Energy Technologies Area

Energy Performance Indices EP_C and EP_H Calculation Methodology and Implementation in Software tool

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1. INTRODUCTION & BACKGROUND

Energy performance indices, EP_C and EP_H of window attachments are developed on the basis of ISO 18292 standard (ISO 2011), which gives methodology for calculating heating and cooling energy performance of windows. This methodology is based on the results of energy simulation of a typical residential building (house) in a typical cooling and heating climate.

2. Derivation of Energy Performance Index

For the purpose of calculating energy performance indices of window attachments, Houston climate was selected for cooling performance index, EP_C and Minneapolis was selected for heating energy performance index, EP_H. Energy simulation is done using the sub-hourly energy analysis program EnergyPlus (DOE 2016). Three different cases are simulated:

A. Typical house with windows replaced by adiabatic surfaces (i.e., zero heat flux through window surfaces)
B. Typical house with baseline windows
S. Typical house with baseline windows and window shade/attachment over them

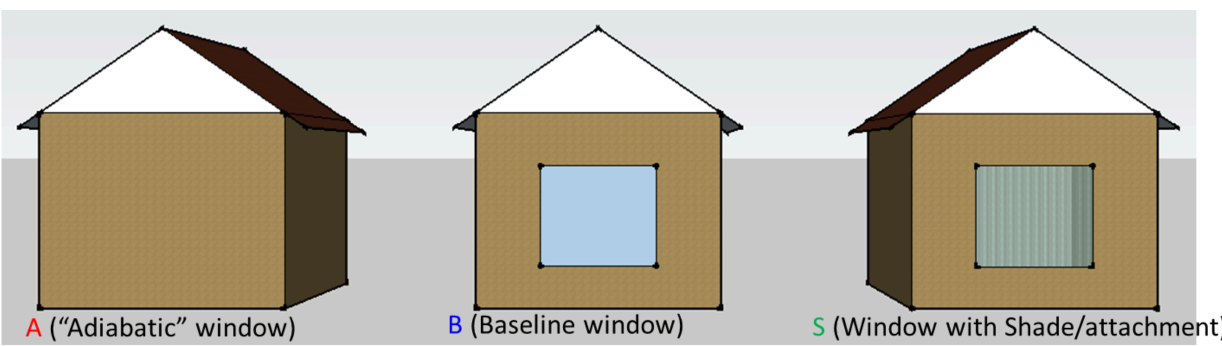


Figure 1. Schematic of three different house models

Energy simulation is done over the typical TMY3 year for each location and results of energy for each case are expressed as:

E_A: annual HVAC cooling or heating energy use of the house with "adiabatic" window

E_B: annual HVAC cooling or heating energy use of the house with baseline window only

E_S: annual HVAC cooling or heating energy use of the house with window attachment.

Based on the results of energy simulation, the following quantities are calculated:

$E_{B\text{-}A} = E_B - E_A$, annual energy use caused by the baseline window

$E_{B\text{-}S} = E_B - E_S$, window attachment energy savings vs. the baseline window

Energy performance indices of window attachments, $EP_{C,}$ and EP_H are defined as the ratio of annual cooling/heating energy saving resulting from the addition of window attachment to the annual energy use caused by the baseline window without attachment.

$$EP_C = \frac{(E_{B-S})_{Houston}}{(E_{B-A})_{Houston}}$$

$$EP_H = \frac{(E_{B-S})_{Minneapolis}}{(E_{B-A})_{Minneapolis}}$$

Typical house is defined from the DOE standard residential building model, combining several building vintages into a single typical house. The listing of assumptions is detailed in Appendix A.

Energy plus runs for both *Baseline* and *Adiabatic* runs are performed once for each climate, making for four sets of results (two for heating and two for cooling EP) and saved as fixed information.

EnergyPlus model for the house with baseline windows, E_B is run using the Autosize option for HVAC. This is done once for cooling and once for heating climates. Such calculated HVAC size is then fixed for all subsequent runs, including adiabatic and attachment cases. Baseline windows run is detailed in section 1.1.

