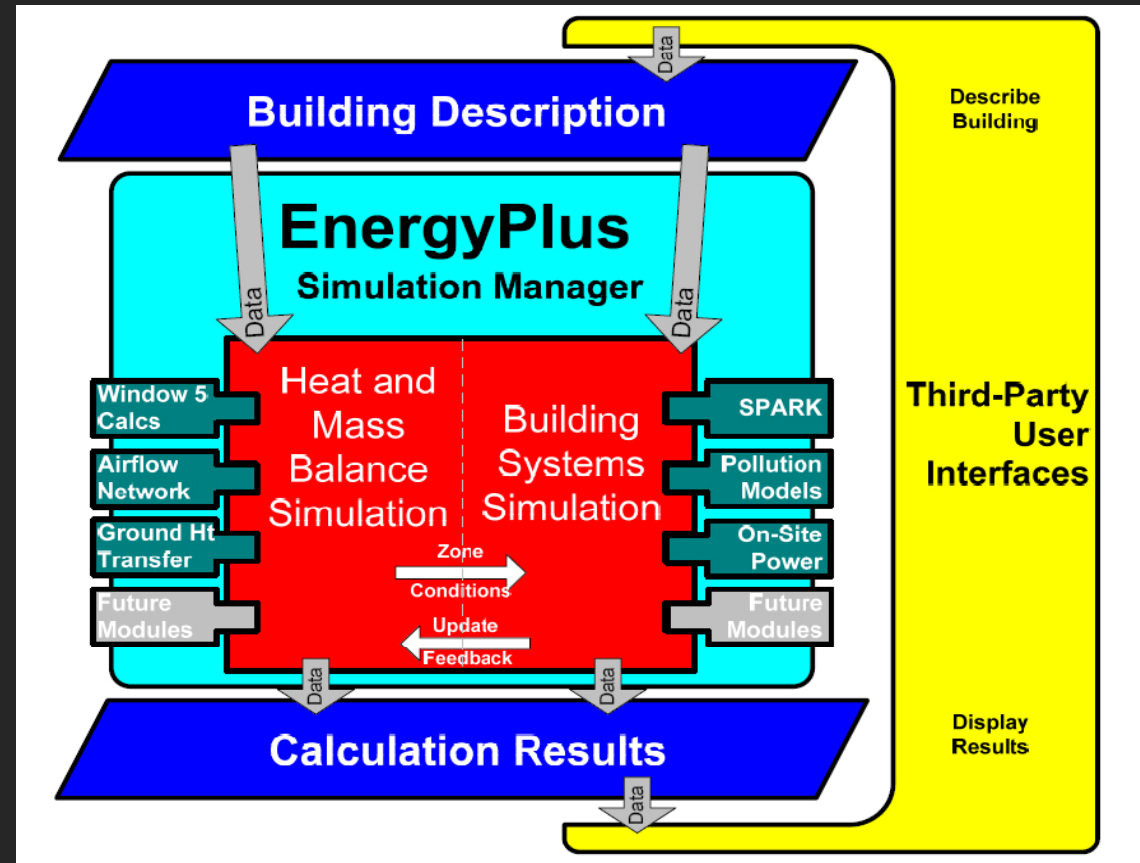
[http://www1.eere.energy.gov/buildings/qualified\\_software.html](http://www1.eere.energy.gov/buildings/qualified_software.html)

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# OVERVIEW

## Energy Plus' Integrated Solution Manager

By using an integrated solution technique, EnergyPlus overcomes the most serious deficiency of the BLAST and DOE-2 sequential simulations— inaccurate space temperature predication due to no feedback from the HVAC module to the loads calculations. Accurate prediction of space temperatures is crucial to energy efficient system engineering, occupant comfort, occupant health, system size, plant size.



Source: D.B. Crawley et al. / Energy and Buildings 33 (2001) 319–331, and Getting Started with Energy Plus, (2007).

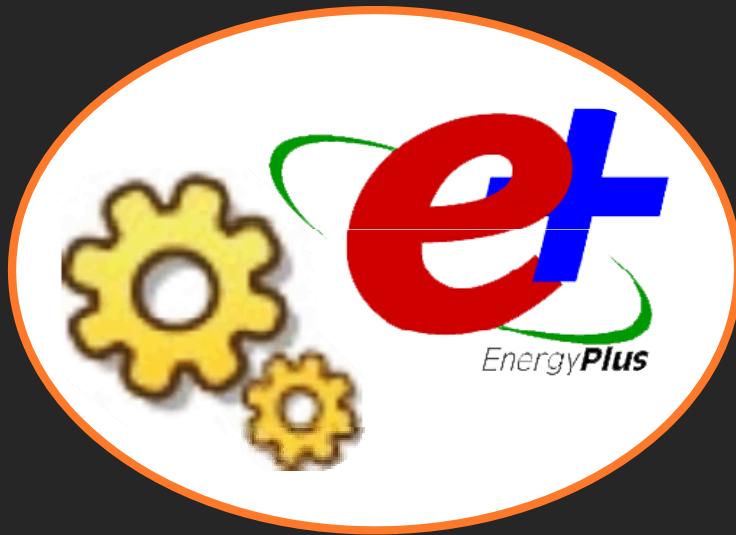
## INFO

Loads calculated (by the heat and mass balance engine) are passed to the building systems simulation module. The building systems simulation module calculates heating and cooling system and plant and electrical system response. Feedback from the building systems simulation module on loads not met is reflected in the next time step of the load calculations in adjusted space temperatures if necessary, and not just reported as unmet hours.



# OVERVIEW

## Choosing a GUI for EnergyPlus?



Simulation engine



Graphical User Interfaces

**INFO**

A number of GUIs are currently available for EnergyPlus. Among those GUIs Ecotect, Google Sketchup (Energy Design Plug-in) and DesignBuilder are specifically geared towards users with a background in design as opposed to engineering. A list of all the available GUIs for EnergyPlus can be found at:

<http://www.eere.energy.gov/buildings/energyplus/>

# OVERVIEW

## Why DesignBuilder?

- We chose DesignBuilder the tool for this tutorial as we found it to be a mature product which offers flexible geometry input and extensive material libraries and load profiles.
- EnergyPlus is integrated within DesignBuilder's environment which allows you to carry out complete simulations without leaving the interface.

## INFO

When bringing whole-building performance simulation closer to designers it is key to make the process of setting up a model and populating it with technical data as simple as possible without compromising accuracy or rigor. Reliable data templates of libraries and components (constructions, materials, schedules, HVAC system, activity profiles, etc) are extremely important in this process as they help designers set up their models in a comprehensive and transparent way.

# OVERVIEW

## Why DesignBuilder?

- Simulation results can be effectively displayed and analyzed. simulation data in a comprehensive manner.
- DesignBuilder has quality control procedures which assure the accuracy of the results in comparison the stand-alone EnergyPlus engine. e.g. As EnergyPlus, it has been tested under the comparative Standard Method BESTEST/ASHARE STD 140.

# OVERVIEW

## Software Limitations

- An advanced user might find the EnergyPlus simulation capabilities that are accessible from the DesignBuilder GUI limiting. In this case a user can export a DesignBuilder model into EnergyPlus ASCII files. Unfortunately, it is currently not possible to import a modified model back into DesignBuilder.
- There are limitations for inputting complex geometry (e.g. geometries defined through smooth functions / free forms)

# INDEX

- SET-UP
- BUILDING A MODEL
- RUN A SIMULATION
- ANALYZE RESULTS

## INFO

It is recommended that you work through the four sections in the order provided. Further information can be accessed through **// links /**distributed throughout the text.

# SET - UP

Follow the instructions outlined below to set-up your computer. Make sure to pay close attention to all the steps and execute them carefully.



| **DesignBuilder™** |

You may download a FREE 30-day evaluation version of the latest DesignBuilder version from the 'DesignBuilder Software' website. This document is based on **DesignBuilder v.1.6.2.0004 BETA** (release date: 07/31/08).

<http://www.designbuilder.co.uk>

## INFO

DesignBuilder Software requires you to provide some general information about yourself before you can download the evaluation version. You must be logged in before attempting to download. If you do not have a login and password, you will have to register first.

# SET - UP

If you have a previous version of DesignBuilder installed you must first uninstall it from the Windows Control Panel>> 'Add or remove programs' before installing a new version. DesignBuilder is designed for Windows Vista, Windows XP SP2 and Windows 2000. Windows 95, 98, ME, NT are not supported.

The file you have to download is a .EXE file. Save it into any folder on your PC and double click on it. Follow the on-screen instructions. The complete installation takes about one or two minutes. You may delete the file after the installation is completed.

Folder directory preferences: It is recommended that you use the default DesignBuilder installation location on your PC which is C:\Program Files\DesignBuilder (see note below).

## INFO

You must be logged on with Administrator privileges to the machine on which you are installing DesignBuilder. Otherwise you will receive error messages during installation and the software will not run.

# SET - UP

When using DesignBuilder with Windows Vista you should ensure that Windows XP SP2 compatibility has been set. You should also check the 'Disable desktop composition' to switch off the 'Aero' interface effect. Without these changes the DesignBuilder screen does not refresh correctly. These settings need to be changed before you run DesignBuilder for the first time. (see note below)

Many of the early graphics adapter drivers written for Vista have bugs preventing DesignBuilder from loading at all. It is recommended you upgrade your graphic adapter drivers.

## INFO

To set DesignBuilder to run in compatibility for Windows XP SP2, right click on the DesignBuilder icon from the start menu and select "Properties". Then click on the Compatibility tab and check "Run this program in compatibility mode for:" and select Windows XP SP2 if it is not already set. Also check the 'Disable desktop composition' to switch off the 'Aero' interface effect. Many recent *ATI Radeon graphics cards* are not compatible with DesignBuilder because of OpenGL compatibility issues. More information about compatibility related problems can be found at <http://www.designbuilder.co.uk>



# SET - UP



## |EnergyPlus |

The EnergyPlus dynamic simulation engines is completely integrated into DesignBuilder and there is no need to install it separately. When you install DesignBuilder, the installation package installs EnergyPlus automatically into a folder under the same directory. e.g. C:\ Program Files\ DesignBuilder\EnergyPlus.



This document is based on **DesignBuilder** v.1.6.2.0004 BETA (07/31/08), which works with EnergyPlusv2.2.0.025 engine.

## INFO

With time, as you become an more advanced user you may want to install EnergyPlus separately to review the files in detail in a text based option with EnergyPlus' IDF editor. In that case you can download EnergyPlus from <http://www.eere.energy.gov/buildings/energyplus/>

# SET - UP

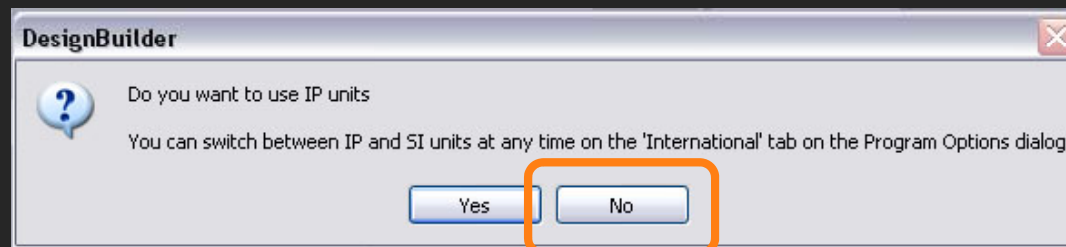
## Customizing **DesignBuilder** - Selecting a Unit System

**DesignBuilder** can be used with either metric (SI) or imperial (IP) units. Because the most databases that come with the program were originally configured in SI units, IP users may find some of the default assumptions awkward. For example, even though the glazing's U-values are displayed in (Btu/h\* $\text{ft}^2$ \*F), the names and descriptions associated with every glazing are still displayed in mm.

# SET - UP

## Customizing DesignBuilder - Selecting a Unit System

The first time you run DesignBuilder a window will pop up asking you which UNIT SYSTEM you want to use: IP (Inch-Pound) or SI (International System). For the purpose of this document, to the question: “Do you want to use IP Units?” Click “NO”.

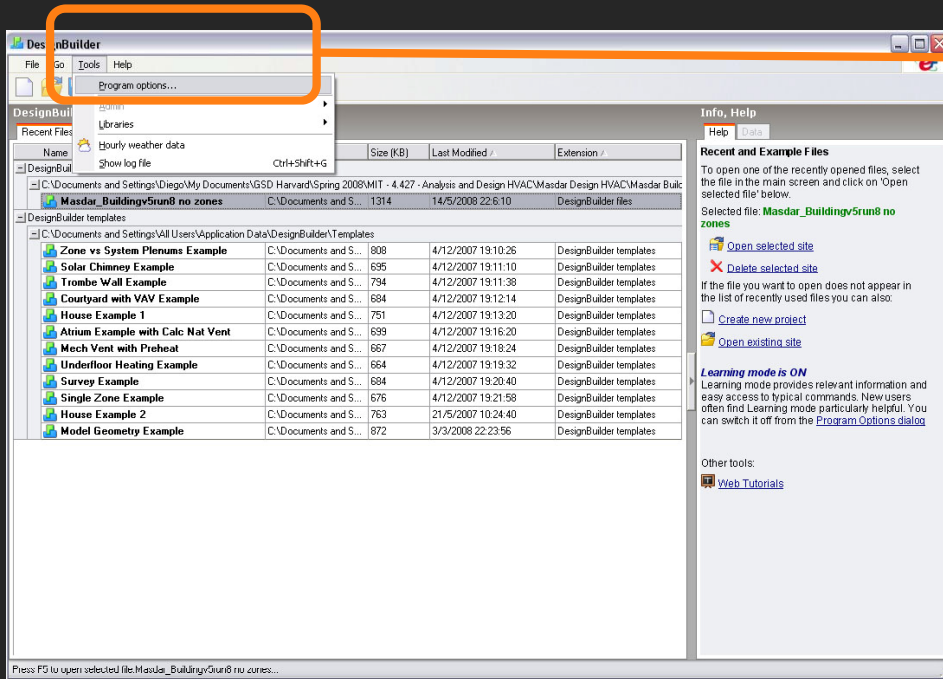


## INFO

As the pop up window states, you can later switch between IP and SI units at any time. (In the next page you can see how to switch between SI and IP units).

# Customizing DesignBuilder - Selecting a Unit System

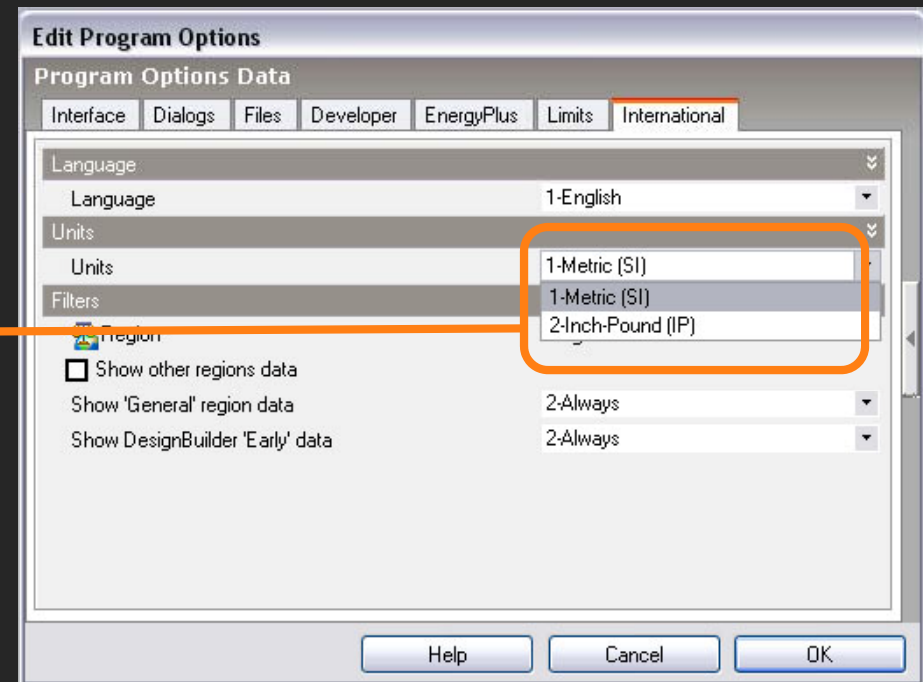
1.



To switch between SI and IP units go to “Tools” > “Program Options”

2.

Under “Units” you find:  
1-Metric (SI) and  
2-Inch-Pound (IP)



# BUILDING A MODEL

Now that you have downloaded and installed DesignBuilder/EnergyPlus, follow the steps outlined below to learn how to build a simple model and to carry out a building energy performance simulation.

At the end of this section you should be able to:

- Understand the basis of DesignBuilder's user interface and its data organization model
- Build a simple model

## INFO

Please finish reading this whole section before you go on and watch the DesignBuilder online tutorials.

# BUILDING A MODEL

We suggest you first work through Tutorial #1 (User Interface) on the DesignBuilder website. The tutorial is an excellent way to familiarize yourself with the interface and its capabilities. Follow each step carefully as we will continue to work on the file you create in Tutorial #1.



## **TUTORIAL #1**

Tutorial number one will introduce you to the overall layout of the GUI and to the construction of building models. It shows you how to create a new project, describes the basic drawing tools and briefly talks about data hierarchies within EnergyPlus.

## **INFO**

Please review the next 4 slides before you work through Tutorial #1.

# BUILDING A MODEL

DesignBuilder Software has made these tutorials available online. You can either watch them online or download them to your computer to watch them offline.

- To watch them online, launch DesignBuilder, from the WINDOWS™ ‘START’ menu, choose ‘PROGRAMS’ > ‘DesignBuilder’ > ‘DesignBuilder’, then click in the link “web tutorials” that you will find at the center right of your screen under “other tools”. This will launch your web browser directly to the tutorial’s page.
- To download the tutorials go to DesignBuilder’s webpage: <http://www.designbuilder.co.uk>, then to “Downloads” and then “Tutorial”.

