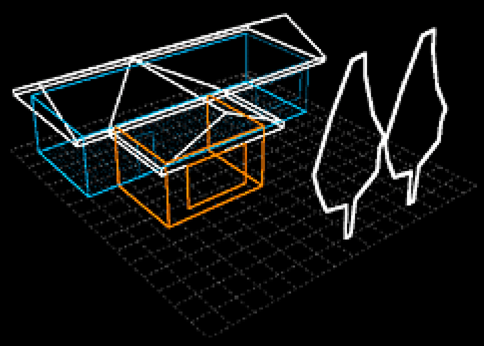
THERMAL PERFORMANCE- Introduction



Loading the Thermal Model

The first step in this tutorial is to load a model file containing a Simple House. To learn how to construct this model, you may want to attempt the **Simple House** tutorial before proceeding.

1. **Open Thermal Intro.eco from the Tutorial Files directory located in your main ECOTECT Install directory.**

   There are three zones in this simple model, the north room, south room and ceiling space. We want to analyse all three so we must first ensure that they are all thermal zones - meaning that they each represent a fully enclosed air space.

2. **To determine thermal zones, display the Zone Management panel on the right side of the main window.**

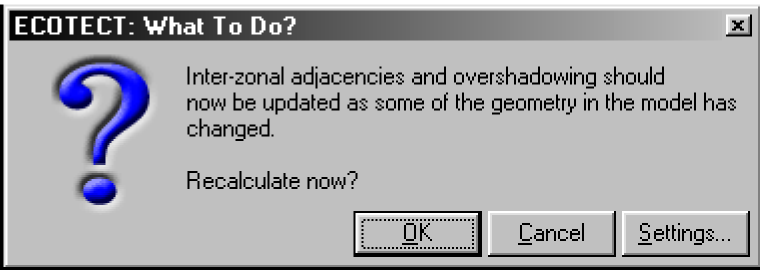
   The images alongside each zone indicate its current state, whether it is hidden/displayed, on/off, locked/unlocked, thermal/non-thermal and its colour, as shown below. The red **T** indicates that each zone is thermal. If any zones in your model (other than the Outside zone) is set as non-thermal, simply click the **Left Mouse button** on the thermal indicator to turn it on.

   To make some of the thermal graphs clearer, each zone is assigned a different colour. If you are using your Simple House tutorial model, you may want to assign similar colours to the three zones so you can follow the rest of this tutorial.

Calculating Internal Temperatures

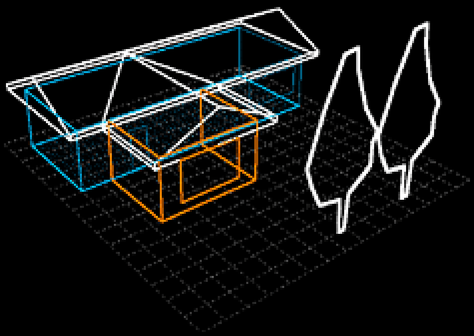
1. **From the Calculate menu, select the Thermal Performance... item.**

   Before thermal calculations can be performed, some pre-processing needs to be done on the model to determine inter-zonal adjacencies and overshadowing tables. These are stored to disk as .ADJ and .SHD files with the same name as the model. If the geometry of the model has changed, ECOTECT will prompt you to recalculate these with the following message box.

