

Apache Profiles Database APpro User Guide

<Virtual Environment> 6.3

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1. Introduction

This User Guide explains how to use APpro, the Profiles Database.

Profiles describe the time variation of thermal input parameters. They are used in ApacheCalc, ApacheSim, ApacheHVAC, MacroFlo, Part L/J and Template Manager. Examples of their use include scheduling plant equipment, modulating casual gains and ventilation rates, specifying the timing and degree of window opening and defining time-varying set-points and supply temperatures.

Profiles are of two types:

1.1.1.1.1 *Modulating profiles* are used to modulate inputs such as gains, ventilation rates and window opening, and to schedule plant. They take the form of a time series of values in the range 0 - 1.

1.1.1.1.2 *Absolute profiles* are used to specify the time variation of variables such as set-points and supply temperatures. They take the form of a time series of a physical variable (most commonly temperature).

Both modulating and absolute profiles can be defined as functions of weather or simulation variables. They are then known as formula profiles.

A profile specifies time variation over a year. It is assembled from *daily profiles* describing the pattern of variation over a day. *Daily profiles* are built into *weekly profiles* to establish a repeating pattern over the weeks of the year. Optionally, different weekly patterns can be used for different date ranges by defining *annual profiles*.

APpro may be accessed by clicking on the APpro icon found in many applications. Its purpose is to allow you to define a set of profiles for use in the project. APpro provides facilities for creating, viewing, editing and copying profiles, aided by access to central 'system' databases of profiles. In the Template Manager, profiles may be transferred from one project to another attached to gains and air exchanges.

2. Units

Certain types of profile, namely absolute profiles and formula profiles, are sensitive to the choice of Units System (metric or IP). These profiles have an attribute indicating the Units System to be used when interpreting their values, together with any variables input to formulae, at run-time. The profile's Units System can be different from the Units System currently set for the project. The Units System for the project may be changed using the <VE> menu option Settings > Preferences > Units, and this setting will be assigned by default to newly created profiles of the types identified above. However, the Units Type for a profile can be edited independently of the Units Type for the Project, so it is possible (for example) for temperature profiles defined in degrees Fahrenheit and degrees Celsius to coexist in the same project.

3. Main Dialogue

3.1. Outline

The main dialogue, headed *APpro - Profiles Database* (Figure 1) displays lists of the profiles in the project in a dialogue headed *Project Profiles*. The profiles are organised in categories: *Daily*, *Weekly* and *Annual*. By double-clicking on a profile you can display its properties and edit them. Buttons on the *Project Profiles* dialogue provide further operations on the profiles such as creating, deleting and copying.

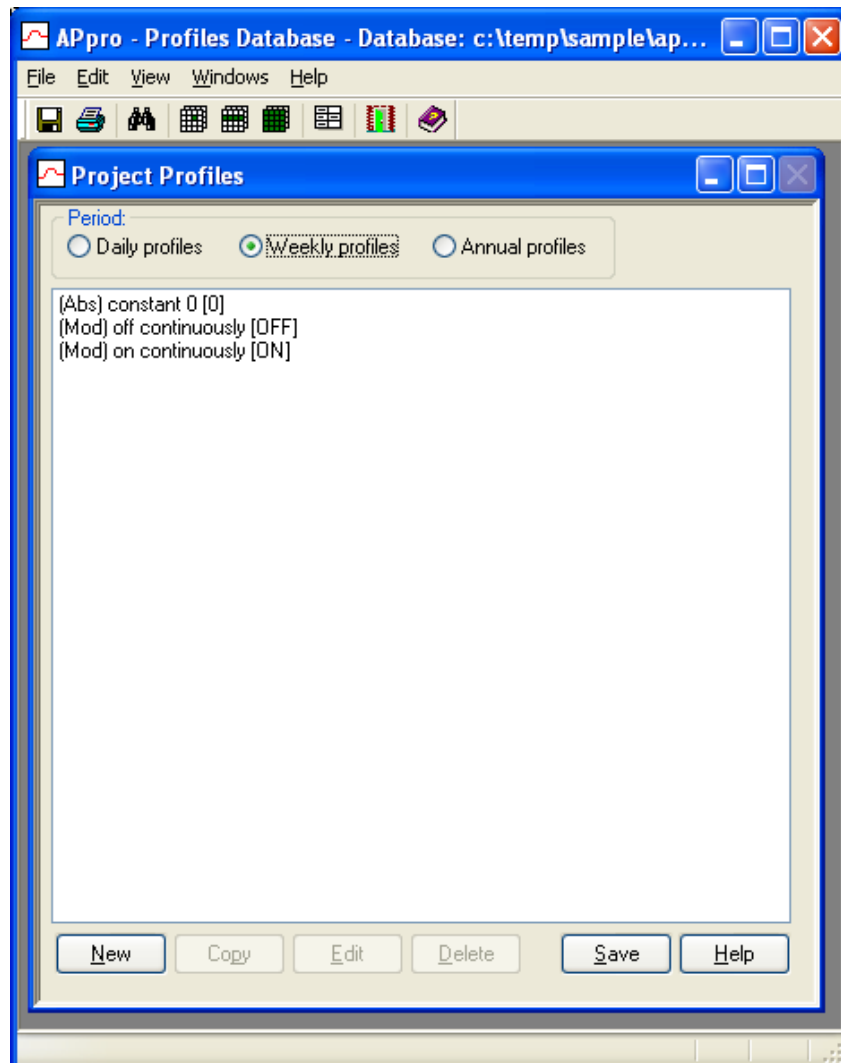


Figure 1 APpro main dialogue, including the Project Profiles dialogue

The menus and toolbar at the top of the interface provide access to features such as the system profiles databases, printing options and search facilities.

When you first enter APpro with a new project you will see a list of default profiles, together with any additional profiles that have been brought into the

project via templates. The APro facilities allow you to add to and edit these profiles so that they describe the time variation patterns required to describe events and activities in the building.

3.2. Daily, Weekly and Annual Profiles

Profiles are organised in three categories, selected with radio buttons:

3.2.1.1.1 *Daily profiles* cover a period of one day. Daily profiles are used as building blocks to create time variation patterns over longer periods.

3.2.1.1.2 *Weekly profiles* cover a period of one week, and are built up from seven daily profiles, plus a special holiday daily profile. When used directly, this pattern is assumed to continue throughout the year. However a weekly profile may also be used in an annual profile if you need further refinement of the schedule.

3.2.1.1.3 *Annual profiles* are sets of weekly profiles, each one starting and ending on defined dates in the year, and together defining the variation over a whole year. A common use for annual profiles is to allow different set-points to be specified for summer and winter; a more complex use may be for specifying different lighting schedules at different times of year.

3.2.1.1.4 *NB Annual profiles replace monthly profiles. Any monthly profiles in your existing projects will be converted automatically to equivalent annual profiles.*

When the term profile is used outside the context of APro it always refers to a weekly profile or an annual profile. In this context a profile always represents a pattern of time variation covering the entire year (as mentioned above, a weekly profile is assumed to continue throughout the year).

Note: Holiday assignment is currently only used in UK Building Regulations for Non-Domestic building compliance. Holidays are pre-assigned (note the 1st Jan) by the UK ODPM and BRE. Holiday assignment will be included in the next development phase.

3.3. Project Profile Lists

Within each category (daily, weekly, annual) a list of project profiles is displayed, with the following summary information:

Description: A description of the profile in words.

ID (in square brackets): A unique identifier assigned to the profile when it is created.

To edit a profile, double-click its entry on the list. Alternatively click once on the profile and then on the *Edit* button.

3.4. Project Profile Buttons

The buttons on the Project Profiles dialogue perform the following operations:

New: creates a new profile and opens it for editing.

Copy: copies the selected profile to a new profile, which is then opened for editing.

Edit: displays a dialogue allowing you to edit the profile data.

Save: saves all profiles to file.

Help: provides help on the Project Profiles dialogue.

3.5. Menus

The menu options are described below. Some of these functions are also accessible from elsewhere in the interface.

File

3.5.1.1.1 *Save*: Saves the project data to file.

3.5.1.1.2 *Print*: Displays options for printing profile data.

3.5.1.1.3 *Exit*: Exit APpro.

Edit

3.5.1.1.4 *Find a daily profile*: Accesses a facility for finding daily profiles in either the system database or the project database. See *Finding a daily profile* for details.

3.5.1.1.5 *Profile substitution table*: Displays the profile substitution table. See *NCM Considerations* for details.

3.5.1.1.6 *Allow NCM edits*: If this is ticked on it allows NCM profiles to be edited. See *NCM Considerations* for details.

View

3.5.1.1.7 *System daily profiles*: Accesses the system database of daily profiles.

3.5.1.1.8 *System weekly profiles*: Accesses the system database of weekly profiles.

3.5.1.1.9 *System annual profiles*: Accesses the system database of annual profiles.

Windows

3.5.1.1.10 *Cascade Windows*: Arranges the windows in an overlapping cascade

3.5.1.1.11 *Tile*: Arranges the windows in a grid pattern.

3.5.1.1.12 *Arrange icons*: Arranges the icons representing minimised windows.

3.5.1.1.13 *Project Profiles (etc)*: A list of the displayed windows with a tick indicating which has the current focus.

Help

- 3.5.1.1.14 *Contents:* Displays the contents of the Help facility
- 3.5.1.1.15 *About:* Provides information on the software version.
- 3.5.1.1.16 *IES Ltd:* Provides contact information for IES Ltd.

3.6. Toolbars

The toolbar icon options are described below. Some of these functions are also accessible from elsewhere in the interface.

Save: Saves the project data to file.

Print: Displays options for printing profile data.

Find a daily profile: Accesses a facility for finding daily profiles in either the system database or the project database. See *Finding a daily profile* for details.

System daily profiles: Accesses the system database of daily profiles.

System weekly profiles: Accesses the system database of weekly profiles.

System annual profiles: Accesses the system database of annual profiles.

Profile substitution table: Displays the profile substitution table. See NCM Considerations for details.

Exit: Exits APpro. You will be prompted to save any edits.

Help: Provides help on using APpro.

4. Editing a Daily Profile

The dialogue displaying the attributes of a project daily profile is shown in Figure 2. This dialogue appears when daily profile is selected for editing by means of a double click or the *Edit* button. It displays the properties of a daily profile and allows them to be edited.

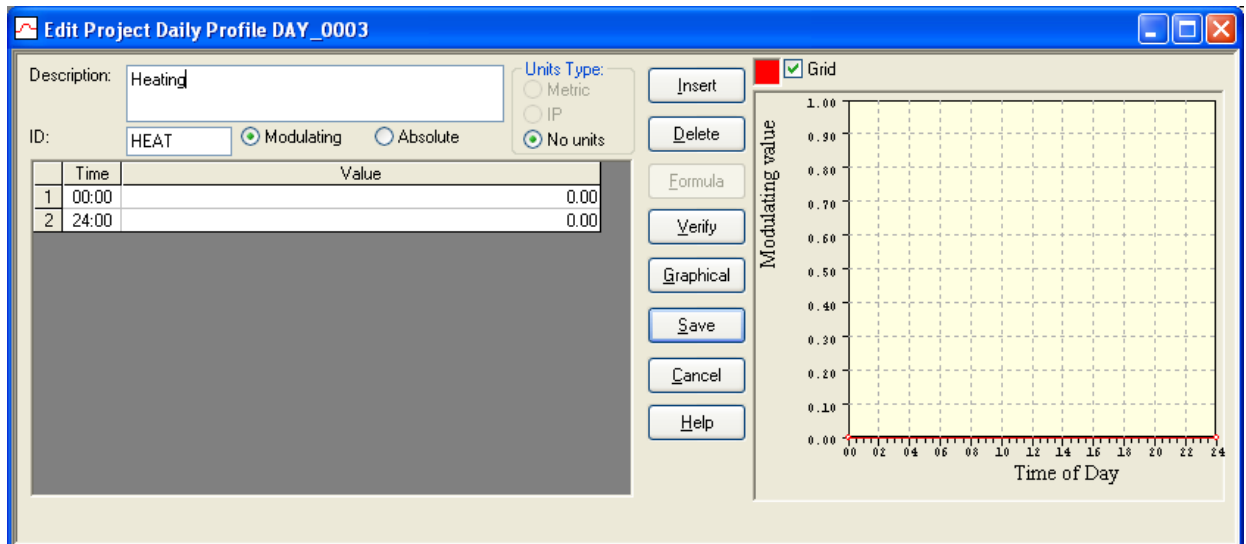


Figure 2 Editing a daily profile

The fields displayed on the dialogue are:

Description:

A description of the profile in words.

ID:

A unique identifier assigned to the profile when it is created. The ID may be edited on creation of the profile, but not thereafter.

Modulating/Absolute:

The type of profile, selected with a radio button when the profile is created. A *Modulating* profile specifies a time-varying value, and is used to modulate an input parameter or as a control switch. Where the profile is used as a control switch, values greater than 0.5 are interpreted as 'on' and other values as 'off'. An *absolute* profile specifies a time-varying physical variable such as temperature.