EnergyPlus model of a house with window attachment is run at least once per product for fixed attachments (i.e., window panels, solar screens, surface-attached films), two times for 1-D operation shades (e.g., roller shades, cellular shades, pleated shades, roman shades, etc.), where one run is for shade fully closed and second run is for shade half closed (fully retracted option is identical to baseline window); and 7 runs for 2-D operation shades (venetian blinds, vertical blinds, etc.). More details are provided in section 1.3.

3. EnergyPlus Runs

Energy analysis is done using EnergyPlus simulation tool and IDF input file for EnergyPlus simulation is created from the collection of include files (*.inc). The reason for splitting IDF files into several include files is that for different runs, only individual include files would be replaced. The list of include files in following sections are marked in green, yellow, and red, signifying how these files are set. Green colored include files are fixed and are used in each case, E_A, E_B, and E_S. Yellow colored include files are fixed, but are inserted based on the case being run. Red colored include files are specific to each window attachment and are prepared on the fly. More details about include files are provided in Appendix C.

Besides IDF files for each run, energy simulation also requires a weather data file (TMY3 file). The weather data file names for these two climates are listed below:

- Houston: USA_TX_Houston-Bush.Intercontinental.AP.722430_TMY3.epw
- Minneapolis: USA_MN_Minneapolis-St.Paul.Intl.AP.726580_TMY3.epw

3.1 Adiabatic Windows Run

Houston:

- AERC_Base_Building_Houston.inc
- Air_infiltration_adiabatic_Houston.inc
- System_sizing_Houston.inc

Minneapolis:

- AERC_Base_Building_Minneapolis.inc
- Air_infiltration_adiabatic_Minneapolis.inc
- System_sizing_Minneapolis.inc

Both climate zones:

- Window_configuration.inc
- Window_construction_adiabatic.inc

3.2 Baseline Windows Run

For the baseline window run, the following include files are provided.

Houston:

- AERC_Base_Building_Houston.inc
- Air_infiltration_baseline_Houston.inc
- System_autosize_Houston.inc

Minneapolis:

- AERC_Base_Building_Minneapolis.inc
- Air_infiltration_baseline_Minneapolis.inc
- System_autosize_Minneapolis.inc

Both climate zones:

- Window_configuration.inc
- Window_construction_baseline.inc

3.3 Windows with Attachments

Window construction “include” files for windows with attachments that are first defined for each window attachment in the WINDOW software tool and exported as an IDF file. While most of window attachments have single degree of freedom in operation (retraction operation only) or 0 degree of freedom (fixed window attachments) and therefore have single construction description for its deployed position, some attachments have 2 degrees of freedom (e.g., louvered shades), resulting in 4 window construction records:

1) horizontal slats, or 0 deg
2) closed slats, or 90 deg
3) -45 deg
4) 45 deg

Depending on the degree of freedom for window attachments, a different number of EnergyPlus runs will be required. Table 1 gives a summary for each window attachment class/type. Automation calculations are available for all shading products with 1 or 2 degrees of freedom (1D or 2D).

Table 1. Simulation runs for different deployment situation of each shade

Shade Type	Code	Degrees of freedom	Fully Deployed (top & bottom window w/ shade)	Half Deployed (only top window w/ shade)	Total runs
Roller Shades	RS	1	1 run	1 run	2
Cellular Shades	CS	1	1 run	1 run	2
Solar Screens	SS	0	1 run	--	1
Applied Films	AF	0	1 run	--	1
Horizontal (Venetian) Blinds	VB	2	4 runs	3 runs	7
Vertical Louvered Blinds	VL	2	4 runs	3 runs	7
Window Panels	WP	0	1 run	--	1
Pleated Shades	PS	1	1 run	1 run	2
Roller Shutters	ER	1	1 run	1 run	2
Roman Shades	RM	1	1 run	1 run	2
Louvered Shutters	LS	2	4 runs	3 runs	7
Awnings Operable	AO	1	1 run	1 run	2
Awnings Seasonably Fixed	AS	1	1 run	--	1
Awnings Fixed	AY	0	1 run	--	1
Window Quilts Operable	RS	1	1 run	1 run	2
Window Quilts - Fixed	SS	0	1 run	--	1

3.3.1 Fully Deployed Window Attachments Runs

The include files needed for fully deployed window attachments run are listed below.

