TRN-RESDH5: TRNSYS Residential AC/Dehumidifier Model – SHORT TIMESTEP

A Tool for Evaluating Hybrid Configurations and Control Options in Single-Zone Building Applications

Operating and Reference Manual

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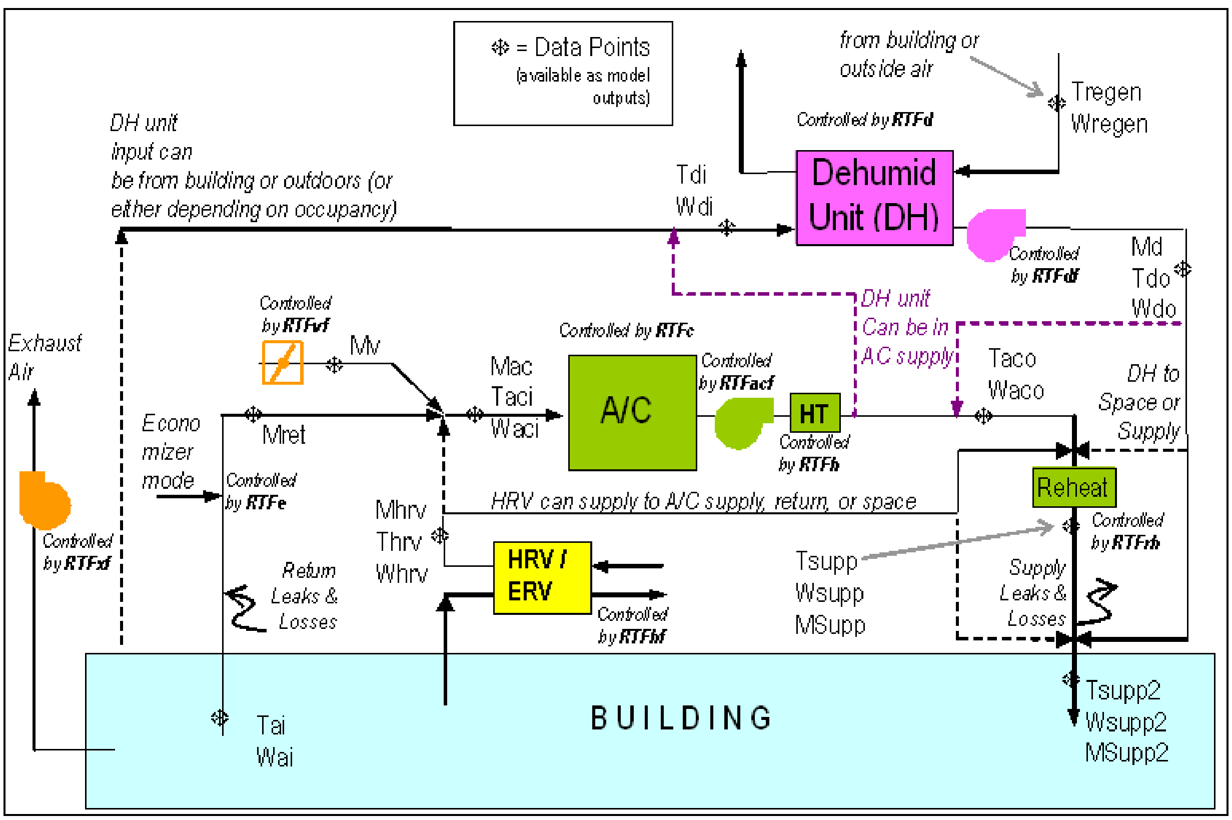
Overview

The original TRN-RESDH Residential Desiccant Model uses TRNSYS and TRNSED[1] to simulate a two zone building (house with attic) with either conventional or hybrid dehumidification systems on an hourly basis. This new version simulates building performance at very small timestep (e.g., 0.02 hrs). Figure 1 shows the configuration and control options that are available. The system can include a DX cooling coil, a heating coil, and an optional ventilation pretreatment system such as a desiccant unit OR Energy Recovery Ventilator OR a dehumidifier. The model is unique in that it allows several HVAC configurations and control options to be considered:

- Conventional AC with or without economizer,
- Different temperature and humidity control set points during occupied/unoccupied periods,
- Multiple types of control (AUTO or CONSTANT) for AC supply fan and desiccant process fan that can vary between periods,
- Options for reheat-based humidity control with alternate heating set points,
- Models to predict moisture evaporation from the cooling coil during the off-cycle,
- Desiccant configuration options that allow regeneration and process air to come from indoors or ambient (and control options that alternate these configurations for occupied/unoccupied periods),
- Tracking indoor CO_2 levels via a first order mass balance that considers time-varying occupant generation and ventilation rates.



[1] TRNSYS is a software tool developed by the Solar Energy Laboratory at the University of Wisconsin, Madison to simulate the transient performance of thermal systems. TRNSED provides a menu-based user interface to TRNSYS so that specific applications can be developed for non-expert users.

Figure 1. Overall HVAC System Schematic of Possible Configurations

Several options are available for each component. For example, the AC unit capacity, efficiency, and sensible heat ratio can at nominal conditions be specified. Similarly, many types of desiccant/ventilation units are available, including several gas-fired desiccant units, enthalpy wheels, the Drykor liquid desiccant unit, and various residential dehumidifier options.

The TRNSED user interface to the model is shown in Figure 2. The user can configure the various sections of the program by clicking the various tabs. One can also navigate to the tabs by clicking on the appropriate equipment in the layout diagram on the main tab. The user selects the desired settings by operating the pull-down menus and by entering data in the text boxes. The types of inputs are grouped according to topic: “Dehumid/Vent Unit”, “AC Unit”, “Fan Control Options” and “SetPts/Building”. Since the tool is aimed at HVAC-related issues, most of the inputs are focused on that topic with less emphasis on the building details. However, the TRNSYS-based model supports single-zone or two-zone detailed building simulations based on TRNSYS Type 56 module. The TRNBuild.EXE application can be used to change the building details.

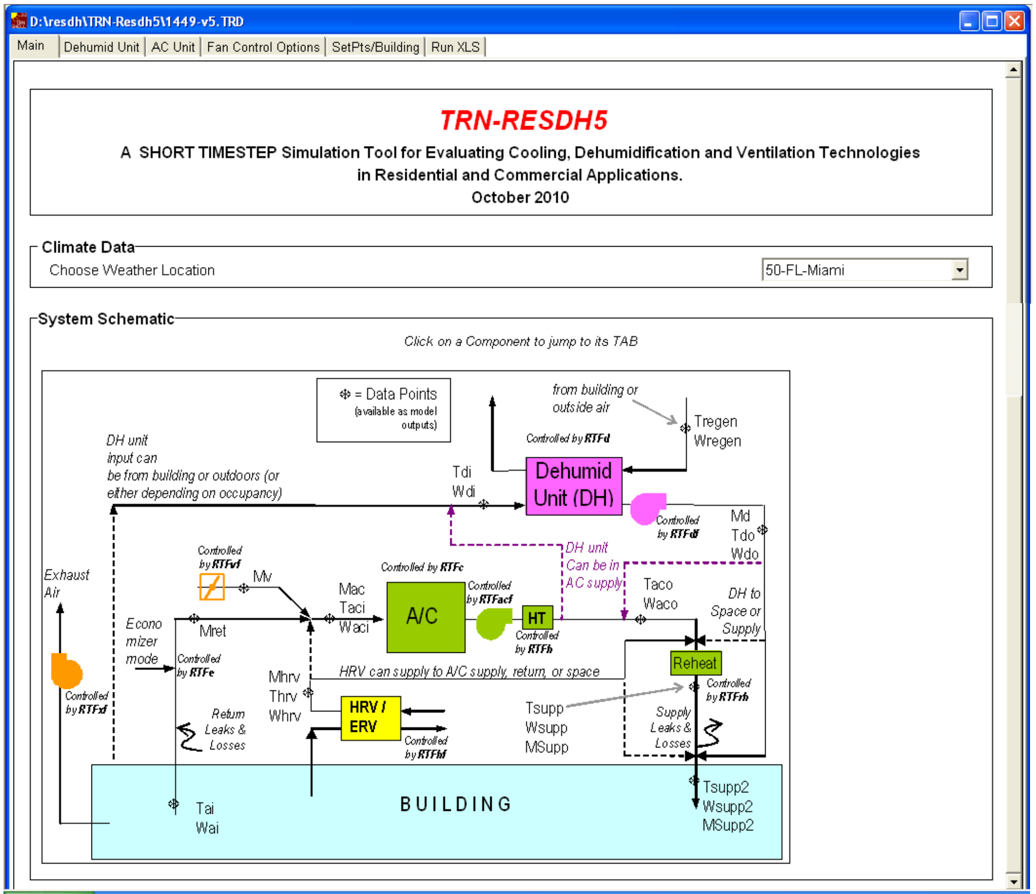


Figure 2. Top of the Main Input Menu for TRN-RESDH Model

An EXCEL spreadsheet has been developed to automatically load and process the hourly output data generated by TRNSYS. The spreadsheet uses Python procedures to spawn multiple runs and process the results.

The remainder of this document provides brief instructions on installation and use of the software. The appendices give details of the menu inputs and program output.

Version History

TRN-Resdh is the newest revision of the TRN-Des tool, which was released on December 9, 2002 and is documented is an ASHRAE paper[2]. The TRN-Des release mainly included commercial building applications TRN-Resdh enhanced the TRN-Des model by adding equipment and building details to consider residential applications. Table 1 summarizes the revision history of TRN-Resdh with versions listed by build date (YYYY.MM.DD).

Table 1. TRN-Resdh Revision History

[2] Henderson, H.I. and J. Sand. 2003. *An Hourly Building Simulation Tool to Evaluate Hybrid Desiccant System Configuration Options*. KC-03-5-1, ASHRAE Transactions, Vol. 109. Pt. 2. June.

Revision	Changes
2003.04.29	Initial release of TRN-Resdh. Changes from TRN-Des include residence building type , desiccant units 18-20 and inclusion of the TRN-Resdh Results spreadsheet utility.
2003.11.12	Input menu changes and updates to spreadsheet utility. Added GTI-DH and GTI-AC example TRD files.
2004.02.20	TRN-Resdh2. Changed numeric entries to more descriptive pull down menus. Added help screens. Added new floor options such as crawl space and new desiccant equipment options. Added option for user specified ACH and two stories. Changes to spreadsheet utility now archive monthly data.
2004.05.14	TRN-Resdh2. Added varying infiltration options based on weather conditions. Floor options and GTI-AC example TRD file modified. Spreadsheet utility updated. Created Windows Installer executable for distributing files.
2004.07.07	TRN-Resdh2. Revised Desiccant Unit Fan Power. Cleaned up minor errors.
2005.02.22	TRN-Resdh2. Changed Data Loading back end to utilize "TRN-Resdh2.exe". Added features for archiving plots and reloading data from previous runs.
2006	TRN-Resdh3. Added ability to model duct leakage, latent degradation, infiltration,. Converted building to Type 56. Added enhanced AC control options, Lennox, etc.
2008.10.04	TRN-Resdh4. Short timestep version. Added ability to consider thermostat dynamics, off-cycle evaporation, and various fan control options (including CFI).
2010.10.29	TRN-Resdh5. Changes Short-timestep version to have an HRV and allow a desiccant unit to be installed in the AC supply duct.

Installation and Operation of TRN-RESDH

Installation

TRN-Resdh is provided as zip file that should be installed in a subdirectory named "TRN-RESDH5".

Operation

Running a Simulation

Instructions for using the software are listed below. These instructions assume that you are relatively familiar with the Windows operating system, including navigating between directories and finding files with Windows Explorer.

1. Double click on ***TRN-ResDH5.exe*** to start the program. Click on "OK" when the TRNSED startup screen appears.

2. Select the building type (or *.TRD file) you would like to use. The TRD file includes commands that will be used by TRNSYS during the calculations phase as well as instructions to build the menus for the TRNSED user interface. The screen interface shown in Figure 2 appears.

3. Use the scroll bar at the right to move up and down screen. Use the pull-down menus and text boxes to review the input options for the simulation, and modify as desired. (See the next section for details of the input options and modeling details).

4. Begin the simulation by pressing <F8> or by selecting TRNSYS-Calculate from the menu bar. If you modified the model you will be asked to save the file. Select "OK" to overwrite the current .TRD file with any changes.

5. During the simulation, the online plotter will displays several variables from the simulation as it progresses (see Figure 3 below).

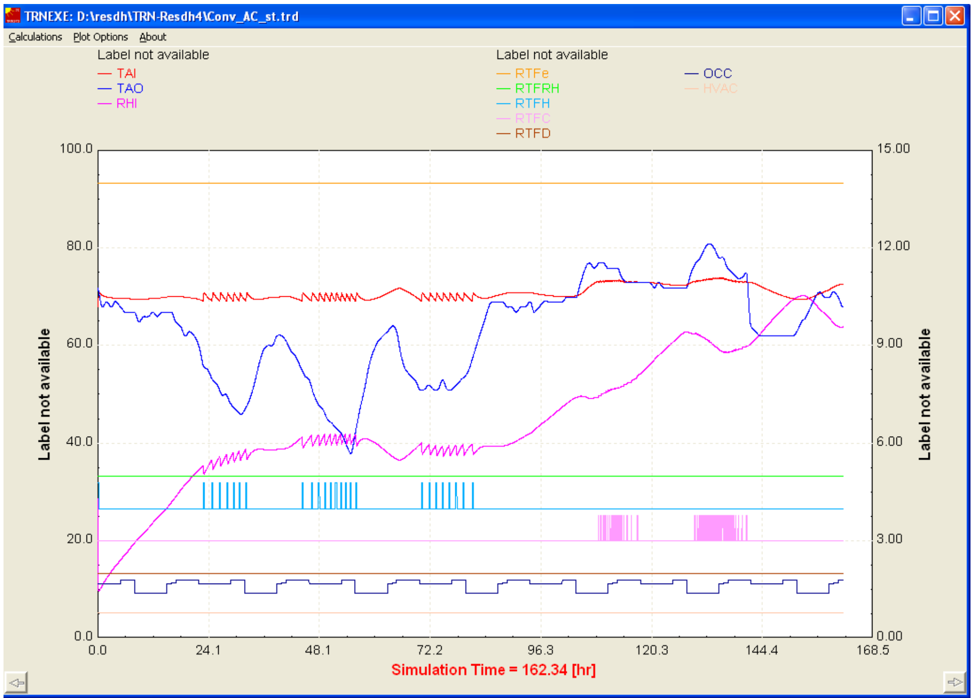


Figure 3. On-line Plotting Window for TRNSYS Simulation

6. When the simulation is finished, click "yes" to exit the online plotter. The simulation is now complete.

The hourly results from TRN-Resdh simulations are stored in several ASCII output files. These files contain hourly data for space conditions, equipment operation, and energy use as listed in Table 2 (see Appendix A for the full description).