Units Type:

The units system applying to the profile. In the case of absolute profiles and formula modulating profiles, the Units Type must be set to Metric or IP (inch-pound) to indicate the units system to be used to interpret the numerical values of the profile and any variables appearing in the formulae. The Units Type is initialised to the current units system set for the project, but this setting may be edited. For

non-formula modulating profiles the Units Type is immaterial, and is set by default to No units.

Profile times and values:

A daily profile is defined as a series of values applying at different times of day.

Time:

The time at which the associated value applies. Times are subject to daylight-saving adjustments as set in APiocate. The first and last rows of the table must have times 0:00 and 24:00, respectively. If the profile undergoes an abrupt change at a particular time the transition must be defined using two rows of the table having the same time but different values or formulae.

Value:

The value of the profile at the stated time. This may be a numerical value or a formula (see Formula Profiles).

The buttons perform the following functions:

Insert: Inserts a row in the table above the selected row.

Delete: Deletes the current row of the table.

Formula: Accesses a facility for generating formula profiles (see – Formulae Profiles)

Verify: Verifies the correctness of the data, checking for impossible sequences of times and values.

Graphical: Accesses a facility for editing the profile graphically (see – *Graphically Edit Daily Profile*).

Save: Saves the edits made to the profile and exits the dialogue.

Cancel: Discards the edits made to the profile and exits the dialogue.

Help: Provides help on editing a daily profile.

4.1. Graphically Editing a Daily Profile

The facility headed *Graphically Edit Daily Profile*, accessed via the *Graphical* button on the Daily Profile editing dialogue, will allow you to edit the profile by manipulating points on a graph, shown in Figure 3 below:

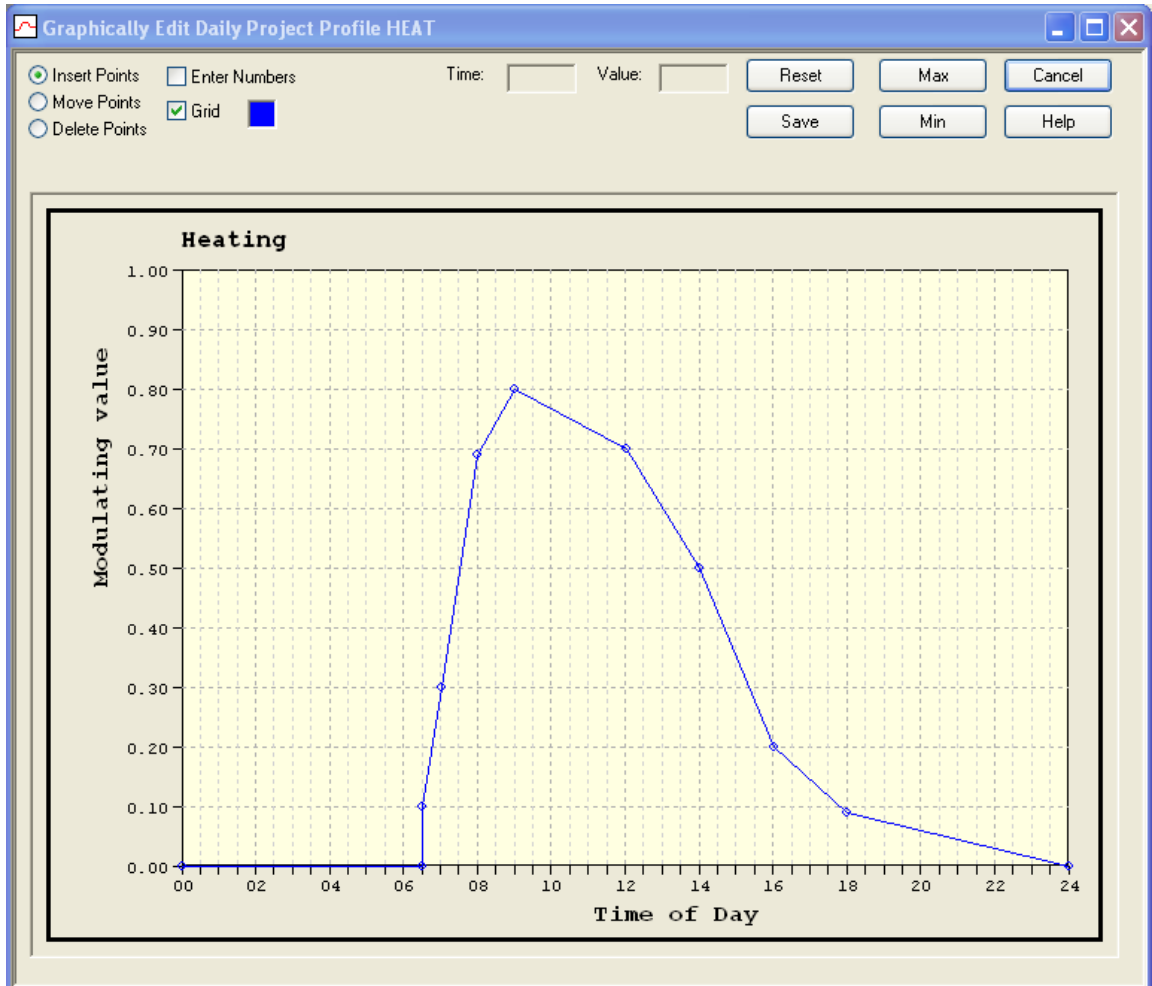


Figure 3 Graphically editing a daily profile

The settings and buttons have the following meanings:

Points editing mode radio buttons:

Insert Points: Allows you to insert points by clicking on the graphic.

Move Points: Allows you to move points by clicking and dragging.

Delete Points: Allows you to delete points by clicking on the graphic.

Enter Numbers: if you tick this box you will be prompted to enter numerical times and values for inserted or moved points.

Grid: toggles the grid on and off.

Reset: resets the profile times and values to their settings on entry to the facility.

Max: allows you to set the maximum of the value axis.

Min: allows you to set the minimum of the value axis.

Save: closes the graphical editing facility and saves any edits

Cancel: closes the graphical editing facility and discards any edits

Help: provides help on graphical editing.

5. Editing a Weekly Profile

The dialogue displaying the attributes of a project weekly profile is shown in Figure 4. This dialogue appears when a weekly profile is selected for editing by means of a double click or the *Edit* button. It displays the properties of a weekly profile and allows them to be edited.

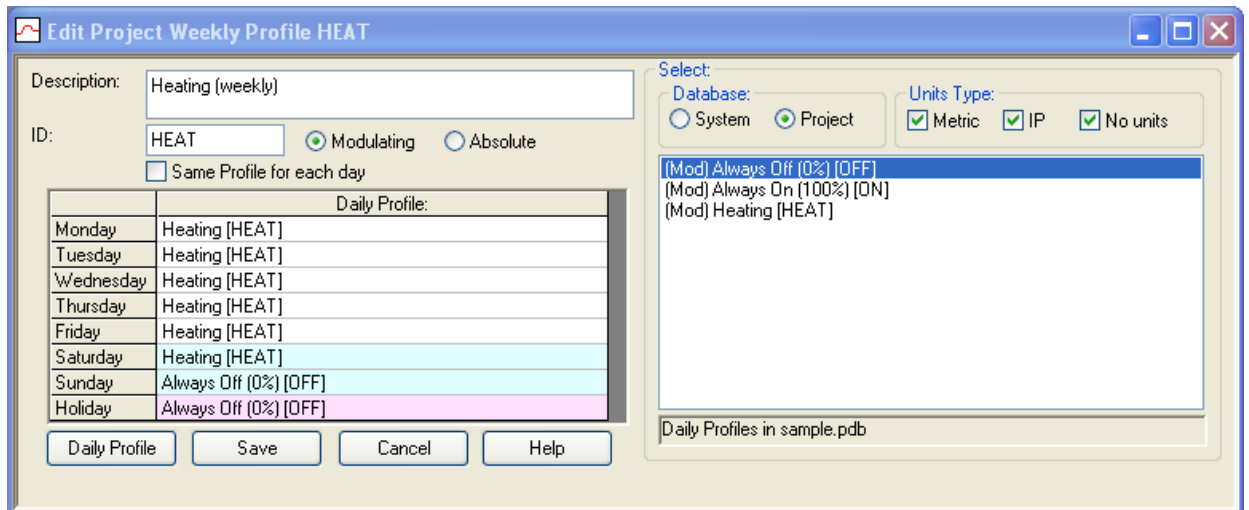


Figure 4 Editing a weekly profile

Daily profiles may be assigned from either the system or project daily profile databases. The source profiles are listed on the right of the dialogue in the box headed *Select*. The list is controlled by the following buttons:

Database: Switches between the two databases:

System: A centrally stored database of daily profiles.

Project: Daily profiles in the project.

Units Type: Restricts the listing to daily profiles expressed in particular unit types:

Metric: Profiles expressed in metric units.

IP: Profiles expressed in inch pound units.

No units: Profiles expressed in no units (non-formula modulating profiles).

The attributes of the weekly profile are:

Description:

A description of the profile in words.

ID:

A unique identifier assigned to the profile when it is created. The ID may be edited on creation of the profile, but not thereafter.

Modulating/Absolute:

The type of profile, selected with a radio button when the profile is created. A *Modulating* profile specifies a time-varying value in the range 0 - 1, and is used to modulate an input parameter or as a control switch. An *absolute* profile specifies a time-varying physical variable such as temperature. A weekly profile may only reference daily profiles of the same type.

Daily profiles for each weekday:

A weekly profile is defined as a series of eight daily profiles, one for each day of the week, plus one to be used whenever a holiday is in effect. Selecting a daily profile in this table and clicking the *Daily Profile* button displays its attributes, but they may not be edited here. To assign the daily profile for a particular weekday, first click on the row of the table corresponding to the weekday, then select one of the daily profiles from the list appearing on the right of the dialogue, using a double-click. This will be assigned to the selected weekday, and if the check box *Same profile for each day* is ticked, it will be assigned to all weekdays.

Note: Holiday assignment is currently only used in UK Building Regulations for Non-Domestic building compliance. Holidays are pre-assigned (note the 1st Jan) by the UK ODPM and BRE. Holiday assignment will be included in the next development phase.

Buttons provide the following functions:

Same profile for each day: if ticked, replicates day profile assignments over all weekdays.

Daily profile: displays the attributes of the selected daily profile.

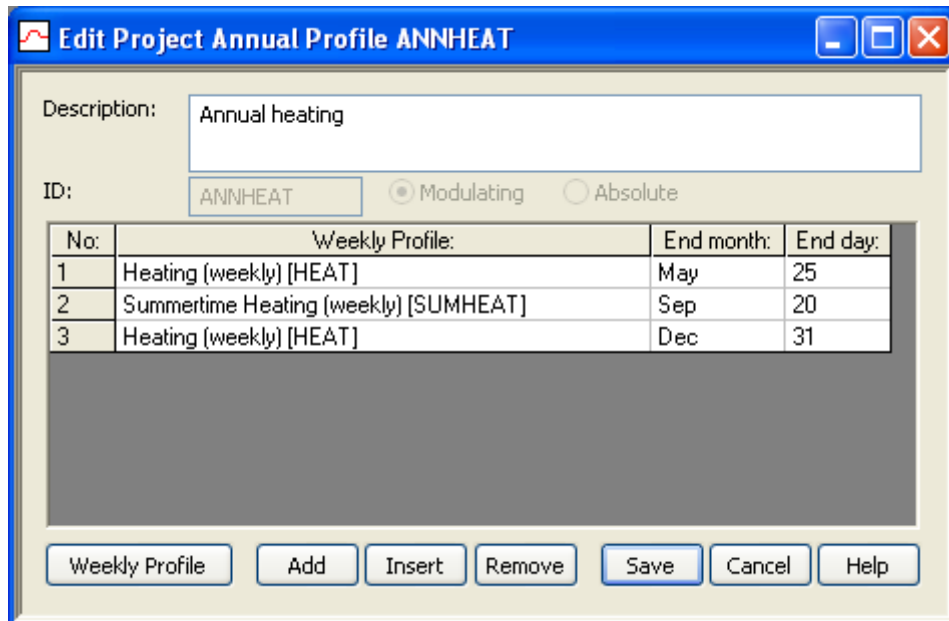
Save: closes the dialogue and saves any edits.

Cancel: closes the dialogue and discards any edits.

Help: provides help on editing weekly profiles.

6. Editing an Annual Profile

The dialogue displaying the attributes of a project annual profile is shown in Figure 5. This dialogue appears when an annual profile is selected for editing by means of a double click or the *Edit* button. It displays the properties of a monthly profile and allows them to be edited.