Houston:

- AERC_Base_Building_Houston.inc
- Air_infiltration_user_input_Houston.inc
- System_sizing_Houston.inc

Minneapolis:

- AERC_Base_Building_Minneapolis.inc
- Air_infiltration_user_input_Minneapolis.inc
- System_sizing_Minneapolis.inc

Both climate zones:

- Window_configuration.inc

- 1D window attachments: Window_construction_user_input.inc
- 2D window attachments – louvered blinds:
    - Window_ construction_user_input0.inc
    - Window_ construction_user_input90.inc
    - Window_ construction_user_input-45.inc
    - Window_ construction_user_input+45.inc

3.3.2 Half-Deployed Window Attachments Runs

The include files needed for half-deployed window attachments run are listed below.

Houston:

- AERC_Base_Building_Houston.inc
- Air_infiltration_baseline_Houston.inc
- System_sizing_Houston.inc

Minneapolis:

- AERC_Base_Building_Minneapolis.inc
- Air_infiltration_baseline_Minneapolis.inc
- System_sizing_Minneapolis.inc

Both climate zones:

- Window_configuration.inc
- Window_construction_baseline.inc
- 1D window attachments: Window_construction_user_input.inc
- 2D window attachments – louvered blinds:
    - Window_ construction_user_input0.inc
    - Window_ construction_user_input90.inc
    - Window_ construction_user_input-45.inc
    - Window_ construction_user_input+45.inc

3.3.3 Automation Window Attachments Runs

The include files needed for Automation window attachments run are listed below.

Houston:

- EMS_cooling.inc
- Shd_Sched_N_Cooling.csv
- Shd_Sched_E_Cooling.csv
- Shd_Sched_S_Cooling.csv
- Shd_Sched_W_Cooling.csv

Minneapolis:

- EMS_heating.inc
- Shd_Sched_N_Heating.csv
- Shd_Sched_E_Heating.csv
- Shd_Sched_S_Heating.csv

- Shd_Sched_W_Heating.csv

4. Calculation of Energy Use

Energy use for each case is calculated from HVAC system results of EnergyPlus simulation. Instructions for generating correct output results are provided in include file EP_Output_Fields.inc, shown in Appendix B. Results are stored in IDF_input_file_name.csv file. The following output fields are used in calculation of energy use:

Houston:

- "CENTRAL SYSTEM_UNIT1: Air System DX Cooling Coil Electric Energy [J](Hourly)"
- "CENTRAL SYSTEM_UNIT1:Air System Fan Electric Energy [J](Hourly)".

Minneapolis:

- "CENTRAL SYSTEM_UNIT1: Air System Gas Energy [J](Hourly)"
- "CENTRAL SYSTEM_UNIT1:Air System Fan Electric Energy [J](Hourly)".

For brevity and subsequent use in equations, the following nomenclature will be used:

$E_{DX\,Coil}(\tau_h)$ = CENTRAL SYSTEM_UNIT1: Air System DX Cooling Coil Electric Energy [J](Hourly)

$E_{Fan}(\tau_h)$ = CENTRAL SYSTEM_UNIT1:Air System Fan Electric Energy [J](Hourly)

$E_{Gas}(\tau_h)$ = CENTRAL SYSTEM_UNIT1: Air System Gas Energy [J](Hourly)

Total energy, required for the calculation of E_A, E_B, and E_S is calculated by summing up all hours when the cooling system is on (CS=ON) in Houston and when the heating system is on (HS=ON) in Minneapolis. "CS=ON" when "CENTRAL SYSTEM_UNIT1: Air System DX Cooling Coil Electric Energy [J](Hourly)", is larger than 0. Correspondingly, "HS=ON" when "CENTRAL SYSTEM_UNIT1: Air System Gas Energy [J](Hourly)", is larger than 0. The energy totals are also corrected to source energy using following conversion factors:

SF_E = conversion factor from electricity to source energy in GJ, $3.167 \cdot 10^{-9}$

SF_G = conversion factor from natural gas to source energy in GJ, $1.084 \cdot 10^{-9}$

4.1 Adiabatic Windows Runs

The energy use for adiabatic window runs are calculated from output of EnergyPlus simulation for adiabatic window case and normalized using source energy correction, which is applied to selected energy contributions.

