

CONTAM TO ENERGYPLUS INFILTRATION FEATURES OF THE CONTAM RESULTS EXPORT TOOL

The screenshot shows a dialog box titled "EnergyPlus Whole Building ACH Export - Options". It contains the following fields and controls:

- "Select a CONTAM ACH File (*.ach):" with a "Browse..." button and the text "No file selected."
- "Enter a name for the output files:" with a text input field containing "file".
- "IDF filename:" with a text input field containing "file.idf".
- "CSV Schedule filename:" with a text input field containing "file.csv".
- "Building Surface Area" with a text input field containing "1000" and a dropdown arrow.
- "Cancel" and "OK" buttons at the bottom.

The screenshot shows a dialog box titled "EnergyPlus Zone Specific ACH Export - Select Input Files". It contains the following fields and controls:

- "Select CONTAM Project File (*.prj):" with a "Browse..." button and the text "No file selected."
- "Select CONTAM Sim File (*.sim):" with a "Browse..." button and the text "No file selected."
- "Cancel" and "OK" buttons at the bottom.

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March 2015



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Abstract

As HVAC (heating, ventilation, and air conditioning) equipment efficiencies continue to be improved to reduce building energy use, greater emphasis has also been placed on improving building envelope performance. Although the energy impacts of unintended infiltration through the building envelope on a energy use can be significant, current energy simulations and building designs generally do not accurately account for envelope infiltration and the benefits of improved airtightness. Infiltration has long been recognized as a key component of heating and cooling loads, and various methods exist to account for infiltration in load calculations and more detailed energy analysis. However, the inputs for these methods are not readily available. Multizone building airflow models exist that can accurately calculate infiltration rates as a function of building configuration, airtightness, weather conditions and system operation. However, current such tools are not well-integrated with energy analysis tools. Thus, methods have been developed to incorporate infiltration rates from the multizone airflow model, CONTAM, into a building simulation model, EnergyPlus. This document describes how to use the two CONTAM to EnergyPlus infiltration export features of the CONTAM Results Export Tool available at http://www.bfrl.nist.gov/IAQanalysis/webapps/contam_results_exporter/. One feature exports whole building infiltration rates, and the other exports zone-specific infiltration rates.

Keywords

airflow, CONTAM, energy, EnergyPlus, infiltration, simulation

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Current strategy for modeling of infiltration in EnergyPlus

EnergyPlus is a building energy simulation software developed by the U. S. Department of Energy (DOE). It has several infiltration models, including ZoneInfiltration:DesignFlowRate (DOE 2013). This model uses the following empirical equation to calculate infiltration:

$$\text{Infiltration} = I_{\text{design}} \cdot F_{\text{schedule}} [A + B|\Delta T| + C \cdot W_s + D \cdot W_s^2] \quad (1)$$

where:

I_{design} is defined by EnergyPlus as the "maximum amount of infiltration expected at design conditions". According to the documentation, EnergyPlus provides several options to input this design flow rate (h^{-1} , $\text{m}^3/\text{s} \cdot \text{m}^2$, m^3/s), which is ultimately converted to mass flow using the outdoor air density at each time step.

F_{schedule} is a factor between 0.0 and 1.0 that can be scheduled, typically to account for the impacts of fan operation on infiltration.

$|\Delta T|$ is the absolute indoor-outdoor temperature difference in $^{\circ}\text{C}$.

W_s is the wind speed in m/s .

A , B , C , and D are constants, for which values are suggested in the EnergyPlus user manual (DOE 2013). However, those values are based on studies in low-rise residential buildings and do not apply very well to taller buildings and mechanically ventilated buildings. See Ng et al. (2014) for an alternative approach to generating A , B , C , and D for improved infiltration modeling using this equation. Given the challenges in determining valid coefficients for a given building, a common strategy used in EnergyPlus for incorporating infiltration is to assume fixed infiltration rates, sometimes using a different constant value depending on whether the HVAC system is on or off. However, this strategy does not reflect known dependencies of infiltration on outdoor weather and the complexities of HVAC system operation.

Multizone airflow modeling is the accepted approach to calculate infiltration based on the fundamental airflow physics (Walton 1989). The AIRFLOW NETWORK model in EnergyPlus is based on an early version of CONTAM with restrictions on the type of analyses that it can perform, including only being able to include the effects of a single heating, ventilating, and air conditioning (HVAC) system on infiltration (DOE 2013). The full CONTAM model is not restricted this way, so in order to incorporate more physically-reasonable and whole-building/system infiltration calculations into EnergyPlus simulations, the CONTAM Results Export Tool provides users two ways to incorporate CONTAM infiltration rates into an EnergyPlus model. One feature that exports whole building air change rates and the other that exports zone-specific air change rates. Users of these features need to be familiar with how to perform CONTAM simulations (Walton and Dols 2013) and how to modify EnergyPlus IDF (input data format) files using either the EnergyPlus IDF Editor program or a text editor.

Exporting Whole Building Air Change Rates

The feature of the CONTAM Results Export Tool that exports whole building air change rates uses the infiltration rates from a CONTAM simulation to create a schedule of I_{design} values that will be used by EnergyPlus to calculate infiltration rates based on Equation (1), with $A=1$ and $B=C=D=0$.

Using the whole building's infiltration rates calculated by CONTAM, this feature calculates the design infiltration rates normalized by the building's exterior above-grade surface area, I_{design} in Equation (1). The equation used is:

$$I_{\text{design}} = N \cdot V / (3600 A_s) \quad (2)$$

where:

N is the whole building air change rate (h^{-1}) due only to exterior flow paths.

V is the building volume (m^3) calculated by CONTAM.

A_s is the building exterior surface area (m^2), i.e., the gross surface areas of the above-grade walls and the roof.

For this feature, the same I_{design} ($\text{m}^3/\text{s} \cdot \text{m}^2$) will be applied to each zone with exterior surfaces (or “exterior zones”) in the EnergyPlus model, thereby distributing the infiltration uniformly to the entire building envelope. Since I_{design} is normalized by exterior surface area, zones with more exterior surfaces (wall, roof) will have more infiltration than other zones, and interior zones will receive no infiltration in the EnergyPlus model.

There are limitations to this approach. First, exporting whole building air change rates assumes that envelope leakage is uniformly distributed around the building envelope. It also neglects the effects of weather, especially wind direction, on building orientation and how infiltration is thus distributed. If a user requires a more detailed distribution of infiltration, then the zone-specific feature is available and is described in the next section.