# BUILDING A MODEL

Please note that the tutorials are based on an older version of DesignBuilder. This will make your model and screen look slightly different than the ones shown in the tutorial. The older versions of DesignBuilder have less options in the menus and tabs and have different default templates. For example, the default value for wall openings was changed from 30% to 40% in version 1.6.004.

- It is important that you keep all of the defaults as set in your current version and that you only modify the elements or parameters mentioned in the Tutorial.



# BUILDING A MODEL

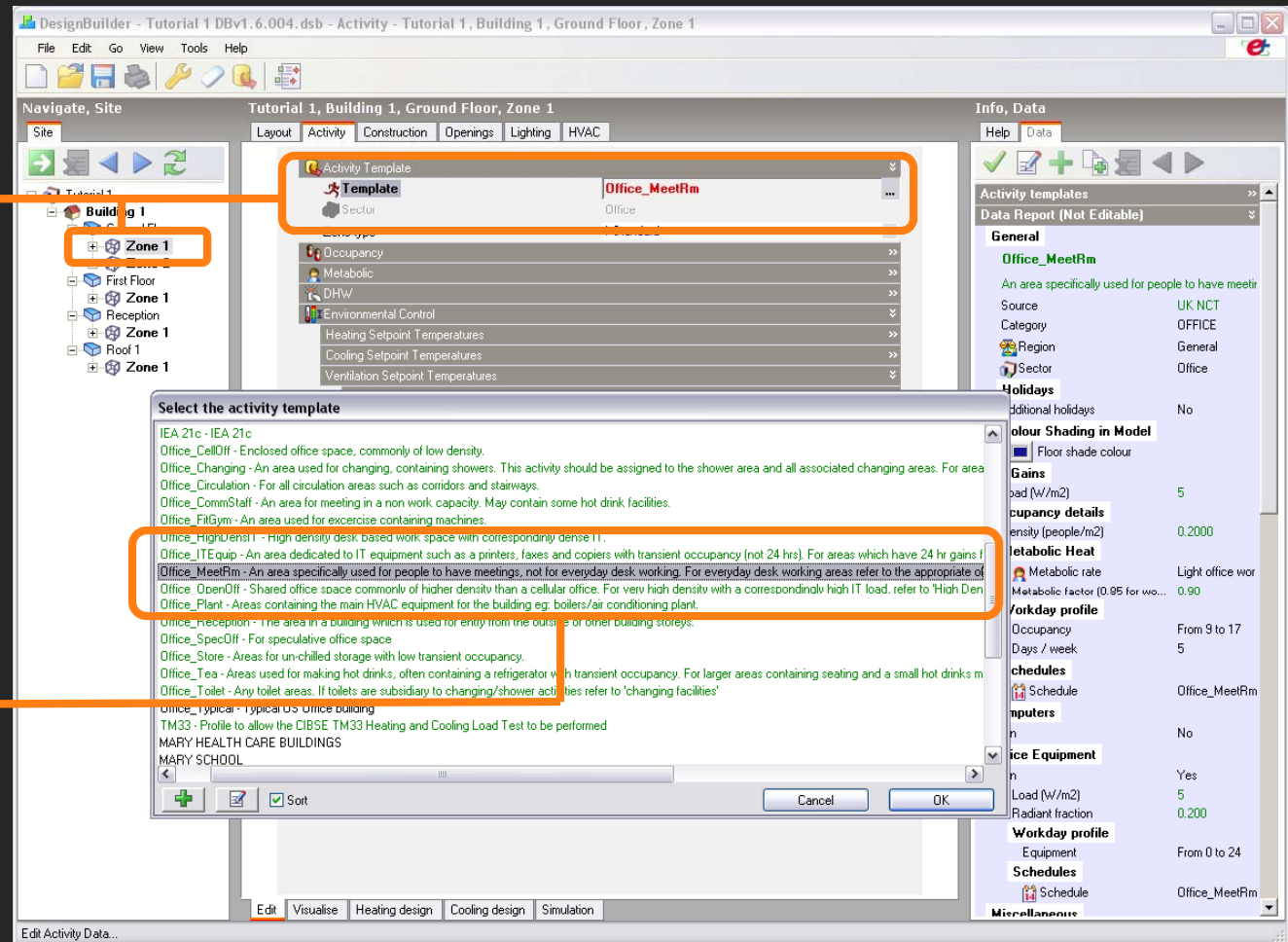
## Selecting a Template

1.

When asked to modify the “Activity” of the meeting room located in the “Ground floor”, click in the “browse” tab to select a different activity template.

2.

Under the ‘Select activity template’ menu, choose the most appropriate template for the space. i.e. ‘Office\_MeetRm’.



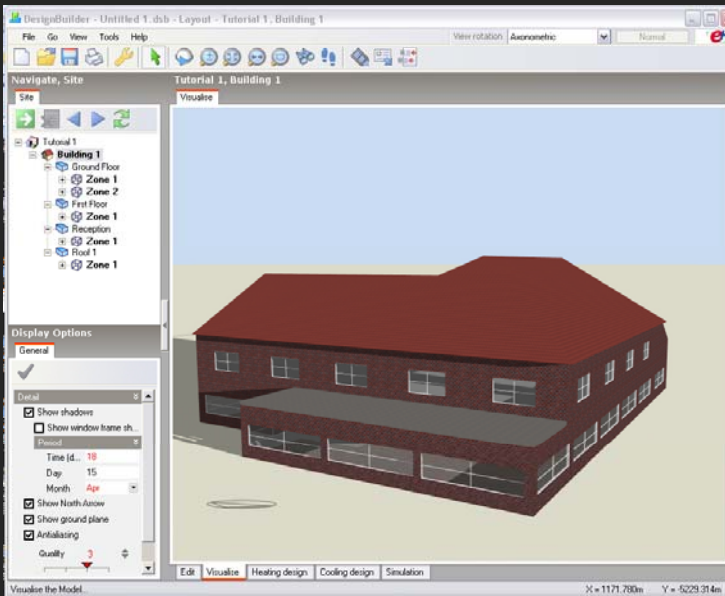
INFO

Note that templates (activity, schedules, constructions, etc.,) might vary between different versions.

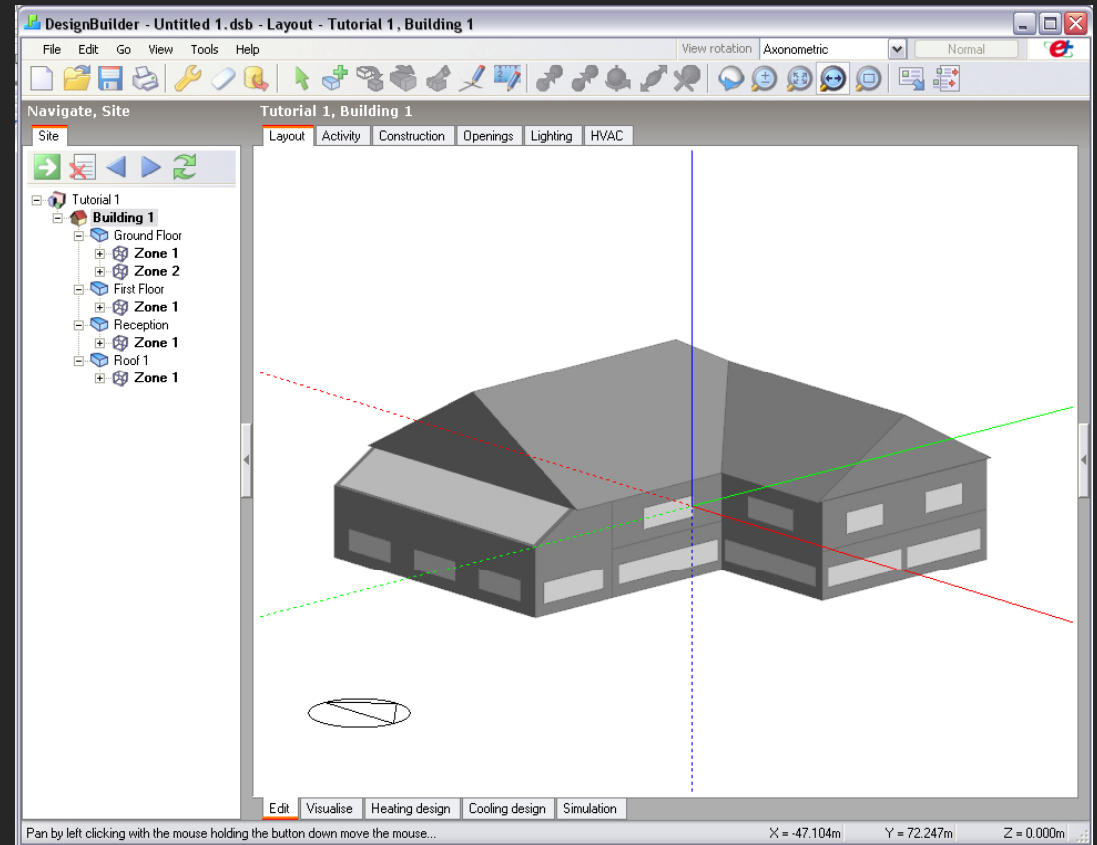
# BUILDING A MODEL

## Inputting Geometry

Once you are finished with Tutorial #1, you should have a model that looks similar to this:



'Visualize' Tab



'Edit' Tab

## INFO

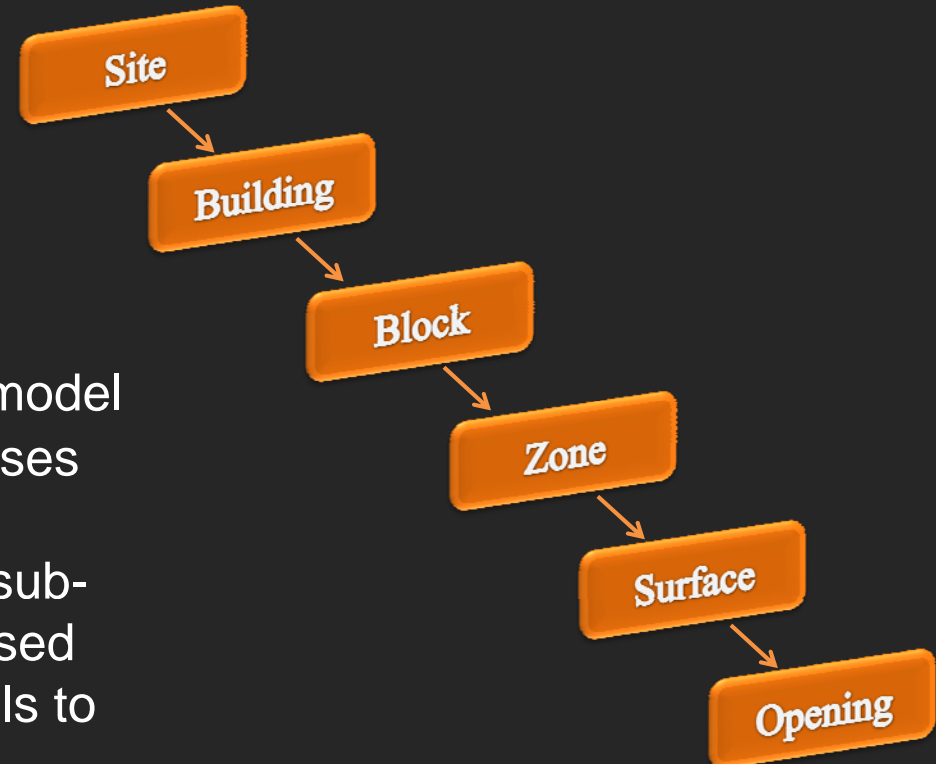
Please start with Tutorial #1 now.

# BUILDING A MODEL

## MODEL DATA HIERARCHY & DATA INHERITANCE

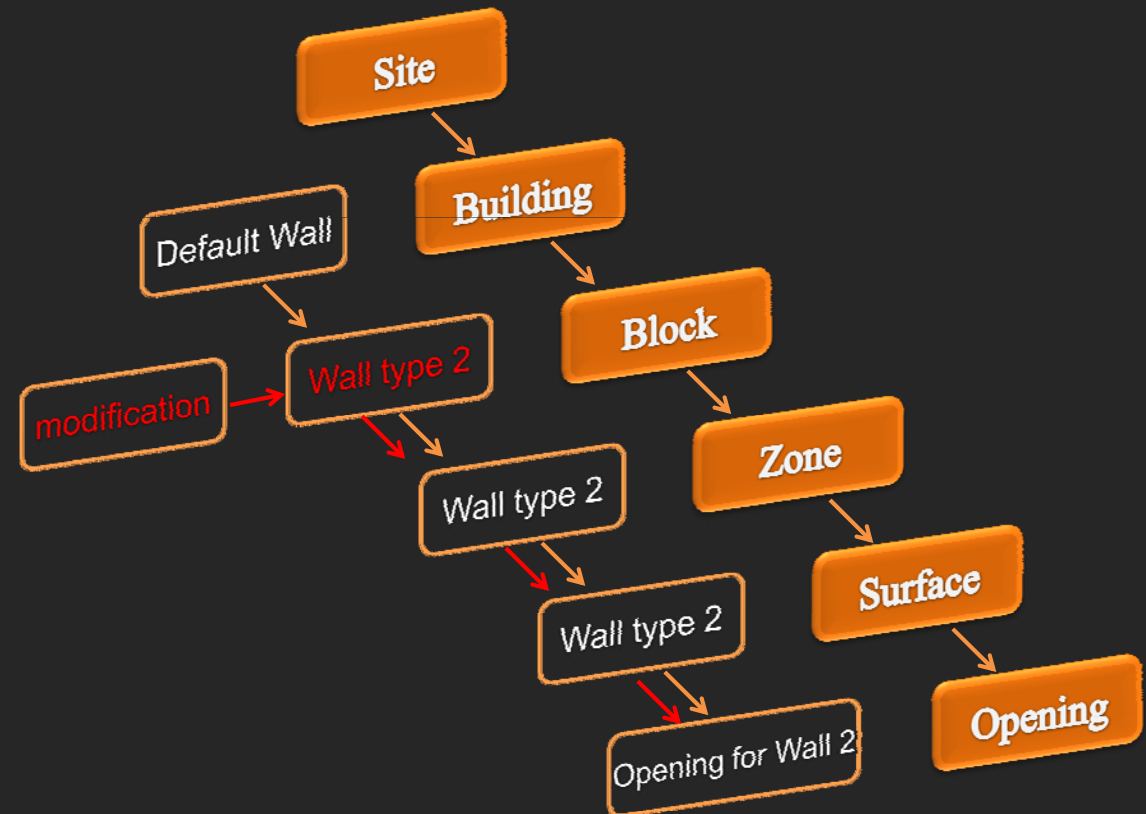
Now that you have watched Tutorial #1 and familiarized yourself with the interface, we will further explain some key aspects of how data input is organized in DesignBuilder / e+

DesignBuilder, same as e+, follows a 'model data hierarchy'. DesignBuilder further uses 'data inheritance' through categories allowing you to automatically populate sub-categories. This way information is passed automatically from higher category levels to lower category level making data input faster and more reliable (see the next slide).



# BUILDING A MODEL

Default data is inherited from the level above in the hierarchy, so block data is inherited from building level, zone data is inherited from block data and surface data from zone data. When you change a setting for a category this change is 'inherited' by all lower levels within the category.

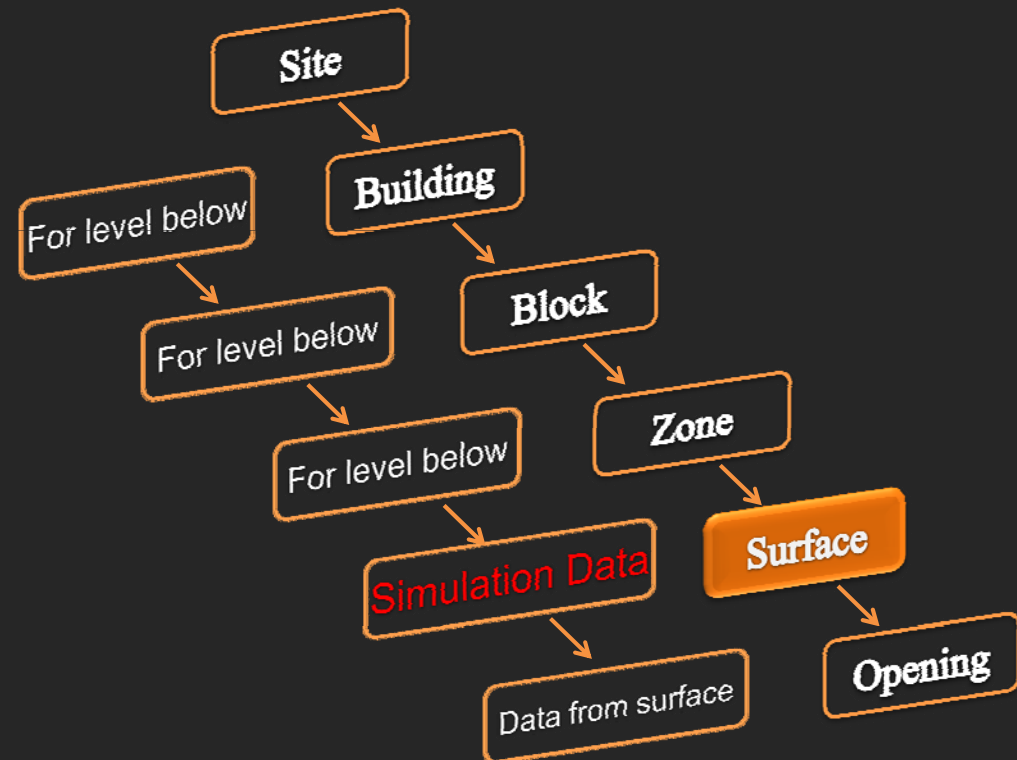


## INFO

This arrangement allows you to either make settings at the building or block level. A selection for a wall type at the building level will affect all walls within the building whereas a selection at the block level will only affect the walls within that particular block.