Houston:

$$E_A = \left(\sum_{CS=ON} E_{DXCoil}\left(\tau_h\right)_A + \sum_{CS=ON} E_{Fan}\left(\tau_h\right)_A \right) \cdot SF_E$$

Minneapolis:

$$E_A = \left(\sum_{HS=ON} E_{Gas}\left(\tau_h\right)_A \right) \cdot SF_G + \left(\sum_{HS=ON} E_{Fan}\left(\tau_h\right)_A \right) \cdot SF_E$$

The resulting energy use E_A is expressed in GJ of source energy. E_A for both locations is calculated once and saved for the calculation of EP.

4.2 Baseline Windows Runs

The energy use for baseline window runs are calculated from output of EnergyPlus simulation for baseline window case and normalized using source energy correction, which is applied to selected energy contributions.

Houston:

$$E_B = \left(\sum_{CS=ON} E_{DXCoil}\left(\tau_h\right)_B + \sum_{CS=ON} E_{Fan}\left(\tau_h\right)_B \right) \cdot SF_E$$

Minneapolis:

$$E_B = \left(\sum_{HS=ON} E_{Gas}\left(\tau_h\right)_B \right) \cdot SF_G + \left(\sum_{HS=ON} E_{Fan}\left(\tau_h\right)_B \right) \cdot SF_E$$

The resulting energy use E_B is expressed in GJ of source energy. E_B for both locations is calculated once and saved for the calculation of EP.

4.3 Windows with Attachments Runs

Energy uses for windows with attachments are done on demand for each attachment for which EP is calculated. Depending on the attachment type, different levels of calculation are done. Details of these calculations for different attachment types are provided below.

4.3.1 Fixed Attachments

For fixed attachments (i.e., non-operable), single and non-weighted calculation is done, similar to cases of adiabatic and baseline window energy use calculations:

Houston:

$$E_S = \left(\sum_{CS=ON} E_{DXCoil}\left(\tau_h\right)_S + \sum_{CS=ON} E_{Fan}\left(\tau_h\right)_S \right) \cdot SF_E$$

Minneapolis:

$$E_S = \left(\sum_{HS=ON} E_{Gas}\left(\tau_h\right)_S \right) \cdot SF_G + \left(\sum_{HS=ON} E_{Fan}\left(\tau_h\right)_S \right) \cdot SF_E$$

The resulting energy use E_S is expressed in GJ of source energy.

4.3.2 Operable Window Attachments

4.3.2.1 Manual Operation - Attachments with 1-D operation, except for Awnings

For these window attachment types, the operation consists of attachment retraction to various degrees. The deployment schedule for operable window attachments, was developed from the results of a behavioral study (DRI 2013). Based on the results of the survey of 2,467 households in 12 markets, a deployment schedule was developed for 3 periods during the day, two periods during the week, and for two seasons. The behavioral study considered three different attachment deployments and identified the percentage of products that were in one of these three positions at different times of day, week and season.

The deployment positions of window attachments considered were:

1. **O:** Open (Baseline window runs)
2. **H:** Half-Open (Half-Deployed window attachment runs)
3. **C:** Closed (Fully-Deployed window attachment runs)

The periods of day considered were:

1. **M:** Morning, including work hours (6:00 a.m. to 12:00 p.m.)
2. **A:** Afternoon (12:00 p.m. to 6:00 p.m.)
3. **N:** Evening/Night (6:00 p.m. to 6.00 a.m. of next day)

The periods of week considered were:

1. **D:** Weekday
2. **E:** Weekend and holidays

Note: Each weather data file contains standard US holidays, which are assigned the weekend schedule in the EnergyPlus input.

