Temperature Level Control Tutorial

It is commonly desired to model a building in temperature level control from energy rate control. This tutorial demonstrates changing the TRNSYS Restaurant Example from energy rate control to temperature level control. There are four important steps to implement temperature level control: turning off the internal heating and cooling in Type56, defining the inputs, defining the outputs, and connecting the proper mechanical components in the Simulation Studio. This tutorial will guide through each of the steps.

Open the *Restaurant.tpf* example project in the Simulation Studio from the TRNSYS Examples directory. Right click on the Type56 component and click *'Edit Building'*. At this point it is recommended that the project and building are saved as different names (*File → Save as*). In the TRNBuild Manager window, open the zone, *DINING*. Open the *Heating* button, and click the off button as shown in Figure 1. This action removes the TRNBUILD internal heating setting for the zone. The internal cooling for the zone is already off, but the internal cooling and heating for the other zone, *KITCHEN*, needs to be turned off.

Figure 1: Heating for Dining Room Zone

In the TRNBuild Manager window open the zone, *KITCHEN*. Open the *Heating* button, and click the off button as shown in Figure 2. The same needs to be done for the internal cooling setting for the zone as shown in Figure 3.

Figure 2: Heating for Kitchen Zone

Figure 3: Cooling for Kitchen Zone

The next step to achieve temperature level control is to create the necessary inputs for Type56 in TRNBuild. Open the *Ventilation Type Manager* from the menu bar (*Typemanager* → *Ventilation*). Only the ventilation for the kitchen zone has been previously defined as shown in the drop down menu in the *Ventilation Type Manager* (Figure 4). Instead of defining the ventilation by a schedule as in Figure 4, click on the blue arrow in *Airchange of Ventilation*.

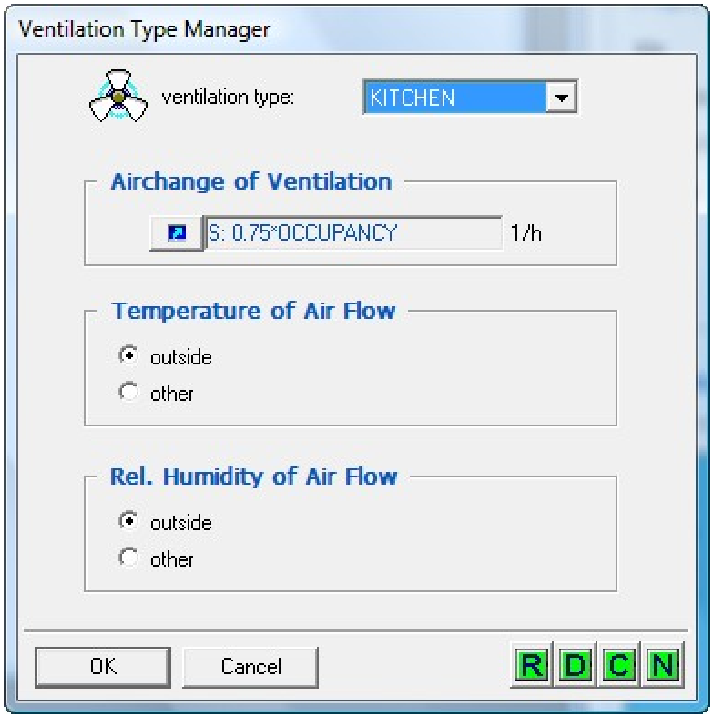

Figure 4: Kitchen Zone Ventilation Prior to Defining Input

Click on the *Input* button rather than the *Schedule* button (Figure 5).