# BUILDING A MODEL

Construction and window-to-wall-ratios default values are inherited down to the surface level where the data is actually used in the calculations.



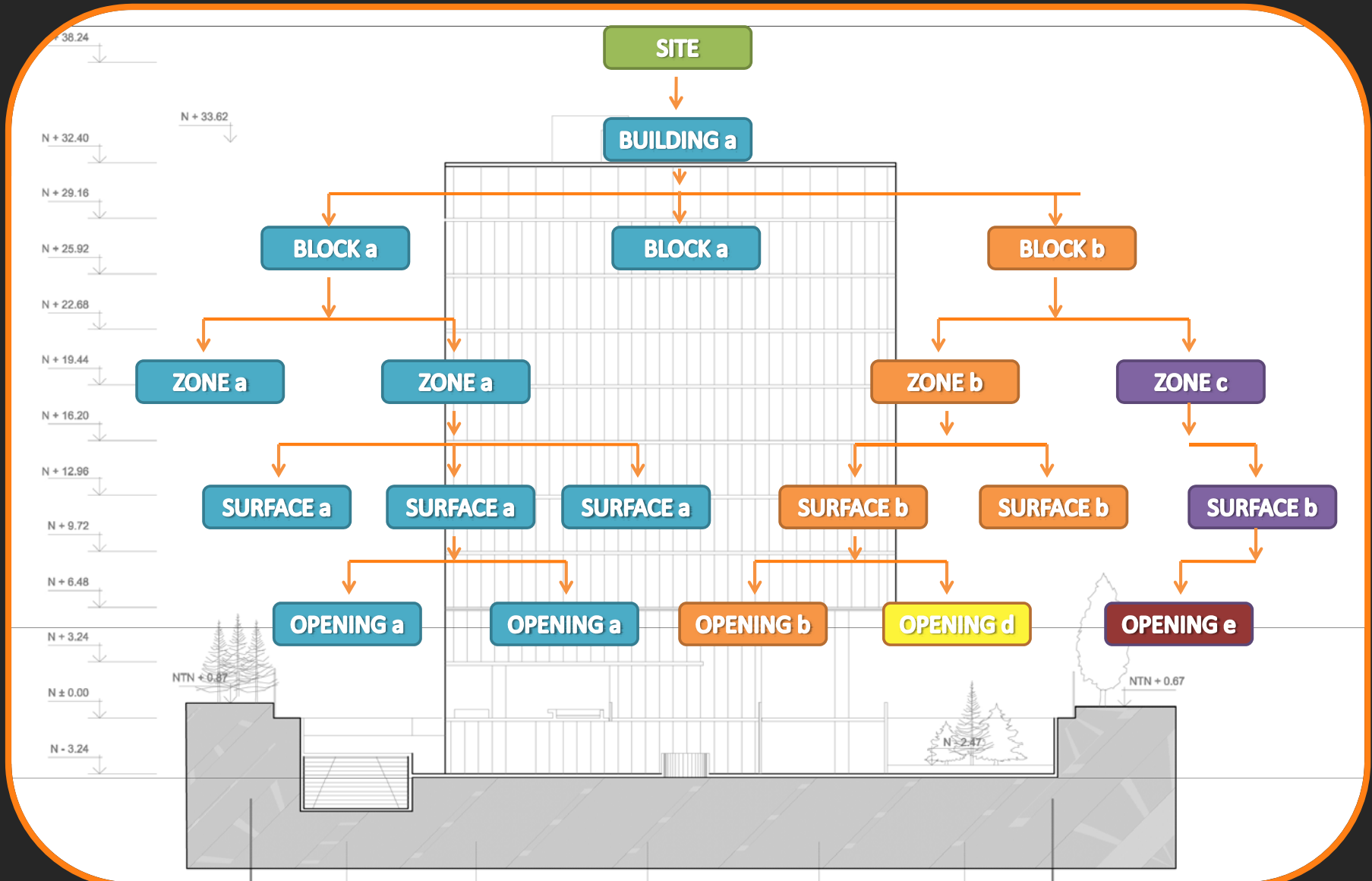
## INFO

For example, it is the External wall construction model data at the surface level that defines the construction used for that external wall. The External wall model data set at zone, block and building level has no effect on the model (other than providing a default values for lower lying levels).

Most data at the building level is “user data” as buildings do not inherit their data from the site level. All openings inherit their data from the surface level.

# BUILDING A MODEL

## MODEL DATA HIERARCHY & DATA INHERITANCE



# SIMULATION

Now that you know how to build a simple model, we suggest that you work through Tutorial #2 (Simulations). We will afterwards review your simulation results from the tutorial with you.

## ■ TUTORIAL #2

Tutorial number two will show you how to run design calculations for winter and summer design conditions and how to carry out an annual simulation using typical weather data for your site. The latter provides an estimate of a building's overall annual fuel consumption.

## INFO

The following slides provide additional information about simulation basics and additional settings.

# SIMULATION

## Heating Design Calculation

A heating design calculation is performed to investigate a building's behavior under extreme weather conditions. Calculation results are typically used to size heating systems and their components.

### INFO

The weather conditions used during a heating design calculation are set according to the building location. The designer may select the "severity" of weather that he or she deems appropriate. Typical heating design temperatures lie in the 99<sup>th</sup> or 99.6<sup>th</sup> percentile of all temperatures that typically occur at a site throughout the year, i.e. 99% or 99.6% of the time it is warmer than the heating design temperature. Heating design calculations are carried out under Steady State (SS) conditions (stable temperatures over a several-hour period), which means that thermal mass effects are ignored. The calculations assume worst case conditions including no solar gains, no internal gains (lighting, equipment, occupancy, etc) and design conditions for wind speed and direction. The resulting "design heat loss" (the sum of all heat flows out of a building) is further multiplied by a "sizing factor" to determine the "design heating load" (the capacity of heating equipment required to offset all heat losses). See also [ASHRAE Handbook of Fundamentals, 2001 \(ISBN 1-883413-87-7\) TC.29](#).



# SIMULATION

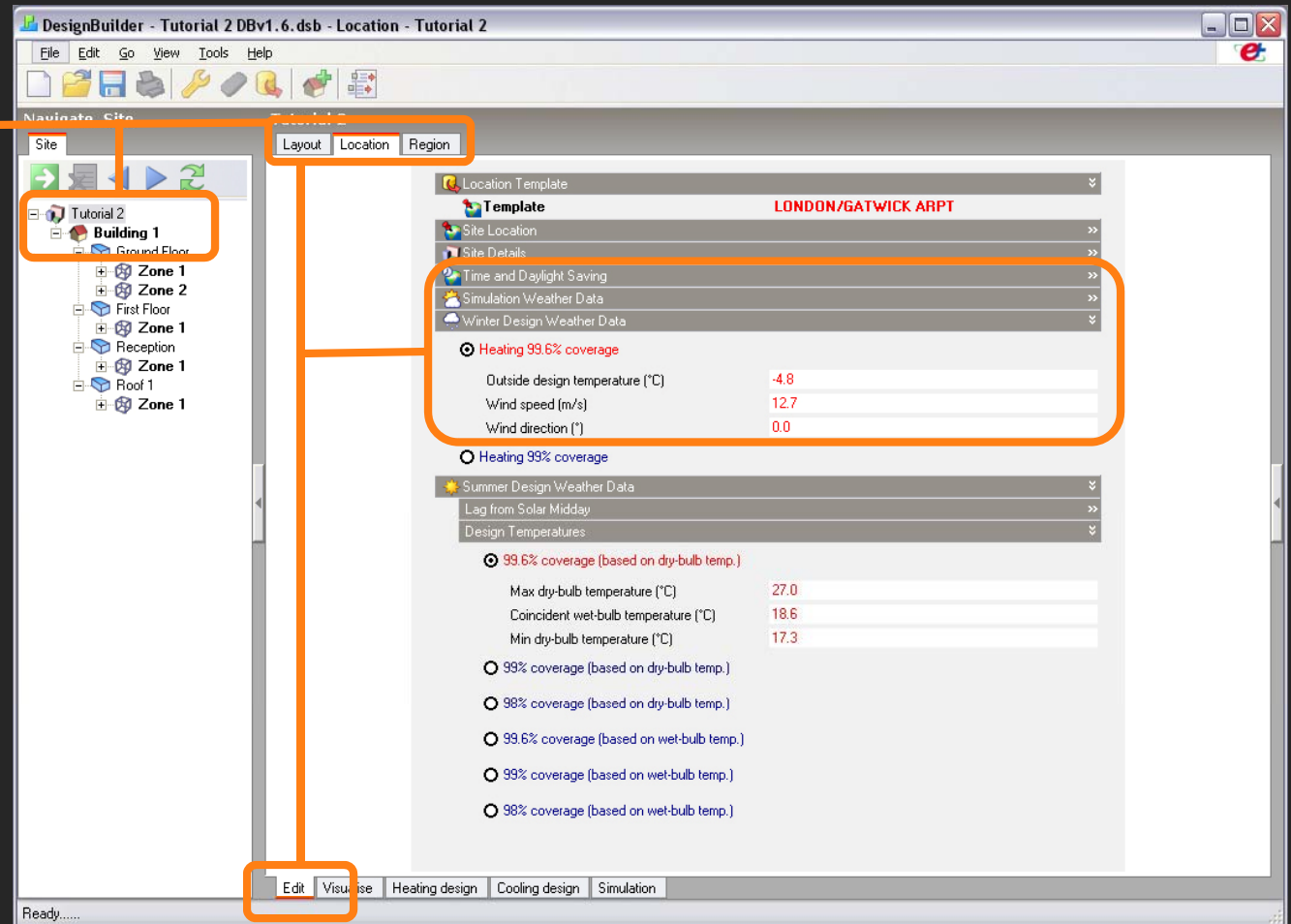
## Setting the Heating Design Temperature

1.

Go to the “edit” tab go to “Site” level > “Location” > “Winter Design Weather Data”.

You may select a "severity" of heating design weather (winter conditions) that seems appropriate to your project. As a result you will see which design temperatures are used by the calculation.

- a 99% design temperature is one that will be exceeded, statistically speaking, for 88 hours in a typical year
- a 99.6% design temperature is one that will be exceeded, statistically speaking, for 35 hours in a typical year.



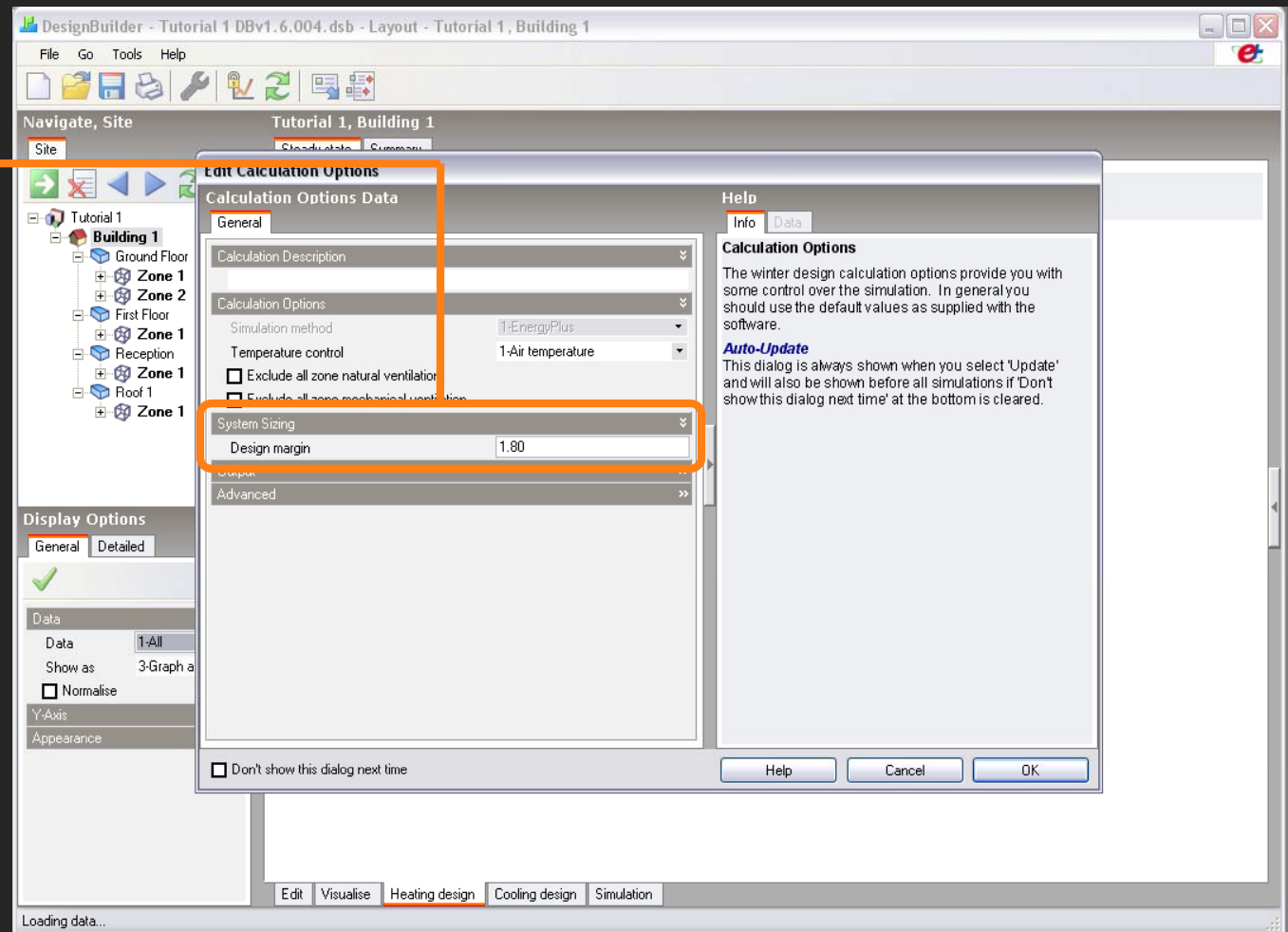
# SIMULATION

## Sizing Factor

2.

Select a “Design margin” for the heating system of “1.8”.

The Heating Design margin is used to multiply calculated steady state heating loads in each zone to give a recommended heating plant size. It accounts for the additional heat required to bring the building up to temperature in a reasonably short preheat period and allows you to be confident that comfort conditions will be maintained in all but the most extreme winter conditions.



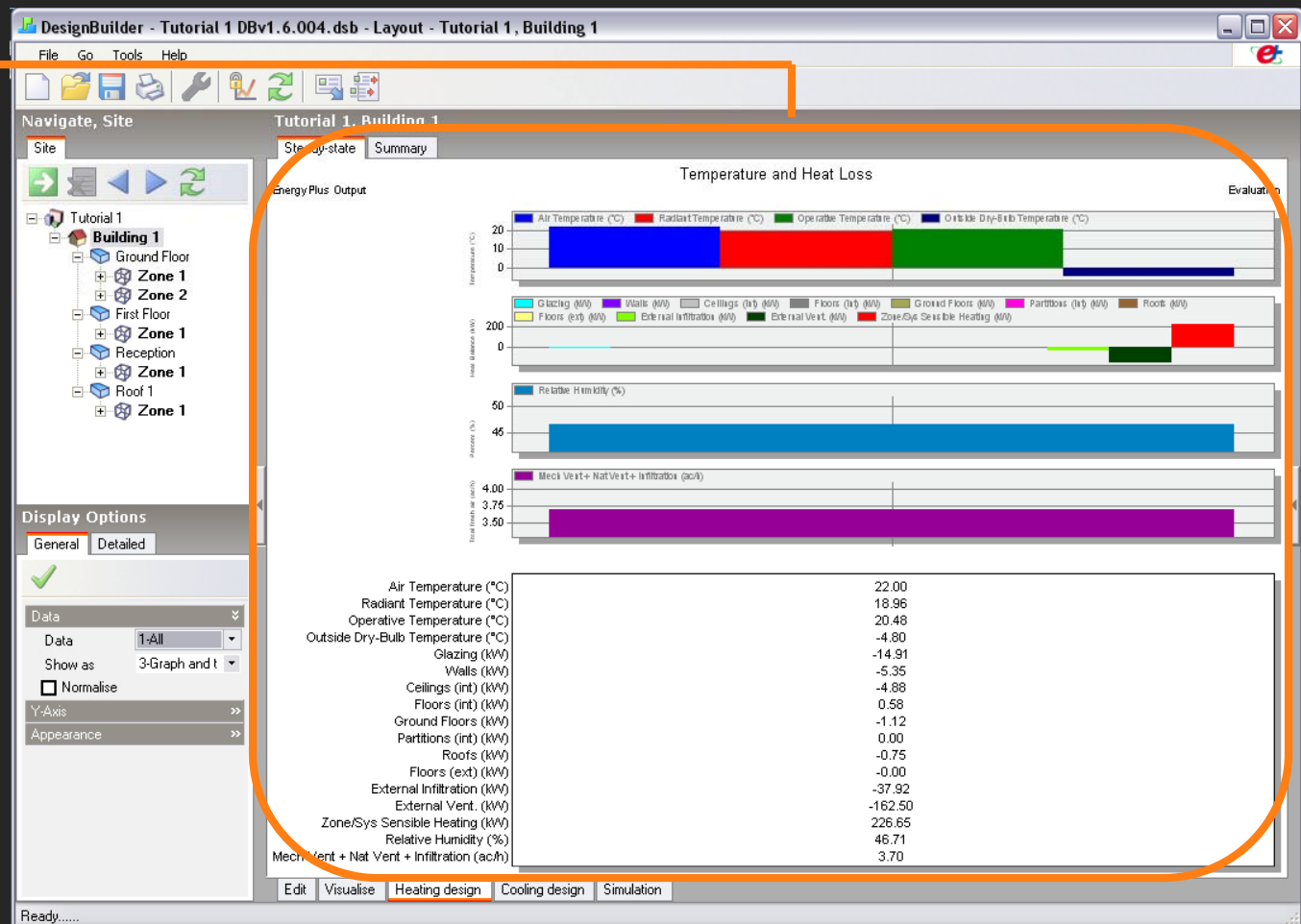
# SIMULATION

## Results of a Heating Design Calculation

3.