Time-weighting of energy use is done in addition to the consideration when the cooling or heating system is on, to calculate E_S. In order to describe the weighting calculation methodology, indices for hourly, daily, and weekly periods are used. Hourly energy values are labeled using τ_h. Different days in a week (i.e., weekday vs. weekends and holidays) are labeled using index τ_d, and different weeks in a season are labeled using index τ_w. Using this notation, the following equations are used to calculate weighted source energy use from operable window shades with 1 degree of freedom:

$$E_S = E_O + E_H + E_C$$

Where:

$$E_O = \sum_{\tau_w = S_1}^{S_N} \left(E_{SDO}(\tau_w) + E_{SEO}(\tau_w) \right) + \sum_{\tau_w = W_1}^{W_N} \left(E_{WDO}(\tau_w) + E_{WEO}(\tau_w) \right)$$

$$E_H = \sum_{\tau_w = S_1}^{S_N} \left(E_{SDH}(\tau_w) + E_{SEH}(\tau_w) \right) + \sum_{\tau_w = W_1}^{W_N} \left(E_{WDH}(\tau_w) + E_{WEH}(\tau_w) \right)$$

$$E_C = \sum_{\tau_w = S_1}^{S_N} \left(E_{SDC}(\tau_w) + E_{SEC}(\tau_w) \right) + \sum_{\tau_w = W_1}^{W_N} \left(E_{WDC}(\tau_w) + E_{WEC}(\tau_w) \right)$$

Where (Equations 5-16):

$$E_{SDO}(\tau_w) = \sum_{\tau_d=1}^{5} \left(F_{SDMO} \cdot \sum_{\tau_h=6}^{12} E_O(\tau_w, \tau_d, \tau_h) + F_{SDAO} \cdot \sum_{\tau_h=12}^{18} E_O(\tau_w, \tau_d, \tau_h) + F_{SDNO} \cdot \sum_{\tau_h=18}^{6(+1day)} E_O(\tau_w, \tau_d, \tau_h) \right)$$

$$E_{SEO}(\tau_w) = \sum_{\tau_d=6}^{7} \left(F_{SEMO} \cdot \sum_{\tau_h=6}^{12} E_O(\tau_w, \tau_d, \tau_h) + F_{SEAO} \cdot \sum_{\tau_h=12}^{18} E_O(\tau_w, \tau_d, \tau_h) + F_{SENO} \cdot \sum_{\tau_h=18}^{6(+1day)} E_O(\tau_w, \tau_d, \tau_h) \right)$$

$$E_{WDO}(\tau_w) = \sum_{\tau_d=1}^{5} \left(F_{WDMO} \cdot \sum_{\tau_h=6}^{12} E_O(\tau_w, \tau_d, \tau_h) + F_{WDAO} \cdot \sum_{\tau_h=12}^{18} E_O(\tau_w, \tau_d, \tau_h) + F_{WDNO} \cdot \sum_{\tau_h=18}^{6(+1day)} E_O(\tau_w, \tau_d, \tau_h) \right)$$

$$E_{WEO}(\tau_w) = \sum_{\tau_d=6}^{7} \left(F_{WEMO} \cdot \sum_{\tau_h=6}^{12} E_O(\tau_w, \tau_d, \tau_h) + F_{WEAO} \cdot \sum_{\tau_h=12}^{18} E_O(\tau_w, \tau_d, \tau_h) + F_{WENO} \cdot \sum_{\tau_h=18}^{6(+1day)} E_O(\tau_w, \tau_d, \tau_h) \right)$$

$$E_{SDH}(\tau_w) = \sum_{\tau_d=1}^{5} \left(F_{SDMH} \cdot \sum_{\tau_h=6}^{12} E_H(\tau_w, \tau_d, \tau_h) + F_{SDAH} \cdot \sum_{\tau_h=12}^{18} E_H(\tau_w, \tau_d, \tau_h) + F_{SDNH} \cdot \sum_{\tau_h=18}^{6(+1day)} E_H(\tau_w, \tau_d, \tau_h) \right)$$

$$E_{SEH}(\tau_w) = \sum_{\tau_d=6}^{7} \left(F_{SEMH} \cdot \sum_{\tau_h=6}^{12} E_H(\tau_w, \tau_d, \tau_h) + F_{SEAH} \cdot \sum_{\tau_h=12}^{18} E_H(\tau_w, \tau_d, \tau_h) + F_{SENH} \cdot \sum_{\tau_h=18}^{6(+1day)} E_H(\tau_w, \tau_d, \tau_h) \right)$$