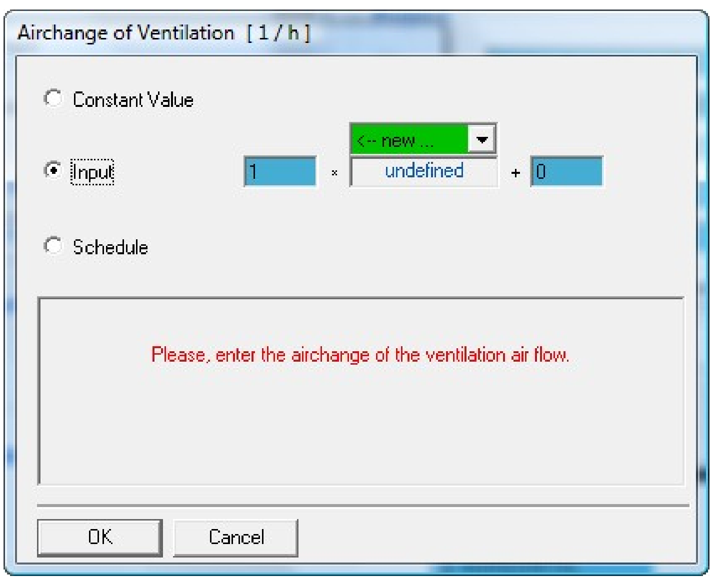

Figure 5: Defining Ventilation as an Input into Type56

A new input may be created by using the drop-down menu and clicking on '← *new…*' (Figure 6).

Figure 6: Creating a New Input for Ventilation

Define the new input as *M_DOT_KITCH* in the pop-up window and press the *OK* button (Figure 7).

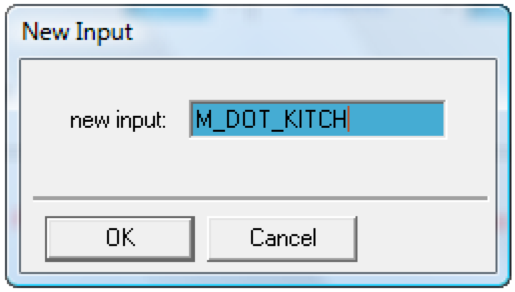

Figure 7: Naming the New Input for Ventilation

It is extremely vital to note that the ventilation is rate is an airchange of ventilation (1/hr). To convert the TRNSYS flow rate units of *kg/hr* to air changes of ventilation, multiply by the inverse of the product of the density of air and the zone volume (Equation 1).

$$Airchange = \frac{1}{\rho_{air} \times V_{zone}} \times \dot{m}_{air} \qquad (1)$$

In the case of the kitchen zone with a volume of 168.75 m^3 and assuming that air has a density of 1.20 kg/m^3, the multiplier for the input mass flow rate would be about 0.005 as shown in Figure 8. Alternatively, an external equation may be used in the Simulation Studio for the conversion.

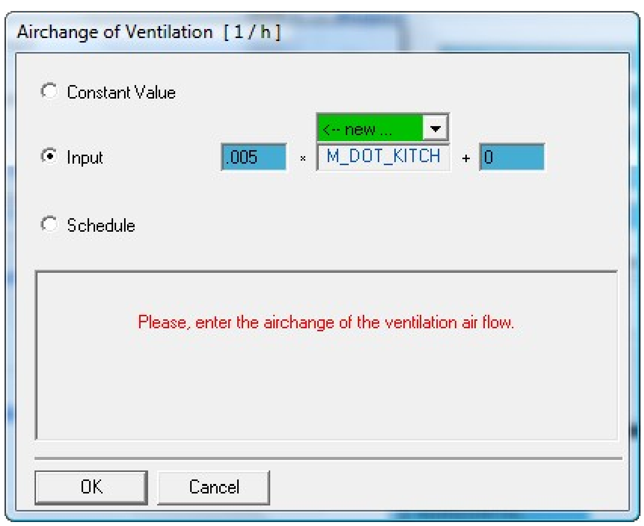

Figure 8: Using a Multiplier to Convert Input Mass Flow Rate

Press the *OK* button to go back to the Ventilation Type Manager for the kitchen zone. The *Temperature of Air Flow* and the *Relative Humidity of Air Flow* also need to be defined as inputs. Using the previous process to define inputs, create a new input for the inlet temperature and relative humidity to the kitchen zone called *T_IN_KITCH* and *RH_IN_KITCH*, respectively. The *Ventilation Type Manager* for the kitchen zone should look like that in Figure 9.