Depending on the version of DesignBuilder that you are working with, your results will vary from those in the tutorials. If our are using **version DB v.1.6.2.0004**, your first screenshot after performing the heating design calculation should look like this.

Tutorial # 2 will still show you a simplified version of the results. It will not display the table view and will not display Relative Humidity values (RH) or air changes rates (ac/h). The results that you will get will also vary from those in the tutorial as you are not using the exact same design parameters. (This is a result of changed default values in DesignBuilder.)



# SIMULATION

## Cooling Design Calculations

Same as a heating design calculation, a cooling design calculation is performed to investigate a building's behavior under extreme conditions, in this case cooling conditions. The calculation results are typically used to size HVAC systems and their components

### INFO

Cooling Design calculations are made to determine a building's required cooling load needs. Cooling load is the capacity of the equipment to account for all the heat gains of the building (external and internal) assuming dynamic conditions. Dynamic temperature variations mean that heat storage occurring in the building envelope and/or interior elements is considered (in DB, defined as default as half-hourly temperatures). As a result cooling loads are often not equivalent to total heat gains. Cooling design calculations also assume worst case conditions such as clear sky solar gains, full typical capacity internal gains (lighting, equipment, occupancy, etc) and no wind. **DesignBuilder however allows you to consider scheduled natural ventilation.** Weather conditions for "cooling design calculations follow the same criteria as for "heating design calculations" and will not necessary represent any actual year, and the designer may select the "severity" of weather that he or she deems appropriate. The resulting maximum cooling load in each zone is multiplied by a "Design Margin" to give a "Design Cooling Capacity" (the capacity of equipment required to offset such a load). More information about Cooling Design Calculations can be found in **ASHRAE Handbook of Fundamentals, 2001 (ISBN 1-883413-87-7) TC.29**

# SIMULATION

## TUTORIAL #2 The Basis of Cooling Design Calculations

When carrying out cooling design calculations in zones which are not mechanically cooled free-floating temperatures are calculated and may include the effects of natural or mechanical ventilation.

This is the case of the first cooling design calculation in tutorial #2, when you will first see free-floating temperatures as a result of not having mechanical cooling activated by default.

# SIMULATION

## Setting the Cooling Design Temperature

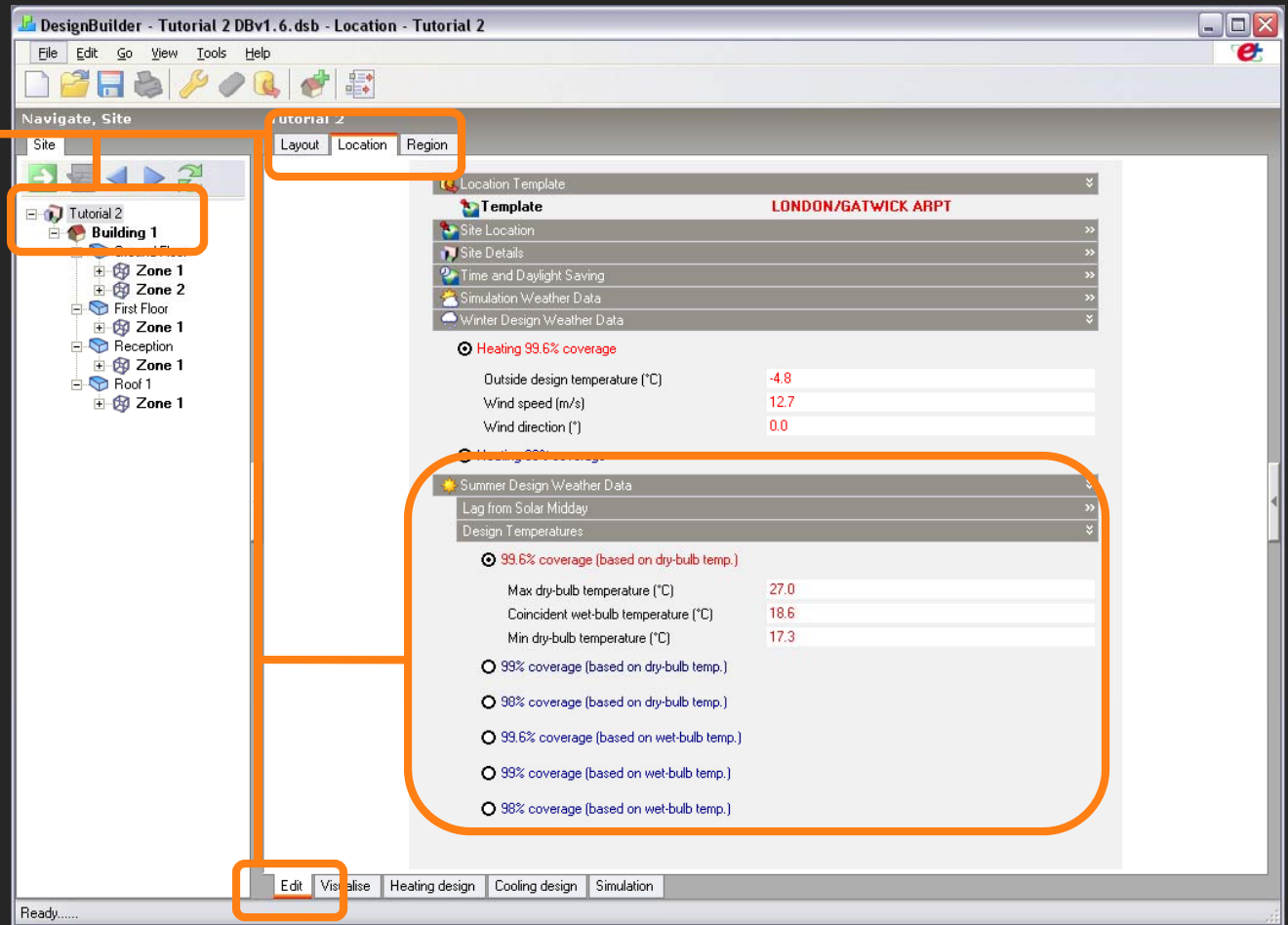
1.

Go to the “edit” tab then to “Site” level > “Location” > “Summer Design Weather Data”.

You may select a "severity" of cooling design weather (summer conditions) that seems appropriate to your project. As a result you will see which design temperatures are going to be used by the calculation.

- a 99% design temperature is one that will be exceeded, statistically speaking, for 88 hours in a typical year

- a 99.6% design temperature is one that will be exceeded, statistically speaking, for 35 hours in a typical year.



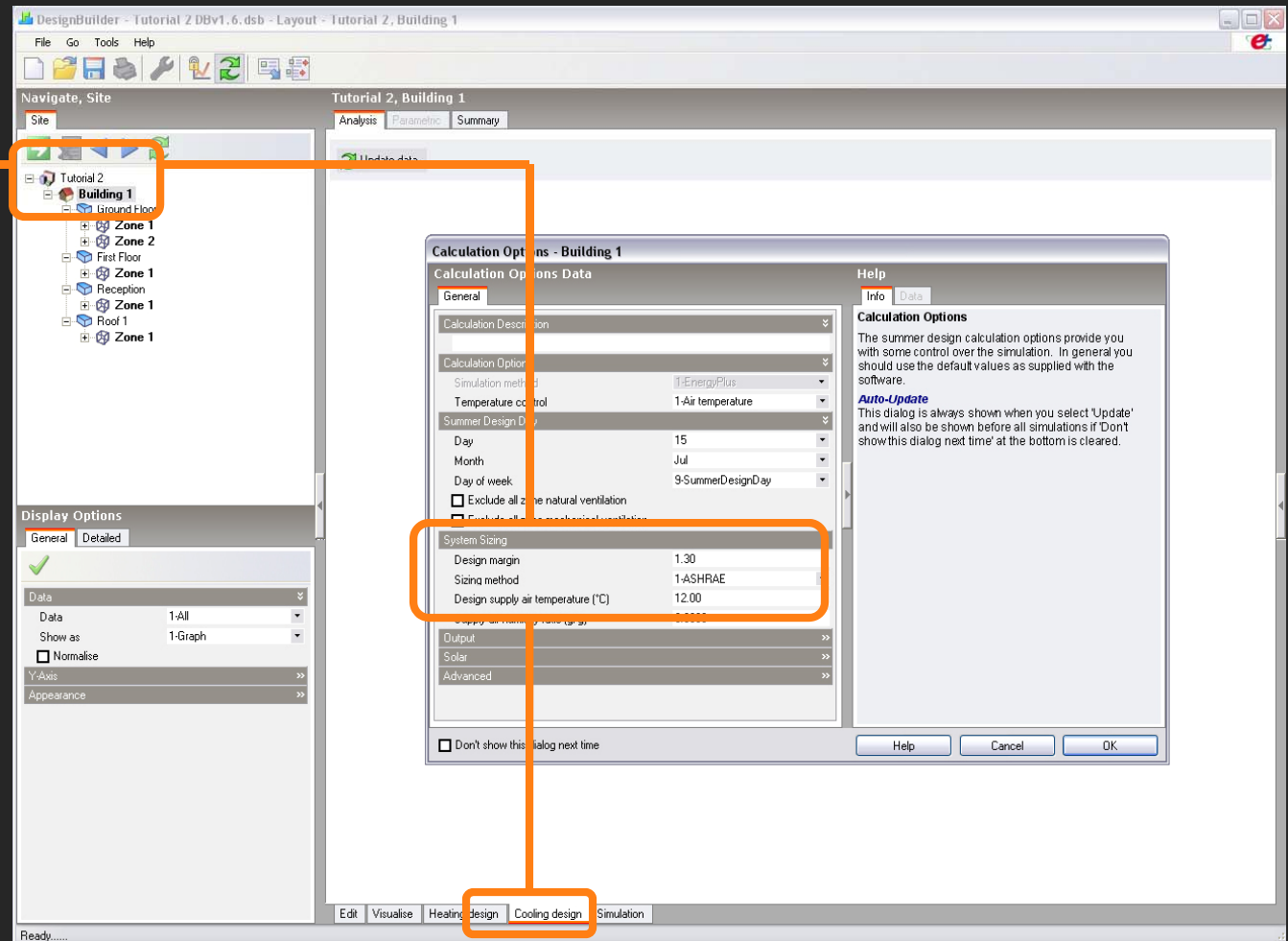
# SIMULATION

## Safety Factor

2.

Go to the “Site” level > then to the “Cooling Design” tab.

The Cooling Design margin is a 'safety factor' used to multiply calculated cooling loads in each zone to give a recommended maximum cooling equipment capacity. It accounts for the additional cooling required to cool the building within a reasonably time period and allows you to be confident that comfort conditions will be maintained in all but the most extreme summer conditions (risk depends on the Summer Design Weather Data options selected at site level). For this exercise please keep the default value.



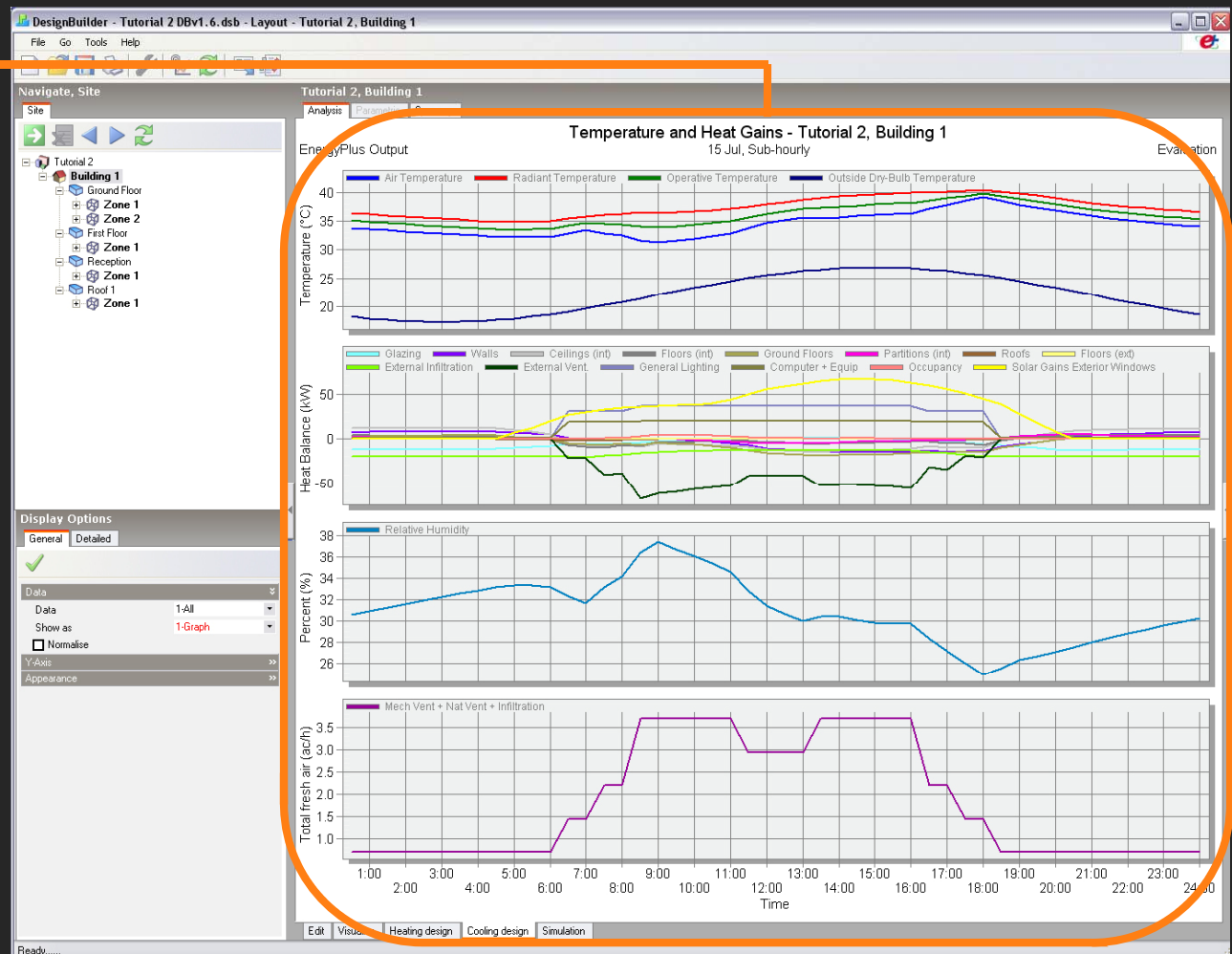
# SIMULATION

## Cooling Design Calculation

3.

Due to the version you are working on, your results will vary compared to the ones in the tutorials. Your first screenshot after performing the heating design calculation should be similar to this (if you are using version DB v.1.6.2.0004).

Tutorial # 2 will still show you a simplified version of the results. It will not display Relative Humidity values (RH) or air changes rates (ac/h). The results that you will get will also vary from those in the tutorial as you are not using the exact same design parameters. (This is a result of changing default values in DesignBuilder.)





# SIMULATION

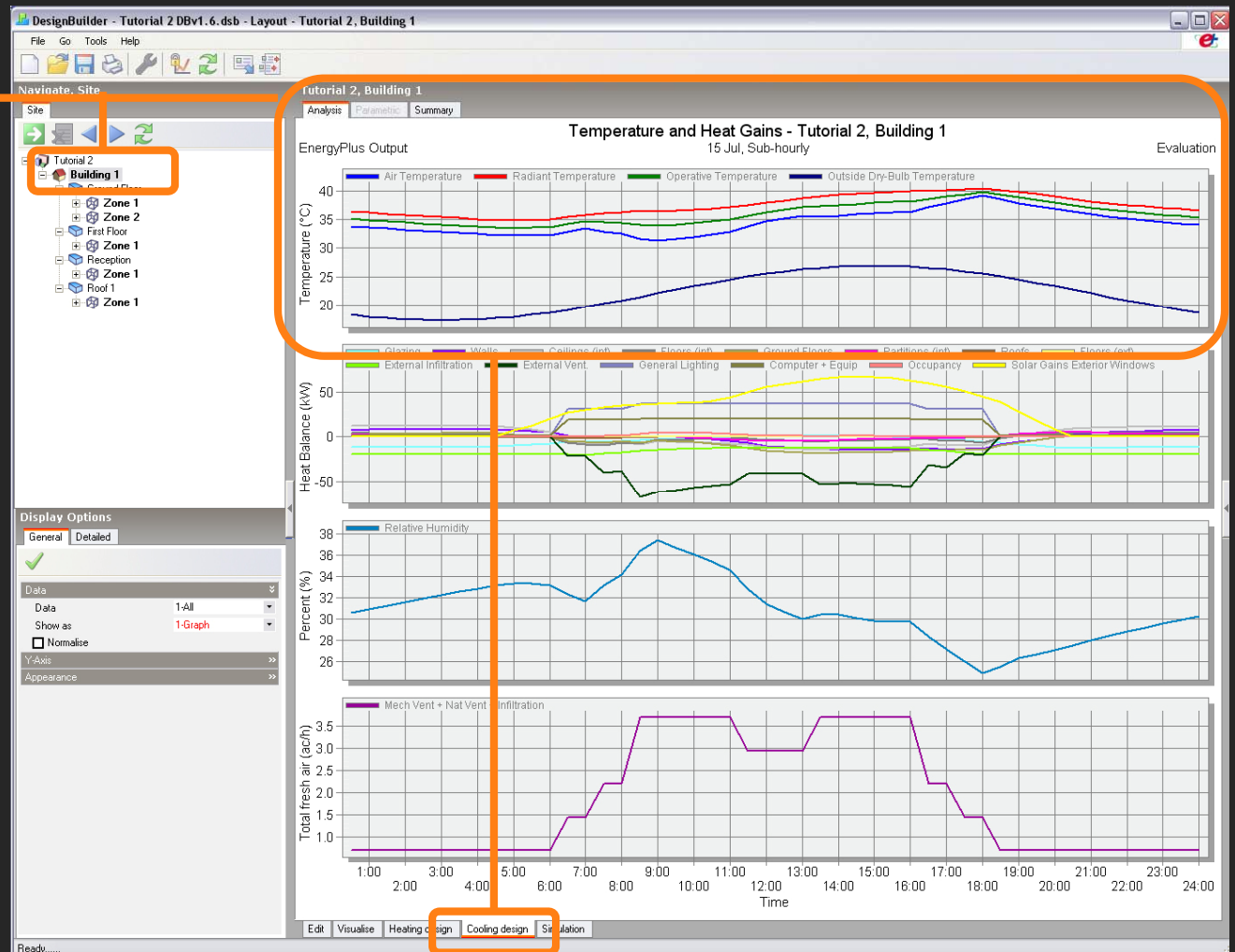
## Analyzing temperature profiles

### 4.

The first result you will get when performing the first cooling design calculation in Tutorial #2 will show you free-floating temperatures as a result of not having mechanical cooling activated by default.