No:	Weekly Profile:	End month:	End day:
1	Heating (weekly) [HEAT]	May	25
2	Summertime Heating (weekly) [SUMHEAT]	Sep	20
3	Heating (weekly) [HEAT]	Dec	31

Figure 5 Editing an annual profile

An annual profile is defined when different weekly profiles are needed for different times of the year (remember that weekly profiles used directly are assumed to repeat throughout the year).

The attributes of the annual profile are:

Description:

A description of the profile in words.

ID:

A unique identifier assigned to the profile when it is created. The ID may be edited on creation of the profile, but not thereafter.

Modulating/Absolute:

The type of profile, selected with a radio button when the annual profile is created. A *Modulating* profile specifies a time-varying value in the range 0 - 1, and is used to modulate an input parameter or as a control switch. An *absolute* profile specifies a time-varying physical variable such as temperature. An annual profile may only reference weekly profiles of the same type.

Weekly profiles:

This column displays a weekly profile for each entry. Selecting a weekly profile in the table and clicking the *Weekly Profile* button displays its attributes, but they may not be edited here.

End month and End day:

These columns display the end date for each entry. These dates must increase down the table. The start date for the first entry is always January 1st. The start date for subsequent entries is one day later than the end date of the previous entry. The end date of the final entry must be set to December 31st.

Buttons provide the following functions:

Add: adds another entry to the end of the table.

Insert: inserts another entry at the current row in the table.

Remove: removes the current entry from the table.

Save: closes the dialogue and saves any edits.

Cancel: closes the dialogue and discards any edits.

Help: provides help on editing monthly profiles.

7. Finding a Daily Profile

The facility called *Find a Daily Profile*, accessed via the options of that name on the Edit menu and toolbar, provides facilities for quickly finding daily profiles with particular attributes. It covers both system and project daily profiles.

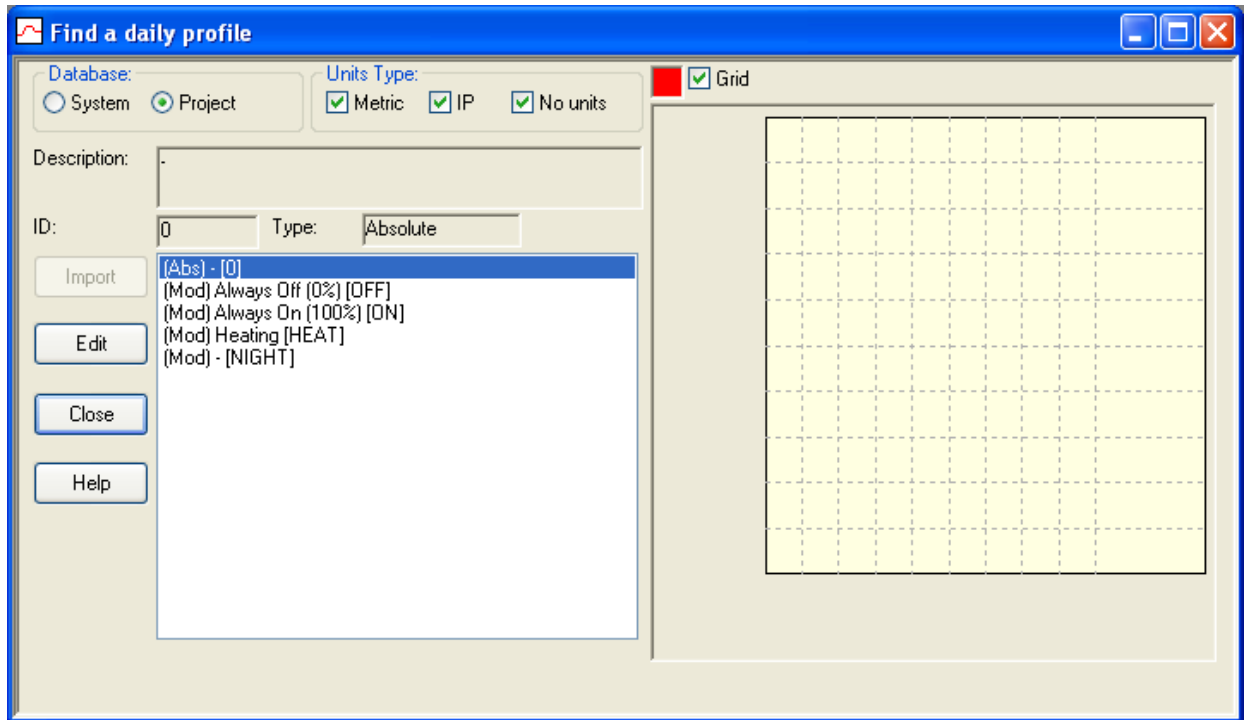


Figure 6 Finding a daily profile

When a profile is selected from the list the following attributes are displayed:

Description:

A description of the profile in words.

ID:

A unique identifier assigned to the profile when it is created.

Type:

The profile type (*modulating* or *absolute*)

A graph of the profile is also displayed.

Buttons provide the following functions:

Database: Switches between the two databases:

System: A centrally stored database of daily profiles.

Project: Daily profiles in the project.

Units Type: Restricts the listing to daily profiles expressed in particular unit types:

Metric: Profiles expressed in metric units.

IP: Profiles expressed in inch pound units.

No units: Profiles expressed in no units (non-formula modulating profiles).

Import: Copies the profile to the project from the system database.

Edit: Displays a dialogue for editing the profile.

Close: Closes the *Find a daily profile* dialogue.

Help: Provides help on the *Find a daily profile* dialogue.

8. System Daily Profiles

The system daily profiles database is a central store of daily profiles available for importing into projects. Many of these are referenced by system weekly and monthly profiles.

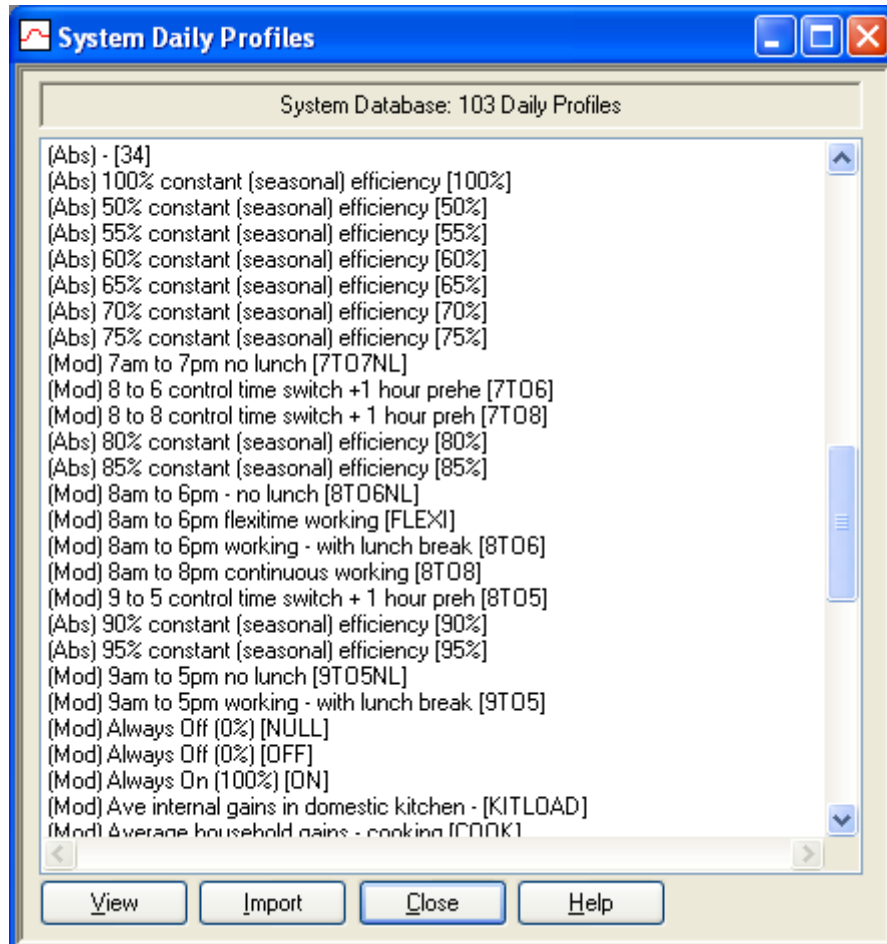


Figure 7 Viewing system daily profiles

A list of system daily profiles is displayed. To view a profile, double-click its entry on the list. Alternatively click once on the profile and then on the *View* button.

Buttons provide the following functions:

View: displays the data for the selected profile.

Import: imports the profile into the project.

Close: closes the system daily profiles database dialogue.

Help: provides help on using the system daily profiles database.

9. System Weekly Profiles

The system weekly profiles database is a central store of weekly profiles available for importing into projects. If you import a weekly profile any daily profiles that it references will be imported too.

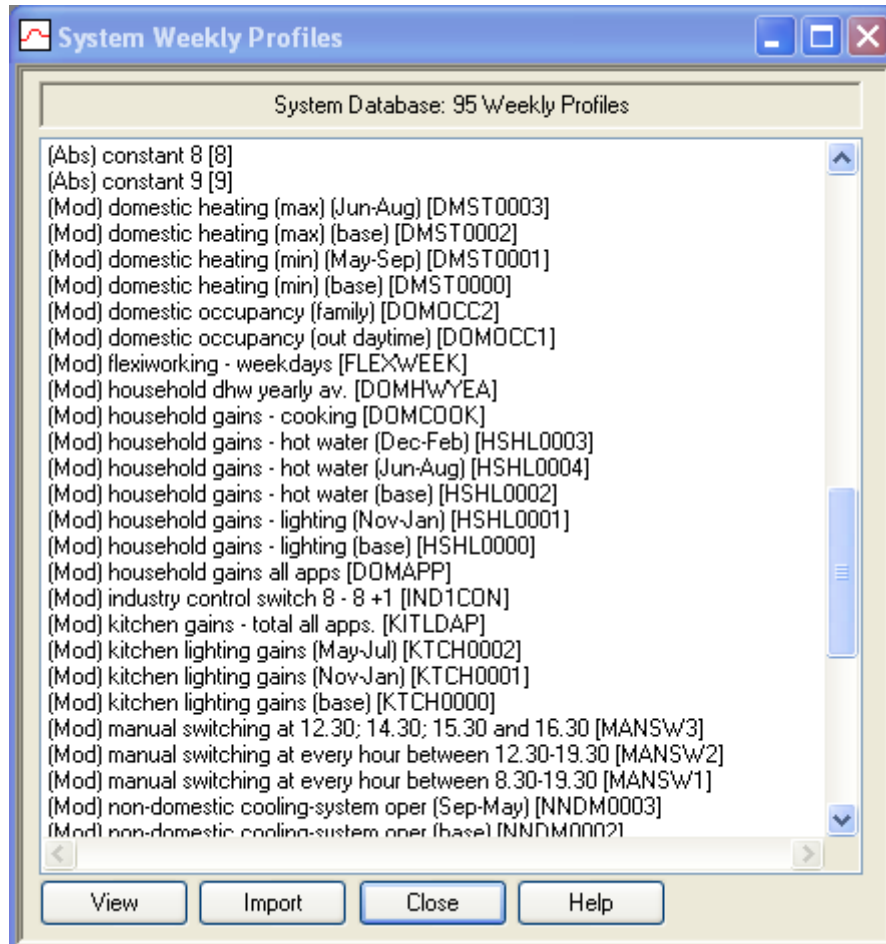


Figure 8 Viewing system weekly profiles

A list of system weekly profiles is displayed. To view a profile, double-click its entry on the list. Alternatively click once on the profile and then on the *View* button.

Buttons provide the following functions:

View: displays the data for the selected profile.

Import: imports the profile into the project, along with the daily profiles it references.

Close: closes the system weekly profiles database dialogue.

Help: provides help on using the system weekly profiles database.

10. System Annual Profiles

The system annual profiles database is a central store of annual profiles available for importing into projects. If you import an annual profile any weekly profiles that it references will be imported too.