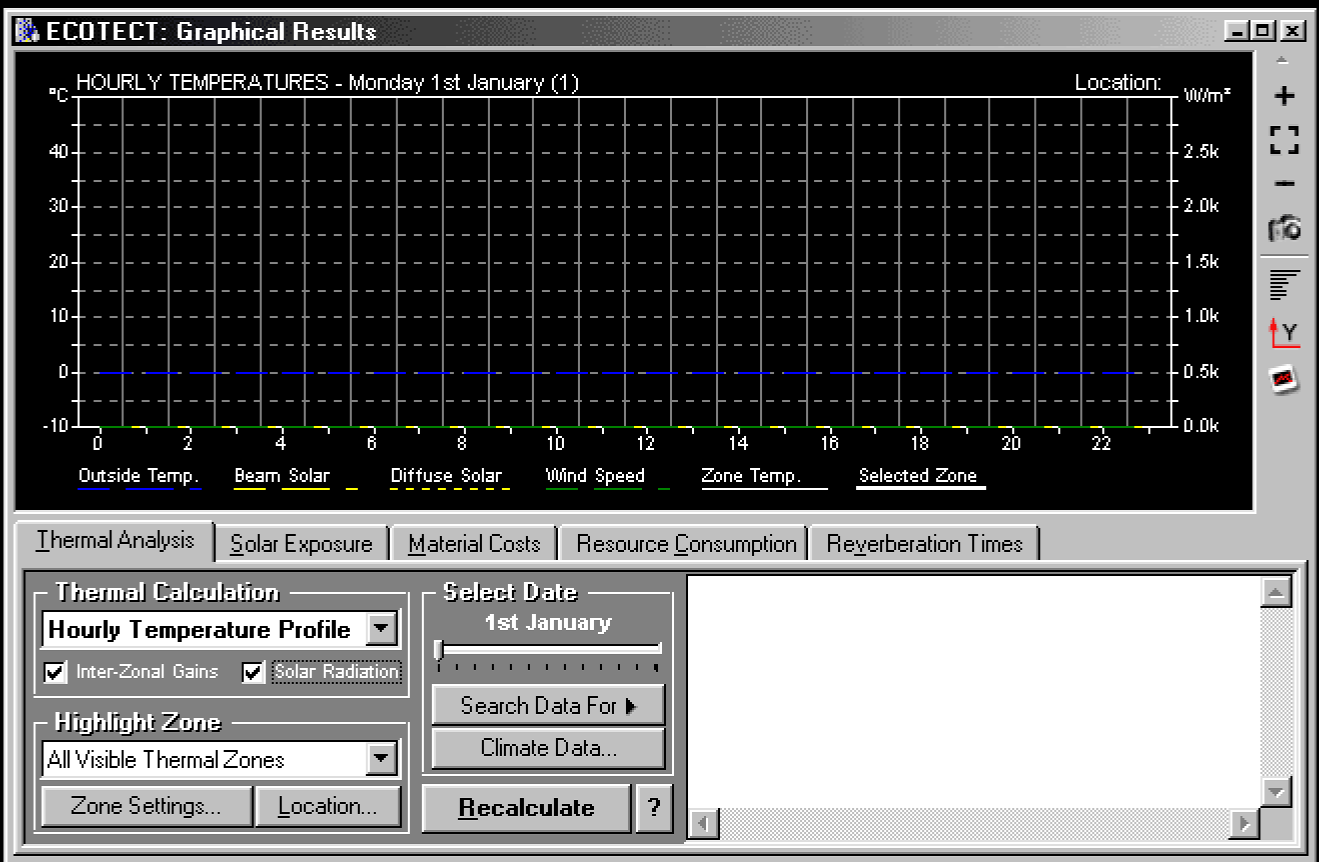


2. **Click the OK button to recalculate inter-zonal adjacencies and overshadowing.**

   During this calculation, objects in successive zones will highlight and small dots will appear within some of these. These dots indicate that the object is overlapped by another object on a different zone, an inter-zonal adjacency. ECOTECT uses the resulting values to determine heat flow between zones at different temperatures and hourly shading during incident radiation calculations.



   When these calculations have finished, a blank graph will display as shown below.