One can see that the “radiant temperature” (red), “operative temperature” (green) and “air temperature” (blue) are well above the “outside temperature” (dark blue).

The operative temperature is also above the comfort temperature of 24°C-27°C recommended by ASHRAE STD 55 and ISO 7730 at 50%RH when considering natural ventilation.



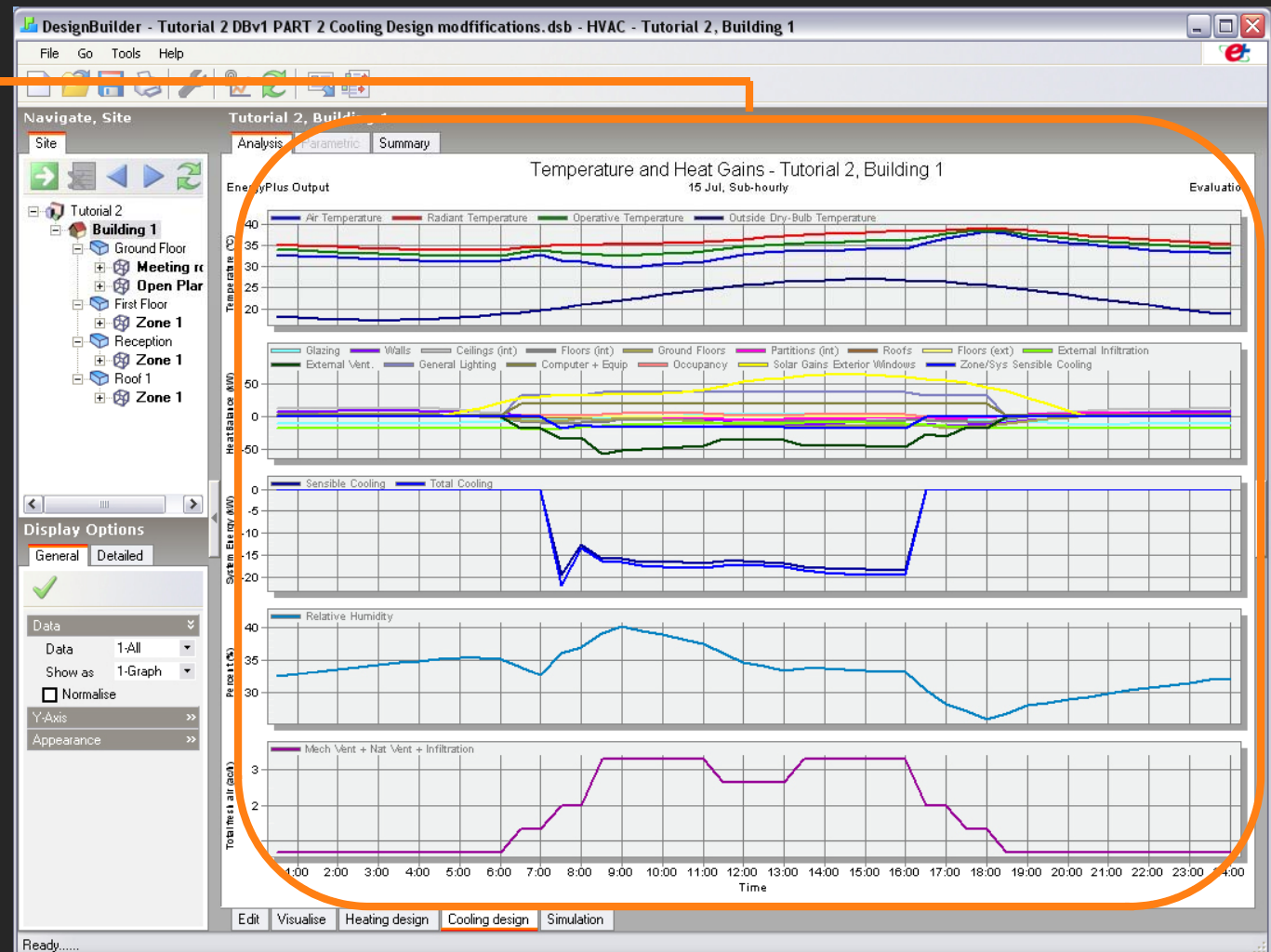
# SIMULATION

## Cooling Design Calculation

5.

Your screenshot after performing the second cooling design calculation with mechanical cooling activated, should look like this.

The tutorial wont display as default the “System Energy” demand, the “Relative Humidity” nor the “Mechanical Vent + Nat Vent + Infiltration (the sum of outside air in ac/h).



# SIMULATION

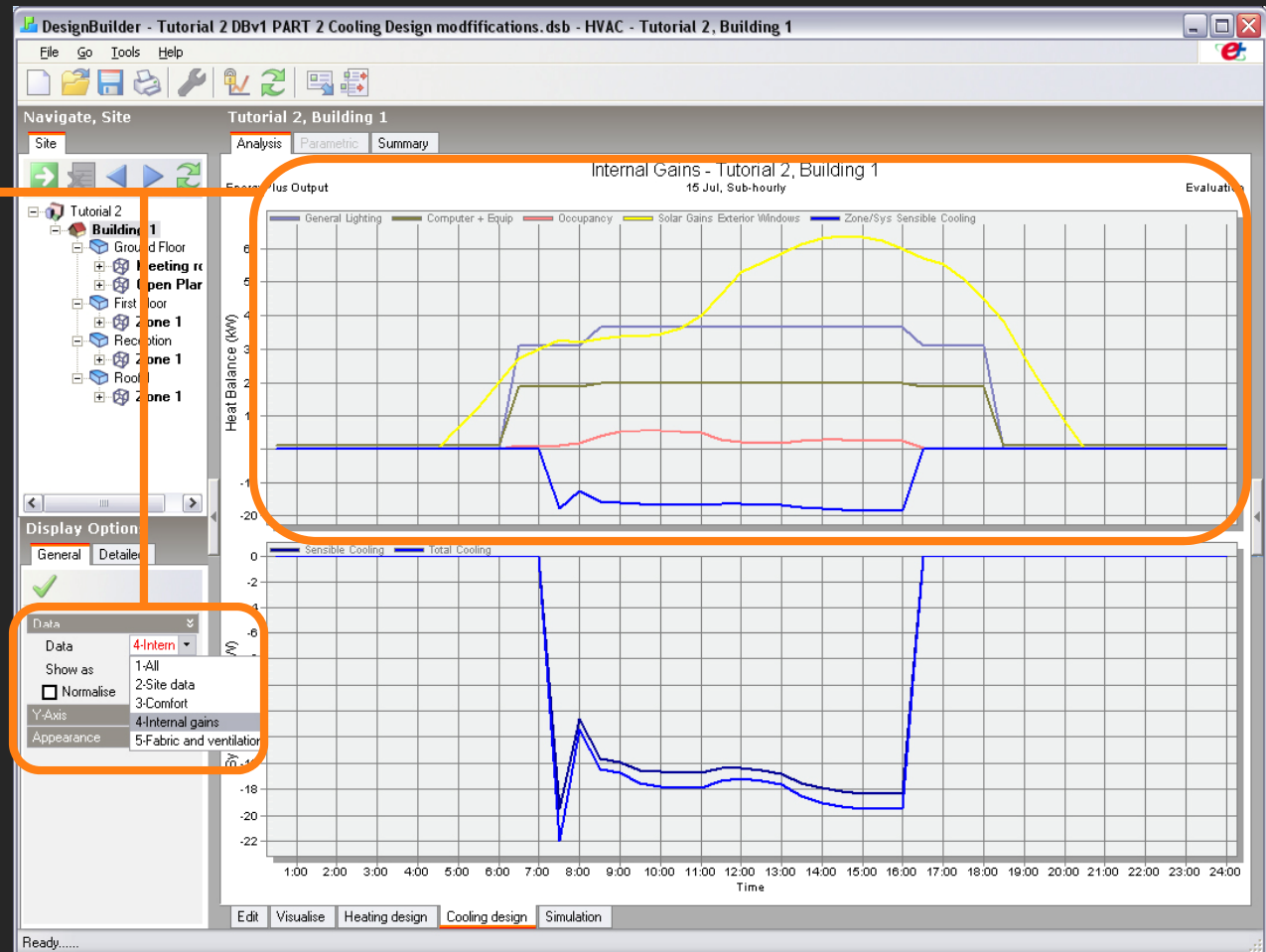
## Analyzing Internal Gains

6.

If you go to the “Data” tab in the “Display Options” menu, you can select different data display options. In “Internal Gains” you can find the “Zone/Sys Sensible Cooling”

“Zone/Sys Sensible Cooling” is the sensible cooling effect on the zone of any air introduced into the zone through the HVAC system. It includes any “free cooling” due to introduction of relatively cool outside air.

Cooling is always shown as a negative heat gain in the results. It is best thought as the energy required to cool-down the space to the set temperature, hence part of the zone heat balance. In the “Internal Gains” graphs you can see its correlation with solar gains or other heat gain sources and their schedules



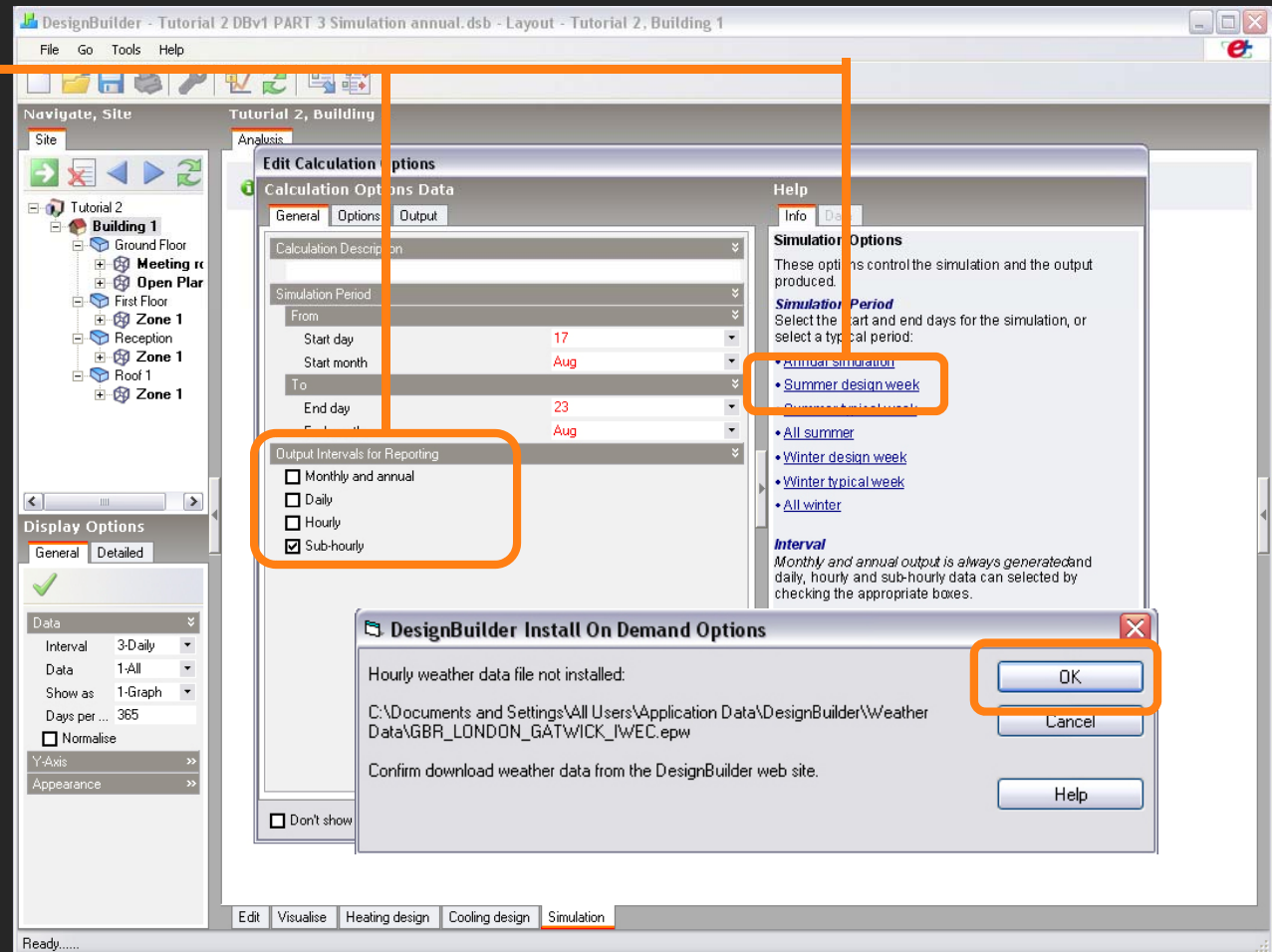
# SIMULATION

## Simulating a Summer Design Week

7.

At the “Building Level” go to the “Simulations” to perform the “real weather data simulation”.

When you first select “Sub-hourly” weather data for a Summer Design Week calculation, you will be prompted to download the hourly from DesignBuilder web site. Select “OK”.



# SIMULATION

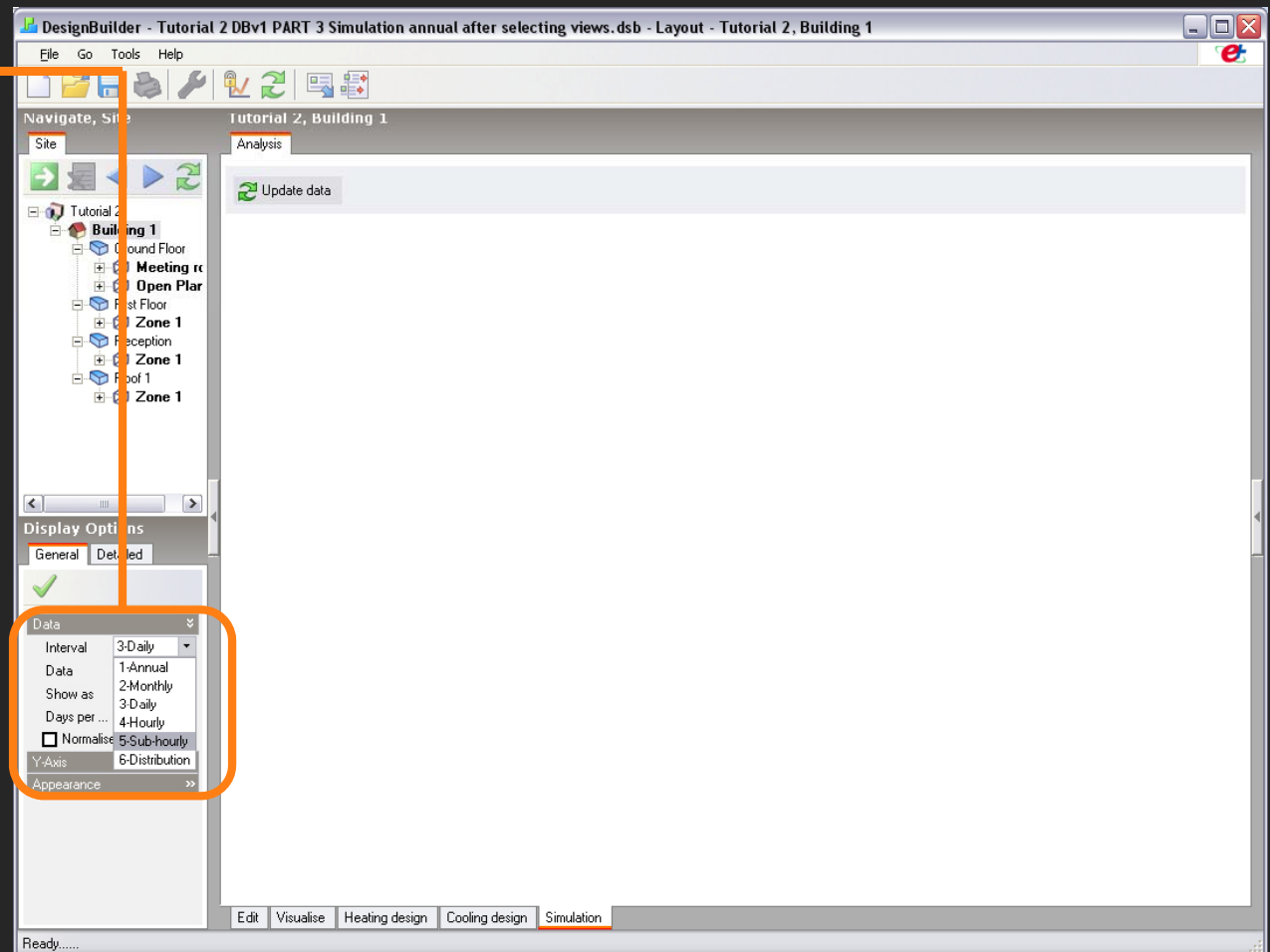
## Simulating a Summer Design Week

8.