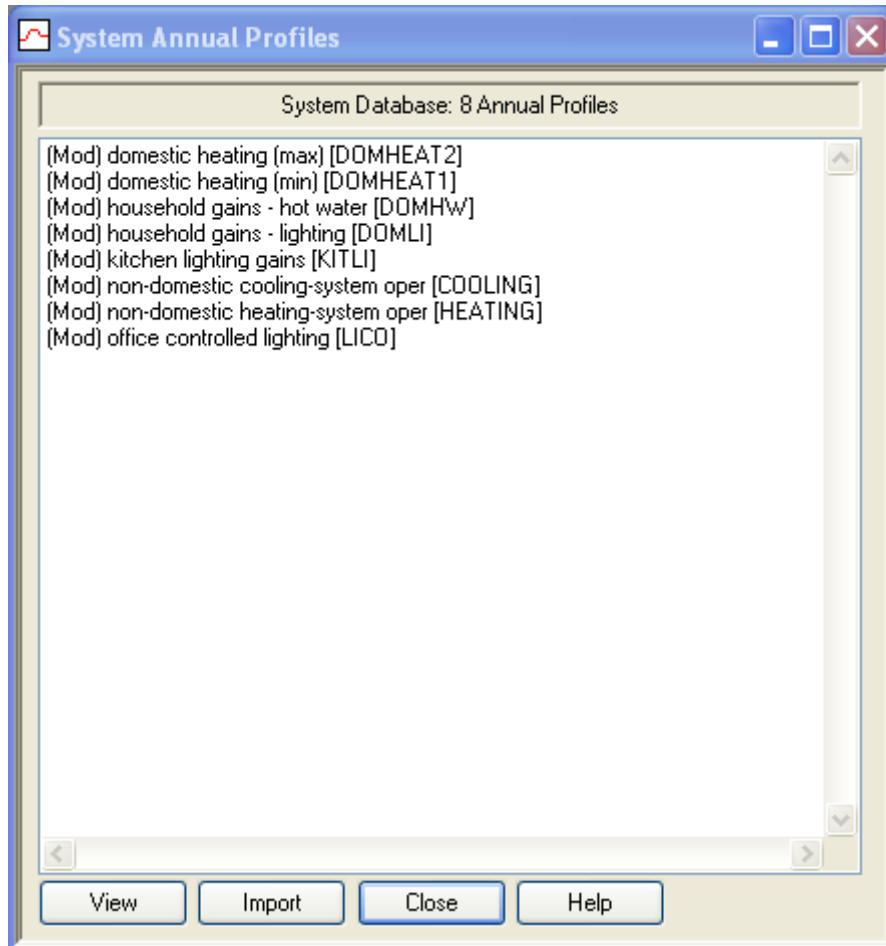


Figure 9 Viewing system annual profiles

A list of system annual profiles is displayed. To view a profile, double-click its entry on the list. Alternatively click once on the profile and then on the *View* button.

Buttons provide the following functions:

View: displays the data for the selected profile.

Import: imports the profile into the project, along with the weekly profiles that it references.

Close: closes the system annual profiles database dialogue.

Help: provides help on using the system annual profiles database.

11. NCM Considerations

When using profiles in the UK Building Regulations Part L2 (2006) National Calculation Methodology (NCM) calculations using the IES ApacheNCM route to compliance, special considerations apply:

11.1. NCM Profiles

Special profiles are required for the NCM calculations, based on the NCM Building Type and the selected NCM Activity for the room. These are imported automatically from the NCM database using the <VE> template mechanism. However, although they are imported into your project database, they should not be edited. Therefore, when they are displayed, APro will (by default) use the same dialogue box as is normally used for system profiles, where the profiles are uneditable. The *Allow NCM edits* option allows you to override this – but this is for use in-house by IES and it is not recommended that you edit any NCM-specific database items.

11.2. Profile Substitution Table

The profile substitution table allows you to replace each profile used in the standard design and simulation calculations with a substitute profile (usually but not necessarily an NCM profile) which is suitable to be used in its place for the ApacheNCM calculations:

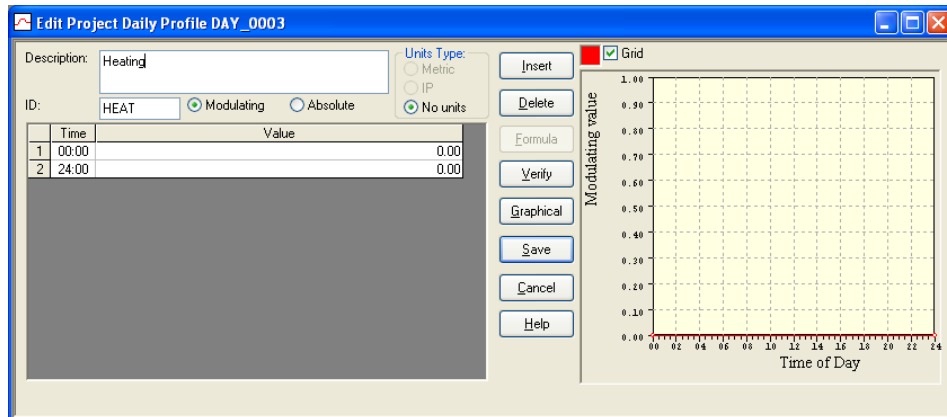
Profile substitution table

Profile:	Substitute profile for Building Regulations:
constant 0 [0]	<no substitution>
off continuously [OFF]	<no substitution>
on continuously [ON]	<no substitution>
Heating [HEAT]	<no substitution>
Annual heating [ANNHEAT]	<no substitution>
	off continuously [OFF]
	on continuously [ON]
	NCM Airport_Bag_Cool_wk1 [BRE] [NCMW2302]
	NCM Airport_Bag_Equip_wk1 [Blue Star] [NCMW2300]
	NCM Airport_Bag_Light_wk1 [Blue Star] [NCMW2299]
	NCM Airport_Bag_Occ [Blue Star] [NCMA0005]
	NCM Airport_Bag_Occ_wk1 [Blue Star] [NCMW2297]
	NCM Airport_Bag_Occ_wk2 [Blue Star] [NCMW2298]
	NCM Airport_CellOff_Cool_WK1 [Blue Star] [NCMW0109]
	NCM Airport_CellOff_Equip_WK1 [Blue Star] [NCMW0110]
	NCM Airport_CellOff_Light_WK1 [Blue Star] [NCMW0111]
	NCM Airport_CellOff_Occ_WK1 [Blue Star] [NCMW0107]
	NCM Airport_Check_Cool_wk1 [Blue Star] [NCMW2296]
	NCM Airport_Check_Equip_wk1 [Blue Star] [NCMW2294]
	NCM Airport_Check_Light_wk1 [Blue Star] [NCMW2293]
	NCM Airport_Check_Occ [Blue Star] [NCMA0015]
	NCM Airport_Check_Occ_wk1 [Blue Star] [NCMW2291]
	NCM Airport_Check_Occ_wk2 [Blue Star] [NCMW2292]
	NCM Airport_CirculationPub_Cool_wk1 [BRE] [NCMW2410]
	NCM Airport_CirculationPub_Equip_wk1 [Blue Star] [NCMW2408]
	NCM Airport_CirculationPub_Light_wk1 [Blue Star] [NCMW2407]
	NCM Airport_CirculationPub_Occ [Blue Star] [NCMA0025]
	NCM Airport_CirculationPub_Occ_wk1 [Blue Star] [NCMW2405]
	NCM Airport_CirculationPub_Occ_wk2 [Blue Star] [NCMW2406]
	NCM Airport_Circulation_Cool_WK1 [Blue Star] [NCMW0124]
	NCM Airport_Circulation_Equip_WK1 [Blue Star] [NCMW0125]
	NCM Airport_Circulation_Light_WK1 [Blue Star] [NCMW0126]
	NCM Airport_Circulation_Occ_WK1 [Blue Star] [NCMW0122]
	NCM Airport_CommStaff_Cool_wk1 [Blue Star] [NCMW2323]

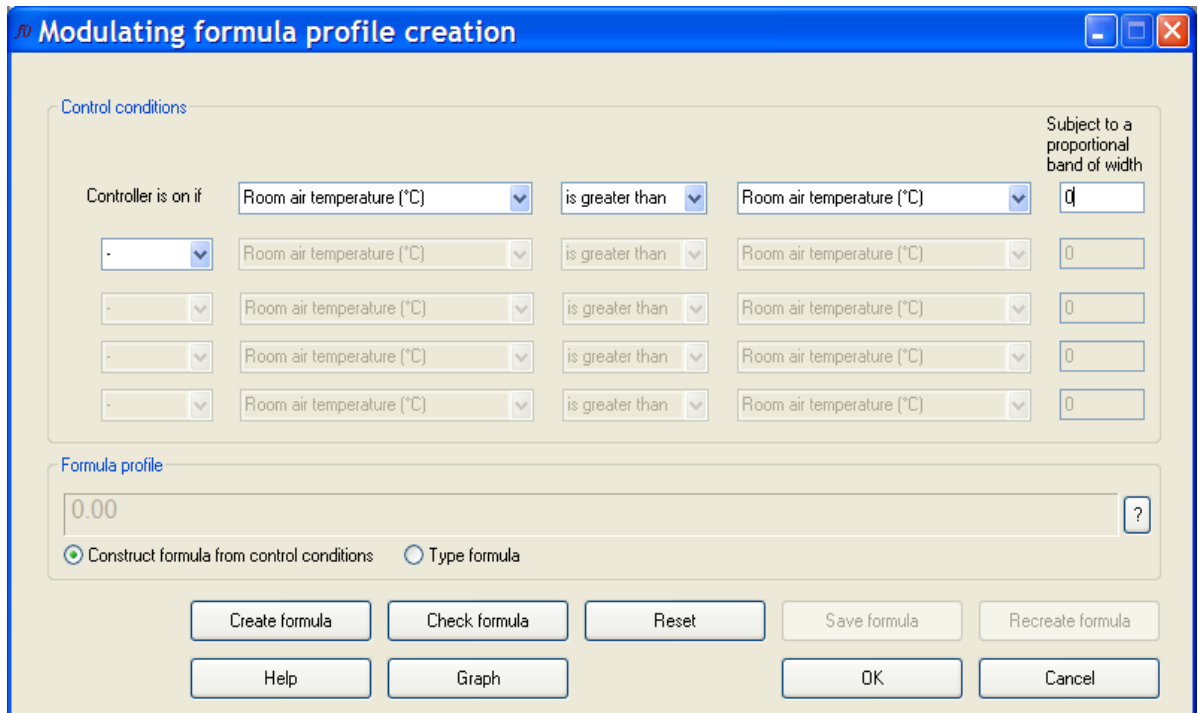
Use this dialogue box if you wish to replace one or more of the profiles and simulation with substitute profiles suitable for use in the NCM calcu

12. Formula Profiles

In a formula profile the profile value is not specified numerically, but instead defined as a mathematical function of weather and/or simulation variables. Formula profiles are supported by ApacheSim, ApacheHVAC and MacroFlo. They may be used in both modulating and absolute profiles. They are not supported by ApacheCalc, which will set their values to 0 at all times.



You can if you wish type a formula directly into a row of the Daily Profile table in place of a numerical value. In the case of modulating profiles the software provides some assistance with this task: you can click on the Formula button to invoke a utility that creates a formula automatically from control conditions. The Formula button activates the “Modulating formula profile creation” dialog:

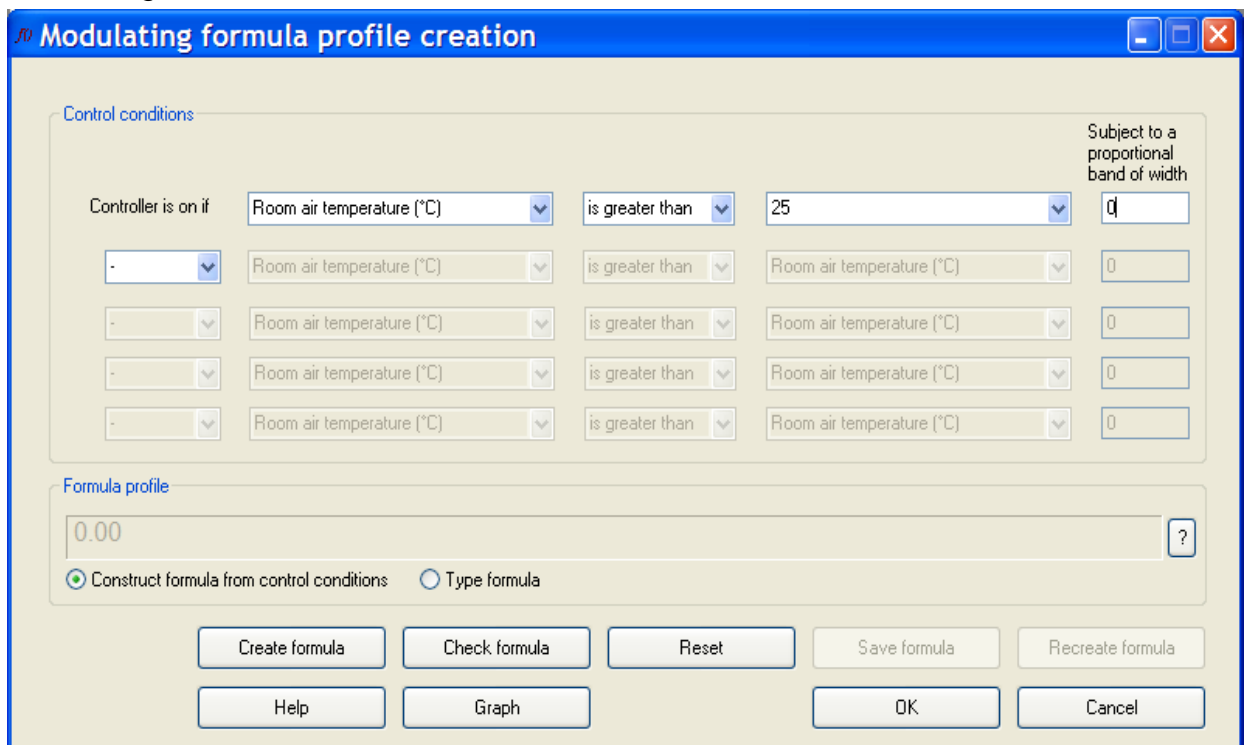


To create a formula, use the drop down boxes to select variables, or type into the drop down box to enter a number. The control conditions are interpreted by reading along the dialog from left to right. This utility is best described using examples.