Exporting Zone-Specific Air Change Rates

The feature of the CONTAM Results Export Tool that exports zone-specific building air change rates uses the airflow rates of leakage paths from a CONTAM simulation to create a schedule of I_{design} values that will be used by EnergyPlus to calculate infiltration rates based on Equation (1), with $A=1$ and $B=C=D=0$.

Using the airflow results calculated by CONTAM, this method calculates the air flow between each zone and the outdoors, taking into account that there may be multiple leakage paths modeled between a zone and the outdoors and that there may be both infiltration and exfiltration between each zone and outdoors. Since there are no leakage paths modeled between interior zones and the outdoors in CONTAM, interior zones will receive no infiltration in the EnergyPlus

model. The infiltration for each zone is used to create a schedule of unique I_{design} (m^3/s) values for each exterior zone (i.e., any zone in the CONTAM model that has a connection with the ambient zone) to be input into the EnergyPlus model. Special consideration by the user is needed to ensure that the infiltration exported by the tool for a zone matches with the corresponding zone in the EnergyPlus model. Though the exfiltration is exported using this feature, EnergyPlus only uses the infiltration for energy calculation purposes when using the ZoneInfiltration:DesignFlowRate object. The exfiltration rates may be used with the ZoneAirflow object but that process will not be covered in this document.

User Interface, Inputs and Outputs

The user interface, user inputs, and outputs will be described in this section. The web-based CONTAM Results Export Tool can be found at http://www.bfrl.nist.gov/IAQanalysis/webapps/contam_results_exporter/ and is shown in Figure 1. The other features of this tool (Export .sim file to text files, Compute temporal/spatial averages of concentrations, and Process exposure results) can be found in Polidoro et al. (2015).

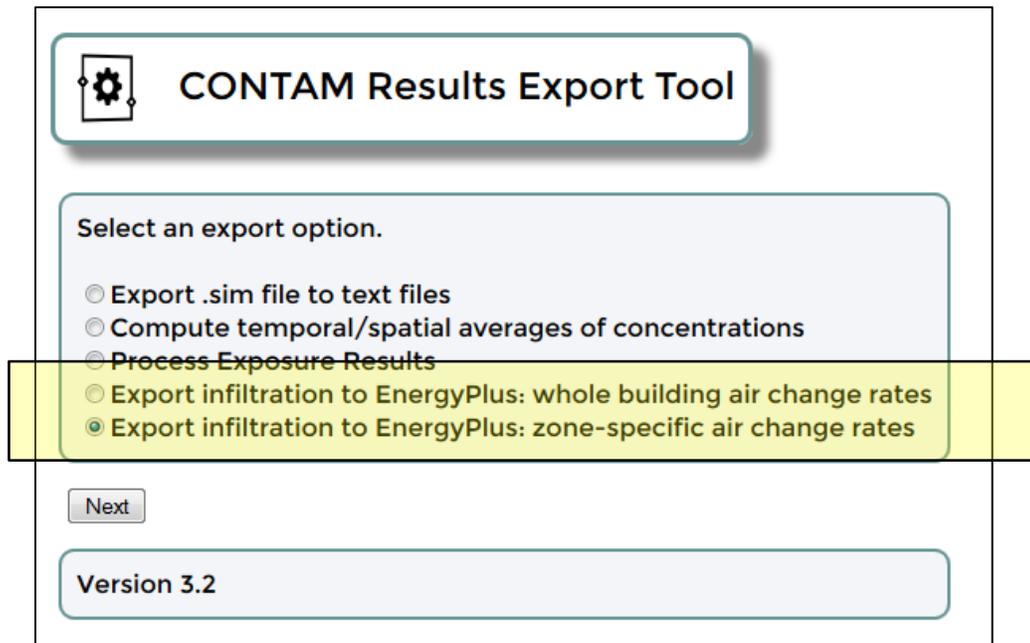


Figure 1. CONTAM Results Export Tool user interface (infiltration features highlighted)

Exporting Whole Building Air Change Rates

On the CONTAM Results Export Tool interface, select the “Export infiltration to EnergyPlus: whole building air change rates” radio button. Then click “Next”, and the user interface for exporting whole building air change rates (Figure 2) will appear. The inputs are:

1. **CONTAM .ach File:** Before performing a CONTAM simulation, enable the option to export a detailed whole building air change rate file (.ach file). This file contains the whole-building air change rate for each time step calculated using the amount of outdoor air coming into a building through flow paths (i.e., leakage) and mechanical systems. It

should be noted that only the flow through the flow paths is used by this tool (also referred to as “infiltration” in this document).

In order to utilize the schedule of infiltration rates in an EnergyPlus simulation, the following constraints are placed on the CONTAM simulation:

- a. Both the CONTAM and EnergyPlus simulations start on January 1, 00:00:00 and end on December 31, 24:00:00.
- b. The number of time steps in the CONTAM simulation must be at least 8760. The smallest time step allowed in EnergyPlus is one minute. Ideally, the time step in the CONTAM and EnergyPlus simulations should match.
- c. Do not simulate Daylight Savings in CONTAM.

Click the Browse button to select a CONTAM .ach file.

2. **Enter a name for the output files:** This name will be given to the partial IDF and comma separated values (CSV) schedule files created by the tool. The filename defaults to the name of the .ach file chosen, with an .idf extension. The user may change the name of the partial .idf file by changing the name in this text box. There should be no commas in the filename.
3. **Building Surface Area:** This is the exterior surface area of the building being modeled. It includes the above-grade gross areas of exterior walls and the roof area. This surface area can be input in m², ft² and other units by opening the drop down box to the right of the text box. The user can also obtain this value from the results of an EnergyPlus simulation under the InputVerificationandResultsSummary section of Output:Table:SummaryReports.

The screenshot shows a dialog box titled "EnergyPlus Whole Building ACH Export - Options". It features a close button in the top right corner. The dialog contains the following elements:

- A field for "Select a CONTAM ACH File (*.ach):" with a "Browse..." button and the text "No file selected."
- A field for "Enter a name for the output files:" with a text box containing the value "file".
- A field for "IDF filename:" with a text box containing the value "file.idf".
- A field for "CSV Schedule filename:" with a text box containing the value "file.csv".
- A field for "Building Surface Area" with a text box containing the value "1000" and a unit selection dropdown menu.
- "Cancel" and "OK" buttons at the bottom left.