Table 2. Output Files From TRN-RESDH Desiccant Software

File	Description	Variables
For_21.dat	Space Conditions	To Wo Ti Wi RHi OCC Msuup Tsupp Wsupp ACH
For_31.dat	AC Units	Mac Taci Waci Taco Waco Qsac Qlac RTFc RTFh Qh
For_41.dat	AC and Desiccant Misc.	RTFacf ACKW FANKW Tadp RTFdf DFANKW RTFrh Qrh RTFe Tslab_SI
For_51.dat	Desiccant	Md Tdi Wdi Tdo Wdo Qsd Qld RTFd DGAS DKW
For_71.dat	Building Loads	PEOPLE LIGHTS EQUIP INFQ INFW QCONV SCHQs SCHWg TMIN TMAX
For_81.dat	Air Flows	MAC MACMX MRET MD MD_R MDMX Qflrc Qflrr
For_91.dat	Other Data	rtf_shr C_i Cs RTFvf RTFxf KWVF KWXF ANO DNO btype KWHT RTFhf KWHF

Using the Summary Spreadsheet – Single Run Processing

We have also provided an EXCEL spreadsheet that can summarize and compare the simulation results from different runs. The The spreadsheet can also spwan multiple parametric runs. The file is named *"TRN_Resdh4.xls"*, and can be used as follows:

1. Open ***TRN_Resdh5.xls*** using Microsoft Excel. The file can be run from the TRN-Resdh "Run XLS" Menu tab. The file is located in the "TRN-Resdh5" directory.
2. Load the data from the simulation, by pressing the Load Data button on the "*Instructions*" worksheet (see Figure 4).
3. Summary data for the current run is presented on the "*Archived Annual Results*" worksheet in an annual summary.

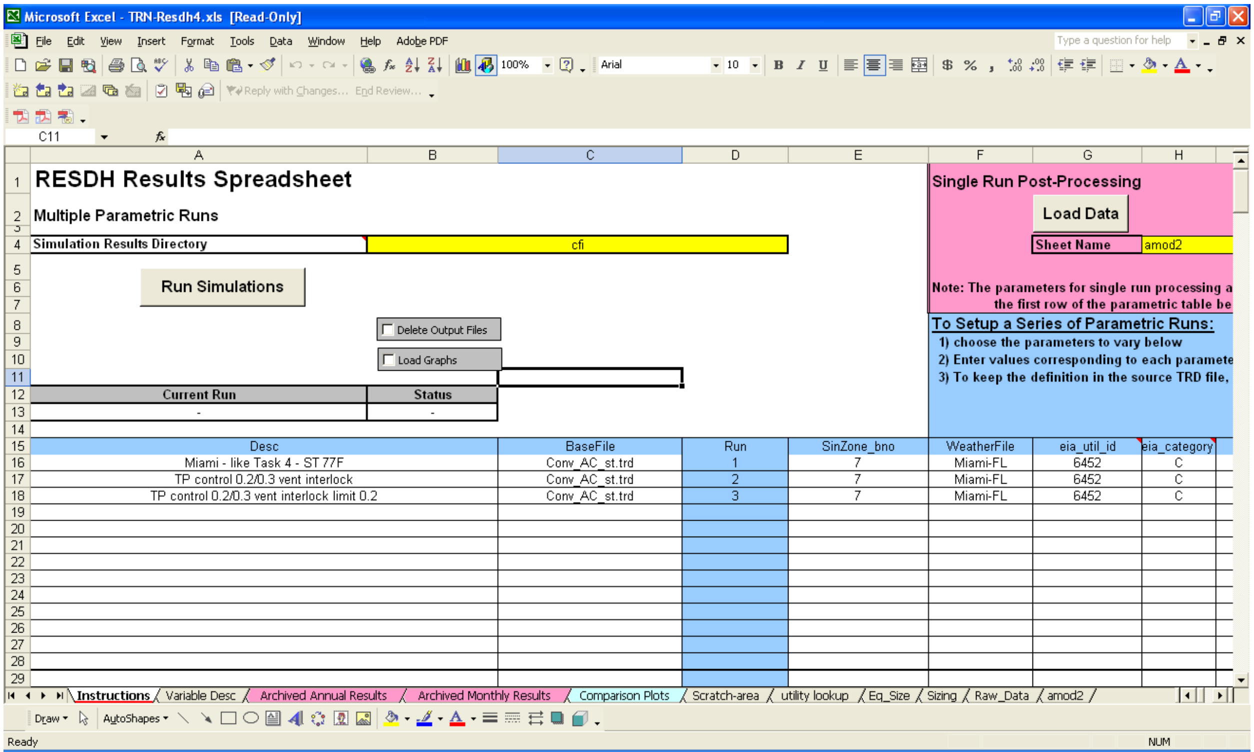


Figure 4. Screen Shot of TRN-RESDH5.XLS Spreadsheet

Using the Summary Spreadsheet – Multiple Run Processing

The spreadsheet can also spawn multiple parametric runs by specifying a base TRD file and multiple parametric changes. The TRN-RESDH.XLS spreadsheet also provides the means to define, execute and post-process results from multiple TRNSYS runs. The system includes:

1. A parametric run table (in the "*Instructions*" sheet) that defines the input parameters to vary. Each column of the table corresponds to an input parameter to change and each row defines the parameter values associated with each simulation run.
2. A control panel on the "*Instructions*" sheet that indicates where to put the results and provides other tools to manage the process.

The parametric inputs (or variables) for multiple runs is defined starting on row 15 (blue row) of the "*Instructions*" sheet (see Figure 4). The input variables, which were described for each TRNSYS menu in the sections above, are entered into row 15. The different values to be used for the variables are entered in the subsequent rows. The set of values in each row represent the set of inputs for one simulation run.

The key concept behind the multiple run system is that the program starts with a base TRD file, searches the file for the occurrence of the variable name, and then replaces the value after that variable name with the new value.

There are also several special variable names that do not occur in the TRNSYS TRD file but tell the program to do a certain operations. These are listed below in Table 3.

Table 3. Special Input Variables for Parametric Runs

Input Variable	Description	Value or Units
Desc	Descriptive text for the simulation run	any string
WeatherFile	Weather File must match label in pulldown menu for EUR or USA (and the file path for custom)	e.g., Las Vegas-NV (USA) or BE-Uccle (EUR)
eia_util_id	Utility ID for EIA rate taken from Form 826 (if less than 1 it is taken as constant electric utility rate, in $/kWh)	Valid rate ID OR 0.xx (see the f826*.csv file in "util_rates" directory)
eia_category	Utility Customer Class for EIA rate (Residential, Commercial, Industrial, Other, Total)	R, C, I, O, T
eia_state	State for EIA rate (for utilities are in multiple states)	Valid Two letter State ID
GasRate	Cost of Natural Gas in $/therm (default is 0.90/therm)	xx.xx

Other special variables include the index corresponding to each entry in the pull down menus such as:

Table 4. Special Input Variables for Parametric Runs – Corresponding to Pull-Down Menus

Input Variable	Description	Values
RES_DNO	Number of Desiccant Unit, corresponding to # in Pull-down Menu (Res_dh_units.txt)	Changes parameters DTYPE and DPAR3a through DPAR18
COM_DNO	Number of Desiccant Unit, corresponding to # in Pull-down Menu (Com_dh_units.txt)	Changes parameters DTYPE and DPAR3a through DPAR18
ANO	Number of AC Unit, corresponding to # in Pull-down Menu (AC_units.txt)	Changes AC unit performance and other characteristics
LNO	Latent Degradation characteristics, corresponds to row in pull-down Menu (LatDeg.txt)	Changes various latent degradation parameters associated with cooling coil
SINZONE_BNO	Building number corresponding to # in Pull-down Menu (Single_Zone_buildings.txt)	Changes BUI file, and other building specific characteristics
TWOZONE_BNO	Building number corresponding to # in Pull-down Menu (Two_Zone_buildings.txt)	Changes BUI file, and other building specific characteristics
ACH_TYPE	Infiltration characteristics corresponding to # in Pull-down Menu (Infiltration.txt)	Changes infiltration parameters
TNO	Thermostat characteristics corresponding to # in Pull-down Menu (Tstat.txt)	Changes thermostat parameters

The parametric table must not have blank row or columns. Entering a "-" for value causes the default value in the TRD file to be used. Expert users can also change other values in the TRD file. The only rule is that the variable should not be defining an equation (expression), but must be of the simple form:

VAR = value

General Description of Model Inputs

Many more equipment, building and control options are available than the residential options described above. This section describes the general model inputs that can be changed via the TRNSED menu. The data can be viewed and modified by using the pull-down menus and the data entry text boxes. The various tabs are shown in Figure 5, Figure 6, Figure 7 and Figure 8.