$$E_{WDH}(\tau_w) = \sum_{\tau_d=1}^{5} \left(F_{WDMH} \cdot \sum_{\tau_h=6}^{12} E_H(\tau_w, \tau_d, \tau_h) + F_{WDAH} \cdot \sum_{\tau_h=12}^{18} E_H(\tau_w, \tau_d, \tau_h) + F_{WDNH} \cdot \sum_{\tau_h=18}^{6(+1day)} E_H(\tau_w, \tau_d, \tau_h) \right)$$

$$E_{WEH}(\tau_w) = \sum_{\tau_d=6}^{7} \left(F_{WEMH} \cdot \sum_{\tau_h=6}^{12} E_H(\tau_w, \tau_d, \tau_h) + F_{WEAH} \cdot \sum_{\tau_h=12}^{18} E_H(\tau_w, \tau_d, \tau_h) + F_{WENH} \cdot \sum_{\tau_h=18}^{6(+1day)} E_H(\tau_w, \tau_d, \tau_h) \right)$$

$$E_{SDC}(\tau_w) = \sum_{\tau_d=1}^{5} \left(F_{SDMC} \cdot \sum_{\tau_h=6}^{12} E_C(\tau_w, \tau_d, \tau_h) + F_{SDAC} \cdot \sum_{\tau_h=12}^{18} E_C(\tau_w, \tau_d, \tau_h) + F_{SDNC} \cdot \sum_{\tau_h=18}^{6(+1day)} E_C(\tau_w, \tau_d, \tau_h) \right)$$

$$E_{SEC}(\tau_w) = \sum_{\tau_d=6}^{7}\left(F_{SEMC} \cdot \sum_{\tau_h=6}^{12} E_C\left(\tau_w,\tau_d,\tau_h\right) + F_{SEAC} \cdot \sum_{\tau_h=12}^{18} E_C\left(\tau_w,\tau_d,\tau_h\right) + F_{SENC} \cdot \sum_{\tau_h=18}^{6(+1day)} E_C\left(\tau_w,\tau_d,\tau_h\right)\right)$$

$$E_{SWC}(\tau_w) = \sum_{\tau_d=1}^{5}\left(F_{WDMC} \cdot \sum_{\tau_h=6}^{12} E_C\left(\tau_w,\tau_d,\tau_h\right) + F_{WDAC} \cdot \sum_{\tau_h=12}^{18} E_C\left(\tau_w,\tau_d,\tau_h\right) + F_{WDNC} \cdot \sum_{\tau_h=18}^{6(+1day)} E_C\left(\tau_w,\tau_d,\tau_h\right)\right)$$

$$E_{WEC}(\tau_w) = \sum_{\tau_d=6}^{7}\left(F_{WEMC} \cdot \sum_{\tau_h=6}^{12} E_C\left(\tau_w,\tau_d,\tau_h\right) + F_{WEAC} \cdot \sum_{\tau_h=12}^{18} E_C\left(\tau_w,\tau_d,\tau_h\right) + F_{WENC} \cdot \sum_{\tau_h=18}^{6(+1day)} E_C\left(\tau_w,\tau_d,\tau_h\right)\right)$$

Where:

τ_d = days of the week, where 1=Monday, and 7=Sunday. The weekend schedule is also applicable to holidays

τ_w = weeks of the year, where S_1 = first week of the cooling season, and S_N = last week of the cooling season, W_1 = first week of the heating season, and W_N = last week of the heating season. S1, SN, W1, and WN are defined in Appendix D.

τ_h = hours in a day, where 1=1:00 a.m., 12 = 12:00 p.m., and 24 = 12:00 a.m. For the evening/night period, the summation goes from 18 (6:00 p.m.) until 24 (12 a.m.), then the hours reset to 0 and go until 6 a.m. This is indicated in the equations as (+1 day) in the upper limit of the summation sign for the evening/night period

Table 2. Energy Use Variables

	Cooling Weekday	Cooling Weekend	Heating Weekday	Heating Weekend
Open	E_{SDO}	E_{SEO}	E_{WDO}	E_{WEO}
Half-open	E_{SDH}	E_{SEH}	E_{WDH}	E_{WEH}
Closed	E_{SDC}	E_{SEC}	E_{WDC}	E_{WEC}