Figure 2. User interface for exporting whole building air change rates

When exporting whole building air change rates, the outputs are:

1. **Partial .idf File:** A partial EnergyPlus .idf file is created, which contains only the following EnergyPlus objects:

- **ScheduleTypeLimits** – This is a generic limits object that is required by the Schedule:File object. It assigns the values in the Schedule:File object as dimensionless.
- **Schedule:File** – This object calls the CSV file (described below) that is created and contains the I_{design} values.
- **ZoneInfiltration:DesignFlowRate** – This object calls the Schedule:File object for the values of I_{design} calculated using CONTAM infiltration rates. This object applies the I_{design} values to any or all of the zones in the EnergyPlus file. The user can apply I_{design} values to multiple zones by copying and pasting a separate ZoneInfiltration:DesignFlowRate object for each zone and entering a unique Zone Name for the “Zone or ZoneList Name” field for each ZoneInfiltration:DesignFlowRate object. The user can also apply I_{design} values to a group of zones by creating a ZoneList and entering the name of the ZoneList object for the “Zone or ZoneList Name” field of the ZoneInfiltration:DesignFlowRate object. It may be beneficial to the user to create a ZoneList containing all of the exterior zones only. The user only needs to create one new ZoneInfiltration:DesignFlowRate object (the one created by this tool), which reduces error in transferring parameter values from the partial .idf file to the EnergyPlus project file.

It should be noted that this feature was developed for use with EnergyPlus v8.2. For earlier versions of EnergyPlus, see the EnergyPlus documentation for the format of the ScheduleTypeLimits, Schedule:File, and ZoneInfiltration:DesignFlowRate objects created by this tool that may require editing before running an EnergyPlus simulation.

2. **CSV File:** A schedule of I_{design} values is calculated using the CONTAM infiltration rates. These values are written to a CSV file that is called during the EnergyPlus simulation by the Schedule:File object. The .csv file needs to be located in the same directory as the EnergyPlus simulation file.

Exporting Zone-Specific Building Air Change Rates

On the CONTAM Results Export Tool interface, select the “Export infiltration to EnergyPlus: zone-specific air change rates” radio button. Then click “Next”, and the user interface for exporting zone-specific air change rates (Figure 3a) will appear. The inputs are:

1. **CONTAM .prj File:** Browse to the location of the CONTAM project (.prj) file.
2. **CONTAM .sim File:** Browse to the location of the CONTAM simulation (.sim) file, which is generated at the completion of a simulation.

After the .prj and .sim files are selected, a progress screen (Figure 3b) may appear that shows the timesteps being processed by the tool. When this is complete, a link will be provided to the .zip file containing the results/outputs (Figure 3c).

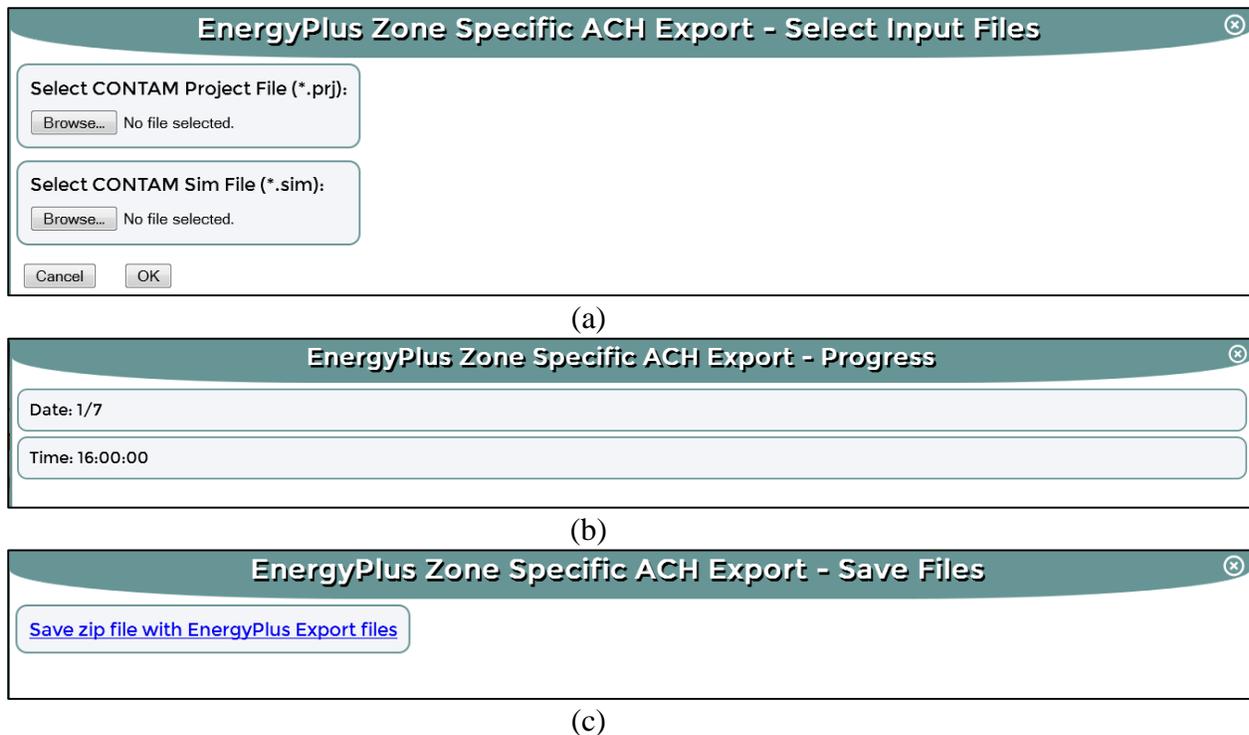


Figure 3. User interfaces for exporting zone-specific air change rates

When exporting zone-specific building air change rates, the outputs are:

1. **Partial .idf File:** The tool creates a partial EnergyPlus .idf file, similar to the file when exporting whole building air changes, except for the differences mentioned below:
 - ScheduleTypeLimits – This object remains the same.
 - Schedule:File – There was only one Schedule:File object created when using the feature that exports whole building air change rates. In contrast, when using the feature that exports zone-specific air change rates, multiple Schedule:File objects, one for each exterior zone, will be created. The entry for the “Name” of each Schedule:File follows the naming convention “Level”_”CONTAM zone name”_infil_sched.
 - ZoneInfiltration:DesignFlowRate – There was only one ZoneInfiltration:DesignFlowRate object created when using the feature that exports whole building air change rates. In contrast, when using the feature that exports zone-specific air change rates, multiple ZoneInfiltration:DesignFlowRate objects, one for each exterior zone, will be created. The entry for the “Name” of each ZoneInfiltration:DesignFlowRate follows the naming convention “CONTAM level”_”CONTAM zone name”_infil.
2. **CSV File:** The format of the CSV file created when using the feature that exports whole building air change rates was a column of time stamps and a column of I_{design} values. In

contrast, the CSV file created when using the feature that exports zone-specific air change rates has the following columns: time stamp, zone 1 infiltration, zone 1 exfiltration, zone 2 infiltration, zone 2 exfiltration ...zone n infiltration, zone n exfiltration. Where n is the number of exterior zones. An example is given at the end of this document. As mentioned above, even though the exfiltration is exported using this feature, EnergyPlus only uses the infiltration for energy calculation purposes. The .csv file needs to be located in the same directory as the EnergyPlus simulation file.

Implementing in EnergyPlus

To enable EnergyPlus to use CONTAM infiltration rates in energy simulations, the user can use a text editor or the EnergyPlus IDF Editor program. The process is similar, whether implementing whole building or zone-specific infiltration rates in EnergyPlus. Any differences will be noted.

Using a text editor

Using a text editor, open the EnergyPlus project file and the partial .idf file created by the Infiltration Tool as shown in Figure 4. Copy and paste the ScheduleTypeLimits and Schedule:File objects from the partial .idf file into the EnergyPlus project file. If implementing whole building infiltration rates, there will be one ScheduleTypeLimits and one Schedule:File object. If implementing zone-specific infiltration rates, there will be multiple Schedule:File objects, one for each exterior zone. If the CONTAM model has more exterior zones than in the EnergyPlus model, multiple ZoneInfiltration:DesignFlowRate objects can be applied to the same zone in EnergyPlus. It is up to the user to decide which EnergyPlus zones will be assigned multiple ZoneInfiltration:DesignFlowRate objects.

The objects can be located anywhere in the EnergyPlus project file, though using the “Save as” function in IDF Editor will re-order the objects in the EnergyPlus project file and group similar objects together.

In the EnergyPlus project file, use the Find function to find any existing ZoneInfiltration objects. Delete the existing ZoneInfiltration objects or make them comment lines by adding an exclamation point (!) at the beginning of each line.

```

MOff(schedule)2013-12-27(noDST) - Notepad
File Edit Format View Help
Holiday;                !- Special Day Type

!- ===== ALL OBJECTS IN CLASS: SITE:GROUNDTEMPERATURE:BUILDINGSURFACE =====
Site:GroundTemperature:BuildingSurface,
  19.527,                !- January Ground Temperature {C}
  19.502,                !- February Ground Temperature {C}
  19.536,                !- March Ground Temperature {C}
  19.598,                !- April Ground Temperature {C}
  20.002,                !- May Ground Temperature {C}
  21.640,                !- June Ground Temperature {C}
  22.225,                !- July Ground Temperature {C}
  22.375,                !- August Ground Temperature {C}
  21.449,                !- September Ground Temperature {C}
  20.121,                !- October Ground Temperature {C}
  19.802,                !- November Ground Temperature {C}
  19.633;                !- December Ground Temperature {C}

!- ===== ALL OBJECTS IN CLASS: SITE:WATERMAINSTEMPERATURE =====
Site:WaterMainsTemperature,
  CORRELATION,          !- Calculation Method
  ,                     !- Temperature Schedule Name
  9.69,                 !- Annual Average Outdoor Air Temperature {C}
  28.10;                !- Maximum Difference In Monthly Average Outdoor Air Temperatures

!- ===== ALL OBJECTS IN CLASS: SCHEDULETYPELIMITS =====
! ***SCHEDULE TYPES***
ScheduleTypeLimits,
  Any Number,           !- Name
  ,                     !- Lower Limit Value
  ,                     !- Upper Limit Value
  ,                     !- Numeric Type
  Dimensionless;       !- Unit Type

ScheduleTypeLimits,
  Fraction,             !- Name
  0.0,                  !- Lower Limit Value
  1.0,                  !- Upper Limit Value
  CONTINUOUS;           !- Numeric Type

ScheduleTypeLimits,
  Temperature,          !- Name
  -60,                  !- Lower Limit Value
  200,                  !- Upper Limit Value
  CONTINUOUS;           !- Numeric Type

ScheduleTypeLimits,

```

(a)

```

MediumOfficeNEW-2012-05-22(oahvacstime)(noDST) - Notepad
File Edit Format View Help
ScheduleTypeLimits,
  Any Number,          !- Name
  ,                    !- Lower Limit Value
  ,                    !- Upper Limit Value
  ,                    !- Numeric Type
  Dimensionless;      !- Unit Type

Schedule:File,
  bldg_infil_sched,    !- Name
  Any Number,          !- Schedule Type Limits Name
  MediumOfficeNEW-2012-05-22(oahvacstime)(noDST).csv,        !- File Name
  2,                   !- Column Number
  1,                   !- Rows to Skip at Top
  8760,                !- Number of Hours of Data
  Comma,               !- Column Separator
  No,                  !- Interpolate to Timestep
  60;                  !- Minutes per Item

ZoneInfiltration:DesignFlowRate,
  Zone_Infil,          !- Name
  ZoneList,            !- Zone or ZoneList Name
  bldg_infil_sched,    !- Schedule Name
  Flow/ExteriorArea,  !- Design Flow Rate Calculation Method
  ,                    !- Design Flow Rate {m3/s}
  1,                   !- Flow per Zone Floor Area {m3/s-m2}
  1,                   !- Flow per Exterior Surface Area {m3/s-m2}
  1,                   !- Air Changes per Hour {1/hr}
  0,                   !- Constant Term Coefficient
  0,                   !- Temperature Term Coefficient
  0,                   !- Velocity Term Coefficient
  0;                   !- Velocity Squared Term Coefficient

```

(b)

Figure 4. (a) EnergyPlus project file (b) Partial .idf file

Once existing ZoneInfiltration objects have been removed or disabled, copy and paste the ZoneInfiltration:DesignFlowRate object from the partial .idf file into the EnergyPlus project file. If implementing whole building infiltration rates, a single ZoneInfiltration:DesignFlowRate object is created by the tool and should be applied to every exterior zone. However, even if the ZoneInfiltration:DesignFlowRate object is applied to an interior zone, infiltration will not be modeled for that zone. The user should replace the default entry in the field “Zone or ZoneList Name” with the name of the ZoneList object, or Zone Names (which requires a separate ZoneInfiltration:DesignFlowRate object for each zone), in the EnergyPlus project file (Figure 5).