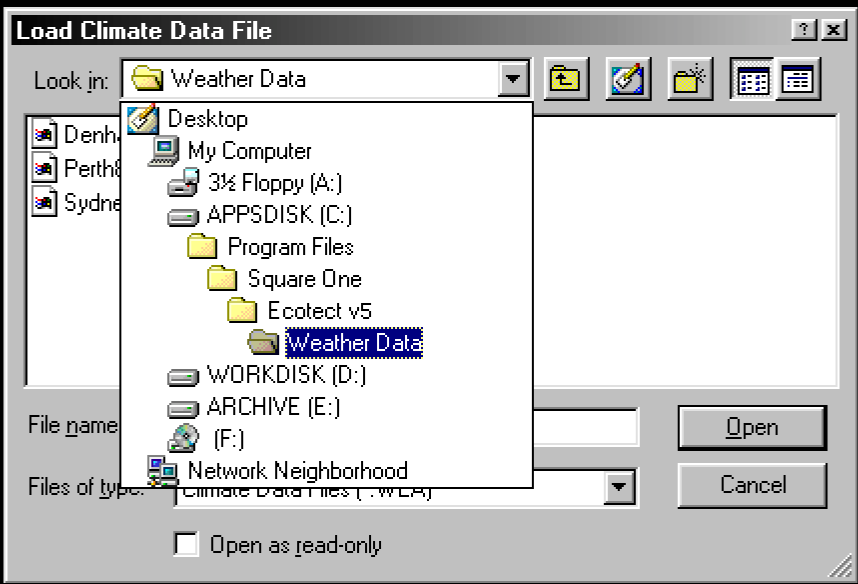


3. **Select the Recalculate button.**

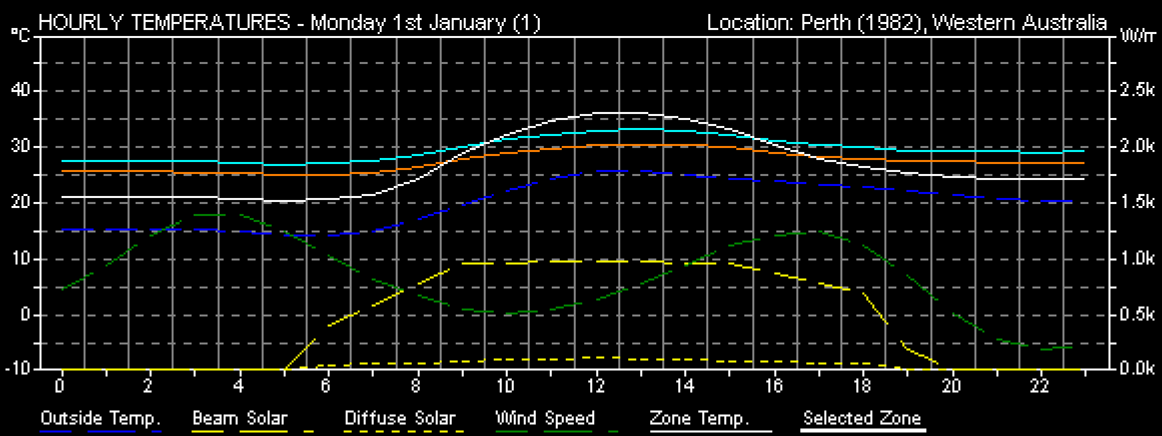
   ECOTECT will detect that no hourly climate data has yet been loaded and will display the following message box. Simply select OK to display the file selection dialog.

ECOTECT comes with a limited range number of WEA files, however you can use the **The Weather Tool** application in the ECOTECT directory to read most weather data file formats and create your own WEA files.

4. **Select the 'Australia - Perth WA - 1.WEA' climate data file from the Weather Data folder located in the ECOTECT install directory.**



5. **The displayed graph should now look something very similar to the following:**