Your screenshot after performing the first real weather simulation should look like this. It won't show immediately any results.

You are currently viewing only "Daily Data", and since you selected to perform just a "Sub-hourly Data" calculation, there is no "Daily" data to be displayed. This is a useful feature to avoid misinterpreting results.

In the "Data" menu, select "5-Sub-hourly". This will display the calculations results. (The tutorial switches to this version automatically).



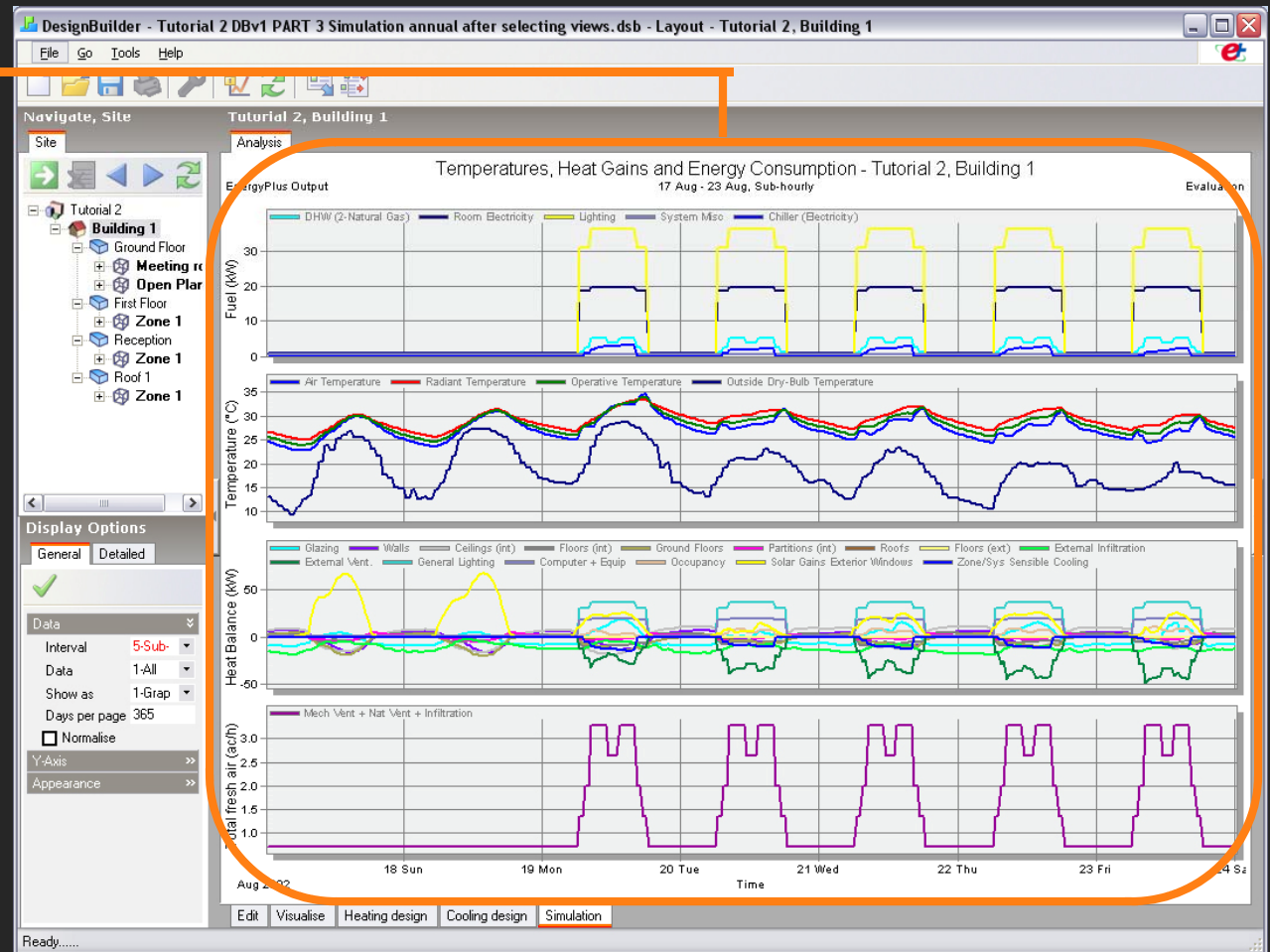
# SIMULATION

## Simulating a Summer Design Week

9.

Your screenshot after performing the first real weather simulation and selecting the “5-Sub-hourly” data display should look like this.

The tutorial wont display as default the “Fuel” demand (estimated period consumption) nor “Total Fresh Air” (the sum of outside air in ac/h, considering mech. vent, nat. vent and infiltrations).



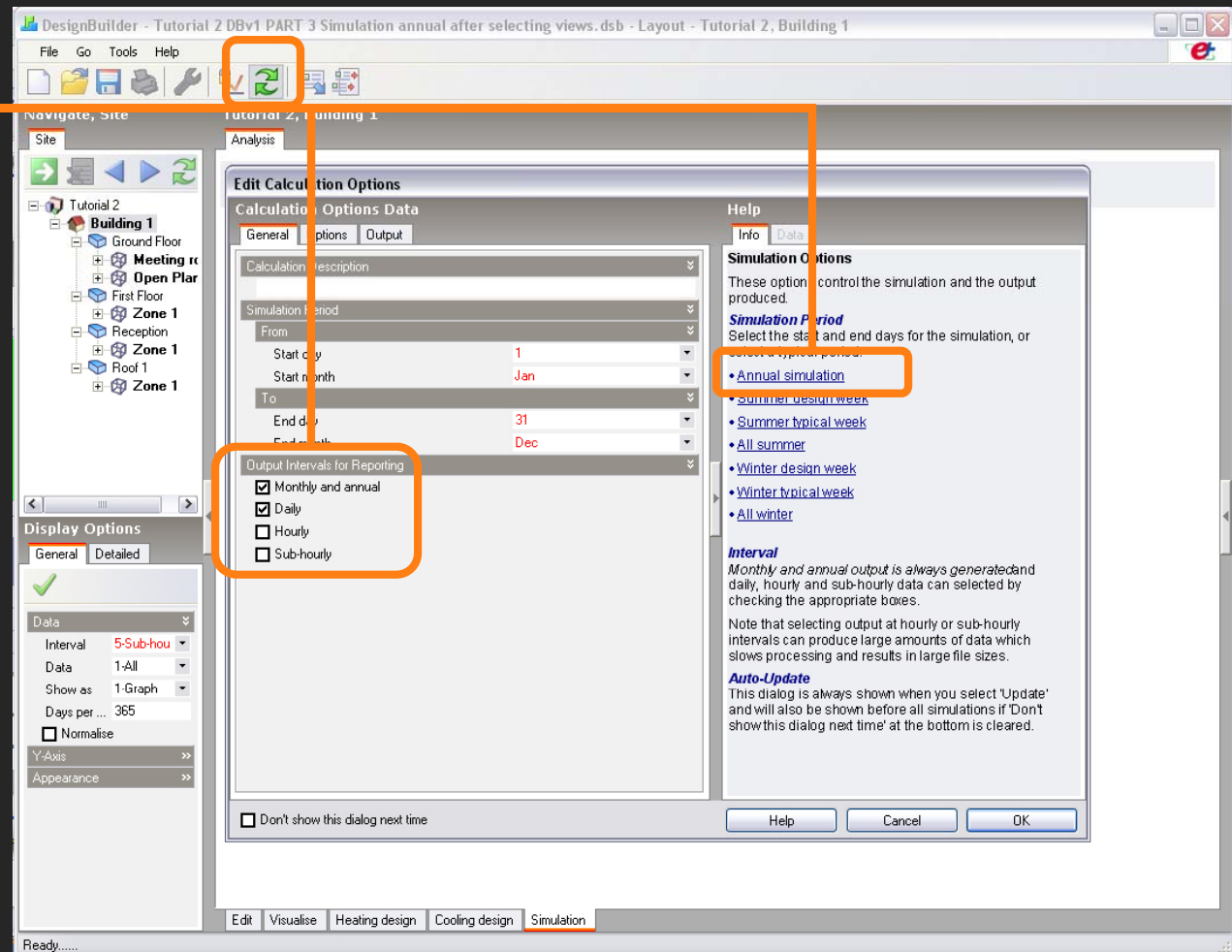
# SIMULATION

## Performing an Annual Simulation

### 10.

To perform the “Annual Simulation” using “real weather data, go the “update” icon. Then select “annual simulation” and select the Daily and the Monthly and annual “Outputs Intervals for Reporting”.

If you don’t select the Monthly and annual interval, you wont be able to display total annual or monthly values under that option in the “Display Options”. This means that even if you calculated the results of the 365 days of the year, the program will not allow you to display for example, the Total Annual Fuel consumption.

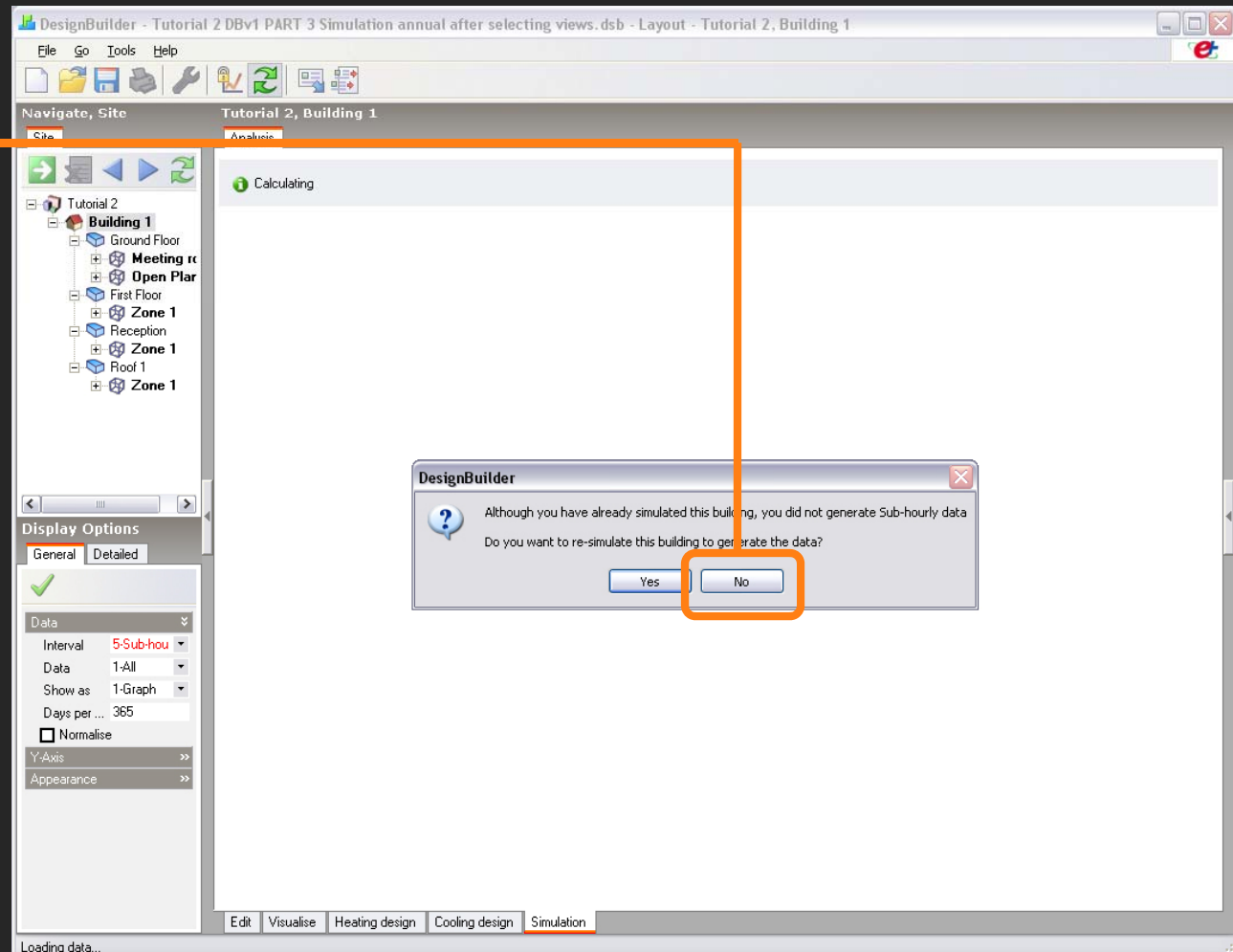


# SIMULATION

## Performing an Annual Simulation

### 11.

When selecting just the “Daily” and “Monthly and Annual” output intervals as reports, if you were still in the “5-Sub-hourly” display option you will be prompted to re-simulate your building using “sub-hourly” calculations. For this tutorial select “NO”.





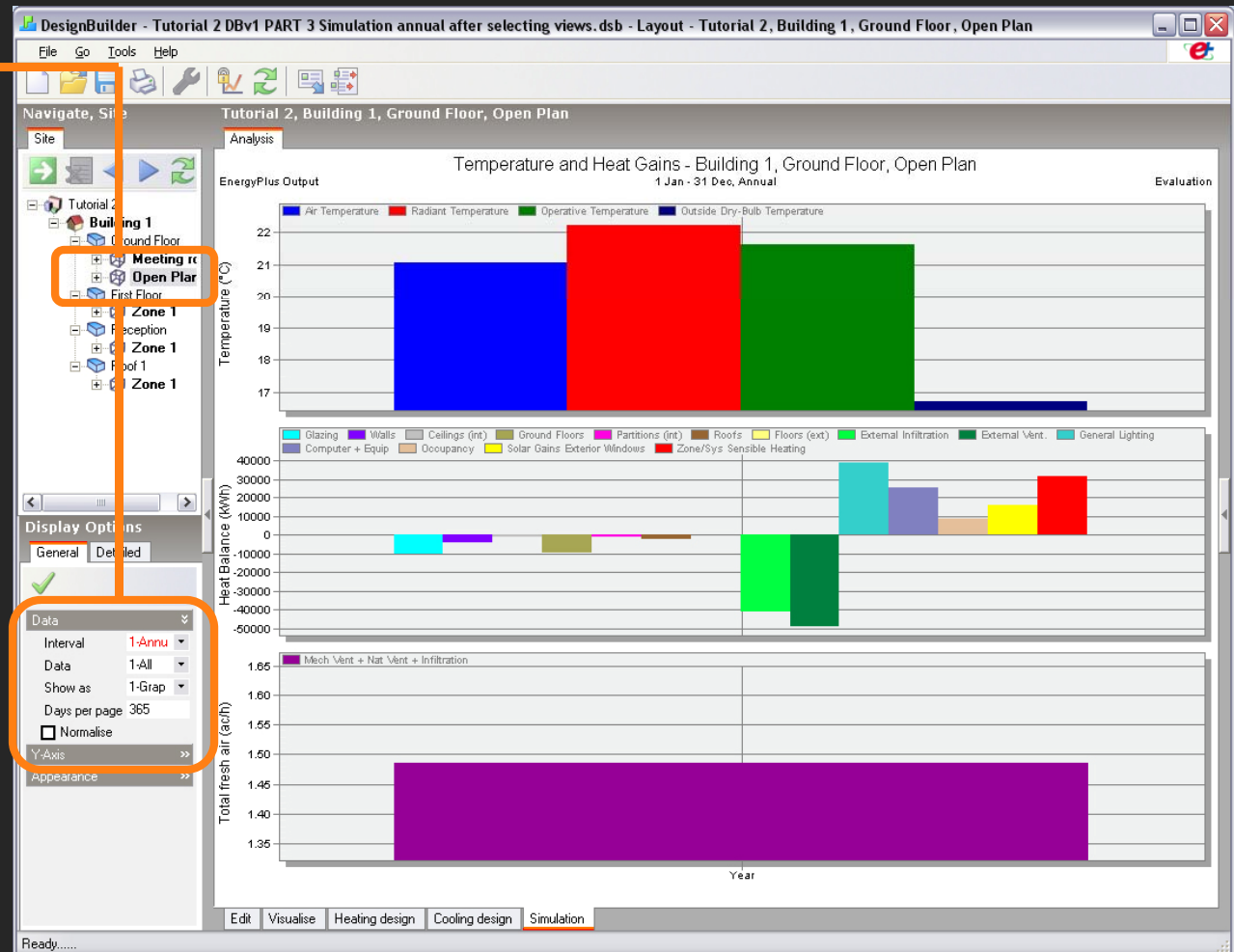
# SIMULATION

## Results of an Annual Simulation

### 12.

If you are still in the “Open Floor” level (as the Tutorial), your screenshot after performing the first real weather simulation and selecting the “1-Annual” data display should look like this.

The tutorial wont display as default the “Total Fresh Air” (the sum of outside air in ac/h, considering mech. vent, nat. vent and infiltrations).



# SIMULATION

## Results of an Annual Simulation

### 13.

When at the “Building level” and having selected the “3-Daily” display option, your screen should look like this.

The tutorial will display instead of the “Total Fresh Air” graph (the sum of outside air in ac/h, considering mech. vent, nat. vent and infiltrations) a “Total CO2” graph. Later on this document you will learn how to display the CO2 information as well.



# RESULTS

In the preceding section you have used DesignBuilder to calculate Heating and Cooling Design Loads and run Annual Simulations using real weather data.

Now you will customize the display of results to allow you to make a more comprehensive analysis and comparison of your building's energy performance. At the end of this sections you will be able to:

- Select which variables to include in the display of Internal Gains, Fuel Breakdown, Comfort or Fuel graphs, including CO2 values.