If implementing zone-specific infiltration rates, the tool creates a separate ZoneInfiltration:DesignFlow Rate object for each exterior zone. The default entries in the fields “Zone or ZoneList Name” are the zone names and levels number in the CONTAM model. If these zone names do not correspond to the names in the EnergyPlus model, the user should change them to match the names in the EnergyPlus model.

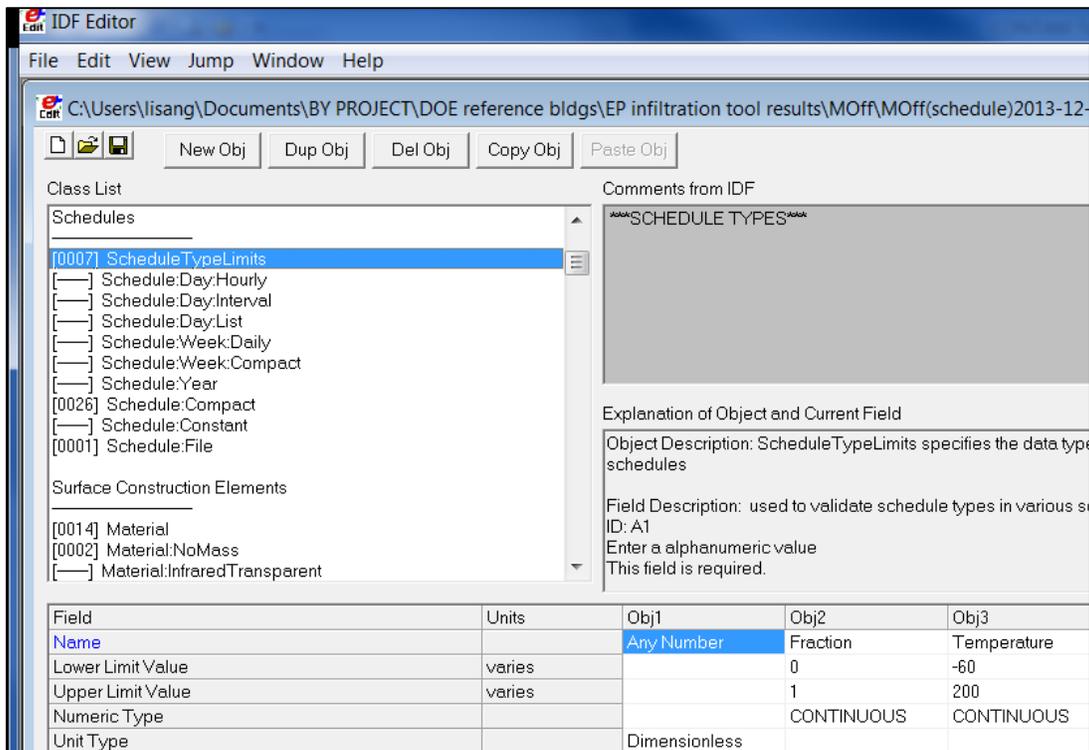
```
ZoneInfiltration:DesignFlowRate,
Zone_Infil, !- Name
ZoneList, !- Zone or ZoneList Name
bldg_infil_sched, !- Schedule Name
Flow/ExteriorArea, !- Design Flow Rate Calculation Method
, !- Design Flow Rate {m3/s}
1, !- Flow per Zone Floor Area {m3/s-m2}
1, !- Flow per Exterior Surface Area {m3/s-m2}
1, !- Air Changes per Hour {1/hr}
0, !- Constant Term Coefficient
0, !- Temperature Term Coefficient
0, !- Velocity Term Coefficient
0; !- Velocity Squared Term Coefficient
```

Figure 5. Partial .idf file showing default entry in the “Zone or ZoneList Name” field.