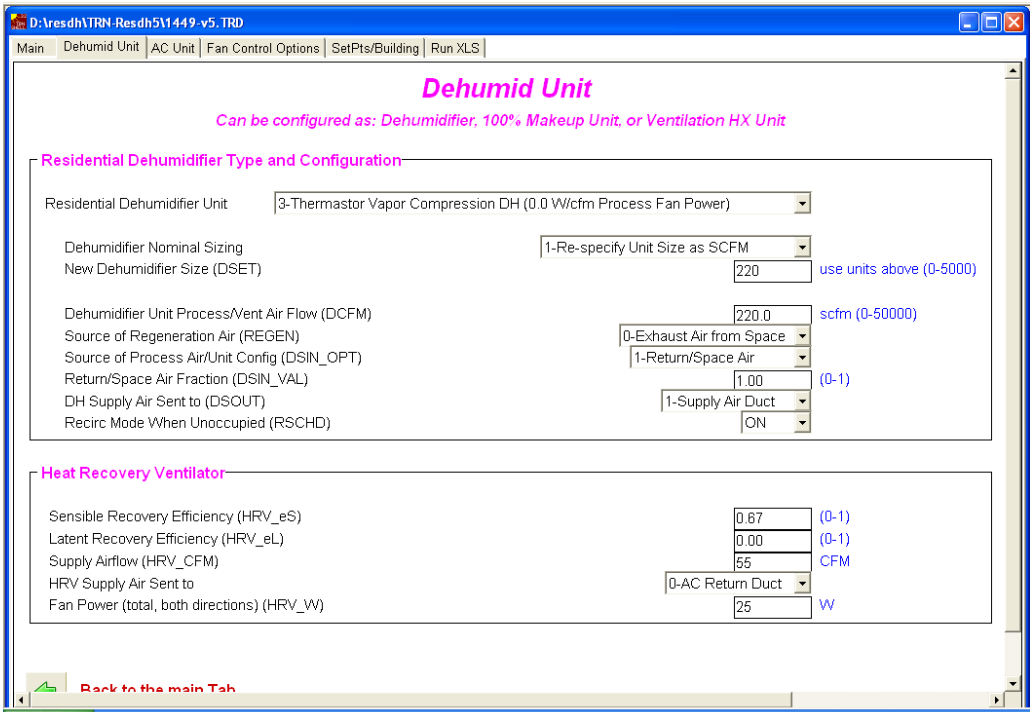


Figure 5. Dehumidification Unit Configuration

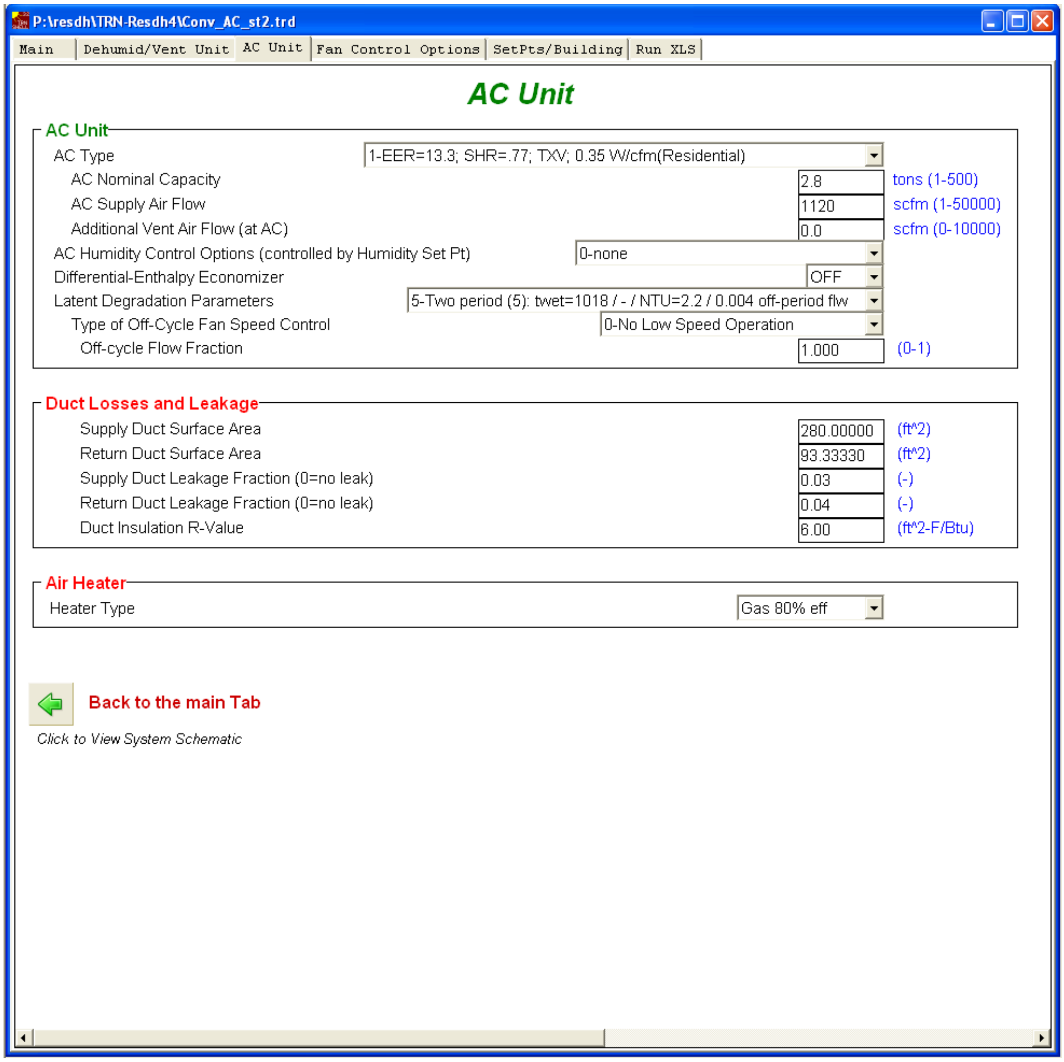


Figure 6. AC Unit Configuration

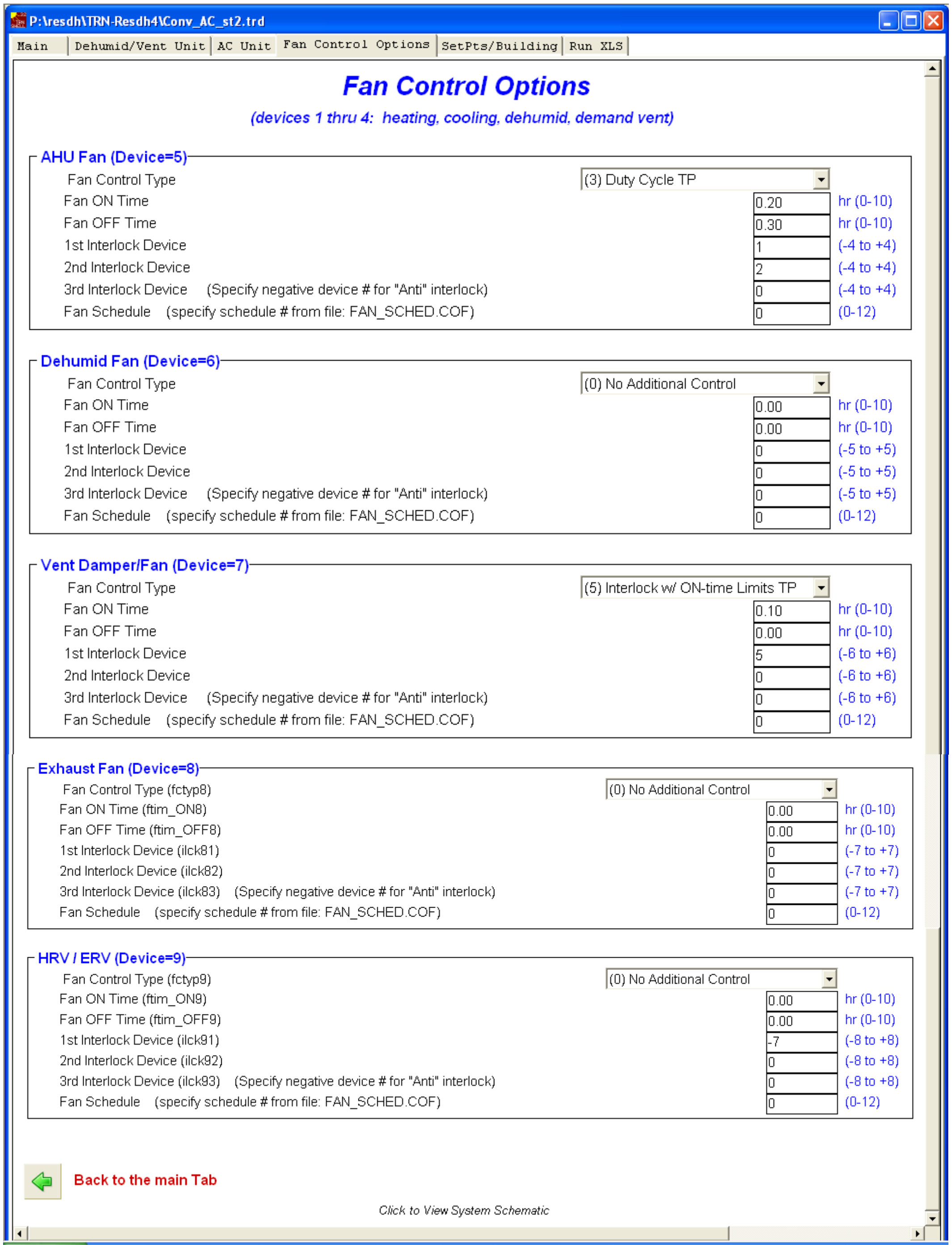


Figure 7. Fan Control Options

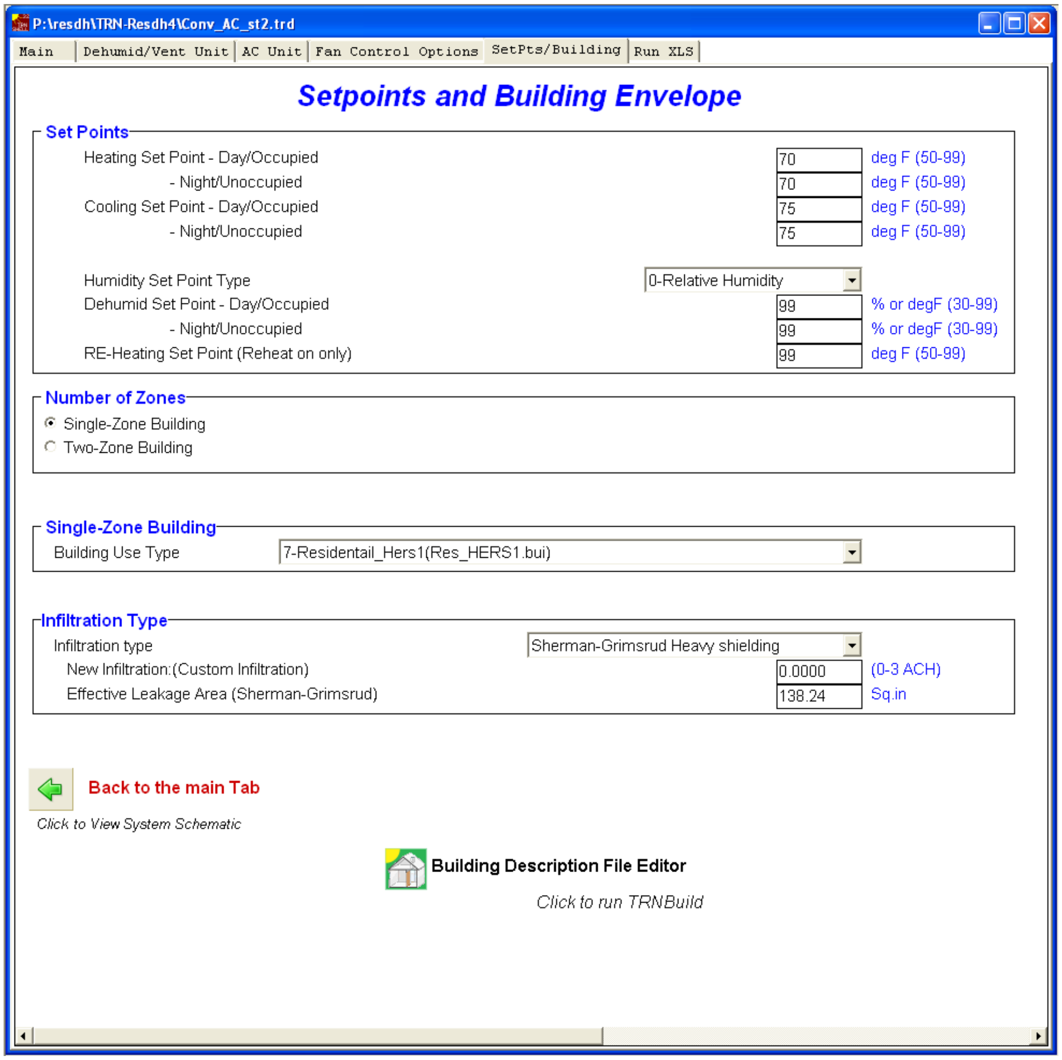


Figure 8. Building Configuration

The program is organized in various functional tabs as follows

1. Main: Climate data and layout figure
2. Dehumid Unit: Dehumid Unit specification and Configuration
3. AC Unit: AC Unit size, configuration, and operation
4. Fan Control Options: control fans and interlock with other devices
5. Building: Various setpoints, building size, configuration and operation\
6. Run XLS: Parametric run and post processing excel sheet launcher.

Comments to the right of selected text boxes (in the blue text) are included to help describe the appropriate input values (such as range and units) for each field.

Climate Data

The weather data for the simulation are selected with the ***Choose Weather Location*** pull down menu. The weather data are TMY2 weather files, which are available for 239 US locations. Ground temperatures data are from Table 4.9 in "Designing the Ground Heat Exchanger" by the National Rural Electric Cooperative Association. The table gives ground temperature data for 111 locations around the US. At locations where ground temperature data for a site was not available, an algorithm was used to select the closest match. All ground temperature variation is given by the following formula:

$$\mathbf{Tg} = \mathbf{Tga} - \tfrac{1}{2} \cdot \mathbf{Tgs} \cdot \exp(-\mathbf{Xs} \cdot (\pi/365/\alpha)^{0.5} \cdot \cos(2\pi/365 \cdot (\mathbf{day} - \mathbf{D}) - \mathbf{Xs} \cdot (\pi/365/\alpha)^{0.5})$$

where :
day - index from 1 to 365
D - the day of year for minimum ground surface temperature in °F
Tga - the mean ground surface temperature in °F
Tgs - the ground surface temperature swing through the year (max-min difference) in °F
Ταβλε 14 - the soil thermal diffusivity, assumed to be 0.6 Btu/hr-ft-°F
Xs - the soil depth in feet

Dehumidification and Ventilation Unit Configuration

Dehumidification units are Residential Dehumidifiers. The Residential models have pull-down menus for ***Unit Type*** that provides many choices for equipment.

The system parameters associated with each option are stored in the file res_des_units.txt". These values are listed in Table 5 and Table 6. The definition of each parameter is described in Table 7.

Table 5. Contents of File "Com_Des_Units.txt"

Menu Description of Desiccant Options	Option (Com_DNO)	Unit Type	Parameter #3	Parameter #4	Parameter #5	Parameter #6	Parameter #7	Parameter #8	Parameter #9	Parameter #10	Parameter #11	Parameter #12	Parameter #13	Parameter #14	Parameter #15	Parameter #16	Parameter #17	Parameter #18
1-Munters DESICalc (shx=.8;evp=.92;leak=8%;5 tons;1.2 1.1 W/cfm)	1	9	5	1.2	1.1	0.8	0.92	1	0.08	2	10.5	0.8	3.74	0	0	0	0	0
2-Munters Olathe (shx=.8;evp=.92;leak=8%;5 tons;1.2 1.1 W/cfm)	2	9	5	1.2	1.1	0.8	0.92	1	0.08	3	10.5	0.8	3.74	0	0	0	0	0
3-Munters DESICalc (w/o Sens HX & evap clr;5 tons;1.2 0.7 W/cfm)	3	9	5	1.2	0.7	0	0	1	0	2	10.5	0.8	3.74	0	0	0	0	0
4-Munters Olathe (w/o Sens HX & evap clr;5 tons;1.2 0.7 W/cfm)	4	9	5	1.2	0.7	0	0	1	0	3	10.5	0.8	3.74	0	0	0	0	0
5-Munters DESICalc (HP =.6;evp=.92;no leak;5 tons;1.2 1.1 W/cfm)	5	9	5	1.2	1.1	0.6	0.92	1	0	2	10.5	0.8	3.74	0	0	0	0	0
6-Munters Olathe (HP =.6;evp=.92;no leak;5 tons;1.2 1.1 W/cfm)	6	9	5	1.2	1.1	0.6	0.92	1	0	3	10.5	0.8	3.74	0	0	0	0	0
7-Munters DESICalc (same as #6 but supply air Setpt=65.)	7	9	5	1.2	1.1	0.6	0.92	-65	0	2	10.5	0.8	3.74	0	0	0	0	0
8-Munters DESICalc (same as #2 but NO evp)	8	9	5	1.2	1.1	0.8	0	1	0.08	2	10.5	0.8	3.74	0	0	0	0	0
9-Munters DESICalc (same as #6 but NO evp)	9	9	5	1.2	1.1	0.6	0	1	0	2	10.5	0.8	3.74	0	0	0	0	0
~~10-Enthalpy Wheel (eff=0.85; each fan=0.3 W/cfm)~~	~~10~~	~~5~~	~~0.85~~	~~0.3~~	~~0.3~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0.92~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~
11-Addison 100% Fresh Air Unit	11	7	0	0	0	0	0	0	0	0	0	0	34.1	0	0	0	0	0
12-Drykor UDT 7.5 (1750-2500 cfm; Vent Bypass; 0.6 W/cfm when ON)	12	10	1	0	0.6	0	0	0	0	0	0	0	1.82	0	0	0	0	0
13-Munters Waltham (no shx;no evp; no post cooling;1.3 & 0 W/cfm)	13	9	0	0	5.2	0	0	0	0	2	0	0	3.74	0	0	0	0	0
14-Two Drykor UDT 7.5 Units (3500-5000 cfm; Vent Byp; 0.6 W/cfm ON)	14	10	2	0	0.6	0	0	0	0	0	0	0	1.82	0	0	0	0	0
15-Three Drykor UDT 7.5 Unts (5250-7500 cfm; Vnt Byp; 0.6 W/cfm ON)	15	10	3	0	0.6	0	0	0	0	0	0	0	1.82	0	0	0	0	0
16-Drykor UDT 7.5 (1750-2500 cfm; 0.6 W/cfm Process Fan Power)	16	10	1	0.6	0	0	0	0	0	0	0	0	1.82	0	0	0	0	0
17-Two Semco REV-4500 Units (DX always Operates w/ Whl)	17	13	25	0.35	0.3	2	0.575	1	185	3	10.5	0.77	0	0	0	0	0	0
18-Two Semco REV-4500 Units (DX Operates w/ whl when TAO > 72)	18	13	25	0.35	0.3	2	0.575	72	185	3	10.5	0.77	0	0	0	0	0	0
19-Two Semco REV-4500 Units (DX controlled for TAS = 60)	19	13	25	0.35	0.3	2	0.575	-60	185	3	10.5	0.77	0	0	0	0	0	0
20-Two Semco REV-4500 Units (VS / TAS = 60)	20	13	25	0.35	0.3	2	0.575	-60	185	3	10.5	-0.77	0	0	0	0	0	0
21-Two Semco REV-4500 Units (VS / TAS = 60 / des whl modulates)	21	13	25	0.35	0.3	2	0.575	-60	185	3	-10.5	-0.77	0.01	0.014	0	0	0	0