# RESULTS

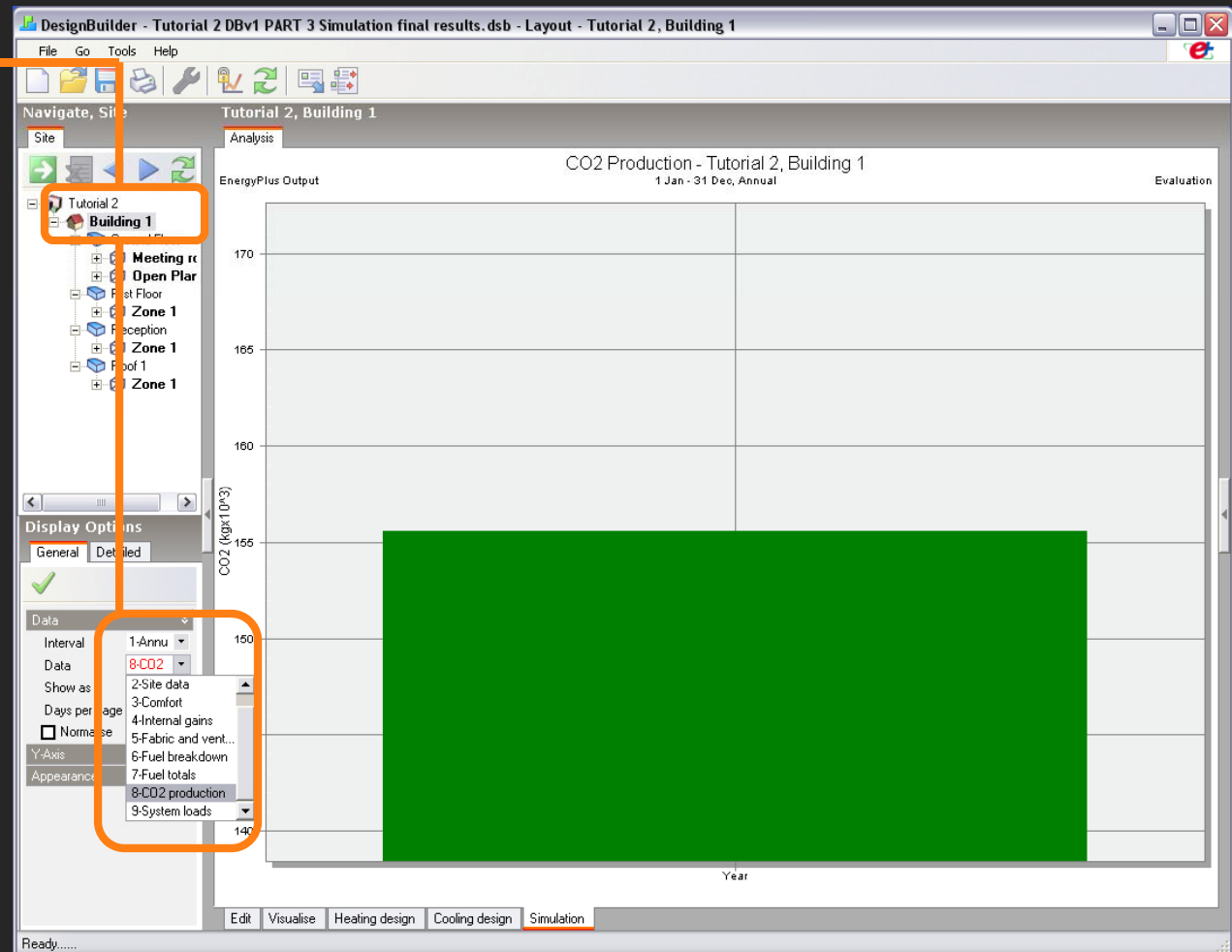
## Customizing results

### 14.

To display the annual CO2 Production for the building:

At the “Building Level”, select “8-CO2 production” data display.

You must know that the “display data” options will vary according to the “level” in which you are: Site, Building, or Block and Zone.



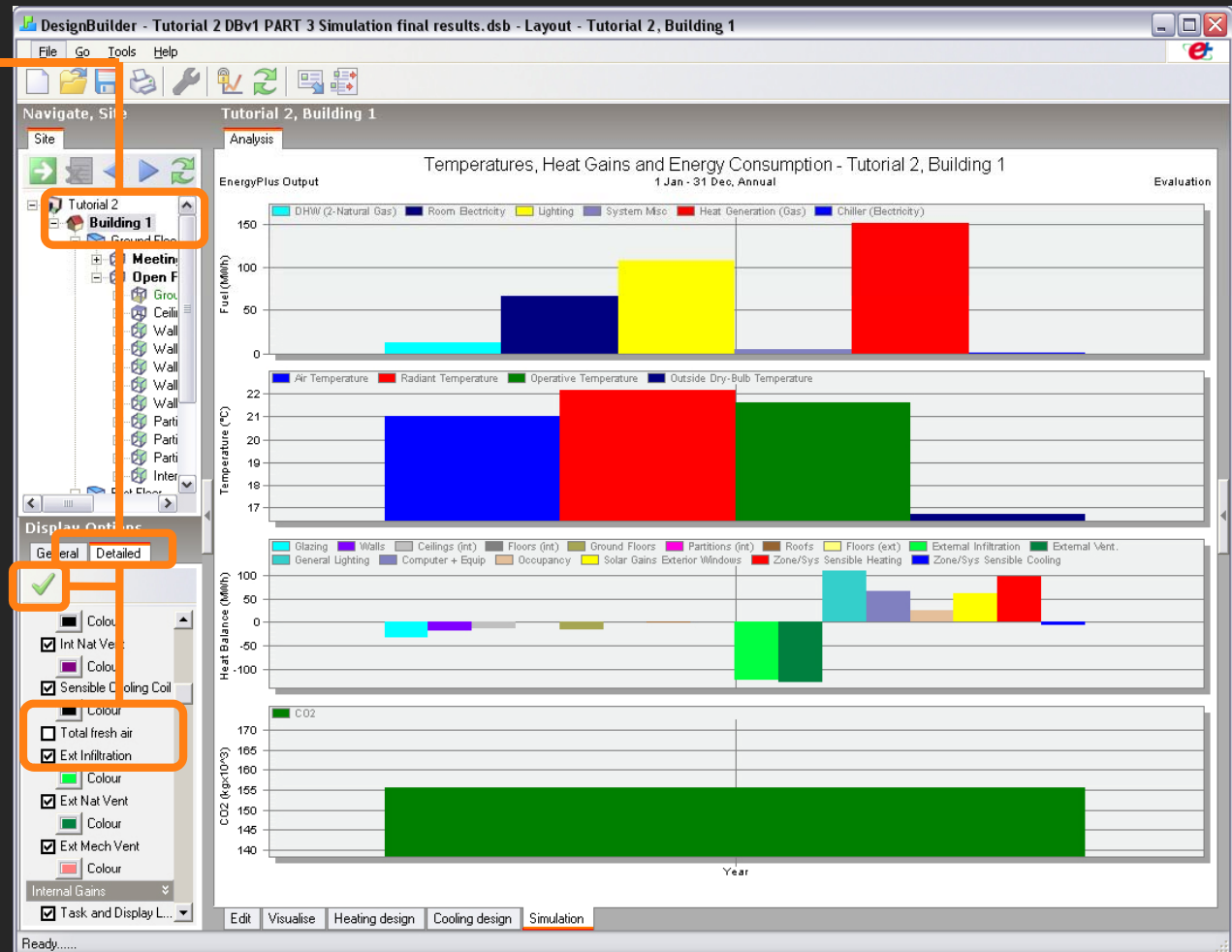
# RESULTS

## Customizing results

### 15.

To display the annual CO2 Production for the building as part of the Summary Graph:

At the “Building Level”, select Data “1-All” data display, then go to the “Detailed” tab in the “Display Options”. Scroll down to the “Heat Gain” category and uncheck the “Total fresh air” option. Keep scrolling down to the “CO2” category and check the “CO2 production” option. Finally click in the “green check icon”.



# RESULTS

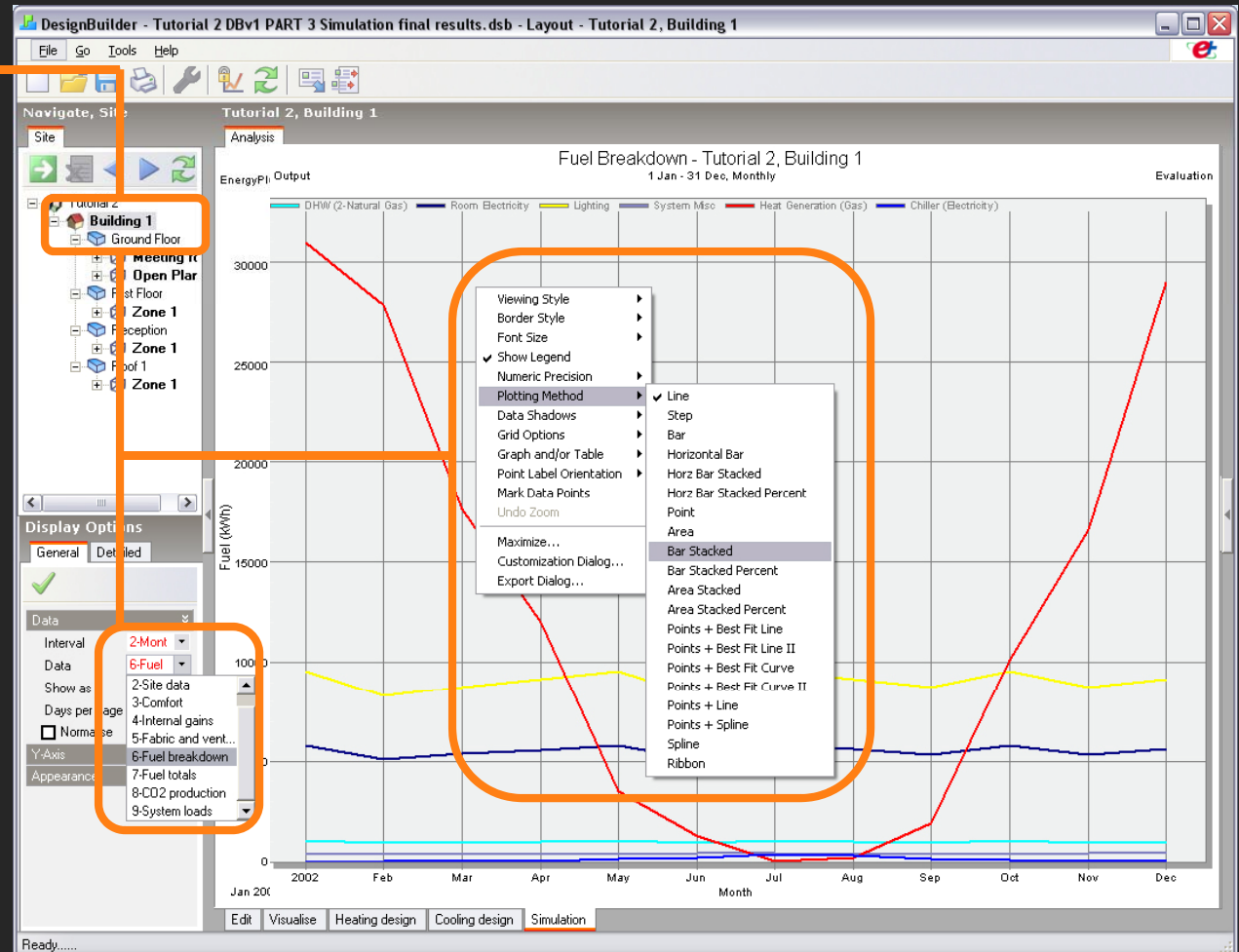
## Customizing results

### 16.

To display the monthly energy consumption by fuel, in a customized graph layout, such as a stack bar graph:

At the “Building Level”, select Data “6-Fuel Breakdown” data display, then go to the “Interval” options in the “Display Options” and select “2-Monthly”.

Once the Monthly Fuel Breakdown graph is displayed, make a “right click” in the center of the graph and select “Plotting Method” > “Bar Stacked”.



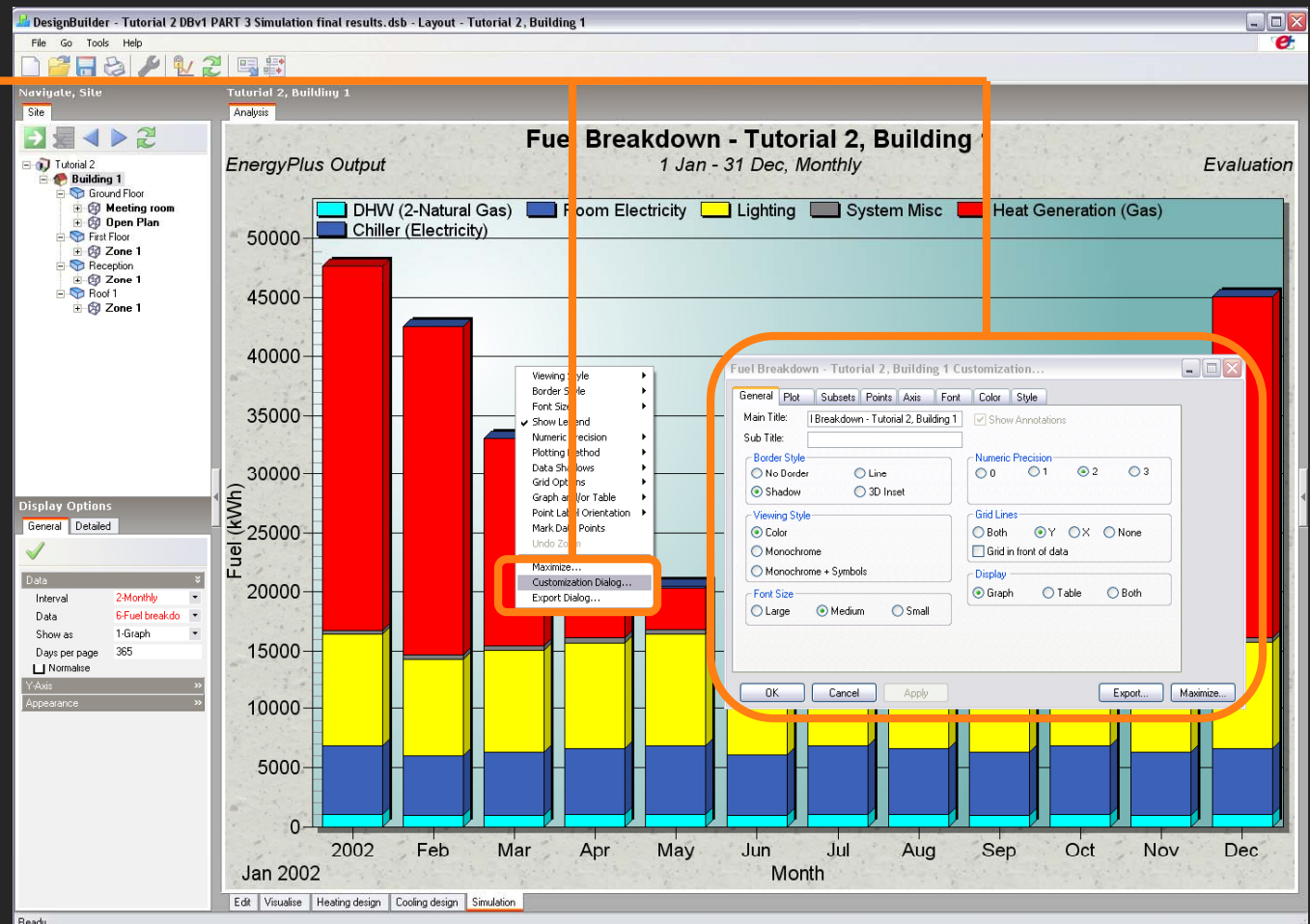
# RESULTS

## Customizing results

17.

To further customize the display of results:

Make a “right click” in the center of the graph and select “Customization Dialog”



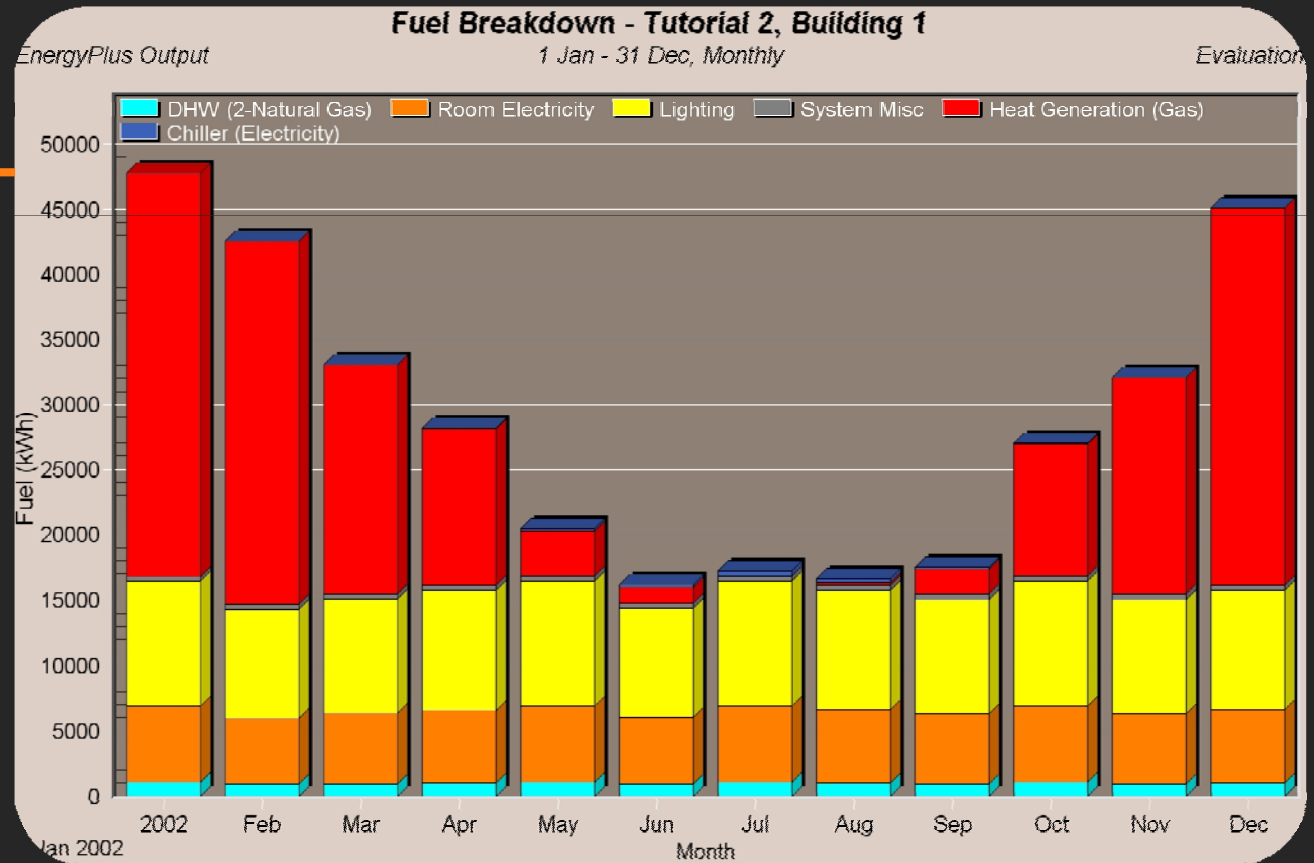
# RESULTS

## Customizing results

### 18.

You can export the graph as an image by making a “right click” on the middle of the graph > select “export”.