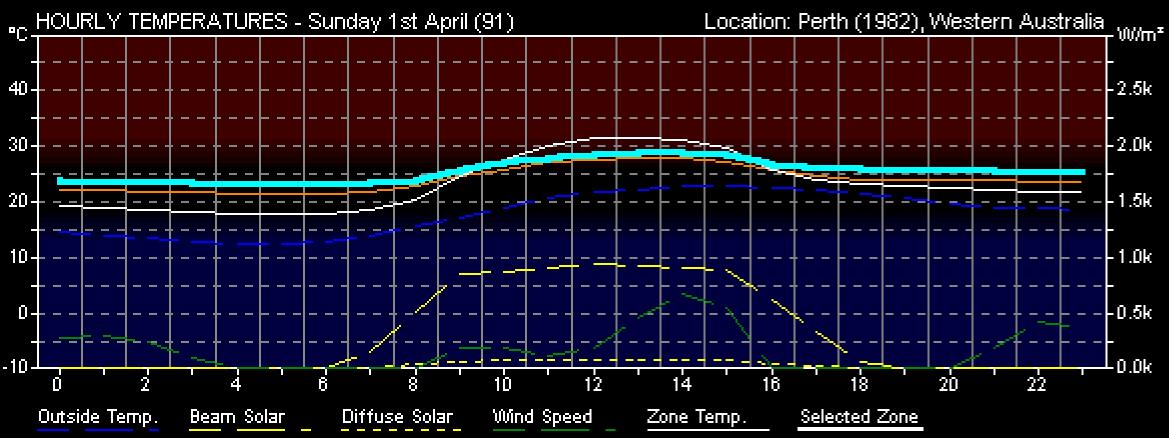


This graph displays the hourly temperature within each zone at the current date (Monday the 1st of January). The dotted and dashed lines represent the climate data on that day, as shown in the legend immediately below the graph, whilst the solid coloured lines show internal environment temperatures.

6. **To change the date at which temperatures are calculated, drag the date slider to the 1st of April.**

If your computer is fast enough you can hold down the **Control** key as you drag the slider to automatically update the graph. The size of the slider means that you may not be able to drag directly to the 1st of April. If not, simply drag to a date that is very close and then use the left or right arrow keys to select the right date.

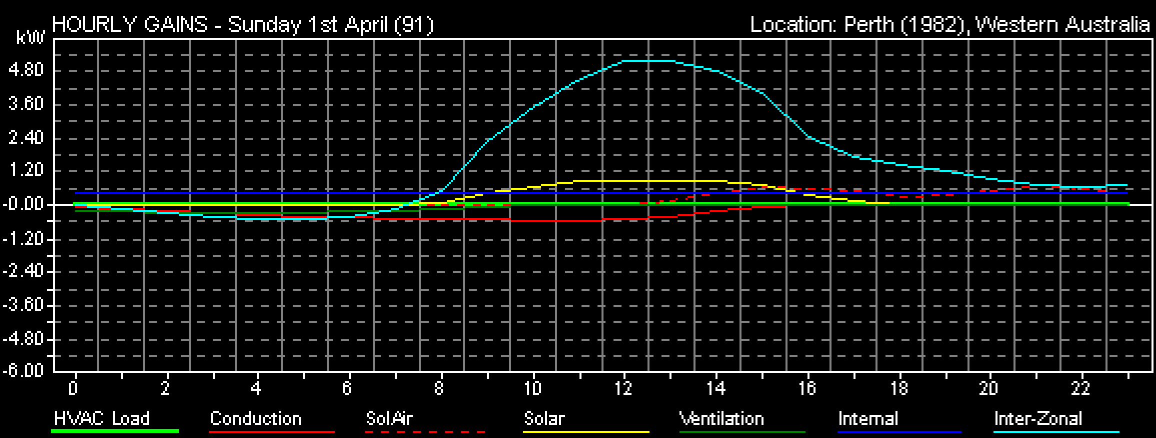
7. **To highlight Zone 1, simply select it from the Highlight Zone section of the dialog.**



The temperature of the selected zone is shown as a double-width line. The red and blue gradients in the graph indicate when the temperature of the zone is above or below its designated comfort range. You can set comfort band values for each zone in the Zone Management dialog box.

This graph shows that the internal environmental temperature in Zone 1 reaches nearly 30°C whilst the peak outdoor air temperature reaches only 23°C. We really need to track down where all that extra heat is coming from.

8. **To display the contribution of all the different sources of heat loss and gain for the selected zone, choose Hourly Heat Gains/Losses in the Thermal Calculation section and select the Recalculate button.**



This graph shows the relative effect of each source of heat flow for each hour of the day, as well as the resulting aggregate HVAC load if a mixed-mode, air-conditioning or evaporative cooling system is used in the zone.

This can be very useful when trying to track down why a zone is behaving the way it does. For example, this particular graph shows that the dominant load in Zone 1 throughout most of the day is actually the inter-zonal load (the light blue line). If you look at the model, it is most likely that this is coming from the Roof Zone immediately above, suggesting that the ceiling between the two is not sufficiently insulated.

Changing Materials in the Model

To try to reduce the inter-zonal gains in Zone 1, we are going to change the ceiling material from *PlasterCeiling* to *PlasterCeilingInsulated* to see what effect this has.