Menu Description of Desiccant Options	Option (Com_DNO)	Unit Type	Parameter #3	Parameter #4	Parameter #5	Parameter #6	Parameter #7	Parameter #8	Parameter #9	Parameter #10	Parameter #11	Parameter #12	Parameter #13	Parameter #14	Parameter #15	Parameter #16	Parameter #17	Parameter #18
22-MAKEUP AIR UNIT (60-tons/10.5-EER/0.77;TCL_min=42;TAS=65;1-stg)	22	14	60	0.35	0	0	0	65	42	1	10.5	0.77	45	3	0	0	0	0
23-MAKEUP AIR UNIT (90-tons/10.5-EER/0.77;TCL_min=42;TAS=60;1-stg)	23	14	90	0.35	0	0	0	60	42	1	10.5	0.77	45	3	0	0	0	0
24-Munters HCU (HCUb-2008/5 Units/stgs 1&2 = 50&60F/ 0.35 W/cfm)	24	15	2	0.35	5	50	60	0	0	0	0	0	3.74	0	0	0	0	0
25-Munters HCU (HCUb-2008/5 Units/stgs 1&2 = 50&70F/ 0.35 W/cfm)	25	15	2	0.35	5	50	70	0	0	0	0	0	3.74	0	0	0	0	0
26-MAKEUP AIR (same as 23; with New Latent tw=1018/tp=544/NTU=2.2)	26	14	90	0.35	2	1018	544	60	42	1	10.5	0.77	45	3	2.2	0	0	0
27-One Semco REV-3000 0.65W/cfm (VS/TAS=60 / des whl modulates)	27	13	14	0.65	0.3	1	0.83	-60	210	2	-10.5	-0.77	0.008	0.02	15	40	80	1
28-MAKEUP AIR UNIT (15-tons/10-EER/0.77;TCL_min=42;TAS=60;1-stg)	28	14	15	0.65	0	0	0	60	42	1	10	0.77	45	3	0	0	0	0
29-Munters HCU (HCUb-1004/0.2 Unit/stgs 1 = 50&70F/ 0.35 W/cfm)	29	15	1	0.35	0.2	50	70	0	0	0	0	0	3.74	0	0	0	0	0

Notes: The shaded regions show the relevant data for each ***Unit Type***

Table 6. Contents of File "Res_DH_Units.txt"

Menu Description of Desiccant Options	Option (RES_DNO)	Unit Type	Parameter #3	Parameter #4	Parameter #5	Parameter #6	Parameter #7	Parameter #8	Parameter #9	Parameter #10	Parameter #11	Parameter #12	Parameter #13	Parameter #14	Parameter #15	Parameter #16	Parameter #17	Parameter #18
1-Conventional DH EF=1.3 (0.0 W/cfm Process Fan Power)	1	11	220	0	0	0	0	0	0	5	0	0	1.46	0	0	0	0	0
2-Heatcraft Desiccant DH (0.0 W/cfm PFan Pwr; 2.05 W/cfm Unit)	2	12	220	0	2.05	0	0	0	0	1	0	0	3.08	0	0	0	0	0
3-Thermastor Vapor Compression DH (0.0 W/cfm Process Fan Power)	3	11	220	0	0	0	0	0	0	2	0	0	1.93	0	0	0	0	0
4-Desiccant DH w/Balanced HX (0.0 W/cfm ProcFan; 2.35 W/cfm Unit)	4	12	220	0	2.35	0	0	0	0	2	0	0	3.11	0	0	0	0	0
5-Desiccant DH w/UNBalanced HX(0.0 W/cfm ProcFan; 2.25 W/cfm Unit)	5	12	220	0	2.25	0	0	0	0	3	0	0	3.11	0	0	0	0	0
6-Conventional DH (0.3 W/cfm Process Fan Power)	6	11	220	0.3	0	0	0	0	0	1	0	0	1.46	0	0	0	0	0
7-Rudd ACDM 958 cfm / Q=11.5 Mbtuh (operates w/ AC is off; 0.35 W/cfm)	7	11	958	0.35	0	0	0	0	1	3	0	0	1.46	0	0	0	0	0
8-Rudd ACDM 958 cfm / Q=23 Mbtuh (operates w/ AC is off; 0.35 W/cfm)	8	11	958	0.35	0	0	0	0	1	4	0	0	1.46	0	0	0	0	0
9-MAU-RHT(0.2-ton/10.5-EER/0.77;TCL_min=42;98% RHT;1-stg;0.7 W/CFM)	9	14	0.2	0.7	0	0	0	0.98	42	1	10.5	0.77	45	3	0	0	0	0

Menu Description of Desiccant Options	Option (RES_DNO)	Unit Type	Parameter #3	Parameter #4	Parameter #5	Parameter #6	Parameter #7	Parameter #8	Parameter #9	Parameter #10	Parameter #11	Parameter #12	Parameter #13	Parameter #14	Parameter #15	Parameter #16	Parameter #17	Parameter #18
10-MAU-RHT (same as 7;with New Latent tw=1018/tp=544/NTU=2.2;0.7 W/CFM)	10	14	0.2	0.7	2	1018	544	0.98	42	1	10.5	0.77	45	3	2.2	0	0	0
11-MAU-RHT(0.3-ton/10.5-EER/0.77;TCL_min=42;98% RHT;1-stg;0.7 W/CFM)	11	14	0.3	0.7	0	0	0	0.98	42	1	10.5	0.77	45	3	0	0	0	0
~~12-Enthalpy Wheel (eff=0.85; each fan=0.3 W/cfm)~~	~~12~~	~~5~~	~~0.85~~	~~0.3~~	~~0.3~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0.92~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~
13-Munters HCU (HCUb-1004/0.2 Unit/stgs 1 = 50&70F/ 0.35 W/cfm)	13	15	1	0.35	0.2	50	70	0	0	0	0	0	3.74	0	0	0	0	0
~~14-Poor Enthalpy Wheel (eff=0.75; each fan=0.5 W/cfm)~~	~~14~~	~~5~~	~~0.75~~	~~0.5~~	~~0.5~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0.92~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~
15-NovelAire Electric Unit (300 cfm; 0.7 W/cfm)	15	16	1	0.7	1	0	0	0	0	0	0	0	3.74	0	0	0	0	0
16-NovelAire Gas-Firect Unit (400 cfm; 0.6 W/cfm)	16	16	2	0.6	1	0	0	0	0	0	0	0	3.74	0	0	0	0	0

Notes: The shaded regions show the relevant data for each ***Unit Type***

Table 7. Dehumidifier/Ventilation Unit Types, Based on Unit Type (parameter "Unit Type")

Unit Type	Unit Type Description	Param #	Other Parameters Used to Define System
0	None (Unit acts as an empty or null box)	#3	Ventilation Fan power (w/cfm)
~~5~~	~~Enthalpy Wheel~~	~~#3~~ ~~#4~~ ~~#5~~ ~~#13~~	~~Wheel efficiency (-)~~ ~~Process fan power (w/cfm)~~ ~~Exhaust fan power (w/cfm)~~ ~~Moisture Removal Sizing (lb/h per 100 scfm)~~
7	Addison 100% Fresh Air Unit	#13	Moisture Removal Sizing (lb/h per 100 scfm)
9	Munters	#3 #4 #5 #6 #7 #8 #9 #10 #11 #12 #13	Rated post cooling coil capacity (tons) Process fan power (w/cfm) Regen fan/other power – cycles with dehumid (w/cfm) SHX efficiency (-) Regen evap cooler efficiency (-) Post cooling set point (F), 1= cycle ON and OFF with des wheel, -xx = operate to maintain supply air set point at abs(xx), xx = operate when ambient above xx SHX leakage rate (-) Des wheel type (2=DesiCalc or 3=Olathe Meas Data) Rated EER of post cooling (Btu/Wh) Rated SHR of post cooling (-) Moisture Removal Sizing (lb/h per 100 scfm)
10	Drykor UDT 7.5	#3 #4 #5	No of nominal 7.5 ton units (#) Unit supply air fan (w/cfm) Additional fan power that cycles ON & OFF w/ unit (W/cfm)

Unit Type	Unit Type Description	Param #	Other Parameters Used to Define System
		#13	Moisture Removal Sizing (lb/h per 100 scfm)
11	Residential Electric Dehumidifier	#3 #4 #10 #13	Nominal unit Airflow (cfm) Process Fan Power (W/cfm) – cycles with Des fan Dehumidifer type (1=Conventional or 2=Thermastor Vapor Compression DH). Coefs from ResDH.COF. Moisture Removal Sizing (lb/h per 100 scfm)
12	Residential Desiccant Dehumidifier	#3 #4 #5 #10 #13	Nominal unit Airflow (cfm) Process Fan Power (W/cfm) – cycles with Des fan Des Unit Fan Power (W/cfm) – cycles with Des unit Des DH type (1=Heatcraft Des DH, 2=Des DH with Balanced HX, 3=Des DH with Unbalanced HX) Coefs from DesDH.COF Moisture Removal Sizing (lb/h per 100 scfm)
13	Semco	#3 #4 #5 #6 #7 #8 #9 #10 #11 #12 #13 #14 #15 #16 #17 #18	Rated post cooling coil capacity (tons) Process fan power (w/cfm) Regen fan/other power – cycles with dehumid (w/cfm) Number of nominal units (#) Fraction of Flow that Bypasses Desiccant Wheel Post cooling set point (F), 1= cycle ON and OFF with des wheel, -xx = operate to maintain supply air set point at abs(xx), xx = operate when ambient above xx Regeneration Temperature (F) Desiccant Wheel Type, 1=REV-2250, 2=REV-3000, 3=REV-4500, 4=REV-6000 Rated EER of post cooling (Btu/Wh) Rated SHR of post cooling (-) Humidity Setpoint 1 (lbs/lbs): Ratio where Wheel is Fully Off Humidity Setpoint 2 (lbs/lbs): Ratio where Wheel is Fully On Temperature Difference (F) for Supply Temperature Reset Schedule Temperature Setpoint 1 (F): Temperature Supply Temperature is at Maximum Temperature Setpoint 2 (F): Temperature Supply Temperature is at Minimum Reset Control: 0=Process Inlet, 1=Regen Inlet

Unit Type	Unit Type Description	Param #	Other Parameters Used to Define System
14	Makeup Air unit	#3 #4 #5 #6 #7 #8 #9 #10 #11 #12 #13 #14 #15 #16 #17 #18	Rated tons Process Fan Power (W/cfm) – cycles with Des fan Latent Degradation model (2- adjust SHR with linear decay 0- No decay) t_{wet} Nominal time after cooling startup when the condensate begins to drain from the pan in cooling coil (seconds). γ The ratio of initial off cycle evaporation rate and steady state latent removal capacity. Reheat control mode Staging and HGB set pt (F) Number of stages Rated EER of the cooling coil Rated SHR of the cooling coil Latent time constant of the cooling coil (Seconds) Maximum cycling rate (Cycles/h) Nominal NTUo of the cooling coil Toff ' (sec) tp' (sec) NTUo'
15	Munters HCU	#3 #4 #5 #6 #7	Model Number: 1=1004, 2=2008, 3=2010, 4=3012, 5=4016, 6=4020, 7=6036, 8=8040 Process Fan Power (W/cfm) – cycles with Des fan Number of nominal units (#) Stage 1 Temperature Setpoint (F) Stage 2 Temperature Setpoint (F)
16	NovelAire Desiccant Units	#3 #4 #5	Unit Type: 1=300 series electric (300 cfm) 2= 400 series gas-fired (400 cfm) Process Fan Power (W/cfm) – cycles with Des fan Number of nominal units (#)

Table 8. Coefficients Describing Desiccant Performance (DesDH.COF) Used for Unit Type=10

```
3
Four functions:  ** HA, btuh/100 cfm ** CAP, (lb/hr)/100 cfm **  Gas, btuh/100 cfm  **  ELEC, watts/100 cfm
1 --------------------  Heatcraft Desiccant DH
-847.020,  28.512,  7796.892,  -4128.123,
-2.452,  0.033,  6.837,  -3.349
6947,      0,      0,      0
205.,      0,      0,      0
65., 85.,  0.35,  0.75
2 --------------------  Desiccant DH with Balanced HX
6739.020,  -80.674,  1564.124,  -828.813
-2.447,  0.033,  6.903,  -3.412
9459.287,  -36.145,  -2058.244,  1084.371
112.,      0,      0,      0
65., 85.,  0.35,  0.75
3 --------------------  Desiccant DH with Unbalanced HX
1737.252,  -8.699,  5676.060,  -3006.515
-2.447,  0.033,  6.903,  -3.412
9819.915,  -41.346,  -2352.278,  1242.245
102.,      0,      0,      0
65., 85.,  0.35,  0.75
```

Table 9. Coefficients Describing Dehumidifier Performance (ResDH.COF) Used for Unit Type=11

```
5
Three functions:  ** HA, btuh/100 cfm ** CAP, (lb/hr)/100 cfm **  ELEC, watts/100 cfm
1 --------  Conventional Dehumidifier
-3469.731, 57.751, 3792.200, 0
-2.731, 0.028, 3.246, 0
-188.582, 8.313, 124.200, 0
65., 85.,  0.35,  0.75
2 -------- Thermostor Dehumidifier with HX (Dec03)
-4290.087, 57.325, 5750.920, -1954.281
-0.128, 0.033, -7.841, 11.437
227.060,5.082,-1476.787, 1652.8130
65., 85.,  0.35,  0.75
3 -------- BSC ACDM (Std Q to Ambient 11.5 Mbtu/h)
-5312.5, 37.612, 6163.4, -1582.
-3.4152, 0.023412, 5.1998, -1.2863
-71.316, 3.2036, 127.23, -23.41
65., 85.,  0.35,  0.75
4 -------- BSC ACDM (Addl Q to Ambient 23 Mbtu/h)
-6497.1, 37.746, 6151.6, -1565.2
-3.4673, 0.02377,  5.2633, -1.3294
-64.552, 3.1484,  118.01, -17.2
65., 85.,  0.35,  0.75
5 --------  Conv DH (EF=1.3 P=92.3% QH=98.0%)
-3399.49, 56.5820, 3715.43, 0
-2.731, 0.028, 3.246, 0
-174.076, 7.67354, 114.646, 0
65., 85.,  0.35,  0.75
```

The other seven inputs in the dehumidifier section of the input screen are described below.

- ***Dehumidifier Nominal Sizing***. This input defines the type of sizing parameter used for the selected unit. Typically, commercial units are sized by Airflow (scfm) and residential units by moisture removal (pints/day). Parameter #13 allows for specification of either value.

- ***New Dehumidifier Size*** (scfm or pints/day). This input defines the rate of air flow or moisture removal across the coil, depending on the ***Dehumidifier Nominal Sizing***. If "Use Default Unit Size" is selected, the nominal sizing listed in Table 5 is used regardless of the entry in this field.

- ***Dehumidifier Unit Process/Vent Air Flow.*** This is the actual airflow through the unit. In most cases, this should be set to the same value as the Nominal CFM (either in the selected unit description or specified by ***New Dehumidifier Size***). Setting a different value will simulate a unit that is not operating at its rated airflow specification.

- ***Source of Regeneration Air.*** Regeneration air can be drawn either from outside or from the space.

- ***Source of Process Air/Unit Config.*** Process air (i.e., the air that is dried by the desiccant) can be drawn either from the outside (Outdoor=0) or from the conditioned space (Return/Space,1,2). Added new option for dehumidifier unit to pull from AC supply duct (=3).

- ***Return/Space Air Fraction.*** Return air fraction of total airflow through the dehumidifier/desiccant unit.

- ***DH Supply Sent to.*** Process air from the dehumidifier unit can be delivered to the conditioned space in parallel with the AC unit (=0) or it can be put into the Supply duct (=1). **The options for air into the return of the AC has been removed**. If air is supplied into the supply duct, it impacts duct losses.