12.1. Step Functions (greater or less than)

If you need a controller to open a window when the room air temperature exceeds 25°C you should select “Room air temperature (°C)” from the first drop down list, “is greater than” from the second drop down list, and type the value “25” into the third drop down list.

The dialog will then look like this:



Modulating formula profile creation

Control conditions

Controller is on if			Subject to a proportional band of width
Room air temperature (°C)	is greater than	25	0
-	is greater than	Room air temperature (°C)	0
-	is greater than	Room air temperature (°C)	0
-	is greater than	Room air temperature (°C)	0
-	is greater than	Room air temperature (°C)	0

Formula profile

0.00 ?

Construct formula from control conditions Type formula

Create formula Check formula Reset Save formula Recreate formula

Help Graph OK Cancel

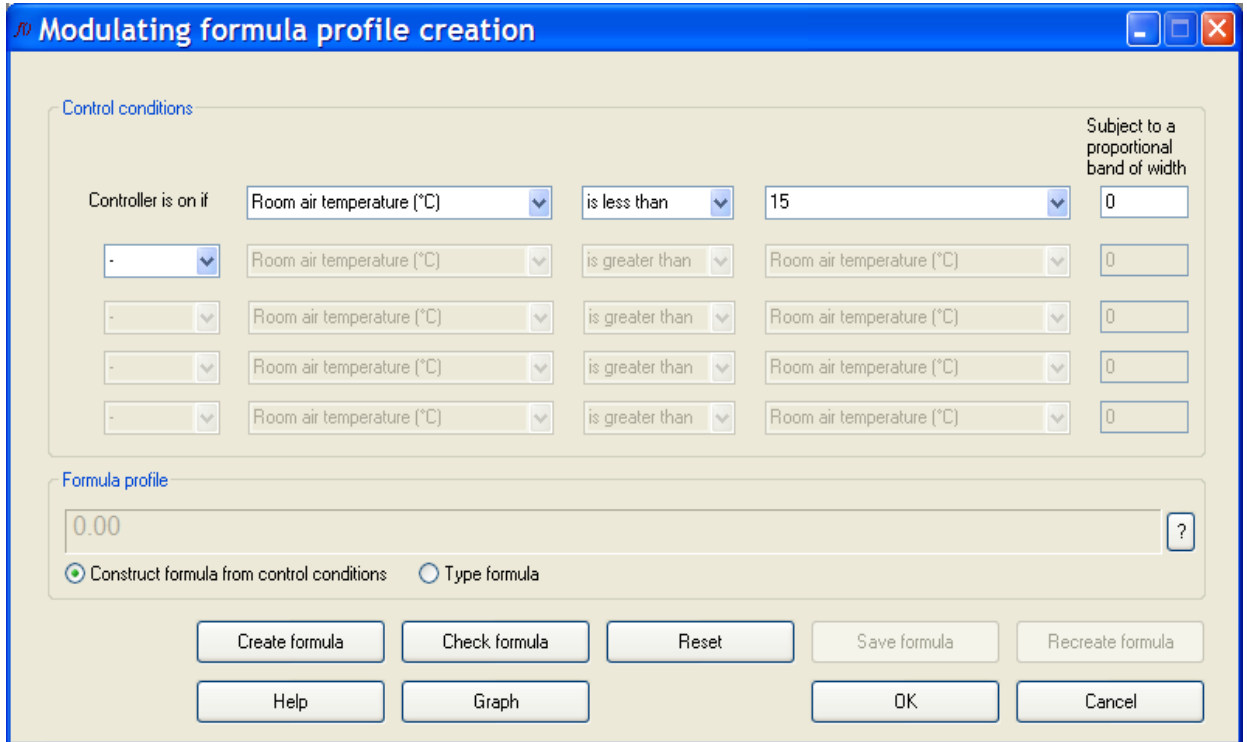
If you now click on the Create formula button you will see the formula “ta>25” appear in the Formula profile box. This formula is the mathematical expression of the control condition, and it will be written in the appropriate row of the daily profile. Note that if IP units were selected the units shown in the drop down lists would be shown as IP units. Numerical values can only be entered into the second drop down box.

Suppose now that you need a formula to trigger a control action when the room temperature drops below 15°C, for example switching on an auxiliary heater defined as an internal gain. (It’s worth emphasising that a formula such as this is

not required for the main room heating control, which is managed in a straightforward way with the room heating set point.)

For this the second drop down box would need to be changed to “is less than” and the value 15 input into the third drop down list.

The dialog will then look like this:



Modulating formula profile creation

Control conditions

Controller is on if	Comparison	Value	Subject to a proportional band of width
Room air temperature (°C)	is less than	15	0
Room air temperature (°C)	is greater than	Room air temperature (°C)	0
Room air temperature (°C)	is greater than	Room air temperature (°C)	0
Room air temperature (°C)	is greater than	Room air temperature (°C)	0
Room air temperature (°C)	is greater than	Room air temperature (°C)	0

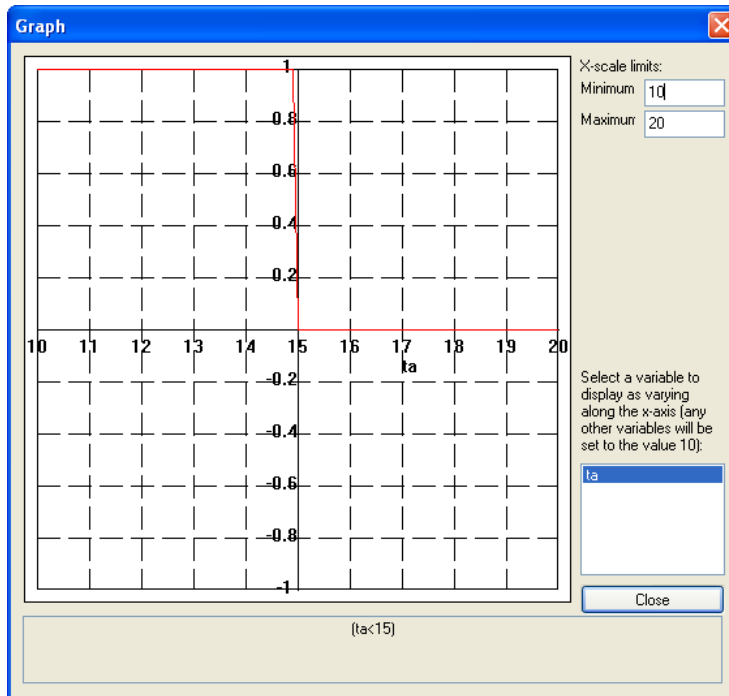
Formula profile

0.00 ?

Construct formula from control conditions Type formula

Buttons: Create formula, Check formula, Reset, Save formula, Recreate formula, Help, Graph, OK, Cancel

By pressing the Create formula button you will now see “(ta<15)” in the Formula profile box. By clicking on Graph you can display the formula graphically, as follows:



The graph shows a value of 1 (ON) below 15 °C and a value of 0 (OFF) above 15 °C. You may use the X-scale limits to set the minimum and maximum values displayed along the x-axis. Note that in cases where the formula contains more than one variable, the Graph facility plots the formula as a function of one variable and set all the others to the value 10.

12.2. Ramp Functions

The previous two examples, " $ta > 25$ " and " $ta < 15$ ", are step function formulae. To create a control action across a range of values – a proportional band – a value must be entered in the box headed "Subject to a proportional band of". Again this is best described by example. To specify a control action that starts to open a window at 23°C and modulates the degree of opening linearly until it is fully open at 27°C you should proceed as follows:

Select "Room air temperature (°C)" from the first drop down list, "is greater than" from the second drop down list, then type the value "25" into the third drop down list (specifying the centre of the proportional band) and the value 4 into the "Subject to a proportional band of width" box.

The dialog will then look like this:

Modulating formula profile creation

Control conditions

Controller is on if is greater than Subject to a proportional band of width

is greater than

is greater than

is greater than

is greater than

Formula profile

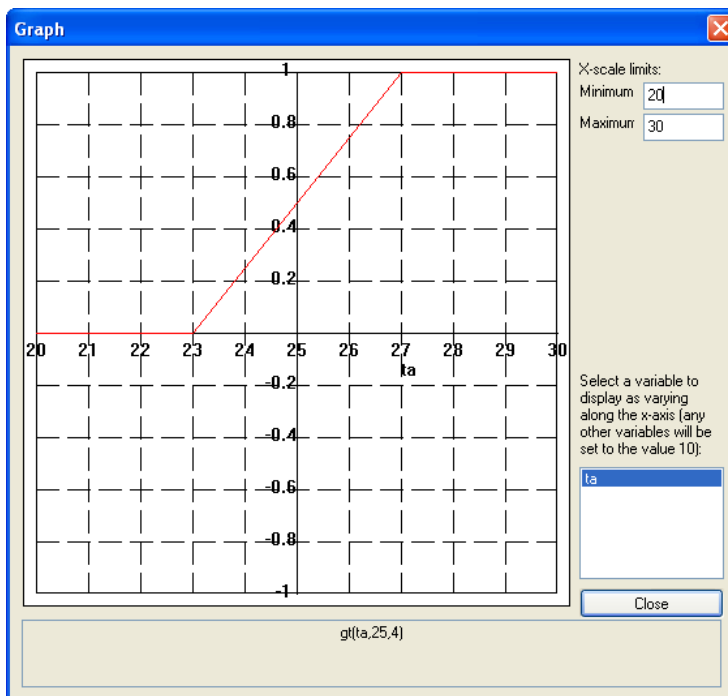
?

Construct formula from control conditions Type formula

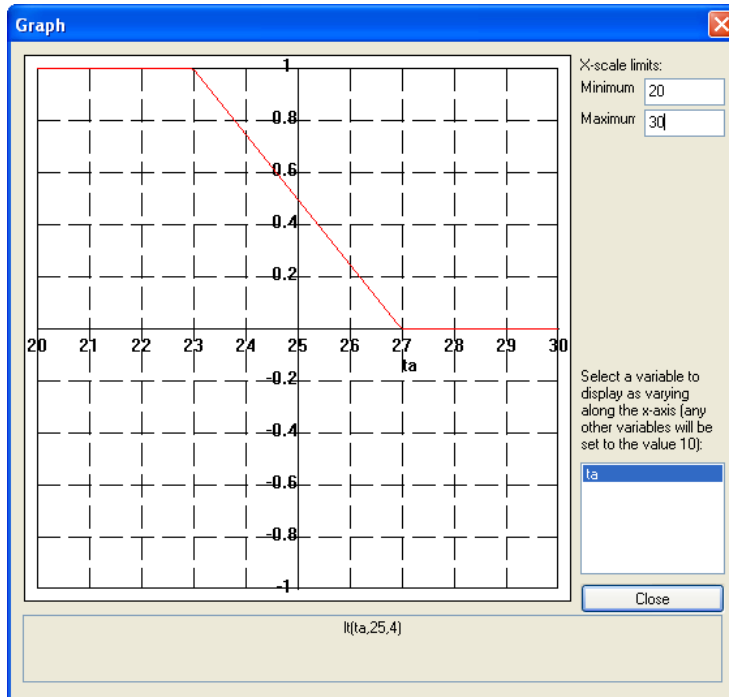
Create formula Check formula Reset Save formula Recreate formula

Help Graph OK Cancel

If you now click on the Create formula button you will see the formula “gt(ta,25,4)” appear in the Formula profile box. The gt() function is a ‘fuzzy’ version of the “greater than” step function, its third argument indicating the proportional bandwidth. By clicking on the Graph button you can display a graph of the control characteristic:



Here you can see the upward ramp function. By choosing “is less than” a downward ramp function can be created:



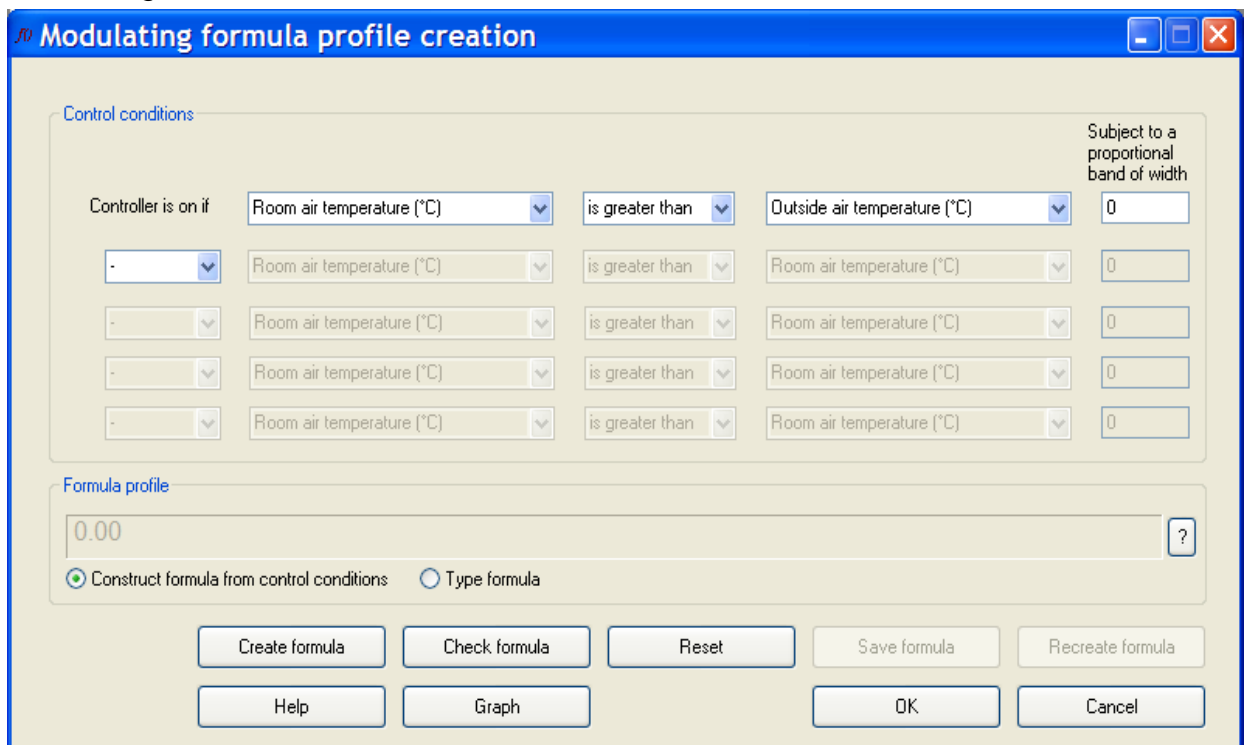
Proportional bands give a smoother type of control than step functions, and are usually a better representation of real controls.

12.3. Comparing Two Simulation Variables

All the previous examples involve a numerical comparison: the formula tests whether a simulation variable is greater or less than a numerical value. Many practical control functions involve comparisons of one variable with another. This can be also achieved with formula profiles.

If a particular action is required when the internal air temperature is greater than the external air temperature this can be achieved using either a step or a ramp function. Select “Room air temperature (°C)” from the first drop down list, “is greater than” from the second drop down list, and “Outside air temperature (°C)” from the third drop down.

The dialog will then look like this:



If you now click on the Create formula button you will see the formula “ta>to” appear in the Formula profile box. Note that only meaningful comparisons can be set up in the formula profiles dialog. A comparison between (say) wind speed and temperature will not be allowed. A formula profile that compares two variables using a Ramp function can also be created, by entering a value in the “Subject to a proportional band of width” box.

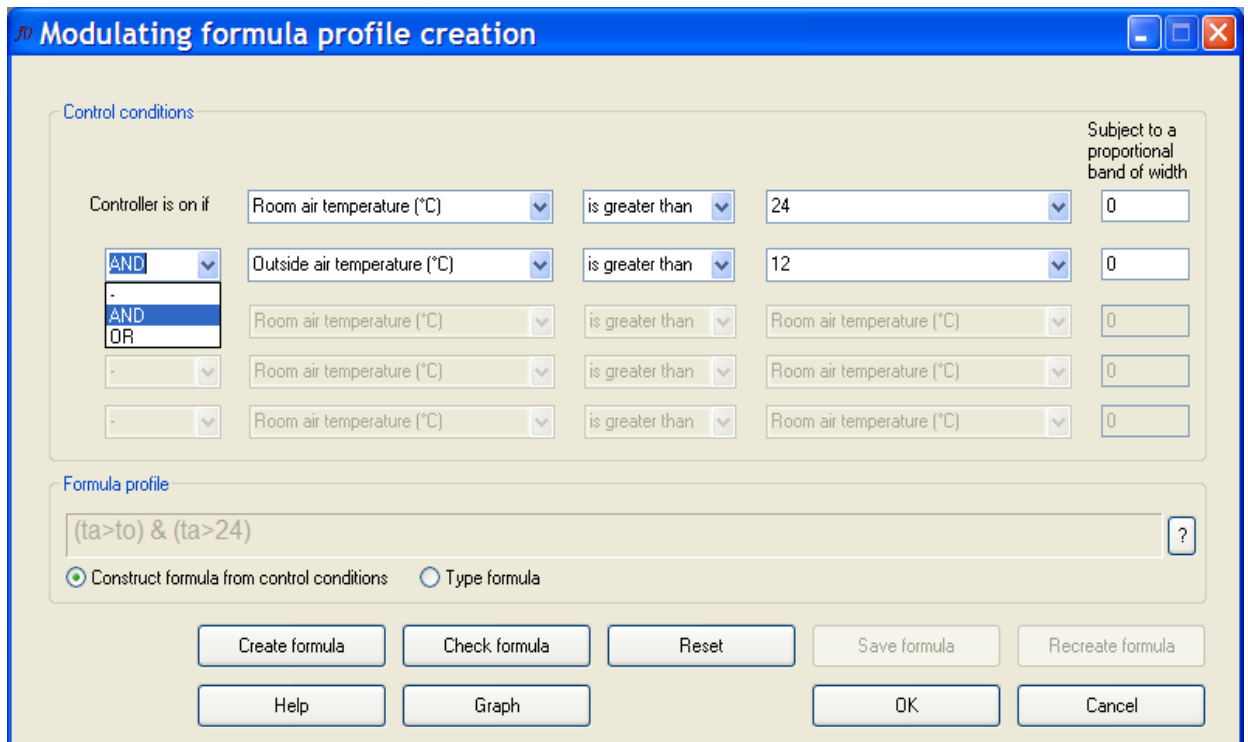
12.4. Logical Operators (AND, OR)

Step and ramp functions can be linked to produce logical formula profiles. There is a drop down box that links the control action “sentences”. These drop down lists contain the logical statements AND and OR. By linking control actions together with the logical statements complicated control can be simply created. Consider a case where window opening is required when the internal air temperature is above 24°C but not if the external temperature is below 12°C.

To create this formula profile first generate the internal air temperature statement: select “Room air temperature (°C)” from the first drop down list, “is greater than” from the second drop down list, and type the value “24” into the third drop down list. The first line will then read

Controller is on if “Room air temperature (°C)” “is greater than” “24”.

Now select the logical statement AND from the third drop down list as shown below:



Control conditions

Controller is on if	Value 1	Operator	Value 2	Value 3	Subject to a proportional band of width
Room air temperature (°C)	is greater than	24	Room air temperature (°C)	0	
Outside air temperature (°C)	is greater than	12	Room air temperature (°C)	0	
Room air temperature (°C)	is greater than	Room air temperature (°C)	Room air temperature (°C)	0	
Room air temperature (°C)	is greater than	Room air temperature (°C)	Room air temperature (°C)	0	
Room air temperature (°C)	is greater than	Room air temperature (°C)	Room air temperature (°C)	0	

Formula profile

(ta>to) & (ta>24)

Construct formula from control conditions Type formula

Buttons: Create formula, Check formula, Reset, Save formula, Recreate formula, Help, Graph, OK, Cancel

Then in the second control line select “Outside air temperature (°C)” from the first drop down list, “is greater than” from the second drop down list, and type the value “12” into the third drop down list.

The full description now reads:

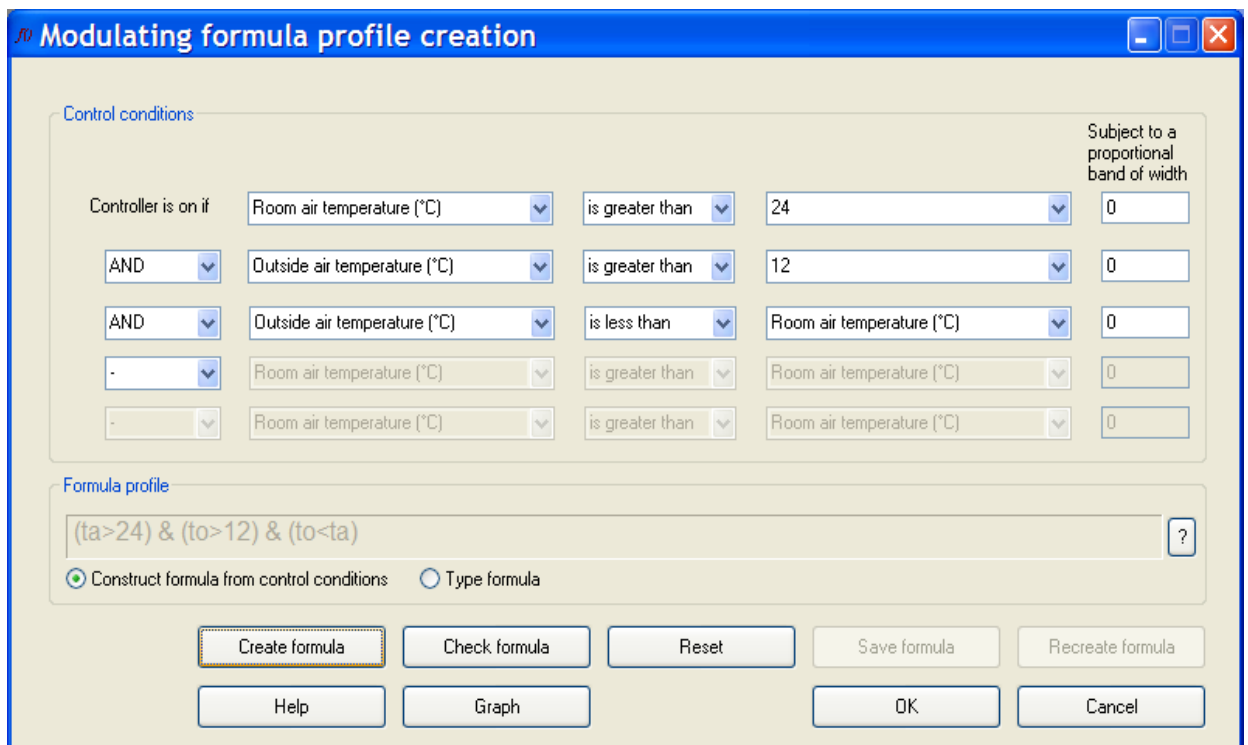
Controller is on if

“Room air temperature (°C)” “is greater than” “24”.

“AND”

“Outside air temperature (°C)” “is greater than” “12”.

This functionality can be extended further. For example if the control action had to ensure that only cooler external air was bought into the zone, the third control line could be used with a further AND statement to give the following:



Control conditions				Subject to a proportional band of width
Controller is on if	Room air temperature (°C)	is greater than	24	0
AND	Outside air temperature (°C)	is greater than	12	0
AND	Outside air temperature (°C)	is less than	Room air temperature (°C)	0
.	Room air temperature (°C)	is greater than	Room air temperature (°C)	0
.	Room air temperature (°C)	is greater than	Room air temperature (°C)	0

Formula profile

(ta>24) & (to>12) & (to<ta)

Construct formula from control conditions Type formula

Buttons: Create formula, Check formula, Reset, Save formula, Recreate formula, Help, Graph, OK, Cancel

The full description is now:

Controller is on if

“Room air temperature (°C)” “is greater than” “24”.