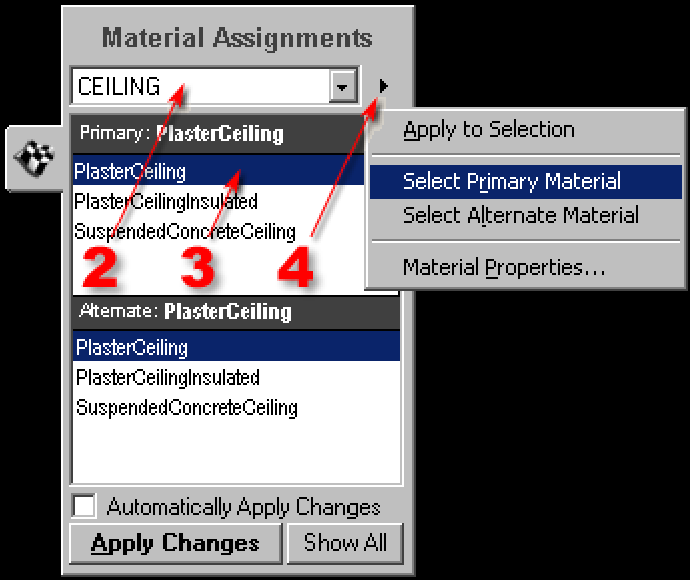
1. **Close the Graphical Results dialog or click in the main application window to bring it to the front.**

2. **Click on the Material Assignments control tab and select CEILING from the Element Type list (step 2 below).**

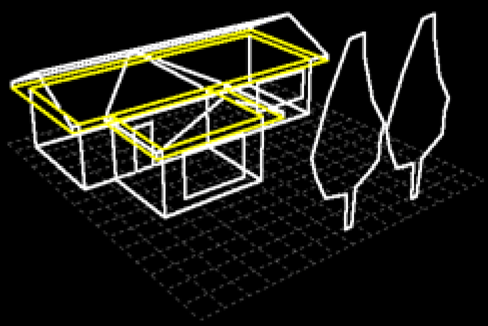
3. **Select PlasterCeiling in the displayed primary materials list (step 3 below).**

4. **Click on the Material Options button and choose the Select Primary Material menu item (step 4 below).**

   This last step selects all objects in the model that have PlasterCeiling as their primary material assignment.



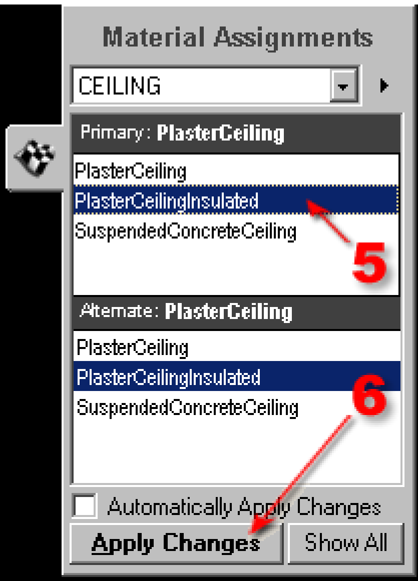
The four objects include the two ground floor zone ceilings and the base of the two roofs, as shown below.



We now need to change the primary material assignment of these objects to *PlasterCeilingInsulated*.

5. **With the four objects still selected, click on the PlasterCeilingInsulated material in the primary materials list (step 5 below).**

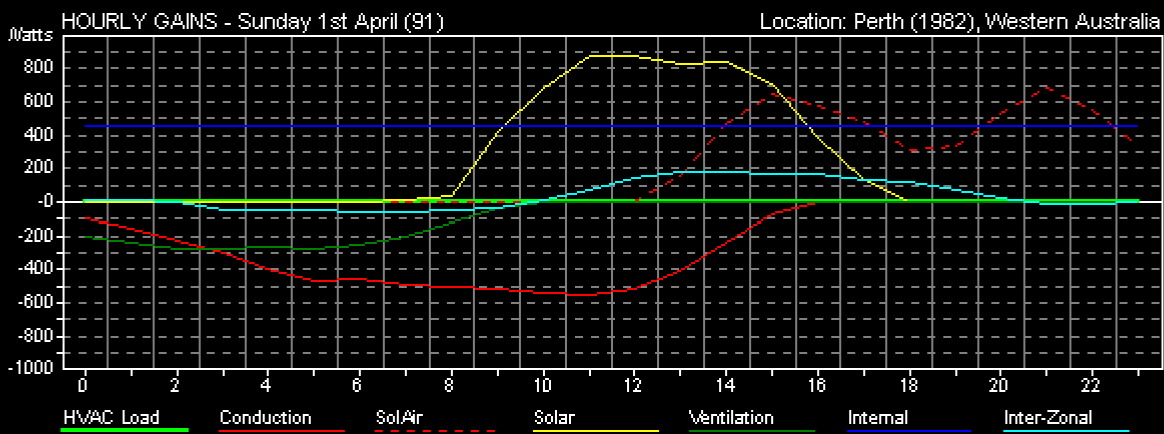
6. **Select the Apply Changes button at the bottom of the control panel (step 6 below).**