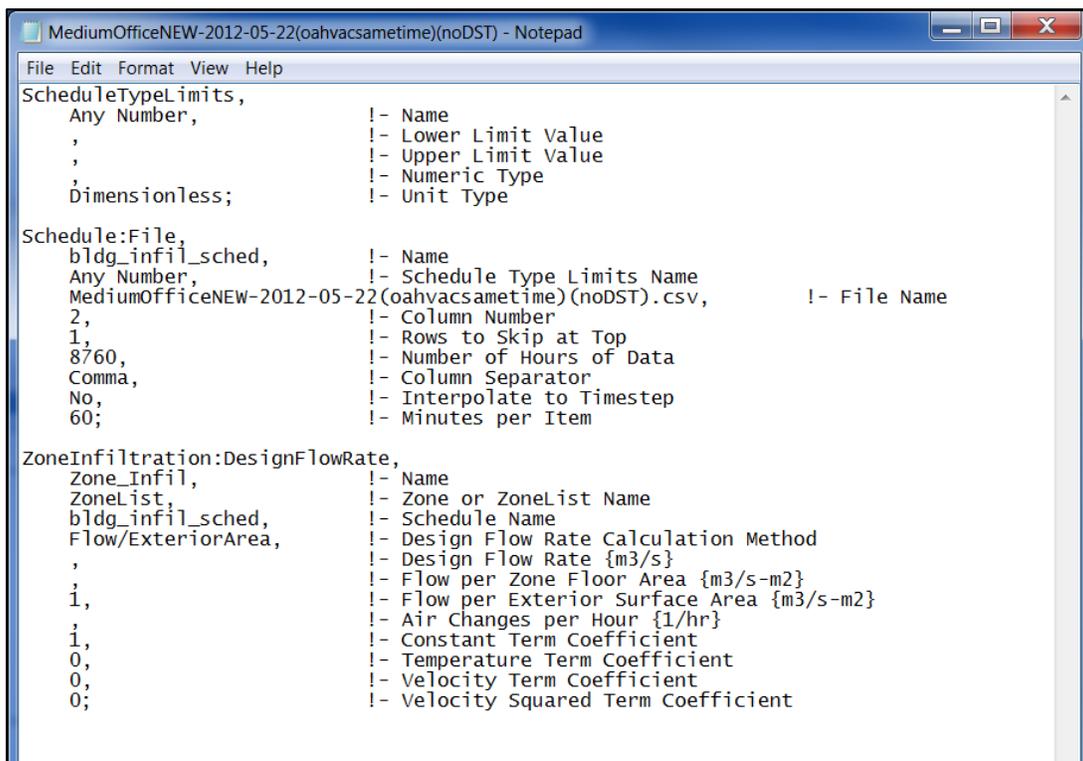
Using EnergyPlus IDF Editor program

Open the EnergyPlus project file in the EnergyPlus IDF Editor program and the partial.idf file in a text editor (Figure 6). In the IDF Editor, scroll to the “Schedules” under Class List and insert a New Obj under Schedule:TypeLimits. The field “Name” should be “Any Number”, and the field “Unit Type” should be “Dimensionless”, as is indicated in the partial .idf file (Figure 6b). Repeat this for the Schedule:File and ZoneInfiltration:DesignFlowRate objects by copying the text in the partial .idf file into the appropriate fields in the IDF Editor. Use Del Obj to remove existing ZoneInfiltration:DesignFlowRate objects.

As was the case when using a text editor, when implementing whole building infiltration rates, the ZoneInfiltration:DesignFlowRate should be applied to every exterior zone. The user should replace the default entry in the field “Zone or ZoneList Name” with the name of the ZoneList object, or Zone Names (which requires a separate ZoneInfiltration:DesignFlowRate object for each zone), in the EnergyPlus project file. When implementing zone-specific infiltration rates, the fields for each ZoneInfiltration:DesignFlowRate object should be entered for each corresponding zone.



(a)



(b)

Figure 6. (a) EnergyPlus project file opened in IDF Editor (b) Partial .idf file

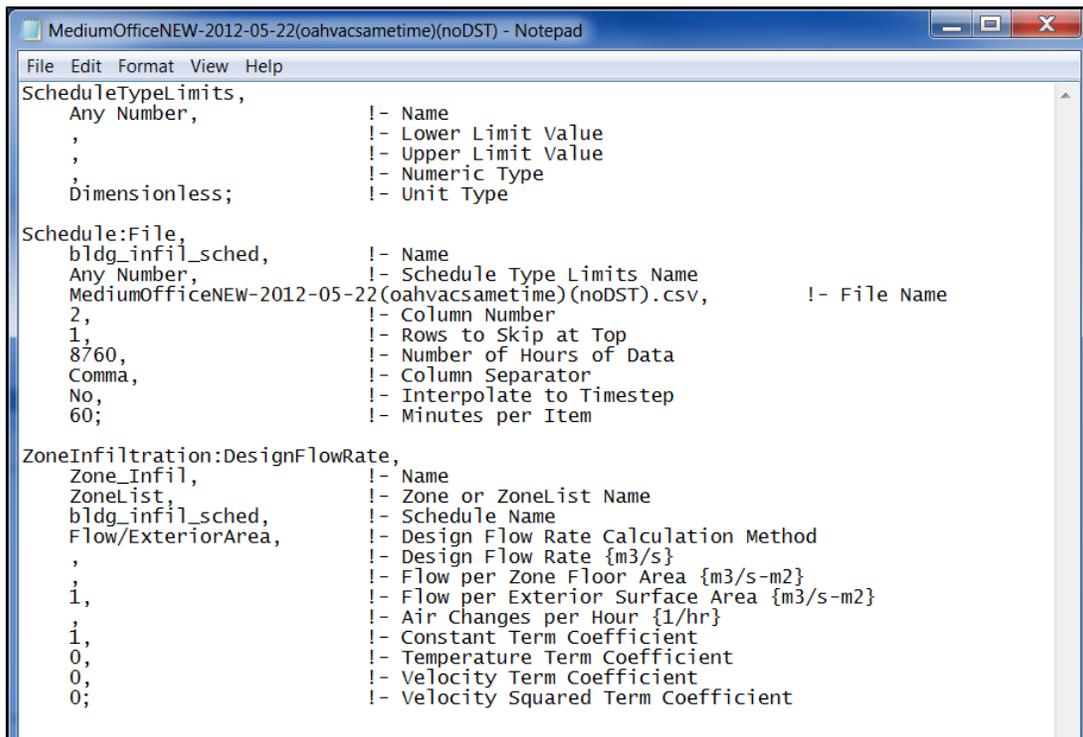
Other Considerations

System on or off: The HVAC system configuration and operating schedules in the CONTAM model should match the configuration in the EnergyPlus model. This is so the infiltration calculated by CONTAM, which is then input into EnergyPlus, will account for the HVAC system effects on infiltration. If the HVAC configurations between CONTAM and EnergyPlus do not match, EnergyPlus simulations can still be performed using the output files from this tool.

Fans on the building envelope: If there are intake fans in the building envelope that are modeled in CONTAM as flow paths, then the airflow through those fans will be included in the infiltration rate by this tool. To prevent this from happening, model intake fans using a duct instead of a flow path.

Examples

Figure 7 is an example of the partial .idf file created by this tool for the feature that exports whole building air change rates.



```
MediumOfficeNEW-2012-05-22(oahvacsametime)(noDST) - Notepad
File Edit Format View Help
ScheduleTypeLimits,
  Any Number,          !- Name
  ,                    !- Lower Limit Value
  ,                    !- Upper Limit Value
  ,                    !- Numeric Type
  Dimensionless;      !- Unit Type

Schedule:File,
  bldg_infil_sched,   !- Name
  Any Number,         !- Schedule Type Limits Name
  MediumOfficeNEW-2012-05-22(oahvacsametime)(noDST).csv, !- File Name
  2,                  !- Column Number
  1,                  !- Rows to Skip at Top
  8760,               !- Number of Hours of Data
  Comma,              !- Column Separator
  No,                 !- Interpolate to Timestep
  60;                 !- Minutes per Item

ZoneInfiltration:DesignFlowRate,
  Zone_infil,        !- Name
  ZoneList,          !- Zone or ZoneList Name
  bldg_infil_sched, !- Schedule Name
  Flow/ExteriorArea, !- Design Flow Rate Calculation Method
  ,                  !- Design Flow Rate {m3/s}
  1,                 !- Flow per Zone Floor Area {m3/s-m2}
  ,                  !- Flow per Exterior Surface Area {m3/s-m2}
  1,                 !- Air Changes per Hour {1/hr}
  0,                 !- Constant Term Coefficient
  0,                 !- Temperature Term Coefficient
  0,                 !- Velocity Term Coefficient
  0;                 !- Velocity Squared Term Coefficient
```