The graph allows you to easily identify which are the predominant energy consumption by end-uses along the year and plan the ECMs accordingly.





# RESULTS

Finally, to display “hourly” or “sub-hourly” values in a more comprehensive manner you may adjust the numbers of days to be display at a time.

We will carry out an example with a Summer Typical Week calculation using the same model built in Tutorial #2. We will display the Comfort Temperatures and the Internal Gains at the same time to study the efficacy of the “external shading devices” implemented in the reception area to control the solar radiation and improve internal comfort conditions.

## INFO

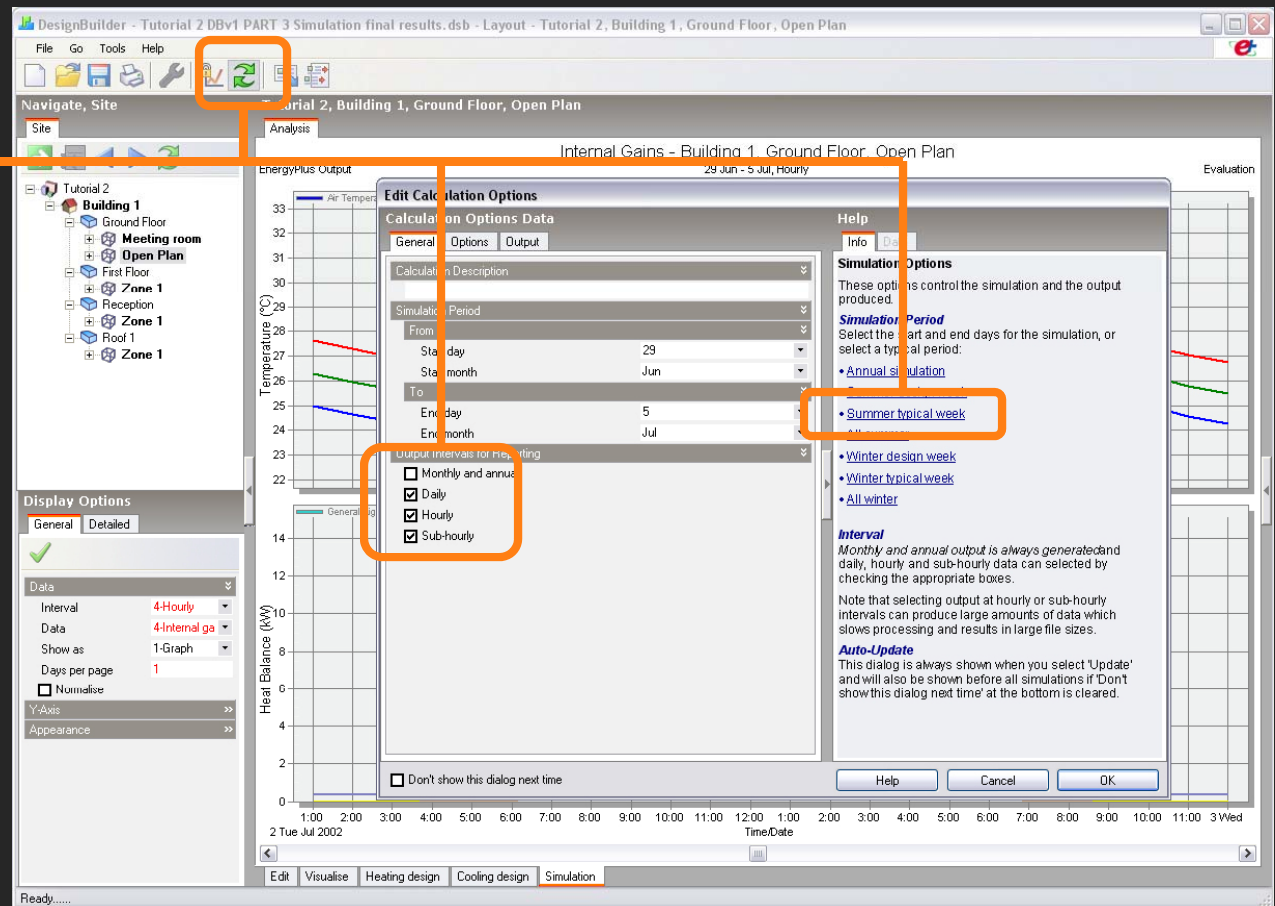
A “Summer Typical Week” is a week identified from the weather data file as being typical of the summer. DesignBuilder uses EnergyPlus format hourly weather data to define external conditions during simulations. Each location has a separate file describing the external temperature, solar radiation, atmospheric conditions etc. for every hour of the year at that location. These hourly weather data sets are often 'typical' data derived from hourly observations at a specific location by the National weather service or methodological office. You can get Weather data for more than 2100 locations in EnergyPlus weather format from the U.S. Department of Energy website: [http://www.eere.energy.gov/buildings/energyplus/cfm/weather\\_data.cfm](http://www.eere.energy.gov/buildings/energyplus/cfm/weather_data.cfm)

# RESULTS

## Customizing Results

19.

Go to the “update icon”, then select “Summer typical week” in the Simulation Options and “Daily”, “Hourly” and “Sub-hourly” as the Output interval Reporting.



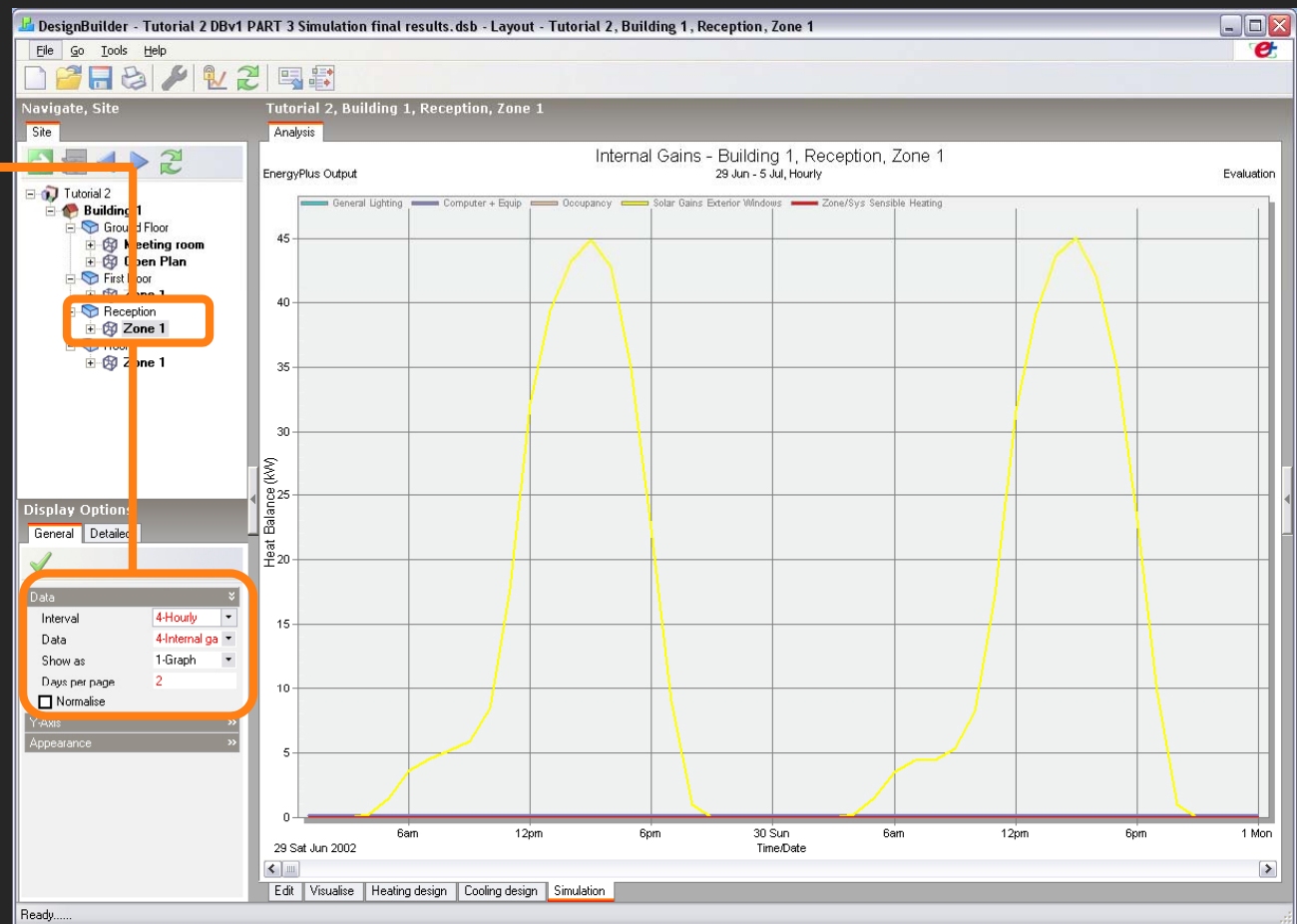
# RESULTS

## Customizing Results

20.

Go to the “Reception” zone, then select “4-Hourly” as the interval and “4-Internal Gains” as the Data .

Select “2” as the Days per page to be displayed.



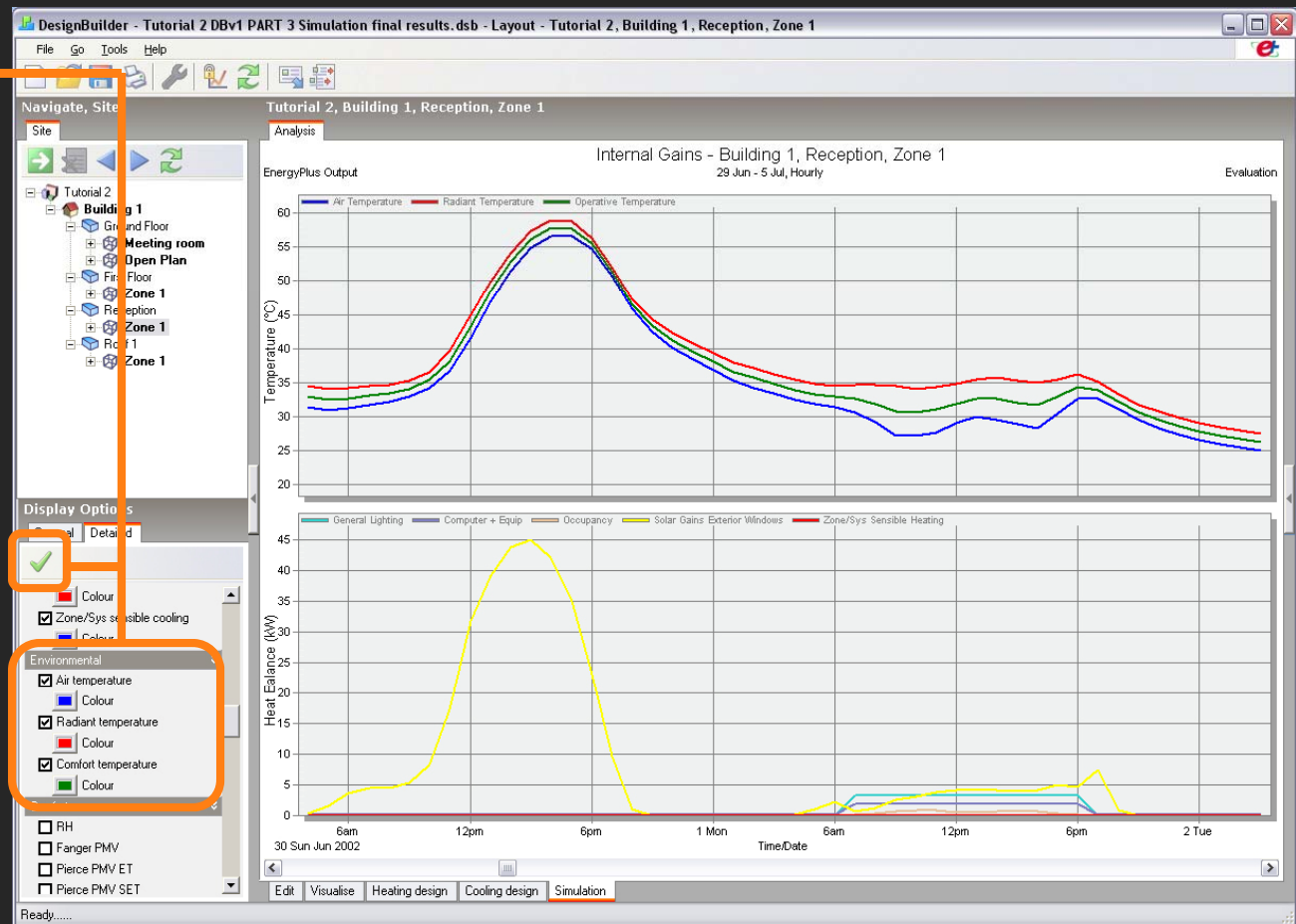
# RESULTS

## Customizing Results

### 21.

Go to the “Detailed” tab in the “Display Options”. Scroll down to the ‘Environmental’ category and check the “Air Temperature”, “Radiant Temperature” and the “Comfort Temperature”. Finally click in the “green check icon” and scroll to display “Sunday and Monday”

Since the shading devices are operating with the same schedule as the occupants, by comparing the internal comfort temperatures on Sunday and Monday we can easily evaluate the efficacy of this ECM.



# CONCLUSION

This document provided a quick, non-exhaustive overview of the building energy performance simulation capabilities offered by DesignBuilder/EnergyPlus. Should you decide to use this tool in the future consult the REFERENCE section for further reading. Remember:

- It is your responsibility to **learn the assumptions and limitations** of the programs you are using.
- Preparing and running a simulation takes time. Before rushing into doing a simulation you should **have a clear idea of how the simulations results can help you resolve a specific design question** that you could not answer otherwise.

# CONCLUSION

- Always consider that **buildings are a complex integration of energy flows and systems** comprising not only the whole of building form and fabric, but also plant and various other environmental control systems.
- All these variables will cause **building energy performance simulations**, which add code and algorithms to the equation making it even more complex, **subject to result in slightly different values from case to case.**

# NEXT STEP

- In this document you have used DesignBuilder to calculate Heating and Cooling Design Loads and run simulations using real weather data. Now you should continue with document number 2, where you will customize data templates and components for the project (glazing, constructions, schedules, shading devices, etc). You will also modify parameters to the interior environment and HVAC Systems.

“Modeling can be no more accurate than the assumptions that lie behind both the proposed building and the baseline building model. Even though the model performs complex calculations accurately on this assumptions, the result will be misleading if the assumptions are faulty.” Document #2 will work on some of the most critical assumptions that will guide you when performing your first basic models.

To access it go to:

<http://www.gsd.harvard.edu/research/gdsquare/tutorials.html>

# REFERENCES

## DesignBuilder:

- Consult the DesignBuilder Help Packages to get further information on the program's underlying calculation methods and how to explore the impact of key design aspects (e.g. natural ventilation) on building energy performance simulations.  
To access it: [run DesignBuilder>>Help>>Content](#).
- We strongly recommend you visit the “Knowledgebase” section in DesignBuilder’s webpage which has answers to most common questions about DB.  
To access it go to: [www.designbuilder.co.uk>Support>Knowledgebase](#).
- Finally, DesignBuilder’s webpage has a very useful “DesignBuilder Forum” where users post all sorts of questions which are usually answered by DesignBuilder software developers. To access it go to: [www.designbuilder.co.uk>Support>DesignBuilder Forum](#).



# REFERENCES

## EnergyPlus:

- Developing a basic understanding of the EnergyPlus simulation parameters and system data relationships is the key to reliable simulations. A list of online resources for EnergyPlus is available under <http://www.eere.energy.gov/buildings/energyplus/>.
- You can find All EnergyPlus Technical Reports at: <http://gundog.lbl.gov/dirpubs/eplall.html>.
- All of the technical reports generated by the Simulation Research Group are available at: [http://gundog.lbl.gov/dirpubs/valid\\_ep.html](http://gundog.lbl.gov/dirpubs/valid_ep.html)
- If you want to advance and connect further with the world of building performance simulations you can subscribe to Energy Plus' mailing list. This mailing list is very active (+300 emails monthly) and normally deals with very technical discussions. To subscribe go to: [http://tech.groups.yahoo.com/group/energyplus\\_support/](http://tech.groups.yahoo.com/group/energyplus_support/)

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The Presidential Instructional Technology Fellows : The Presidential Instructional Technology Fellows (PITFs) program was established to recruit and train fellows in conjunction with the Schools to work with faculty to develop digital course materials with immediate educational benefits. PITFs leverage existing software tools developed here at Harvard and provide outreach(<http://isites.harvard.edu/icb/icb.do?keyword=k2526&pageid=icb.page12917>).