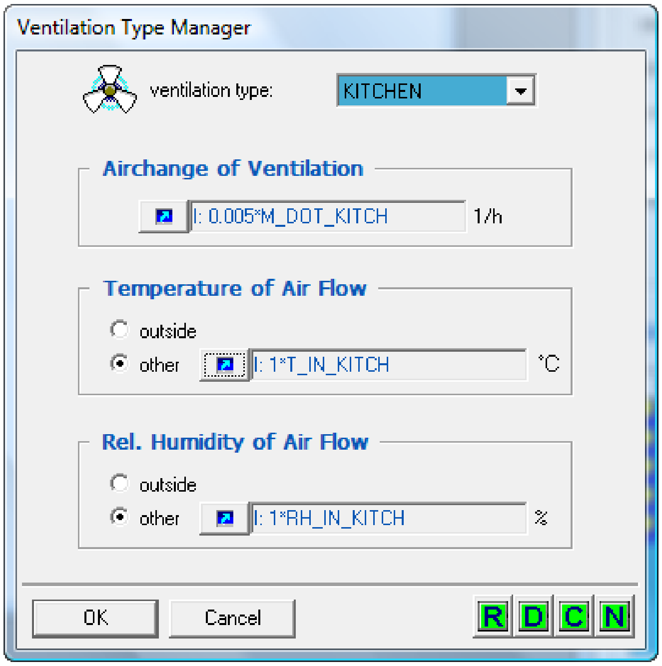

Figure 9: Inputs for the Kitchen Zone Ventilation

The same set of inputs needs to be defined for the dining room zone. To create a new ventilation type, simply click on the *N* in the green box of the lower right hand of the Ventilation Type Manager window (Figure 10). Adding a new ventilation type may also be done by clicking on the zone name in the TRNBuild Manager, clicking on the *Ventilation* icon button in the *Regime Data*, and then adding a new ventilation type.

Figure 10: New Ventilation Type Button

Name the new type, *DINING* and click the *New* button (Figure 11).

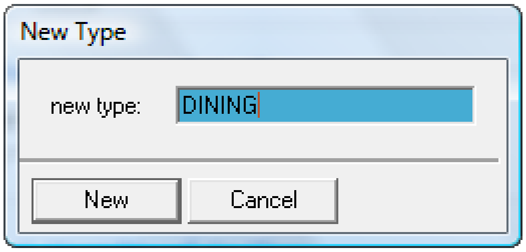

Figure 11: Naming a New Ventilation Type for Dining Room Zone

Using the same process for creating inputs, define the flow rate, inlet temperature, and the inlet relative humidity for the dining room zone, *M_DOT_DINING, T_IN_DINING,* and *RH_IN_DINING*, respectively. Since the dining room is twice the volume as the kitchen zone, the multiplier for the airchange of ventilation will be 0.0025. The ventilation type for the dining room zone should look like that in Figure 12.