Figure 7. Example of Partial .idf file – exporting whole building air change rates

When using the feature that exports zone-specific air change rates, there will be as many ZoneInfiltration:DesignFlowRate objects as there are exterior zones. Figure 8 is an example of the partial .idf file created by this tool for a building with multiple zones. The first Schedule:File object (6_Plenum_infil_sched) is for the zone on the sixth level called “Plenum” in the CONTAM model.

```

MediumOfficeNEW-2012-05-22(oahvacstime)(noDST) - Notepad
File Edit Format View Help
ScheduleTypeLimits,
  Any Number,          !- Name
  ,                    !- Lower Limit Value
  ,                    !- Upper Limit Value
  ,                    !- Numeric Type
  Dimensionless;      !- Unit Type

Schedule:File,
  6_Plenum_infil_sched, !- Name
  Any Number,          !- Schedule Type Limits Name
  MediumOfficeNEW-2012-05-22(oahvacstime)(noDST).csv, !- File Name
  2,                   !- Column Number
  1,                   !- Rows to Skip at Top
  8760,               !- Number of Hours of Data
  Comma,              !- Column Separator
  No,                 !- Interpolate to Timestep
  30;                 !- Minutes per Item

ZoneInfiltration:DesignFlowRate,
  6_Plenum_infil,    !- Name
  6_Plenum,          !- Zone or ZoneList Name
  6_Plenum_infil_sched, !- Schedule Name
  Flow/Zone,        !- Design Flow Rate Calculation Method
  1,                !- Design Flow Rate {m3/s}
  ,                 !- Flow per Zone Floor Area {m3/s-m2}
  ,                 !- Flow per Exterior Surface Area {m3/s-m2}
  ,                 !- Air Changes per Hour {1/hr}
  1,                !- Constant Term Coefficient
  0,                !- Temperature Term Coefficient
  0,                !- Velocity Term Coefficient
  0;                !- Velocity Squared Term Coefficient

Schedule:File,
  6_StairAtPlenum_infil_sched, !- Name
  Any Number,          !- Schedule Type Limits Name
  MediumOfficeNEW-2012-05-22(oahvacstime)(noDST).csv, !- File Name
  4,                   !- Column Number
  1,                   !- Rows to Skip at Top
  8760,               !- Number of Hours of Data
  Comma,              !- Column Separator
  No,                 !- Interpolate to Timestep
  30;                 !- Minutes per Item

ZoneInfiltration:DesignFlowRate,
  6_StairAtPlenum_infil, !- Name
  6_StairAtPlenum,      !- Zone or ZoneList Name
  6_StairAtPlenum_infil_sched, !- Schedule Name
  Flow/Zone,           !- Design Flow Rate Calculation Method
  1,                   !- Design Flow Rate {m3/s}
  ,                    !- Flow per Zone Floor Area {m3/s-m2}
  ,                    !- Flow per Exterior Surface Area {m3/s-m2}
  ,                    !- Air Changes per Hour {1/hr}
  1,                   !- Constant Term Coefficient

```

Ln 1, Col 1

Figure 8. Example of Partial .idf file – exporting zone-specific air change rates

Figure 9 is an example of the CSV file for the feature that exports whole building air change rates.