7. **Click back in the Graphical Results dialog box or, if you can't see it on the screen, select the Thermal Performance... item in the Calculate menu again.**

8. **Select the Recalculate button.**

   Because the geometry hasn't changed, only material assignments, inter-zonal adjacencies don't have to be redone so the graph should be quite quick to update, giving the following.

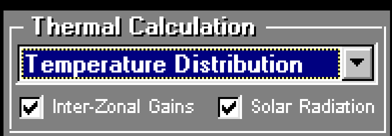


   The effect of insulating the ceiling has been to reduce the peak inter-zonal gain from close to 5000 Watts to less that 200 Watts. If you were interested, the next step could be to shade the north window to reduce the direct solar gain, and then tackle the indirect solar gains by shading the east and west walls or using a lighter-coloured external finish - however that is an exercise for you to follow up at a later time.

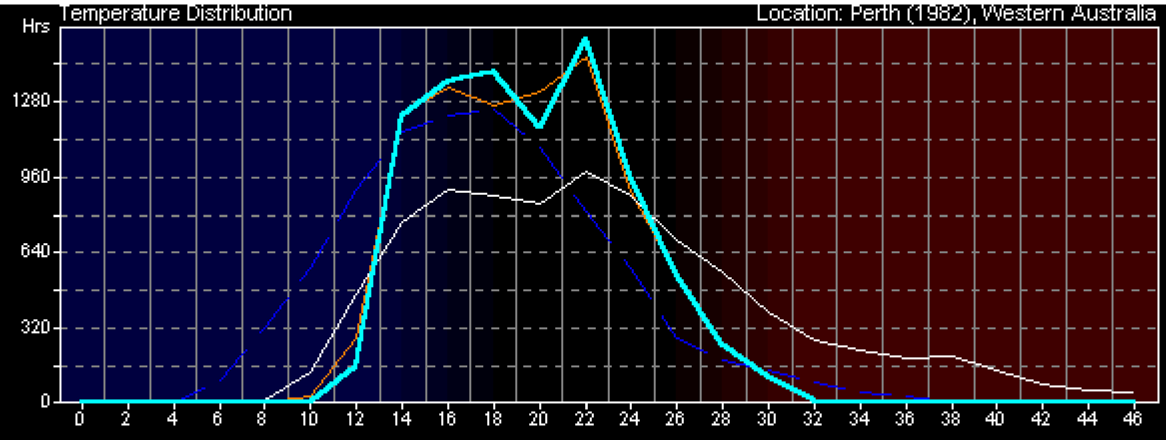
Statistical Analysis

In addition to temperatures and loads on specific days throughout the year, it is often useful to statistically analyse the annual performance of a building. This means displaying how often zones attain particular temperatures and the average daily distribution of losses and gains.

1. **Select Temperature Distribution from the Thermal Calculation section of the dialog box and click Recalculate.**



   After a short calculation time, this will display the following graph.



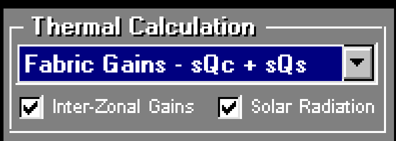
This shows temperature along the bottom axis and the number of hours per year spent at each temperature in the vertical axis. This particular graph shows that the roof zone (pink) regularly reaches temperatures above 30°C and occasionally as high as 44-46°C. Zone 1 (light green) is generally warmer than the outside air temperature (dashed blue), however regularly falls to 14°C and sometimes as low as 12°C. Once again, the blue and red bands represent the boundaries of the selected zone's comfort band.