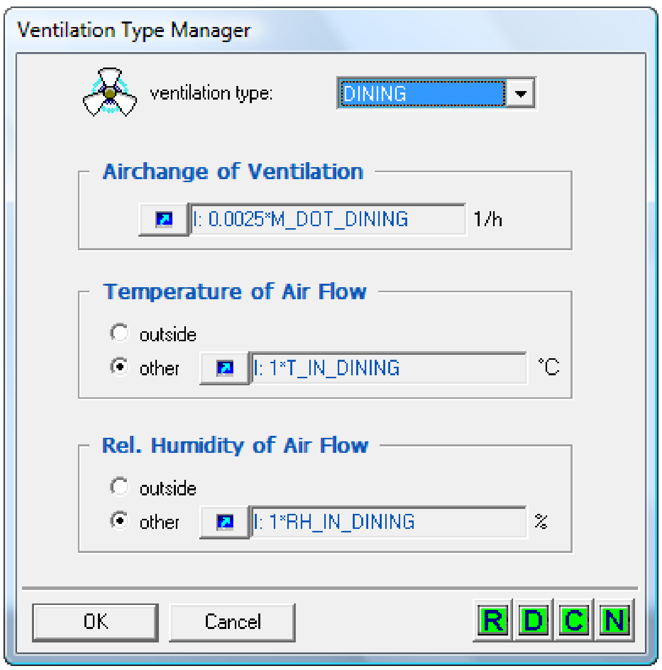

Figure 12: Inputs for Dining Room Zone Ventilation

The necessary inputs for temperature level control have been defined and will be listed as inputs into Type56 in the Simulation Studio.

Now, the necessary outputs for in TRNBuild have to be implemented. In the *Project* window, click on the *Outputs* button (Figure 13).

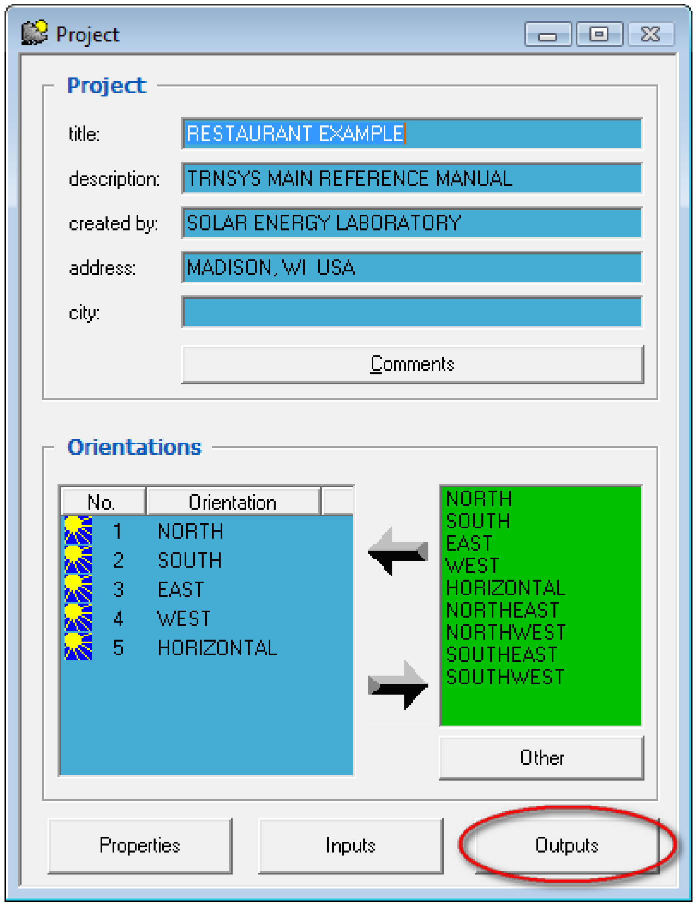

Figure 13: The Project Window with the Outputs Button

Double click on the existing set of outputs for the *DINING, KITCHEN,* and *STORAGE* zones (Figure 14).

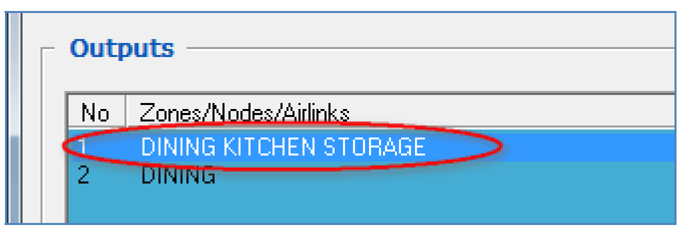

Figure 14: The Output Window

Many of the possible outputs are included, but it is desired to add the relative humidity output, *RELHUM*. Add the *RELHUM* (Figure 15), click *OK,* and click *OK* again in the *Outputs* window.