- ***Recirc Mode When Unoccupied.*** Selecting "ON" for this option lets the desiccant unit draw air from the space (rather than from outside air) during unoccupied hours. This is useful for desiccant-based ventilation pretreatment systems that may require dehumidification during the unoccupied period when ventilation is not required.

[NOT in SHORT TIMESTEP VERSION]

- ***Process Fan Control Method***. There are four control options for the desiccant unit process fan:
  - The "Continuous DH Fan Operation" mode causes the process fan to run continuously, regardless of whether the building is occupied. This mode is required when the unit provides 24-hour ventilation.
  - The "DH Fan Cycles with Dehumidifier" mode sets the fan to cycle based on the call for moisture removal (i.e., the DH supply/process fan is in the AUTO mode).
  - The "Constant Fan (Day/Occ); Cycles (Night/Unocc)" mode runs the supply/process fan constantly during the occupied (or daytime) period but cycles on and off with a call for dehumidification at night. This mode is useful when ventilation is required during the day, but continuous fan operation would be unnecessary at night.
  - The "DH Fan Same as AC Supply Fan" mode locks the desiccant fan to operate together with the AC supply fan. The fans are synched up in this case, and both operate together based on the call for heating, cooling, or dehumidification.

An HRV or ERV component has now been added separately from the dehumidifier unit. The heat exchanger built into the Dehumidifer unit should no longer be used. The inputs for the HRV/ERV are:

- ***Sensible Recovery Efficiency.*** The heat recovery efficiency expressed as fraction between 0 and one (assuming balanced flow).

- ***Latent Recovery Efficiency.*** The moisture recovery efficiency expressed as fraction between 0 and one (assuming balanced flow).

- ***Supply Airflow.*** The ventilation airflow through the HRV (assuming balanced flow).

- ***HRV Supply Air Sent to.*** The air provided by the HRV can be provided to the AC return duct (=0), to the Supply Duct (=1) and to the Space (=2). If the air flow is to supply duct, then it impacts the duct losses.

- ***Fan Power (total Both Directions.*** The power used to provide airflow on both the supply and exhaust sides of the unit, in Watts.

AC Unit

The ***AC Type*** pull-down menu currently includes several different AC units. The parameters that define the units are stored in file "AC_Units.txt" and listed in Table 10.

Table 10. AC Unit Parameters (from "AC_Units.txt")

Menu Description	Option No (ANO)	AC Type	Nominal EER (Bru/Wh)	Nominal SHR (-)	Supply Fan Power (w/cfm)	Charge ratio	Expansion device type	Number of Rows or depth (in)	Heat Pipe Area (ft^2)	Heat Pipe/Des Wheel Type
1-EER=13.3; SHR=.77; TXV; 0.35 W/cfm(Residential)	1	4	13.3	0.77	0.35	1	2	0	0	0
2-EER=10; SHR=.77; Orifice; 0.35 W/cfm	2	4	10	0.77	0.35	1	1	0	0	0
3-EER=10; SHR=.77; Orifice; 0.35 W/cfm; 80% charge	3	4	10	0.77	0.35	0.8	1	0	0	0
4-Cinemark RTU Units (meas fan = 0.375 W/cfm)	4	4	10	0.77	0.375	1	2	0	0	0
5-EER=10; SHR=.77; TXV; 0.5 W/cfm (Commercial RTU)	5	4	10	0.77	0.5	1	2	0	0	0
6-EER=10; SHR=.6; TXV; 0.5 W/cfm (Commercial RTU)	6	4	10	0.6	0.5	1	2	0	0	0
7-EER=13.3;SHR=.77;TXV;0.4 W/cfm;(HP row-2;area-3 ft2;ihp-1)	7	4	13.3	0.77	0.4	1	2	2	3	1
8-EER=13.3;SHR=.77;TXV;0.45 W/cfm;(HP row-2;area=tons;ihp-1)	8	4	13.3	0.77	0.45	1	2	2	-1	1
9-EER=13.3;SHR=.77;TXV;0.45 W/cfm;(GRI-CDQ ;area=tons;4-inch)	9	4	13.3	0.77	0.45	1	2	4	-1	-1
10-EER=13.3;SHR=.77;TXV;0.4 W/cfm;(GRI-CDQ ;area=tons;2-inch)	10	4	13.3	0.77	0.4	1	2	2	-1	-1
11-EER=13.3;SHR=.77;TXV;0.4 W/cfm;(Kosar-CDQ ;area=tons)	11	4	13.3	0.77	0.4	1	2	0	-1	-2
12-EER=14.9; SHR=.77; TXV; 0.365 W/cfm (Residential-RICE)	12	4	14.9	0.77	0.365	1	2	0	0	0
13-EER=14.9; SHR=.77; TXV; 0.183 W/cfm (Residential-RICE)	13	4	14.9	0.77	0.183	1	2	0	0	0
14-EER=15.7; SHR=.77; TXV; 0.183 W/cfm (Residential-RICE)	14	4	15.7	0.77	0.183	1	2	0	0	0
15-EER=16.1; SHR=.77; 0.350 W/cfm (14 SEER Robust)	15	4	16.1	0.77	0.35	1	2	0	0	0

AC Type (4 = DOE_AC, from ASHRAE Secondary Toolkit and EnergyPlus)
Nominal EER of AC at design conditions
Nominal SHR of AC coil (gross) at design conditions
Fan power for AC supply fan (W/cfm)
Charge ratio (1 = 100% or normal charge) Applies a adjustment correlation
Expansion device type (2=TXV, 1=Orifice)
Number or heat pipe rows (or CDQ desiccant wheel depth in inches)
Heat Pipe or Desiccant Wheel Area (each side) in ft^2 (If area < 0 then area = tons)
Heat Pipe (or CDQ type) 1=QDT 8fpi, 2=11 fpi, 3=14fpi, 4=IEC,
-1 = CDQ desiccant wheel per GRI theoretical calcs, -2 = CDQ wheel per Kosar/UIC calcs

The type of air conditioner used on the analysis can also be changed by using different sets of coefficients in the DOE_AC routine (the cooling coil performance map). The file DOE_AC.COF has different Coefficients for different types of AC units. The different options are summarized in the table below. The variable (AC_coef) in the TRD file specifies which set of curves are used.

Table 11. Coefficients Describing the AC Performance Map (DOE_AC.COF)

```
1---------- Original Coefficients
0.418934,-0.00617,0.017421,0,0,0
0.69717199,0.39555,-0.092727
0.282094,0.01167,-0.005832,0,0,0
1.13318,-0.13318,0
2---------- Scroll & TXV
3.276375e-001,  4.820102e-003, -1.127253e-002, -1.178607e-005,  2.651726e-004,-
7.631127e-005,  9.167621e-001, -2.672046e-001, -1.839317e-003, -1.563391e-003
1.,0,0
1.322635e+000,  4.025092e-004,  1.110312e-003,  1.572205e-004, -4.099653e-005,-
1.984337e-004, -1.194344e+000,  3.525346e-001, -2.829006e-003,  1.053955e-002
1.,0,0
3----------- Scroll & Orifice
-8.367789e-001, -2.521029e-003,  3.087349e-002, -2.915081e-005, -1.118899e-
004,5.780102e-005,  1.269519e+000, -3.410001e-001,  2.761531e-004, -8.237261e-003
1.,0,0
1.625048e+000, -8.838663e-005, -1.497481e-002,  1.810974e-004,  1.519203e-004,-
2.535067e-004, -8.786223e-001,  2.835170e-001, -3.939392e-003,  9.747892e-003
1.,0,0
4---------- Recip & TXV
3.507089e-001,  4.880188e-003, -1.286202e-002, -8.296431e-006,  3.049492e-004,-
1.028969e-004,  1.023151e+000, -2.882429e-001, -2.674387e-003, -1.123695e-003
1.,0,0
1.148801e+000,  4.702406e-003, -1.755892e-003,  7.662355e-005, -6.422994e-005,-
8.592802e-005, -1.062768e+000,  2.849563e-001, -8.721605e-004,  7.907555e-003
1.,0,0
5---------- Recip & Orifice
-5.584461e-001, -5.179558e-003,  2.664282e-002, -3.677480e-005, -1.023506e-
004,9.957806e-005,  1.352569e+000, -3.487940e-001,  3.369859e-004, -9.218611e-003
1.,0,0
1.047923e+000,  6.912827e-003, -8.288450e-003,  1.044881e-004,  8.086381e-005,-
1.887510e-004, -7.945050e-001,  2.223765e-001, -2.624555e-003,  8.503491e-003
1.,0,0
```

Table 12 Latent degradation parameters (from LatDeg.txt)

	Option (LNO)	Lat Parameter - Twet (sec)	Lat Parameter - Gamma (-)	Lat Parameter – NTUo	Off-period flow fractionF_off	Latent Degradation Type
1-Old (1): twet=1018 / gam=1.66	1	1018	1.66	0	0	1
2-New (2): twet=1018 / - / NTU=2.2	2	1018	0	2.2	0	2
3-New (3): twet=1018 / - / NTU=2.2 / draindown = n (in AC tab)	3	1018	0	2.2	0	3
4-New (4): twet=1018 / - / NTU=2.2 / overrun = n (in AC tab)	4	1018	0	2.2	0	4
5-Two period (5): twet=1018 / - / NTU=2.2 / 0.004 off-period flw	5	1018	0	2.2	0.004	5
6-No Latent Degradation	6	0	0	0	0	0

The other six inputs for the AC input screen are described below.

- ***AC Nominal Capacity*** (tons). The nominal unit capacity at design conditions.
- ***AC Supply Air Flow*** (scfm). The supply air flow through the AC coil. (the flow through the heat section and to the building could also include any desiccant air flow that bypasses the desiccant unit, see Figure 1).
- ***Additional Vent Air Flow (at AC)*** (scfm). Additional fresh air that enters the AC but does not come through the desiccant unit (see Figure 1). This value is useful in applications without ventilation air pretreatment.
- ***AC Humidity Control Options***. Includes several options for controlling humidity with the air conditioner:
    - ***Condenser reheat***. The AC is held ON to meet the ***Dehumid Set Points*** specified below. The ***RE-Heating Set Point*** is maintained by a separate reheat coil.
    - ***Carrier Thermidistat***. The cooling setpoint is reset downwards as the space humidity increases above the dehumidification set point. The reset limit is 3°F.
    - ***Carrier Super-Thermidistat***. The cooling set point is reset AND the supply fan drops to 80% of full flow was the space humidity exceeds the dehumidification set point.
    - ***Low Supply Air Flow***. The supply airflow drops to 80% of the full flow when the space humidity exceeds the dehumidification set point.
    - ***Lennox Humiditrol w/ 2°F Overcooling***. The AC unit "changes state" when space humidity set point is exceeded and the space temperature drops below the cooling set

point (overcooling occurs). The performance map becomes the Lennox Humiditrol unit when has two possible dehumidification states. The space can only be overcooled by 2°F.
- ***Lennox Humiditrol w/ 4°F Overcooling***. Same as above except space can be overcooled by 4°F.

- ***Differential-Enthalpy Economizer.*** If selected, the economizer pulls the return air flow (see Figure 1) from outdoors when the ambient enthalpy is lower than the return enthalpy and the space temperature is greater than the cooling set point – 0.2°F. The economizer is either on or off for the entire hour (i.e. no fractional runtimes).

- ***Type of Off-Cycle Fan Speed Control***. The speed of the AC supply fan can be reduced during the compressor off-cycle:

  - ***No Low Speed Operation***
  - ***Low (reduced) Speed for supply flow only***
  - ***Low (reduced) Speed for supply flow <u>and</u> ventilation flow***

- ***Off-Cycle Flow Fraction.*** Reduction in flow used above

[NOT in SHORT TIMESTEP VERSION]

- ***Supply Fan Control Method***. There are three control options for the main supply fan:
  - The "Continuous AC Fan Operation" mode causes the supply fan to run continuously, regardless of whether the building is occupied. This mode is required when the unit provides 24-hour ventilation.
  - The "AC Fan Cycles with Compressor" mode sets the fan to cycle based on the call for heating or cooling. This mode applies when the AC supply fan is in the AUTO mode.
  - The "Constant Fan (Day/Occ); Cycles (Day/Unocc)" mode runs the supply fan constantly during the occupied period but cycles on and off with heating or cooling is required at night. This mode is useful when ventilation is required during the day, but continuous fan operation would be unnecessary at night.

- ***Supply Duct Surface Area*** (ft^2). Surface area of supply ducts exposed to attic zone. Used to find conductance losses.

- ***Return Duct Surface Area*** (ft^2). Surface area of return ducts exposed to attic zone. Used to find conductance losses.

- ***Supply Duct Leakage Fraction*** (-). Fraction of supply duct flow discharged into attic zone. Zero equals no leakage. Leak is assumed to occur at duct outlet (after conduction losses).

- ***Return Duct Leakage Fraction*** (-). Fraction of return duct flow pulled from attic zone. Zero equals no leakage. Leak is assumed to occur at AC unit inlet (after conduction losses).

- ***Duct Insulation R-Value*** (ft^2-h/Btu). R-value for duct insulation on supply and return ducts.

- ***Heater Type.*** Either electric or gas furnace

.
- ***Heating Mode Supply Flow*** (cfm). The supply air flow is used when the heater is on.
- ***Heating Mode Supply Fan Power*** (W/cfm). Power consumed by supply fan in the heating mode.
- ***Heater Input Rating*** (Btu/h). Nominal Fuel Input to Heater.

The table below summarizes the options available for thermostat controls. Thermostat dynamics are only applied to the cooling mode. The temperature deadband is used for both heating and cooling.