“AND”

“Outside air temperature (°C)” “is greater than” “12”

“AND”

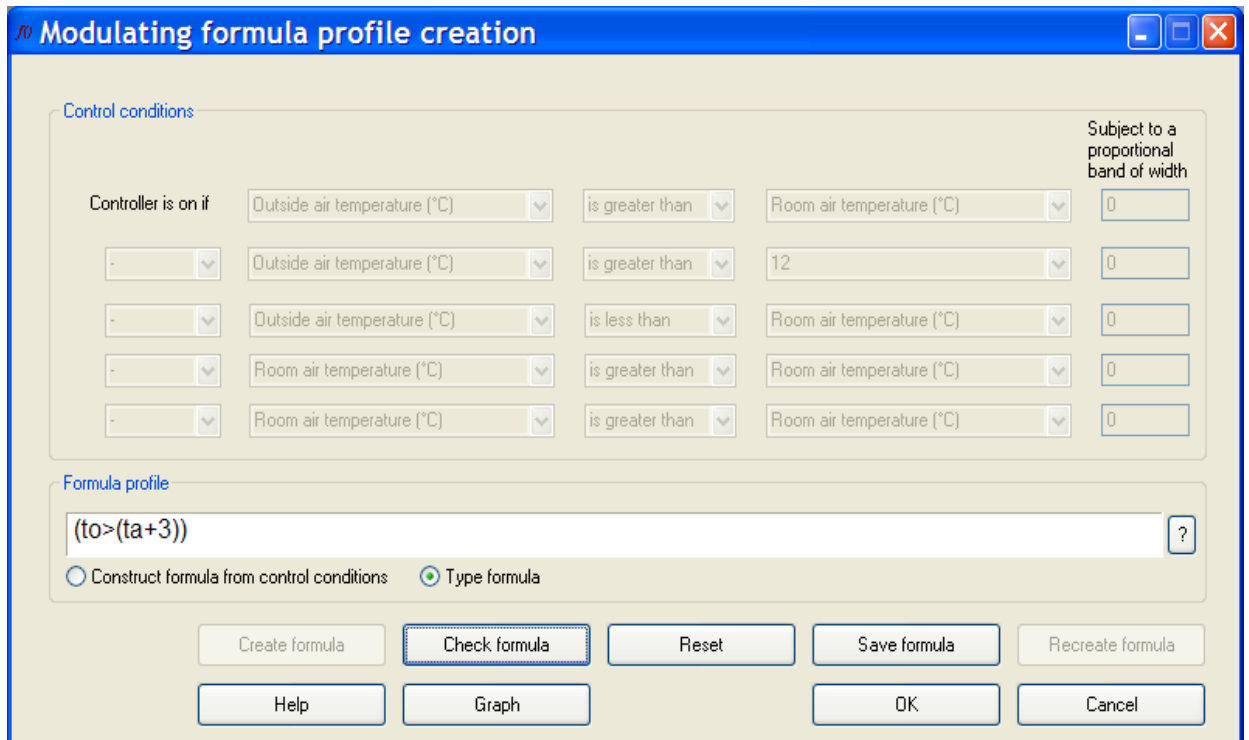
“Outside air temperature (°C)” “is less than” “Room air temperature (°C)”

If you click on the Create formula button you will see that the complete formula is now

“(ta>24) & (to>12) & (to<ta)”.

12.5. Typed Formulae

You do not need to use the control conditions interface to create your formula. By selecting “Type formula” you can simply type the formula or edit an existing one. In the example shown below the control will give an “on” signal (1) when the external temperature is 3°C greater than the internal temperature.



Control conditions

Controller is on if	Variable	Operator	Variable	Value	Subject to a proportional band of width
-	Outside air temperature (°C)	is greater than	Room air temperature (°C)	0	0
-	Outside air temperature (°C)	is greater than	12	0	0
-	Outside air temperature (°C)	is less than	Room air temperature (°C)	0	0
-	Room air temperature (°C)	is greater than	Room air temperature (°C)	0	0
-	Room air temperature (°C)	is greater than	Room air temperature (°C)	0	0

Formula profile

(to>(ta+3))

Construct formula from control conditions Type formula

Buttons: Create formula, Check formula, Reset, Save formula, Recreate formula, Help, Graph, OK, Cancel

To confirm that the formula created is valid for use in ApacheSim you can click on the Check formula button. This will report any errors in the formula.

Refer to later sections for a list of valid functions operators and constants.

12.6. Menu Options

Buttons on the ‘Modulating formula profile creation’ dialog provide the following options:

Create formula: generates a formula based on the specified control conditions

Check formula: checks that the formulae created is valid

Reset: resets all the drop down boxes to the original configuration

Save formula: makes a temporary copy of the current formula

Recreate formula: reproduces the temporarily saved formula

Help: shows the help file for formula profiles

Graph: shows a graphical output of the current created formula profile

OK: saves the profile to the appropriate row of the Daily Profile table

Cancel: exits the formula creation dialog without saving any formulae

12.7. Formula Variables

Formulae can contain any of the following symbols representing weather and simulation variables:

Weather variables:

Variable	Description	Metric unit	IP unit
ws	wind speed	m/s	ft/s
wd	wind direction	degrees clockwise from north	degrees clockwise from north
to	outside air temperature	°C	°F
go	outside air moisture	kg/kg	lb/lb
igh	global radiation on the horizontal plane	W/m ²	Btu/(h·ft ²)
ifh	diffuse radiation on the horizontal plane	W/m ²	Btu/(h·ft ²)
idn	direct normal radiation	W/m ²	Btu/(h·ft ²)

Room variables:

Variable	Description	Metric unit	IP unit
ta	room air temperature	°C	°F
tr	room mean radiant temperature	°C	°F
tdr	room dry resultant temperature	°C	°F
ta_	adjacent room air temperature	°C	°F
g	room moisture content	kg/kg	lb/lb
g_	adjacent room moisture content	kg/kg	lb/lb
rh	room relative humidity	%	%
rh_	adjacent room relative humidity	%	%
sol	short-wave solar gain to room	W	Btu/h
co2	room carbon dioxide concentration	ppm	ppm
e1	room illuminance (sensor 1)	lux	fc
e2	room illuminance (sensor 2)	lux	fc

Variable names can be uppercase or lowercase, e.g TO(1) or to(1), but not mixed case, e.g. To(1).

The illuminances e1 and e2 are computed only when the link to Radiance is used.

NOTE: e2 is not an active variable yet and should not be used.

The input variables, and in the case of an absolute profile the profile value, are interpreted in metric or IP units depending on the Units Type of the profile.

The room variables ta , tr , tdr , g and sol refer to the state of the current room, and the room variables ta_* and g_* to the adjacent room on the other side of a building element. If a profile formula containing a room variable is used in a context where there is no current room (e.g. an on/off controller) the variable is assigned the value 0. Note that a single profile containing room variables can be used in any number of rooms and the result of the formula evaluation will be particular to each room.

A room variable may be linked to a particular room by following its symbol with a pair of brackets containing the room number. For example $ta(12)$ is the air temperature in the twelfth room, the rooms being ordered as shown on the ModelIT Rooms browser. When this syntax is used, the room number must be a literal integer.

Note that the room air solar gain may not be used by the blind and shutter operating percentage profile groups, but the ambient variables such as global radiation on the horizontal plane and direct normal radiation may be.

12.8. Formula Operators

The table below lists the operators that can be used in formula profiles. They include the common arithmetic operators and Parentheses '(' and ')' can be used to define the order of evaluation. In general operator precedence is taken as the table below:

Operator	Precedence	Unary?	Usage	Description
-	1	Yes	-x	Unary minus operator
^	2	No	x ^ y	x raised to the power of y
*	3	No	x * y	Multiplication operator
/	3	No	x / y	Division operator
\	3	No	x \ y	Integer divide operator; divides the first operand by the second and rounds the result to an integer (rounding towards zero)
%	3	No	x % y	Modulo; find remainder of the division of x by y
+	4	No	x + y	Addition operator
-	4	Yes	x - y	Subtraction operator
>	5	No	x > y	"Is greater than" logical operator. Returns 1 if true, 0 if false.
<	5	No	x < y	"Is less than" logical operator. Returns 1 if true, 0 if false.
>=	5	No	x >= y	"Is greater than or equal to" logical operator. Returns 1 if true, 0 if false.
<=	5	No	x <= y	"Is less than or equal to" logical operator. Returns 1 if true, 0 if false.
!	6	Yes	!x	"Fuzzy NOT" logical operator. Returns 1-x, but subject to range [0,1].
&	7	No	x & y	"Fuzzy AND" logical operator. Returns min(x,y), but subject to range [0,1].
	8	No	x y	"Fuzzy OR" logical operator. Returns max(x,y), but subject to range [0,1].

Operators are processed in order of precedence. Operators of equal precedence are evaluated in left-to-right order. Brackets override the processing order, e.g., if $ta=21$, $3*ta-20=43$, but $3*(ta-20)=3$. If in doubt, use brackets.

Operators involving a test for equality (those containing the “=” sign) are for most practical purposes equivalent to the version of the operator without the equals sign.

12.9. Formula Functions

The following mathematical functions are available for use in formula profiles:

Function	Description
gt(x,xs,b)	Fuzzy greater than. Proportional band rising linearly from 0 to 1 as x rises from $x_s-b/2$ to $x_s+b/2$. Like a fuzzy version of $x > x_s$ with the transition between 0 and 1 occurring over a proportional band specified by b
lt(x,xs,b)	Fuzzy less than. Proportional band falling linearly from 1 to 0 as x rises from $x_s-b/2$ to $x_s+b/2$. Like a fuzzy version of $x < x_s$ with the transition between 1 and 0 occurring over a proportional band specified by b
ramp(x,x1,y1,x2,y2)	General ramp function. x=sensed variable, x1=sensed value at lower end of x-axis, y1=returned value at lower end of x-axis, x2=sensed value at upper end of x-axis, y2=returned value at upper end of x-axis
int(x)	Integer value of x, rounded towards zero
ceil(x)	Ceiling - nearest integer above x
floor(x)	Floor - nearest integer below x
if(condition, val1, val2)	Fuzzy logical if. If the condition is 1 or more, returns val1; if 0 or less returns val2; else returns a weighted sum of val1 and val2, where val1's weighting = condition.
min(v1,v2,v3,...)	Minimum of a set of values, v1, v2, v3, ...
max(v1,v2,v3,...)	Maximum of a set of values, v1, v2, v3, ...
log10(x)	Base-10 logarithm of x
log(x)	Natural logarithm of x
exp(x)	e^x , where e is the base of natural logarithms
pow(y, x)	Returns x raised to the power of y
sqrt(x)	Square root of x
abs(x)	Absolute value of x
sign(x)	Returns 1 if x is positive or zero, -1 otherwise
sin(x)	Sine of x (NB x must be in degrees)
asin(x)	Arcsine of x (NB returns value in degrees)
cos(x)	Cosine of x (NB x must be in degrees)
acos(x)	Arccosine of x (NB returns value in degrees)
tan(x)	Tangent of x (NB x must be in degrees)
atan(x)	Arctangent of x (NB returns value in degrees. Use atan2() rather than this if you need the angle to be in the correct quadrant)
atan2(y, x)	Arctangent of y/x (NB returns value in degrees. Use this rather than atan() if you

	need the angle to be in the correct quadrant)
sinh(x)	Hyperbolic sine of x
cosh(x)	Hyperbolic cosine of x
tanh(x)	Hyperbolic tangent of x
rand()	Random value between 0 and 1
rand(min, max)	Random value between min and max
avg(v1,v2,v3,...)	Average of a set of values, v1, v2, v3, ...
sum(v1,v2,v3,...)	Sum of a set of values, v1, v2, v3, ...

In addition, the following functions provide access to the values of room variables in rooms other than that in which the formula applies:

ta(n)	variable ta for room number n
tdr(n)	variable tdr for room number n
tr(n)	variable tr for room number n
rh(n)	variable rh for room number n
g(n)	variable g for room number n
co2(n)	variable co2 for room number n
sol(n)	variable sol for room number n
e1(n)	variable e1 for room number n
e2(n)	variable e2 for room number n

The following constants can be used in formulae profiles:

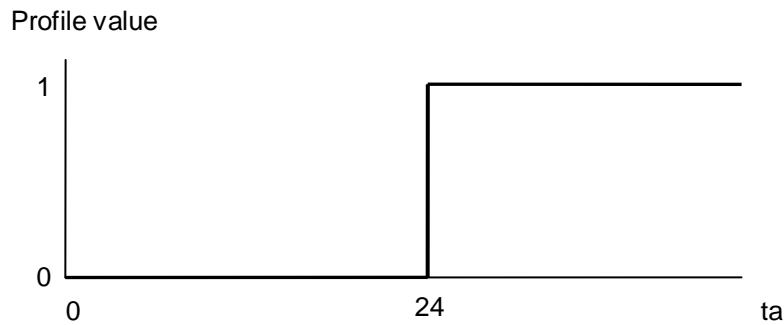
Constant	Description
pi	3.14159265359
e	2.71828182846

Function and constant names, like variable names, are case insensitive.

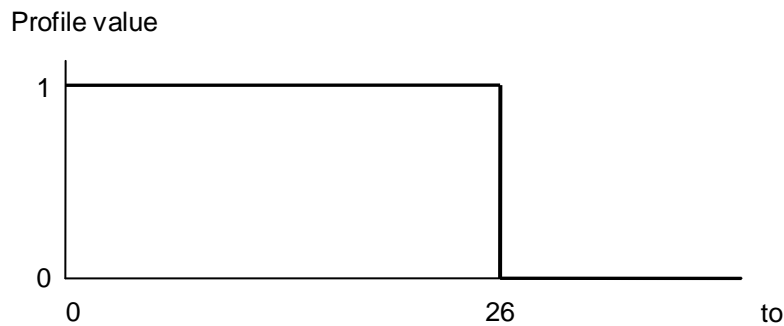
12.10. *Example Modulating Profiles*

The following are some useful formulae for modulating profiles.