It would be reasonable to assume that the lowest temperatures in Zone 1 occur late at night or very early in the morning. This may not be too much of a problem as the occupants would generally be asleep in bed at those times, with close-fitting drapes with pelmets acting to reduce conduction losses through the window.

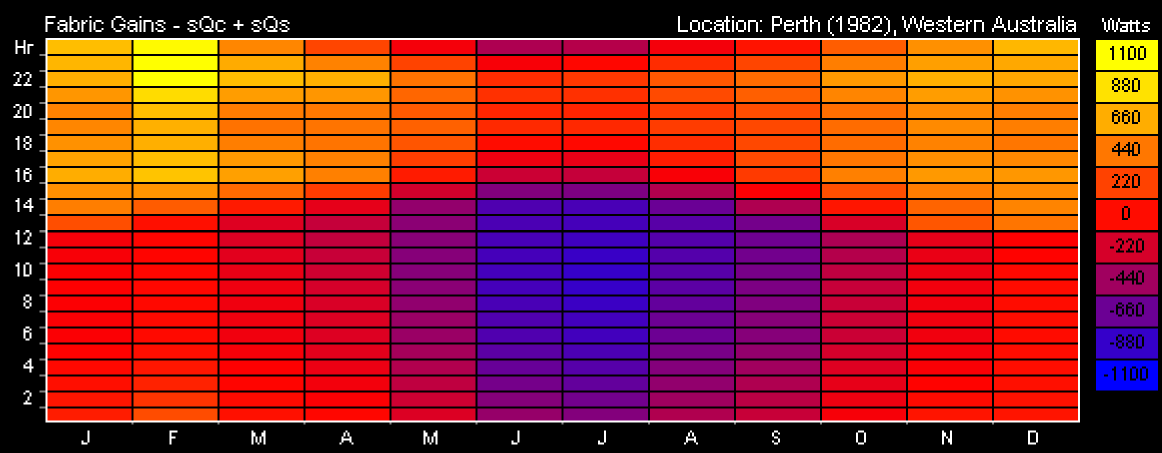
It is important, however, to try to achieve some internal heating in the mid-late evening in winter to prevent the occupants relying on an active heat source. One way to do this is to use exposed thermal mass in the walls to store the external heat and solar radiation. If the thermal mass is thick enough, the time taken for this heat to flow through can be up to 7 hours (thermal lag). This means that 7 hours after the sun has fallen on the external surface, the internal surface starts to warm up.

We now want to check to see if this happens in Zone 1, given that it has *CavityBrick* external walls.

2. **Select Fabric Gains from the Thermal Calculation section of the dialog box and click Recalculate.**



After a short calculation time, this will display the following graph. This graph shows an average day each month, with months along the horizontal axis and hours of the day along the vertical. The colour of each grid square represents the average gain or loss.