Table 13 Thermostat parameters (from Tstat.txt)

	Option (TNO)	Temperature Deadband (°F)	Anticipator Gain (°F)	Anticipator Time Const (sec)	Sensing element Time Const (sec)	Humidity Deadband (% or °F)	CO2 Conc. Dead Band (ppm)
No Dynamics Deadbands: 2.0°F / 3% RH / 5 ppm	1	2.0	0	0	0	3.0	5.0
No Dynamics Deadbands: 1.5°F / 3% RH / 5 ppm	2	1.5	0	0	0	3.0	5.0
Tstat w/Antic (Nmax~2.5) Deadbands: 1.5°F / 3% RH / 5 ppm	1	1.5	2.5	90	300	3.0	5.0
Tstat w/Antic (Nmax~2) Deadbands: 2.0°F / 3% RH / 5 ppm	1	2.0	2.5	90	300	3.0	5.0

Fan Control Options

The short time step version of the model now includes various control options for the four different fans in the system: AC/Heater supply fan, dehumid unit fan, ventilation fan (or damper), and exhaust fan. The fan can be controlled based on the status of the other system devices (heating, cooling, dehumid, ventilation) that are typically controlled by set points and other factors. The devices/fans are listed in the table below:

Table 14 Description of Devices Included on Fan Control Options

Device No	Description	Controlled by

1	Heating	Space temperature
2	Cooling Coil	Space temperature and/or humidity
3	Dehumidification/Ventilation Unit	Space humidity or supply air temperature
4	Ventilation Unit	Space CO_2 Levels
5	Supply/AHU Fan	As defined in the section below
6	Dehumid/Vent Unit Fan	
7	Ventilation Fan (or Damper)	
8	Exhaust Fan	
9	HRV Fan	

For each fan (devices 5-9) the following fan control methods can be specified:

- ***Fan Control Type***. The type of control for this fan:
    - ***(0) No Additional Control***. Fan does not use any of these control methods.
    - ***(1) Always ON/Continuous***. Fan operates continuously
    - ***(2) Scheduled***. Fan is controlled according to the ***Fan Schedule*** specified below.
    - ***(3) Duty Cycle TP***. The fan is duty cycle controlled using the total period (TP) method. The fan duty cycle is determined using the ***Fan ON Time*** and ***Fan OFF Time*** specified below. If the required fan runtime has not been reached by the end of a total period the fan is activated. If the required fan runtime is less than 2 timesteps, then the fan does not operate and remaining runtime is "thrown away".
    - ***(-3) Duty Cycle TP w/o throwaway***. Same as above except small periods of fan operation are NOT thrown away.
    - ***(4) Duty Cycle S***. The fan is duty cycle controlled using the series (S) method. The fan remains off after each cycle of normal operation for ***Fan OFF Time***. It runs for the duration specified by ***Fan ON Time***.
    - ***(5) Interlock with ON-Time Limits TP***. The fan is interlocked with another device but has a maximum runtime specified by ***Fan ON Time.*** The Interlocked device N must be the first ***1st Interlock Device*** specified below. The interlocked device must have either Duty Cycle TP or S control. The total period is taken from the interlocked device.
    - ***(6) Interlock with On-time Limits S.*** Same as above but Duty cycle series control method is used. _

- ***Fan ON Time*** (hrs). The duration of the fan on time expressed in multiples of the time step.

- ***Fan OFF Time*** (hrs). The duration of the fan off time expressed in multiples of the time step. The total period (TP) is the sum of the ON and OFF times.

- ***1st Interlock Device.*** The device # that drives operation of this fan. Must be a lower number than this device. Specify a negative number for anti-interlock (e.g., this device/fan is ON when the interlocked device is OFF and visa versa).

- ***2nd Interlock Device.*** The additional device # that drives operation of this fan. Must be a lower number than this device. Specify a negative number for anti-interlock (e.g., this device/fan is ON when the interlocked device is OFF and visa versa).

- ***3rd Interlock Device.*** The device # that drives operation of this fan. Must be a lower number than this device. Specify a negative number for anti-interlock (e.g., this device/fan is ON when the interlocked device is OFF and visa versa).

- ***Fan Schedule***. Number corresponding to the row in the file FAN_SCHED.COF used to schedule fan operation. Each row in the file has 24 values (1=ON, 0=OFF) for each hour of the day.

Setpoints

This section of the input screen specifies the temperature and humidity setpoints for both the occupied and unoccupied periods. The occupied period for HVAC fan control and set points is specified by the HVAC variable (which comes from the BUI file used by Type 56.). The inputs are described below. Set point can be disabled by entering 99 (for cooling and dehumidification) or zero (for heating, reheating).

- ***Heating Set Point – Day/Occupied*** (°F). Heating set point during the occupied (or daytime) period.

- ***Heating Set Point – Night/Unoccupied*** (°F). Heating set point during the unoccupied (or nighttime) period.

- ***Cooling Set Point – Day/Occupied*** (°F). Cooling set point during the occupied (or daytime) period.

- ***Cooling Set Point – Night/Unoccupied*** (°F). Cooling set point during the unoccupied (or nighttime) period.

- ***Humidity Set Point Type***. The humidity set point can be either relative humidity (%) or the dew point (°F).

- ***Dehumid Set Point – Day/Occupied*** (%RH or °F). Dehumidification set point during the occupied (or daytime) period (method chosen by ***Humidity Set Point Type***).

- ***Dehumid Set Point – Night/Unoccupied*** (%RH or °F). Dehumidification set point during the unoccupied (or Nighttime) period (method chosen by ***Humidity Set Point Type***).

- ***RE-Heating Set Point*** (°F). Heating set point in occupied mode for reheat coil used for case when ***AC Humidity Control Option*** is specified to be "Reheat". The value is used to determine the differential between the occupied cooling set point and the reheat set point. Without reheat selected, this parameter has no meaning.

Building

The building model uses the Type 56 multi-zone building model in TRNSYS. The inputs for Type 56 are defined using the TRNBuild application below. TRNBuild is used to make the BUI file that is used at runtime by Type 56. TRN-REESDH expects a certain format and that certain conventions be followed for the BUI file (see Appendix E).

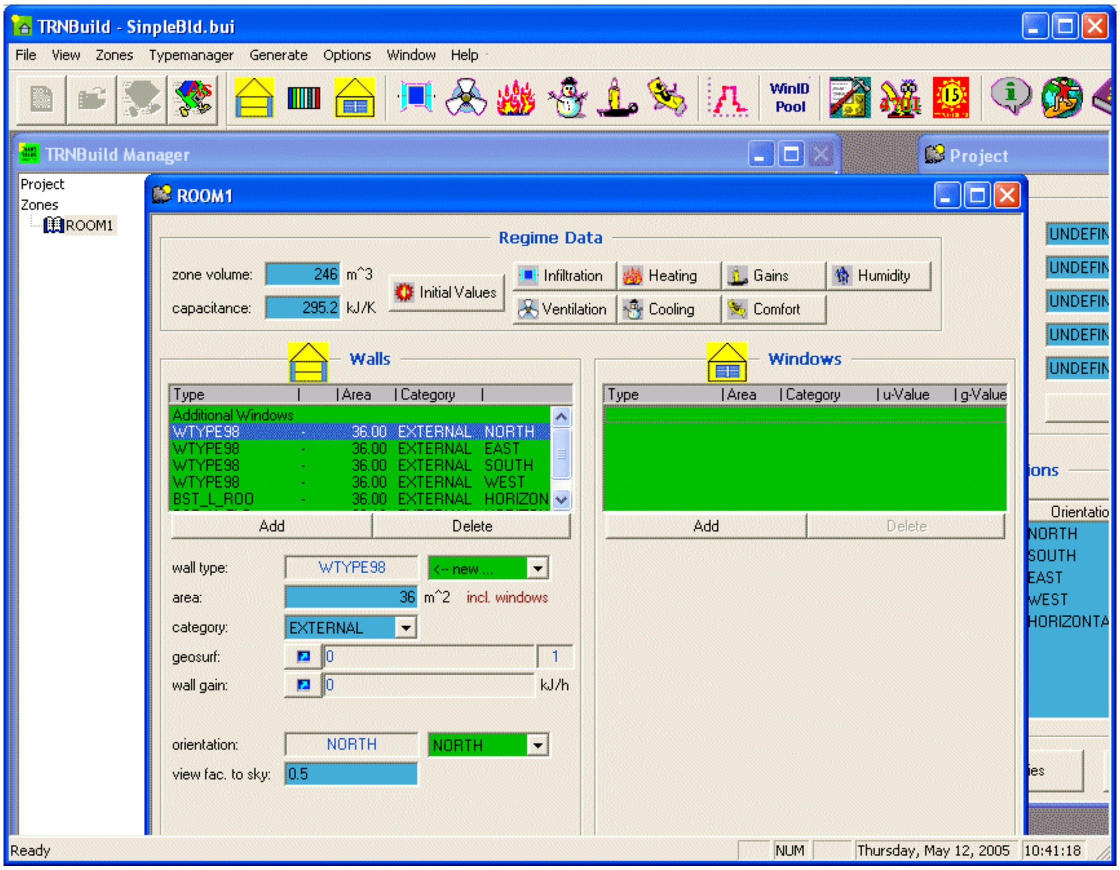


Figure 9. TRNBuild Application Where the Building Details are Defined

The user can select between the two building types:
:

1) Single –Zone Building (with unconditioned attic)
2) Two –Zone Building. (not support in Short time step version)

Though only the Single Zone Building works with the short timestep model. The parameters that describe the building are specified in the files Single_Zone_Buildings.txt and Two_Zone_Buildings.txt files. The available options in the Single zone file are given in the table below.

Table 15 Single zone building parameters from Single_Zone_Buildings.txt

Description	Option (SINZONE_BNO)	9=com)Building Type (used for infiltration: res=8,	Floor area (ft2)	Number of zones	Depth below grade (ft)	Default Infiltration ACH	Wall height (ft)	Peak Number of people *	Heat gain from occupant * (Btu/h)	Light gain (W/ft2)	Equipment gain (W/ft2)
1-Single Story Residence with Basement (residential_basement.bui)	1	8	1600	1	8	0.7	8	4.3	510	0.464	0
2-Single Story Residence with Crawl Space (residential_crawl.bui)	2	8	1600	1	2	0.7	8	4.3	510	0.464	0
3-Single Story Residence with Crawl Space (19 Clone)(res_type19clone.bui)	3	8	1600	1	2	0.7	8	4.3	510	0.379	0
4-Cinemark Theatre - Plano Texas (cinemark.bui)	4	9	19366	1	0	0.2	25	290	350	0.1	0.5
5-Residential_Hers (ResidentailAttic_hers.bui)	5	8	2000	1	0	0.495	8	3	420	0.3	0.5
6-Walgreens (Walgreens.bui)	6	9	16000	1	0	0.2	25	50	640	2	0.75
7-Residential_Hers Zone 1 (Res_HERS1.bui)	7	8	2000	1	0	0.495	8	3	420	0.3	0.3785
8-Residential_Hers Zone 2 (Res_HERS2.bui)	8	8	2000	1	0	0.495	8	3	420	0.3	0.3785
9-Residential_Hers Zone 3 (Res_HERS3.bui)	9	8	2000	1	0	0.495	8	3	420	0.3	0.3785
10-Residential_Hers Zone 4 (Res_HERS4.bui)	10	8	2000	1	0	0.495	8	3	420	0.3	0.3785
11-Residential_HighEff Zone 1 (Res_HighEff1.bui)	11	8	2000	1	0	0.495	8	3	420	0.3	0.3785
12-Residential_HighEff Zone 2 (Res_HighEff2.bui)	12	8	2000	1	0	0.495	8	3	420	0.3	0.3785
13-Residential_HighEff Zone 3 (Res_HighEff3.bui)	13	8	2000	1	0	0.495	8	3	420	0.3	0.3785
14-Residential_HighEff Zone 4 (Res_HighEff4.bui)	14	8	2000	1	0	0.495	8	3	420	0.3	0.3785

* Should match entry in corresponding the bui file

The final inputs are for Air Changes in the space:

- ***Infiltration Type***. Type of Infiltration (ACH_TYPE)

- ***(1) Default Infiltration*** (constant value from Table above)
- ***(2) Custom Infiltration*** (constant value from ***New Infiltration*** below)
- ***(3-5) TRNSYS/ASHRAE Infiltration*** (variable)
- ***(6-10) Sherman Grimsrud Infiltration Method*** (variable)

Table 16. Building Infiltration Input Data (from Infiltration.txt)

Description	K1	K2	K3	A	B	C
1- Default Building Infiltration	0	0	0	0	0	0
2- Custom Infiltration	0	0	0	0	0	0
3 -TRNSYS/ASHRAE Tight infiltraion model	0.1	0.011	0.034	0	0	0
4 -TRNSYS/ASHRAE Medium infiltraion model	0.1	0.017	0.049	0	0	0
5 -TRNSYS/ASHRAE Light infiltraion model	0.1	0.023	0.07	0	0	0
6 -Sherman-Grimsrud No Shielding	0	0	0	1.3	0.1	0.34
7 -Sherman-Grimsrud Light Local shielding	0	0	0	1	0.15	0.3
8 -Sherman-Grimsrud Moderate local shielding	0	0	0	0.85	0.2	0.25
9 -Sherman-Grimsrud Heavy shielding	0	0	0	0.67	0.25	0.19
10 -Sherman-Grimsrud Very heavy shielding	0	0	0	0.47	0.35	0.11

Notes:
TRNSYS/ASHRAE Simplifed Model:
$ACH = K1 + K2\cdot|TAO-TAI| + K3\cdot V$ (airchanges per hour)
TAI and TAO are °C; V is the wind speed in m/s
Sherman/Grimsrud Model:
Use ELA with coefficients A, B, C above. R=0.5, X=0 for single story slab on grade

- ***New Infiltration (Custom).*** Specifies a custom ACH value that is constant for each hour.

- ***Effective Leakage Area (Sherman-Grimsrud).*** Specifies leakage area in square inches.

In previous commercial versions of this TRNSYS model, the ACH rate was only applied when the main air handler was off. This feature has been retained for the commercial building types (btype = 9). However, for residential buildings (btype=8) the specified infiltration rate is used for all periods regardless of fan operation.

TRN-RESDH now takes into account the interactions of unbalanced ventilation with infiltration. The calculation is based on the approach summarized in Barnaby and Spitler (2005) RP-1199.

cfm_{in} = sum of all incoming ventilation flows (vent cfm at AC, dehum/vent unit, etc)
cfm_{out} = sum of all exhaust flows (exhaust fan, dehum/vent unit exhaust, etc)

$$cfm_{balanced} = MIN(cfm_{in}, cfm_{out})$$

$$cfm_{unbalanced} = MAX(cfm_{in}, cfm_{out}) - cfm_{balanced}$$

cfm_{inf} = infiltration flow calculated for building for the timestep

$$cfm_{combined} = MAX(cfm_{unbalanced}, cfm_{inf} + 0.5 * cfm_{unbalanced}) + cfm_{balanced}$$

An alternative method from Sherman is:

$$\mathrm{cfm}_{\mathrm{combined}} \quad = \quad \sqrt{cfm_{unba\ln anced}^2 + cfm_{\inf}^2} \quad + \mathrm{cfm}_{\mathrm{balanced}}$$

The two methods are compared in the plot below.