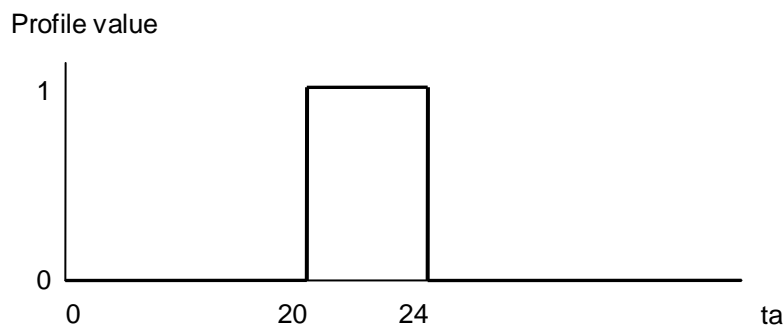
ta>24 1 when ta is greater than 24, and 0 otherwise



to<26 1 when to is less than 26, and 0 otherwise



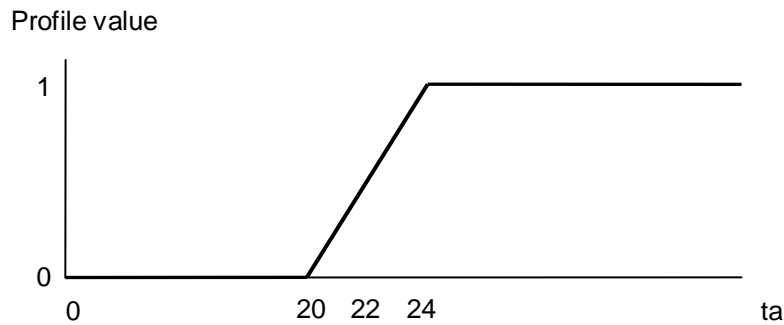
ta>20 & ta<24 1 when ta lies between 20 and 24, and 0 otherwise



ta>to 1 when ta is greater than to, and 0 otherwise

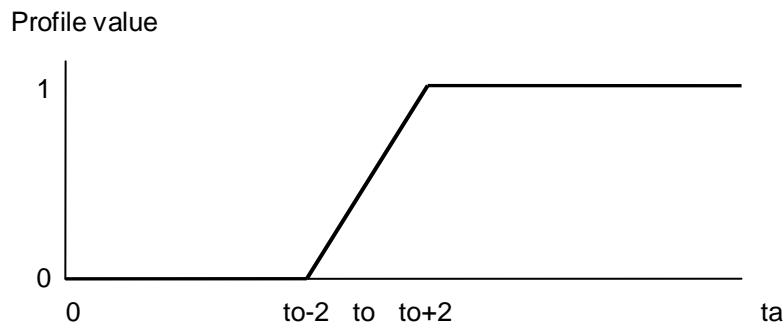
ta>=21 & to>=12 1 when ta is greater than or equal to 21 and to is greater than or equal to 12, and 0 otherwise

gt(ta,22,4) 0 when ta<20 and 1 when ta>24, with a linear ramp in between (a proportional band of width 4K between 20 and 24)



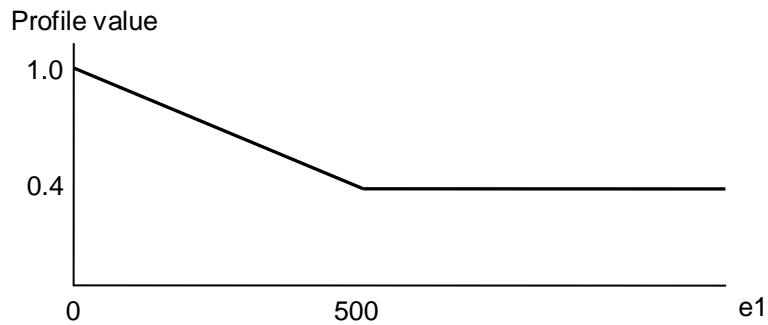
ramp(ta,20,0,24,1) an alternative to the above formula

gt(ta,to,4) rises smoothly from 0 to 1 as ta increases through to, the transition occurring over a band of 4 degrees



lt(to,18,2) & lt(to,ta,4) 1 when to < 18 and to < ta, and 0 otherwise, with bands of width 2 and 4, respectively.

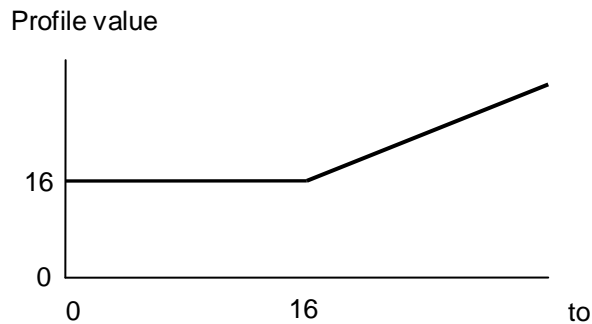
ramp(e1,0,1,500,.4) a formula suitable for applying as a dimming profile controlling lighting gain as a function of available daylight. It modulates the lighting gain as a function of the illuminance on the working plane, e1. The value of the profile falls from 1 at zero illuminance to 0.4 at illuminance 500 lux, thereafter remaining constant at this value. The value 0.4 (which you should set as appropriate) represents the fraction of the room's lighting gain which is not subject to daylight control. The illuminance e1 must be computed using the link to Radiance.



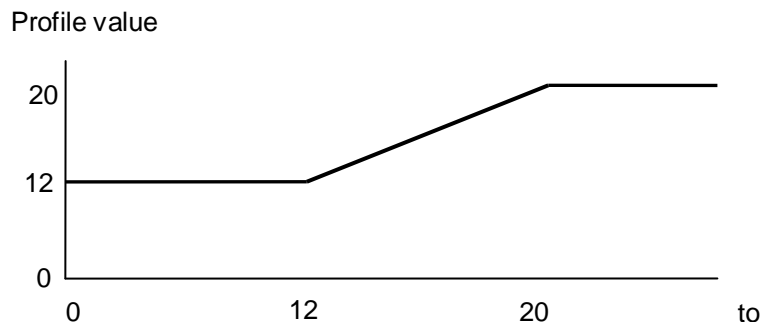
12.11. *Example Absolute Profiles*

The following are some useful formulae for absolute profiles.

if(to<16,16,to) 16 when outside air temperature (to) is less than 16 and to when to is greater than 16 (a supply condition for mechanical ventilation when heating, but not cooling, is available)

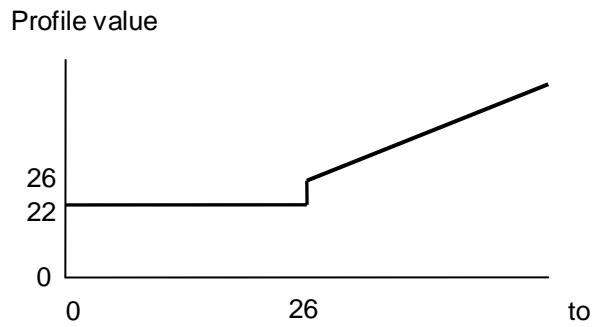


ramp(to,12,12,20,20) emulates a supply condition for mechanical ventilation when the outside air is heated to 12 and cooled to 20.

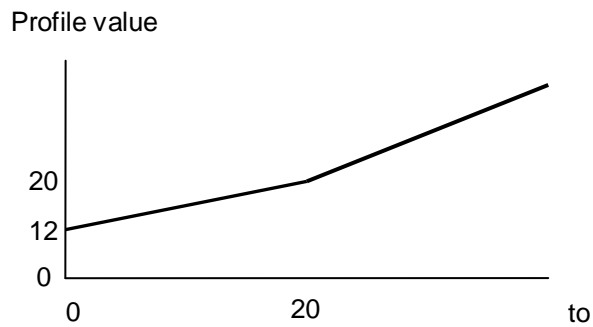


if(to<12,12,if(to<20,to,20)) an alternative to the above formula

if(to<26,22,to+4) 22 when to is less than 26 and to+4 when to is greater than 26 (an adaptive room set-point)



if(to<20,to+.6*(20-to),to) emulates a mechanical supply condition where heat recovery is applied to an outside air supply. The return air is assumed to be at 20°C and the effectiveness of the heat recovery device is 60%.



13. Appendix A: Hints and Tips

13.1. Profile Naming Conventions

Of course it is entirely up to the user how they name their profiles but one should be aware that the selection lists can contain many profiles so finding the desired item becomes easier with a consistent and clear naming convention.

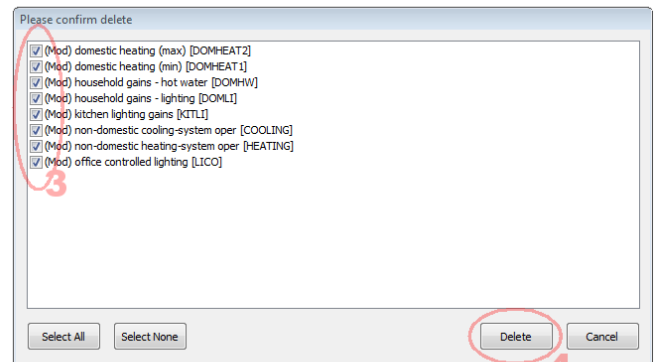
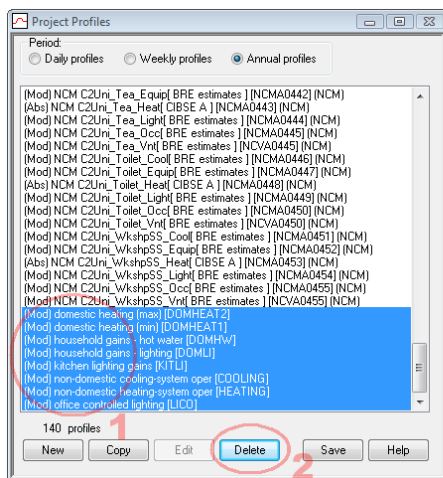
Another thing to bear in mind is that some of the selection lists are not particularly wide so very long profile names can be difficult to tell apart.

e.g. “OCC 8-6 Office occupancy”, “HTG 7-7 Office heating control”.

Obviously the user can decide how they want to

13.2. Deleting Profiles

It is always good practice to keep the profiles database tidy and delete any unused profiles so as not to clutter up the display. The easiest way to do this is to multi-select a group of profiles by using the shift or control keys while clicking on the list.



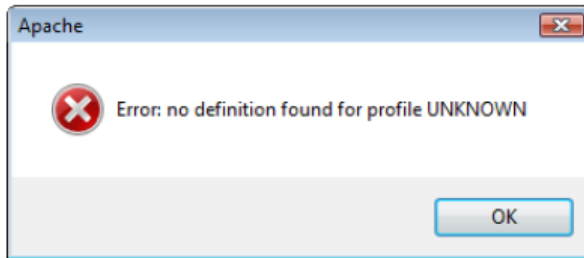
13.3. Keep Formula Profiles as short as possible

The maximum length of a formula profile is 156 characters so be wary of very large strings.

13.4. Replacing missing profiles

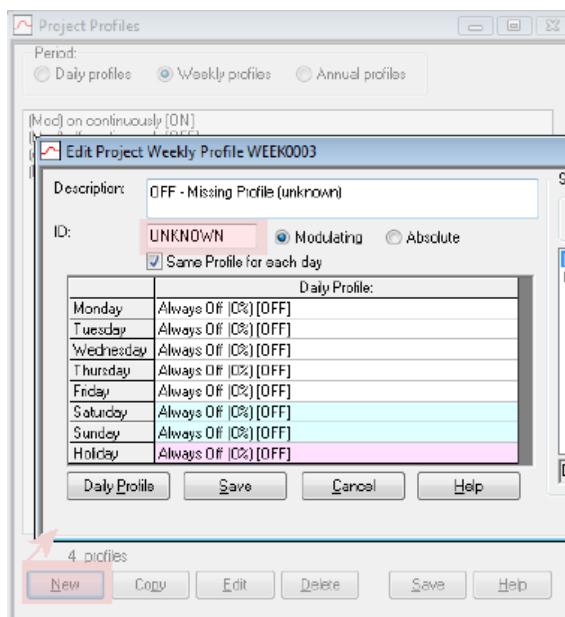
Occasionally projects can become corrupted and parts of the VE reference a profile that has been removed from the project. We can repair these projects by adding the missing profiles back into the database. Consider the following example:

In Apache we receive the error message seen here when we try to run a simulation:



In order to resolve this we need to add a new profile to the database with the ID "UNKNOWN".

1. Create a new weekly modulating profile.
2. Set the ID field to be "UNKNOWN".



Once this is done we can then identify where the profile is used by interrogating the templates and room data then replace if necessary with a more appropriate profile.