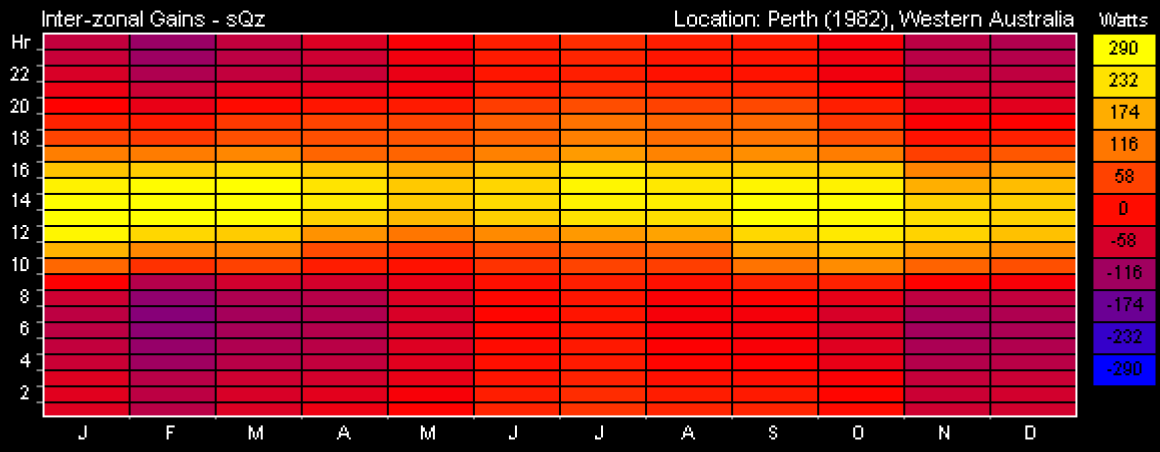


This shows that heat gains from the building fabric, due to both external temperatures and incident solar radiation, occur mainly from about 6pm to 11pm in winter. It also shows that summer gains occur from about 2pm to midnight. This is mainly because the sun rises earlier in summer and spends longer heating up the east wall. This would suggest that some form of summer shading on the east side may be required, but something that doesn't jeopardise morning winter gains.

Another important heat source, as we established earlier, is inter-zonal gains.

3. **Select Inter-Zonal Gains from the Thermal Calculation section of the dialog box and click Recalculate.**

   This will display a similar graph, but now showing when inter-zonal gains occur throughout the year.



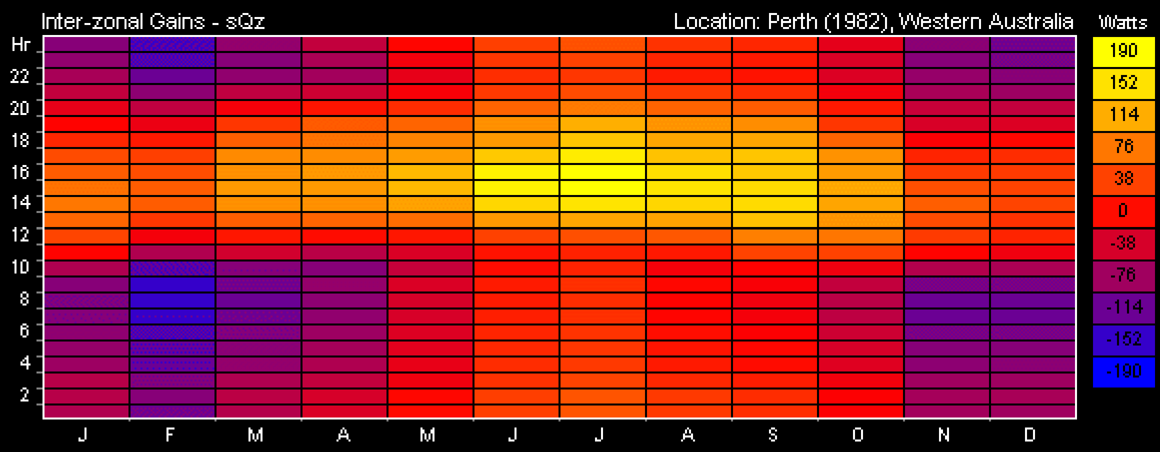
   This graph shows that inter-zonal heat gains occur at the worst possible time, middle of the day in summer. We should really take steps to reduce this. Given that we have already insulated the ceiling, the next option may be to use a different roof material.

4. **Using the same technique as used when we changed the ceiling material, change the roof material assignment from *MetalDeck* to *ClayTiledRoof*.**

   Note that each roof section is grouped together, so selecting one roof object selects them all - including the PlasterCeilingInsulated base. You can either ungroup each roof or use the same 'Select Primary Material' selection method we used before.

5. **Click back into the Graphical Results dialog and select Recalculate.**

   The effect of the clay tiles is to significantly reduce mid-day summer inter-zonal gains whilst still maintaining some useful mid-day heating in winter.



   You can isolate each source of heat flow this way. As you can see, the aim is to gradually optimise the performance of each zone by selecting and testing various materials and even different planning configurations.

   Unfortunately, there are no hard-and-fast rules for thermal design that will always guarantee the right result. There will always be some aspects of the design that you don't have complete control over, such as climate, available materials and building use. You should use the thermal analysis functions in ECOTECT to at least make best use of what you can control.