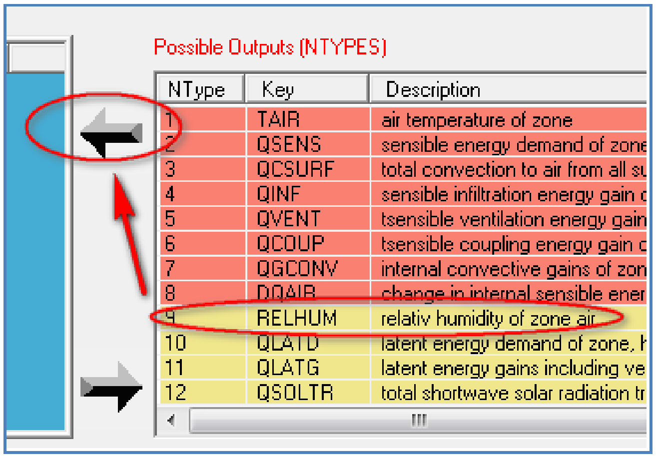

Figure 15: Adding the Relative Humidity Output

Save the **.bui* file, close TRNBuild, and go back to the Simulation Studio. Right click on Type 56 and click on *"Update building variable list"* (Figure 16). This will update the inputs and outputs that were just created in Type56.

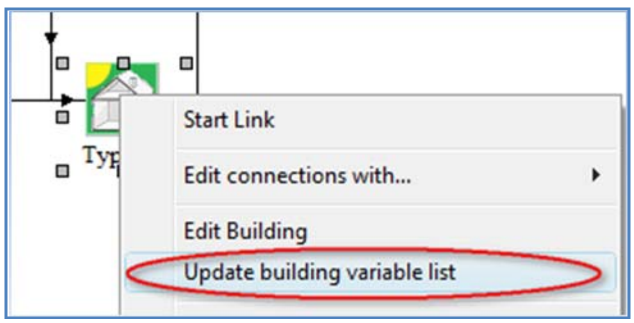

Figure 16: Updating the Type 56 Variable List

The project is now ready to obtain the mechanical components for temperature level control. The user may choose to have both the dining room and kitchen zones on the same mechanical equipment or on separate mechanical equipment as shown in Figure 17. In the case of this example, there is a Type112b fan, a Type92 auxiliary cooling unit, a Type121b furnace, and a Type108 thermostat for each of the two conditioned zones. Grab the components from the proforma window tree on the right side of the Simulation Studio and drag them into the Simulation Studio Project.

The Type108 thermostats will monitor the zone temperatures, so connect the Type56 outputs, *TAIR_KITCHEN* and *TAIR_DINING*, to the respective Type108 input monitoring temperature. The outputs of Type108, *Control signal for 1st stage heating, Control signal for 1st stage cooling, and Conditioning signal*, should be connected as an input to the *Control function* of the Type121b furnace, Tyep92 auxiliary cooling unit, and Type112b fan, respectively. The black dotted lines in Figure 17 represent the control signal connections for the Type108 thermostat.