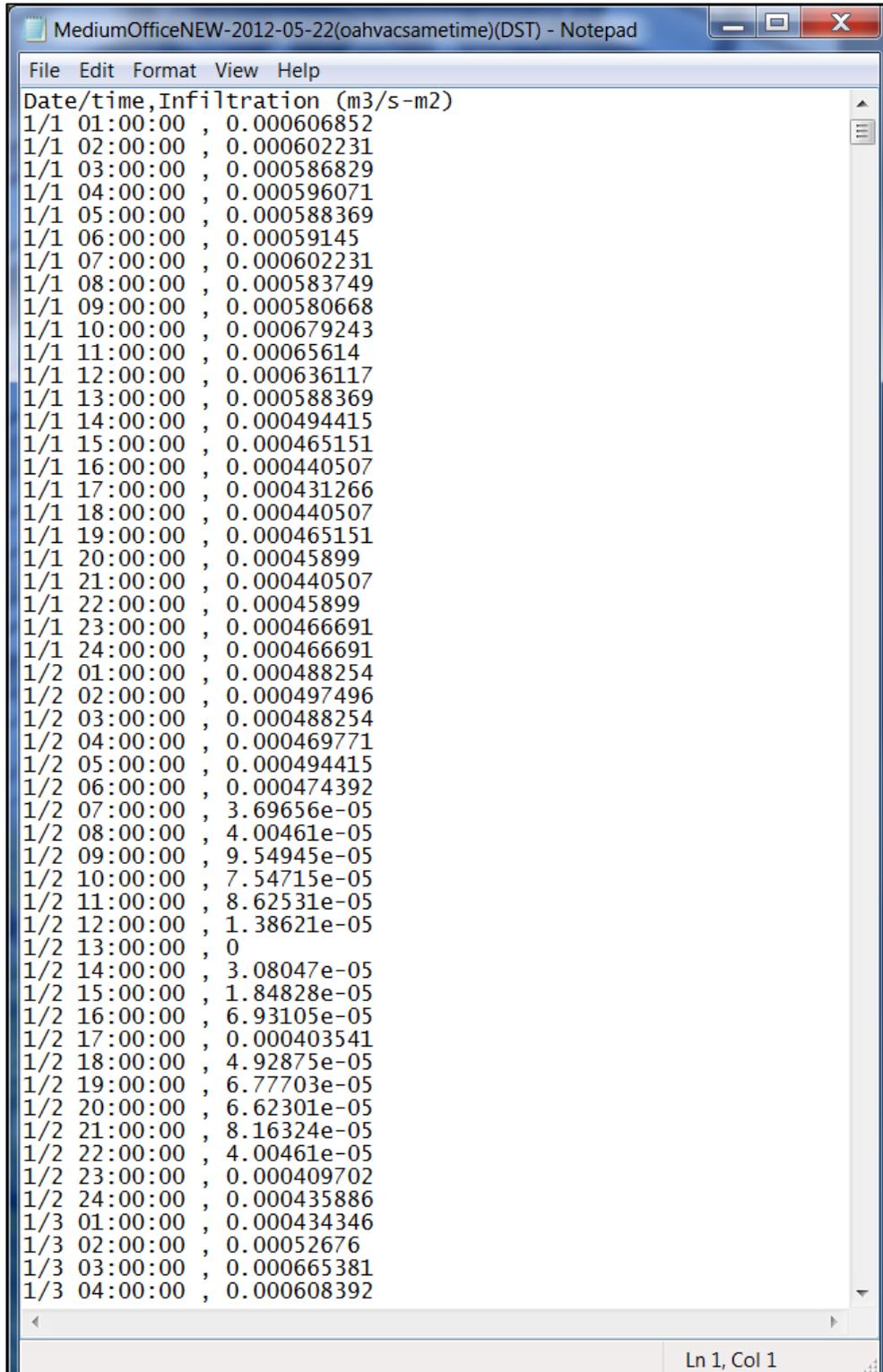
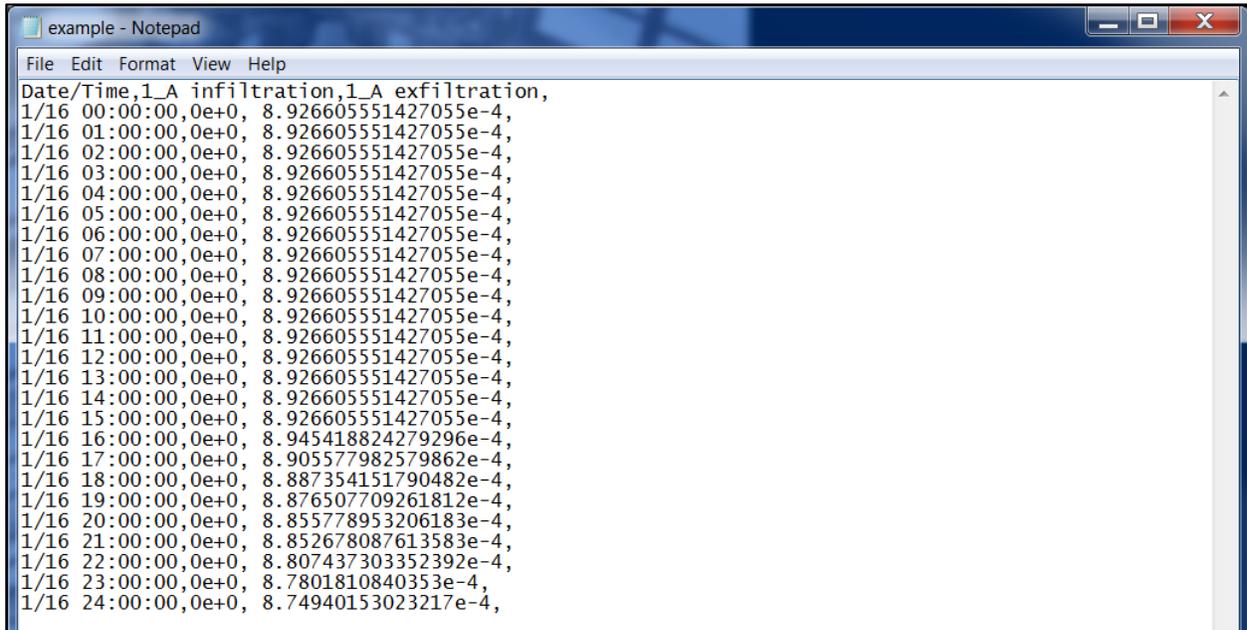


Figure 9. Example of .csv file – exporting whole building air change rates

Here is a partial CSV file for the feature that exports zone-specific air change rates. There will be columns of infiltration and exfiltration values, one set for each exterior zone in units of m³/s.



```
example - Notepad
File Edit Format View Help
Date/Time,1_A infiltration,1_A exfiltration,
1/16 00:00:00,0e+0, 8.926605551427055e-4,
1/16 01:00:00,0e+0, 8.926605551427055e-4,
1/16 02:00:00,0e+0, 8.926605551427055e-4,
1/16 03:00:00,0e+0, 8.926605551427055e-4,
1/16 04:00:00,0e+0, 8.926605551427055e-4,
1/16 05:00:00,0e+0, 8.926605551427055e-4,
1/16 06:00:00,0e+0, 8.926605551427055e-4,
1/16 07:00:00,0e+0, 8.926605551427055e-4,
1/16 08:00:00,0e+0, 8.926605551427055e-4,
1/16 09:00:00,0e+0, 8.926605551427055e-4,
1/16 10:00:00,0e+0, 8.926605551427055e-4,
1/16 11:00:00,0e+0, 8.926605551427055e-4,
1/16 12:00:00,0e+0, 8.926605551427055e-4,
1/16 13:00:00,0e+0, 8.926605551427055e-4,
1/16 14:00:00,0e+0, 8.926605551427055e-4,
1/16 15:00:00,0e+0, 8.926605551427055e-4,
1/16 16:00:00,0e+0, 8.945418824279296e-4,
1/16 17:00:00,0e+0, 8.905577982579862e-4,
1/16 18:00:00,0e+0, 8.887354151790482e-4,
1/16 19:00:00,0e+0, 8.876507709261812e-4,
1/16 20:00:00,0e+0, 8.855778953206183e-4,
1/16 21:00:00,0e+0, 8.852678087613583e-4,
1/16 22:00:00,0e+0, 8.807437303352392e-4,
1/16 23:00:00,0e+0, 8.7801810840353e-4,
1/16 24:00:00,0e+0, 8.74940153023217e-4,
```

Figure 10. Example of .csv file – exporting zone-specific air change rates

Conclusion

This document describes two features of the CONTAM Results Export Tool that can be used to incorporate infiltration rates from the multizone airflow model, CONTAM, into an EnergyPlus building simulation model. This enables users of EnergyPlus to incorporate more physically-reasonable and building specific infiltration calculations into energy simulations. Users of this tool need to be familiar with how to perform CONTAM simulation and how to modify EnergyPlus IDF files using either the EnergyPlus IDF Editor or a text editor.

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