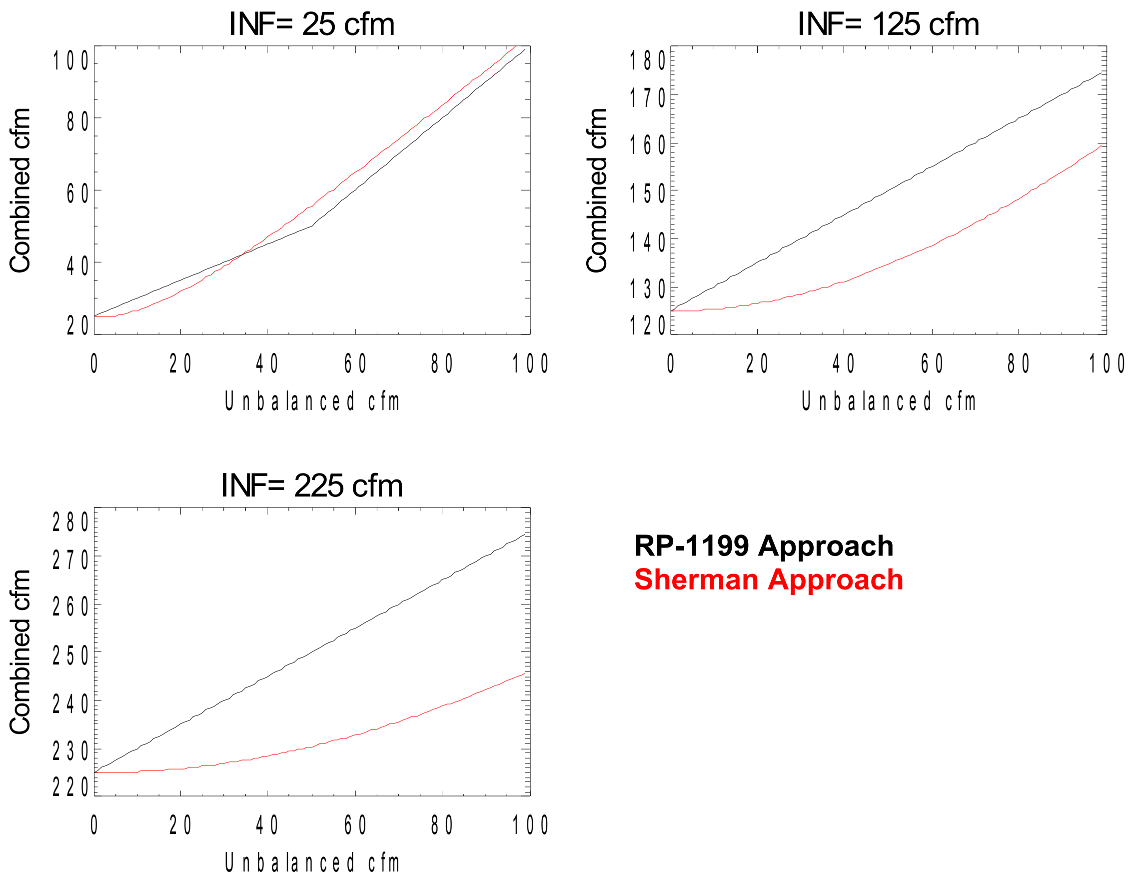


Figure 10. Comparing the Two Approaches of Combining Infiltration and Unbalanced Ventilation

Appendix A

Detailed Description of Output Variables

The following tables describe the hourly output data produced by TRN-RESDH. The data are written to a series of "FOR_XX.DAT" files. Note that some energy use and mass flow variables assume the system ran continuously. These values must be multiplied by their corresponding runtime fraction in order to obtain actual energy total. For example, air conditioning system power (w/o fan) is calculated by multiplying "ACKW" by "RTFc". Table A-8 gives a list of values that must be multiplied by runtime fraction.

Table A-1. Output Variables in file "For_21.dat" – Space Conditions

Variable	Description	Units	TRNSYS Source
Time	Hour of Simulation	hours	
To	Outdoor Air Temperature	°F	Type 89, output 5
Wo	Outdoor Humidity Ratio	lb/lb	Type 89, output 6
Ti	Indoor Air Temperature	°F	Type 19, output 1
Wi	Indoor Humidity Ratio	lb/lb	Type 19, output 2
RHi	Indoor Relative Humidity	%	Type 33, output 6
OCC	Occupancy (1=occupied)	binary	Type 14, output 1
Msupp2	Mass Flow Rate of Supply Air (to space)	lb/hr	calc by eqn
Tsupp2	Temperature of Supply Air (to space)	°F	calc by eqn
Wsupp2	Humidity Ratio of Supply Air (to space)	lb/lb	calc by eqn
ACH	Infiltration Rate	hr^{-1}	calc by eqn

Table A-2. Variables in file "For_31.dat" – AC Unit

Variable	Description	Units	TRNSYS Source
Time	Hour of Simulation	hours	
Mac	Mass Flow Rate of AC Air	lb/hr	calc by eqn
Taci	Temperature of AC Inlet Air	°F	calc by eqn
Waci	Humidity Ratio of AC Inlet Air	lb/lb	calc by eqn
Taco	Temperature of AC Outlet Air (after AC,HT,DH)	°F	calc by eqn
Waco	Humidity Ratio of AC Outlet (after AC,HT,DH)	lb/lb	calc by eqn
Qsac	Max Possible Sensible Heat Removal of AC	Btu/h	Type 107, output 5
Qlac	Max Possible Latent Heat Removal of AC	Btu/h	Type 107, output 6
RTFc	Runtime Fraction for Cooling	0 to 1	Type 159, output 2
RTFh	Runtime Fraction for Heating	0 to 1	Type 159, output 1
Qh[2]	Max rate of heat added to building	Btu/h	calc by eqn

1 - Values must be multiplied by Rtfc to get hourly energy use
2 - Values must be multiplied by Rtfh to get hourly energy use

Table A-3. Variables in file "For_41.dat" – AC and Desiccant Misc

Variable	Description	Units	TRNSYS Source
Time	Hour of Simulation	hours	
RTFacf	Runtime fraction of AC Fan	0 to 1	calc by eqn
ACKW	Full-Power kW of AC Unit (w/o fan)	kW	Type 107, output 4
FANKW	Full-Power kW of AC Fan	kW	Type 107, output 7
Tadp	Dew Point Temperature of air leaving AC	°F	Type 107, output 8
RTFdf	Runtime fraction of Desiccant Fan	0 to 1	calc by eqn
DFANKW	Full-Power kW of Desiccant Fan	kW	Type 108, output 6
RTFrh	Runtime fraction of Reheat	0 to 1	calc by eqn
Qrh	Reheat energy added to air	Btu/h	calc by eqn
RTFe	Runtime fraction of Economizer	0 to 1	calc by eqn
RTFacf_tim	Same as RTFacf	0 to 1	calc by eqn

Table A-4. Variables in file "For_51.dat" - Desiccant

Variable	Description	Units	TRNSYS Ref
Time	Hour of Simulation	hours	
Md	Mass Flow Rate of Desiccant Air	lbs/hr	calc by eqn
Tdi	Temperature of Desiccant Inlet Air (F)	°F	calc by eqn
Wdi	Humidity Ratio of Desiccant Inlet Air (lb/lb)	lb/lb	calc by eqn
Tdo	Temperature of Desiccant Outlet Air (F)	°F	calc by eqn
Wdo	Humidity Ratio of Desiccant Outlet Air (lb/lb)	lb/lb	calc by eqn
Qsd*	Max Sensible Heat Removal of Desiccant	Btu/h	Type 108, output 4
Qld*	Max Latent Heat Removal of Desiccant	Btu/h	Type 108, output 5
RTFd	Runtime fraction of Desiccant	0 to 1	calc by eqn
DGAS*	Full-Power Gas Use of Desiccant	MBtu/h	Type 108, output 7
DKW	Full-Power kW of Desiccant (w/o fan)	kW	Type 108, output 3

* - Values are only valid when Rtfd > 0.

Table A-5. Variables in file "For_71.dat" – Building Loads

Variable	Description	Units	TRNSYS Ref
Time	Hour of Simulation	hours	
PEOPLE	Total heat load due to people (sensible + latent)	Btu/hr	calc by eqn
LIGHTS	Sensible lighting heat load	Btu/hr	calc by eqn
EQUIP	Sensible equipment heat load	Btu/hr	calc by eqn
INFQ	Sensible infiltration heat load	Btu/hr	calc by eqn
INFW	Infiltration Moisture Load	lbs/hr	calc by eqn
QCONV	Convection heat load to building (sensible)	KJ/h	Type 19, output 6
SCHQs	Sensible internal heat gains to building	KJ/h	Type 19, output 7
SCHWg	Moisture gains to building, including ventilation	KJ/h	Type 19, output 8
TMIN	Setpoint for heating	° F	Type 19, output 9
TMAX	Setpoint for cooling	° F	Type 19, output 10

Table A-6. Variables in file "For_81.dat" – Air Flows

Variable	Description	Units	TRNSYS Ref
Time	Hour of Simulation	hours	

MAC	Mass flow rate of air through AC	lb/hr	calc by eqn
MACMX	Max-Power flow rate of air through AC	lb/hr	calc by eqn
MRET	Mass flow rate of air from conditioned space	lb/hr	calc by eqn
MHRV	Mass flow rate of air from HRV	lb/hr	calc by eqn
MD_sp	Mass flow rate of air from DH to space	lb/hr	calc by eqn
MDMX	Maximum flow rate from desiccant	lb/hr	calc by eqn
Qflrc	Convective heat gain from floor	KJ/hr	Type 19, output 11
Qflrr	Radiative heat gain to floor	KJ/hr	Type 19, output 12
TSLAB_SI	Temperature under slab in SI	C	

Table A-7. Variables in file "For_91.dat" – Other Data

Variable	Description	Units	TRNSYS Ref
Time	Hour of Simulation	hours	
rtfv	Runtime fraction for vent fan/damper	0 to 1	calc by eqn
C_i	CO_2 Concentration Inside Space	fraction	Type 160, output 1
Cs	CO_2 Concentration of Supply air	fraction	calc by eqn
rtfvf	Runtime Fraction of Ventilation Fan	fraction	Type 152, output 21
rtfxf	Runtime Fraction of Exhaust Fan	fraction	Type 152, output 22
KWVF	Full-Power kW of Ventilation Fan	kW	calc by eqn
KWXF	Full-Power kW of Exhaust Fan	kW	calc by eqn
ANO	Number of AC system (from menu)	-	calc by eqn
DNO	Number of Desiccant system (from menu)	-	calc by eqn
Btype	Number of building type (from menu)	-	calc by eqn
KWHT	Full-Power kW of Electric Heat	kW	calc by eqn
Rtfhf	Runtime Fraction of HRV Fan	fraction	Type 152, output 23
KWHF	Full-Power kW of HRV Fan	kW	calc by eqn

Table A-7. Variables in file "For_99.dat" – More Data

Variable	Description	Units	TRNSYS Ref
Time	Hour of Simulation	hours	
RHI_1	RH in Zone 1 (house)	% RH	
RHI_2	RH in Zone 2 (attic)	% RH	
TAI_1	Temperature in Zone 1 (house)	F	
TAI_2	Temperature in Zone 2 (attic)	F	
Q2eq	Heat added to Zone 2 (supply duct conduction)	kJ/h	
TH_rise	Temperature rise of heater	F	
Tacoc	Temperature Leaving AC coil	F	
Thrv	Temperature Leaving HRV	F	
whrv	Humidity Ration Leaving HRV	lb/lb	
C_i2	CO_2 Concentration Inside Zone 2 (attic)	fraction	
VW_SI	Wind speed in SI units	m/s	
TAI_tl	Temperature of return air after thermal losses	F	
Tsupp_tl	Temperature of supply air after thermal losses	F	
Mv	Mass flow of ventilation air thru damper/fan	lb/lb	

Table A-8. System Variables that Require Multiplication by Runtime Fraction to Calculate Energy

To Obtain	Multiply This Variable	By This Runtime Fraction
AC System Power (w/o fan)	ACKW	RTFC
Heating Gas Use	Qh	RTFH
AC Fan Power	FANKW	RTFacf
Desiccant Fan Power	DFANKW	RTFdf
Ventilation Fan Power	KWVF	RTFvf
Exhaust Fan Power	kWXF	RTFxf
HRV Fan Power	kWHF	RTFhf
Reheat Energy	QRH	RTFrh
Desiccant power (w/o fan)	DKW	RTFd
Desiccant gas use	DGAS	RTFd
Sensible heat removed by AC	Qsac	RTFc [Not in small timestep version]
Latent heat removed by AC	Qlac	RTFc [Not in small timestep version]
Sensible heat removed by desiccant	Qsd	RTFd
Latent heat removed by desiccant	Qld	RTFd

Appendix B

Detailed Description of TRNSYS Building Model

The core of the simulation model is the building. The building envelope model is based on the Type 56 multi-zone building model in TRNSYS. The inputs to Type 56 are defined using the TRNBuild tool and then saved in a .BUI file (see Figure B-1). TRNSYS reads this file at runtime to generate the building model inputs required by the Type 56 routine. The building model includes all the basic characteristics of a commercial or residential building:

- Heat loss and gains through building walls, roof and floor,
- Solar gains through windows; radiation heat balance in he building zone,
- Scheduled internal sensible and moisture loads for people, equipment, etc,
- Interactions with the heating, ventilation, and air conditioning (HVAC) equipment,
- Scheduled set points for temperature.

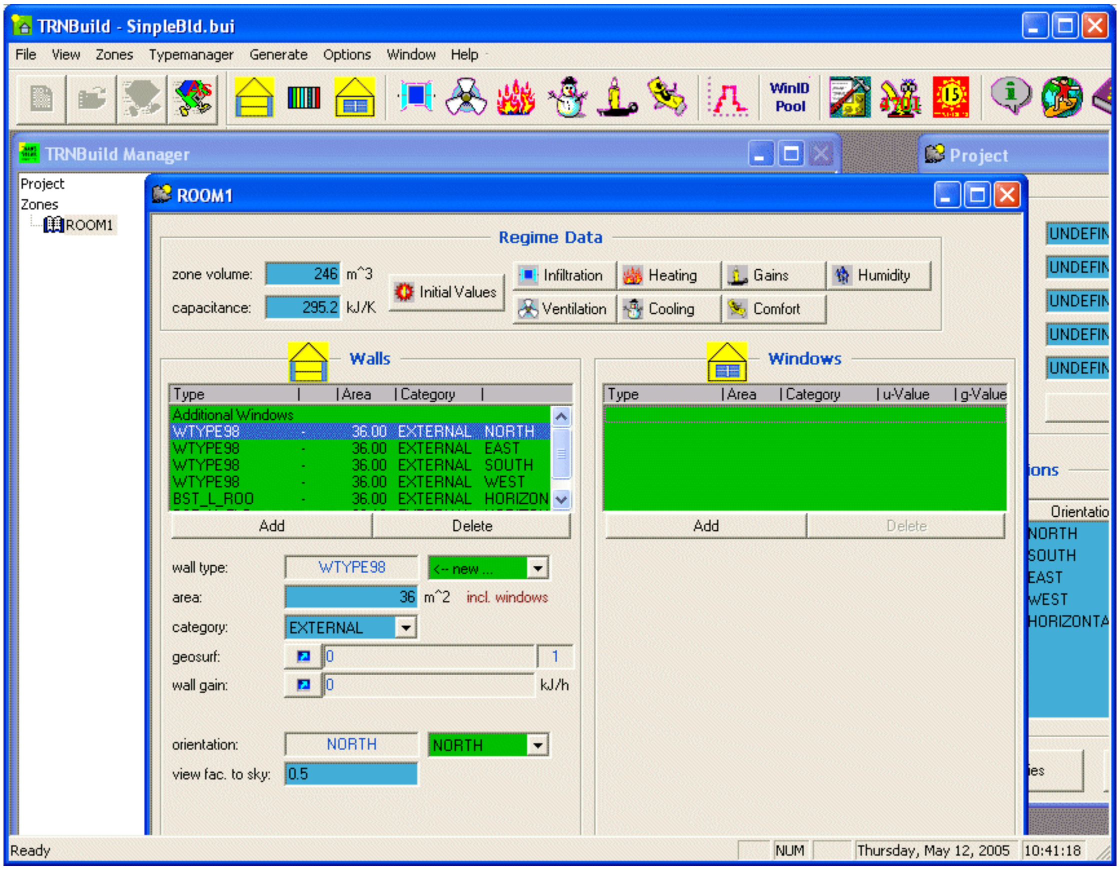


Figure B-1. TRNBuild Application Where the Building Details are Defined

Type 56 allows for multiple zones to be specified with various interactions. For the model developed here, we have implemented the model as one primary conditioned zone with the potential for other unconditioned zones (e.g., an attic). Appendix B provides a detailed description of the specific requirements for the BUI files that are used with TRN-Resdh.