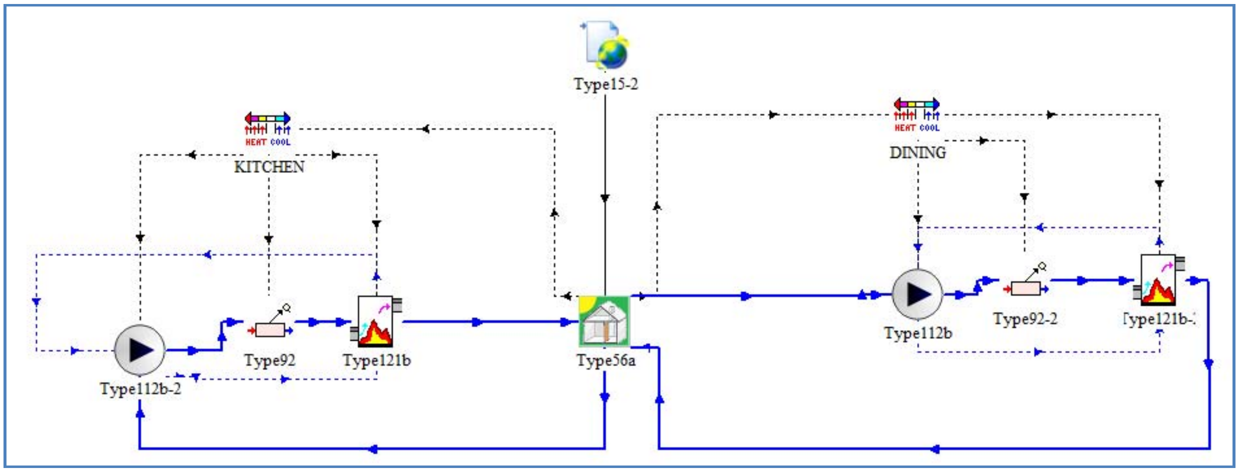

Figure 17: Adding Mechanical Components in the Simulation Studio

The solid blue line represents the air stream temperature flow in Figure 17. The zone outputs of temperature and relative humidity should be connected to the inputs of the Type112b fan. Set the fans at a nominal flow rate of 1500 kg/hr. Continue connecting the air flow rate, temperature, and relative humidity to and from the mechanical equipment in the Simulation Studio. Note that the Type92 auxiliary cooling unit cannot receive relative humidity as an input, so make a connection from the fan to the Type121b furnace to connect the relative humidity only.

When making the connection from the Type121b furnace to the Type56 multi-zone, the new inputs that were created in TRNBuild will be displayed in the connection window (Figure 18).

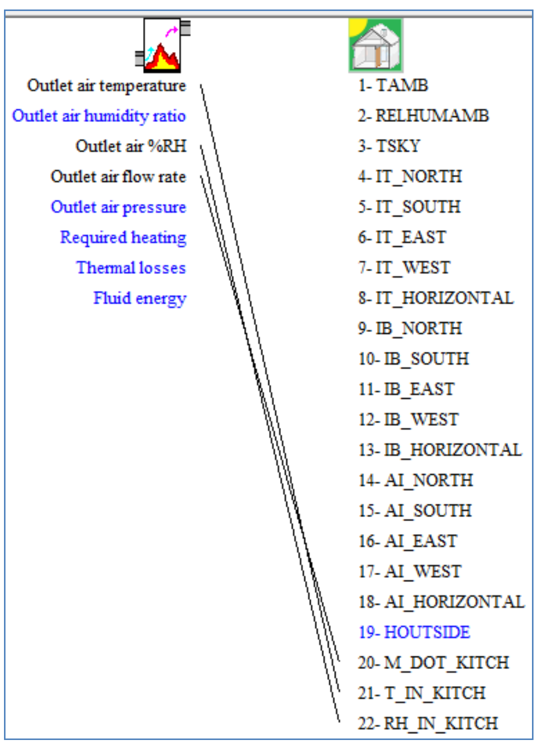

Figure 18: Connection to New Inputs in Type56

It is important to note a few things about using temperature level control in the TRNSYS. There is no output mass flow rate for the air in Type56. As shown in Figure 17 by the blue dotted line in the Simulation Studio, the output air flow rate from Type121b furnace is the input into the Type112b fan. The simulation time step should be small to account for the temperature monitoring of the thermostat. Last, the mechanical conditioning should be adjusted accordingly for the zone loads. Please see the examples *RestaurantTLC.tpf* and *RestaurantTLC.bui* for more details.