The Type 56 building model is driven by typical year weather data (TMY2) on an hour-by-hour basis. The weather files provide information about the ambient temperature, humidity as well as the information about the solar radiation on the various oriented surfaces of the building.

The HVAC system is modeled as a conditioned airflow stream that is provided into the building envelope to hold the desired temperature (and humidity) conditions in the space (i.e., the internal heating and cooling features of Type 56 are disabled). The temperature (and humidity) of the airflow stream supplied to the building are modulated to maintain the desired space conditions (see Figure B-2). Iterations are required to provide the desired space set point while also achieving an energy and mass balance for the building and HVAC systems for each simulation timestep. This "quasi-steady state" approach seeks to simulate the average operating conditions imposed on the building and HVAC system for each hour without requiring the detailed control knowledge and thermostat dynamics that would be required for a small time step simulation (e.g., 1-minute).

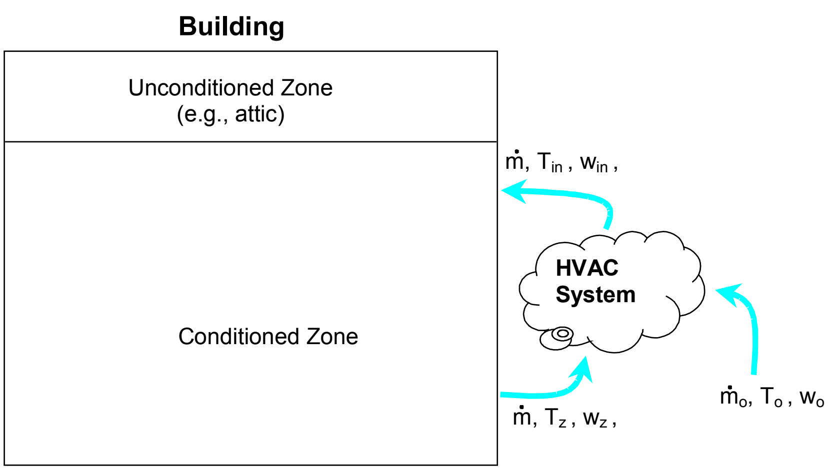


Figure B-2. Schematic of Building and HVAC System Interactions

The building model framework for TRN-Resdh is designed to concentrate on a single zone. Other unconditioned zones are allowed but the HVAC system can only provide cooling and heating to one zone with a single set point.

The TRNBuild application allows the user to define the details of the building envelope, internal gains, schedules and other aspects of building performance.

Windows: Windows are modeled using the multi-node optical and thermal model known as WINDOW 4.1 that was developed by LBL (1994). A library of predefined window systems are available similar to those available in the DOE-2.1e simulation program (Buhl et al 1993).

Floor: Foundation and floor heat transfer is modeling using the correction factor method from Huang et al. (1988) and more recently summarized by Winkelman (1998). The ground temperature for each location is determined using the annual sinusoidal variations defined by Kasuda et al (1965) and IGSHPA (1985).

<u>Zone Heat Balance</u>: Radiation heat transfer between all surfaces determined using the temperature of each interior surface. The thermal mass of furnishings is simulated by adding internal walls that are convectively coupled to the interior zone. The mass of the zone air node also arbitrarily increased by a factor of 10 to simulate the thermal capacitance of material in the space that is closely coupled to the air temperature. The space air volume is also increased by a factor of 10 to simulate the moisture capacitance of furnishings in the space.

<u>Infiltration</u>: An air exchange rate with outdoors or ventilation rate can be specified in the HVAC system.

<u>Internal Gains</u>: Hourly schedules are defined on a daily or weekly basis to specify the variations on lighting, equipment, occupancy, and water draw.

<u>Unconditioned Zones</u>: Additional thermal zones (such as an attic) can be defined and connected to an adjacent zone via a wall. Each zone can have exposed external walls, infiltration, and its own zone heat balance.

Appendix C

Residential Dehumidifier Equipment Models

The residential TRNSYS model (TRN_RESDH) now includes several equipment models specific to residential dehumidification. These include conventional electric dehumidifiers, advanced electric dehumidifier options, as well as first generation and second-generation gas-fired desiccant products. The equipment models and performance maps were selected by Doug Kosar at the University of Illinois-Chicago. All data were first normalized to a "per 100 cfm of process air" basis in order to allow for the size of equipment to be scaled. Then CDH Energy fit this performance data to equations of the form:

$$\text{Value} = C_0 + C_1 {*} T + C_2 {*} rh + C_3 {*} rh^2$$

where: T = Entering Temperature (°F)
rh = Entering Relative Humidity (%)
C_x = Multiple Linear Regression Curve Fit Coefficients

The performance parameter "Value" can be: Gas Use (Btu/h), Electricity Use (W), Sensible Heat Added (Btu/h), or Dehumidification Capacity (lb/h). The nominal performance of the systems are compared in the table below.

Table C-1. Performance of Residential Dehumidifiers

	Dehumid Capacity (pint/day)	Electric Dehumid Efficiency (pint/kWh)	Gas COP (latent/gas)	Equiv Dehumid Efficiency (pint/kWh)
Conventional Electric (220 scfm)	75	2.6	-	2.6
Thermastor Santa Fe (250 scfm)	105	5.4	-	5.4
Heatcraft Desiccant Wheel (220 scfm)	155	14.4	0.47	3.8
Des Wheel w/ Balanced HX (220 scfm)	155	12.6	0.59	4.2
Des Wheel w/ UNBalanced HX (220 scfm)	155	13.1	0.59	4.4

Notes: All performance data at 80°F & 60% RH entering
Equivalent efficiency assumes ratio of gas and electric costs \$0.65/therm & \$0.08/kWh.

Conventional Dehumidifier (Des_unit_type=11, Param#10 = 1)

The conventional dehumidifier is typical of free-standing products that dehumidify and add sensible heat to the space. A nominal 75 pint per day unit is equivalent to 220 scfm of process air. The efficiency of this unit at 80°F and 60% is 2.6 pints/kWh. The normalized performance data in the table below would be multiplied by 2.2 (i.e., 220/100) for the 75 pint/day unit.

Conventional Dehumidifier (220 scfm = 75 pints/day)

Entering Temp (F)	Entering RH (% RH)	All Data per 100 scfm: Dehumid Capacity (lb/hr)	Heat Added (Btu/h)	Electricity (Watts)
80	70%	1.85	3,855	565
80	60%	1.50	3,460	553
80	50%	1.15	3,041	539
80	40%	0.77	2,597	523
75	70%	1.65	3,503	520
75	60%	1.34	3,141	510
75	50%	1.02	2,762	497
75	40%	0.68	2,365	483
70	70%	1.47	3,163	478
70	60%	1.18	2,837	468
70	50%	0.89	2,498	457
70	40%	0.59	2,145	445

DEC/Thermistor Santa Fe Unit (Des_unit_type=11, Param#10 = 2)

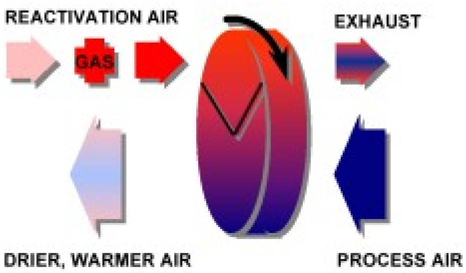
DEC makes a high efficiency dehumidifier twice as efficient as free-standing conventional products. The unit also adds slightly less sensible heat to the space. The unit is nominally a 105 pint per day unit and is equivalent to 250 scfm of process air. The efficiency of this unit at 80°F and 60% is 5.4 pints/kWh. The normalized performance data in the table below would be multiplied by 2.5 (i.e., 250/100) for the 105 pint/day unit.

Thermastor Santa Fe (250 scfm = 105 pints/day)

Entering Temp (F)	Entering RH (% RH)	All Data per 100 scfm: Dehumid Capacity (lb/hr)	Heat Added (Btu/h)	Electricity (Watts)
80	70%	2.66	3,442	413
80	60%	1.85	3,059	332
80	50%	1.50	2,656	320
80	40%	1.13	2,220	304
75	70%	2.49	3,074	390
75	60%	1.65	2,759	304
75	50%	1.33	2,388	292
75	40%	1.00	1,993	278
70	70%	2.25	2,712	360
70	60%	1.53	2,459	286
70	50%	1.17	2,133	266
70	40%	0.87	1,779	254

Heatcraft Desiccant Unit (Des_unit_type=12, Param#10 = 1)

The Heatcraft desiccant model is based on the product being developed by Heatcraft. This unit pulls process air from the space, dries it, and returns it to the space. Reactivation air is pulled from outdoors (see the figure below). The basic Heatcraft design does not include a sensible heat exchanger. The dehumidification capacity of a nominal 220 scfm unit is equivalent to 155 pint/day at 80°F/60% RH. The equivalent dehumidifier efficiency is 3.8 pint/kWh (assuming $0.65/therm and $0.08/kWh).



Heatcraft Desiccant DH (nom. size 220 scfm)

		All Data per 100 scfm of Process Airflow			
Entering Temp (F)	Entering RH (% RH)	Dehumid Capacity (lb/hr)	Heat Added (Btu/h)	Electricity (Watts)	Gas Use (Btu/h)
80	70%	3.30	4,823	205	6,948
80	60%	3.07	4,598	205	6,948
80	50%	2.78	4,311	205	6,948
80	40%	2.41	3,926	205	6,948
75	70%	3.18	4,740	205	6,948
75	60%	2.93	4,493	205	6,948
75	50%	2.62	4,177	205	6,948
75	40%	2.23	3,761	205	6,948
70	70%	3.03	4,619	205	6,948
70	60%	2.76	4,345	205	6,948
70	50%	2.43	3,997	205	6,948
70	40%	2.03	3,556	205	6,948

Desiccant Unit with Sensible Heat Exchanger: Balanced or Unbalanced (Des_unit_type=11, Param#10 = 2 or 3)

The next generation desiccant unit may include a sensible heat exchanger and more efficient fans that will lower fan power. The tables below summarize performance. This unit is more energy efficient mainly because of lower fan power. The equivalent efficiency is 5.3-5.4 pint/kWh (assuming $0.65/therm and $0.08/kWh)

Desiccant DH with Balanced HX (nom. size 220 scfm)

		All Data per 100 scfm of Process Airflow			
Entering Temp (F)	Entering RH (% RH)	Dehumid Capacity (lb/hr)	Heat Added (Btu/h)	Electricity (Watts)	Gas Use (Btu/h)
80	70%	3.30	965	235	5,670
80	60%	3.07	920	235	5,730
80	50%	2.78	862	235	5,806
80	40%	2.41	785	235	5,908
75	70%	3.18	1,380	235	5,835
75	60%	2.93	1,331	235	5,901
75	50%	2.62	1,267	235	5,984
75	40%	2.23	1,184	235	6,095
70	70%	3.03	1,788	235	6,010
70	60%	2.76	1,733	235	6,083
70	50%	2.43	1,663	235	6,175
70	40%	2.03	1,575	235	6,292

Desiccant DH with Unbalanced HX (nom. Size 220 scfm)

		All Data per 100 scfm of Process Airflow			
Temperature (F)	Relative Humidity (% RH)	Dehumid Capacity (lb/hr)	Heat Added (Btu/h)	Electricity (Watts)	Gas Use (Btu/h)
80	70%	3.30	3,508	225	5,487
80	60%	3.07	3,344	225	5,556
80	50%	2.78	3,136	225	5,642
80	40%	2.41	2,855	225	5,759
75	70%	3.18	3,595	225	5,676
75	60%	2.93	3,415	225	5,751
75	50%	2.62	3,185	225	5,846
75	40%	2.23	2,882	225	5,973
70	70%	3.03	3,654	225	5,876
70	60%	2.76	3,454	225	5,959
70	50%	2.43	3,202	225	6,065
70	40%	2.03	2,881	225	6,198

Appendix D

Directory Structure for TRN-RESDH

The main spreadsheet "TRN-RESDH5.XLS" creates various files in the multiple run mode. When the user sets up a series of parametric runs, a subdirectory name is also specified in cell B4 of the "Instructions" sheet. A subdirectory with this name is created in the main directory (usually TRN-RESDH5). Under this directory, a series of subdirectories are created for each run number: Run1, Run2, Run3, …
Each subdirectory holds all the raw data and input files corresponding to the run.

Figure D-1. Files Created in the Run Directory for Each Simulation Run: X

File	Description
CaseRunX.trd	This is the TRNSYS input file created by Python. It shows the net result of all the parameter replacements and substitutions.
FOR_N1.dat (output files)	The hourly output files. N=2,3,..9
*.png (plot files)	Various plots and figures created by the Python routines
Eia_rate.txt	The monthly electric rate data from the EIA files that was used to calculate operating costs
PERF_COF_140.dat	The coefficients used Type 140 (AC model) from DOE_AC.COF and LENNOX.COF
PERF_COF_141.dat	The coefficients used Type 141 (Dehimifier/Desiccant model) from ResDH.COF and DesDH.COF

Other Important Directories include

- ***Util_Rates*** – Includes the EIA utility rate information from Form 826 in a CSV file: f826util2004.csv
- ***TRNBuild*** – Includes the TRNBuild.exe file that can modify the BUI file used by Type 56
- ***UserLib*** – Includes the FORTRAN source code and DLLs for the custom TRNSYS routines developed for TRN-RESDH
- ***Tcl*** – Python routines
- ***Matplotlibdata*** – Python routines

Appendix E

BUI File Conventions

(from April 2006)