Table 3. Deployment Fraction Variables

	Cooling Weekday			Cooling Weekend			Heating Weekday			Heating Weekend		
Deployment	M	A	N	M	A	N	M	A	N	M	A	N
Open	F_{SDMO}	F_{SDAO}	F_{SDNO}	F_{SEMO}	F_{SEAO}	F_{SENO}	F_{WDMO}	F_{WDAO}	F_{WDNO}	F_{WEMO}	F_{WEAO}	F_{WENO}
Half-open	F_{SDMH}	F_{SDAH}	F_{SDNH}	F_{SEMH}	F_{SEAH}	F_{SENH}	F_{WDMH}	F_{WDAH}	F_{WDNH}	F_{WEMH}	F_{WEAH}	F_{WENH}
Closed	F_{SDMC}	F_{SDAC}	F_{SDNC}	F_{SEMC}	F_{SEAC}	F_{SENC}	F_{WDMC}	F_{WDAC}	F_{WDNC}	F_{WEMC}	F_{WEAC}	F_{WENC}

Deployment fraction data for North (heating) and South (cooling) climates are presented in Table 4 and Table 5.

Table 4. Deployment Schedule for North (Heating) Climate Zone

	Cooling Weekday			Cooling Weekend			Heating Weekday			Heating Weekend		
Deployment	M	A	N	M	A	N	M	A	N	M	A	N
Open	0.26	0.24	0.23	0.26	0.25	0.23	0.29	0.30	0.23	0.28	0.29	0.22

Half-open	0.35	0.34	0.32	0.36	0.36	0.33	0.32	0.33	0.28	0.32	0.33	0.29
Closed	0.39	0.41	0.45	0.38	0.39	0.44	0.39	0.38	0.49	0.40	0.38	0.49

Table 5. Deployment Schedule for South (Cooling) Climate Zone

Cooling Weekday				Cooling Weekend			Heating Weekday			Heating Weekend		
Deployment	M	A	N	M	A	N	M	A	N	M	A	N
Open	0.17	0.15	0.13	0.18	0.17	0.14	0.23	0.23	0.17	0.23	0.23	0.17
Half-open	0.26	0.25	0.23	0.26	0.25	0.24	0.25	0.26	0.22	0.27	0.27	0.23
Closed	0.57	0.60	0.65	0.56	0.58	0.62	0.52	0.51	0.61	0.51	0.50	0.59

Cooling and heating periods are defined for each city in Appendix D.

$E(\tau_w, \tau_d, \tau_h)$ is calculated as follows for each city:

Houston:

$$E_O(\tau_w,\tau_d,\tau_h)=\left(E_{DXCoil}(\tau_h)_B+E_{Fan}(\tau_h)_B\right)_{CS=ON}\cdot SF_E$$

$$E_H(\tau_w,\tau_d,\tau_h)=\left(E_{DXCoil}(\tau_h)_H+E_{Fan}(\tau_h)_H\right)_{CS=ON}\cdot SF_E$$

$$E_C(\tau_w,\tau_d,\tau_h)=\left(E_{DXCoil}(\tau_h)_C+E_{Fan}(\tau_h)_C\right)_{CS=ON}\cdot SF_E$$

Minneapolis:

$$E_O(\tau_w,\tau_d,\tau_h)=\left(E_{Gas}(\tau_h)_B\right)\cdot SF_G+\left(E_{Fan}(\tau_h)_B\right)_{HS=ON}\cdot SF_E$$

$$E_H(\tau_w,\tau_d,\tau_h)=\left(E_{Gas}(\tau_h)_H\right)\cdot SF_G+\left(E_{Fan}(\tau_h)_H\right)_{HS=ON}\cdot SF_E$$

$$E_C(\tau_w,\tau_d,\tau_h)=\left(E_{Gas}(\tau_h)_C\right)\cdot SF_G+\left(E_{Fan}(\tau_h)_C\right)_{HS=ON}\cdot SF_E$$

4.3.2.2 Manual Operation - Awnings (Special Case for 1-D Operation)

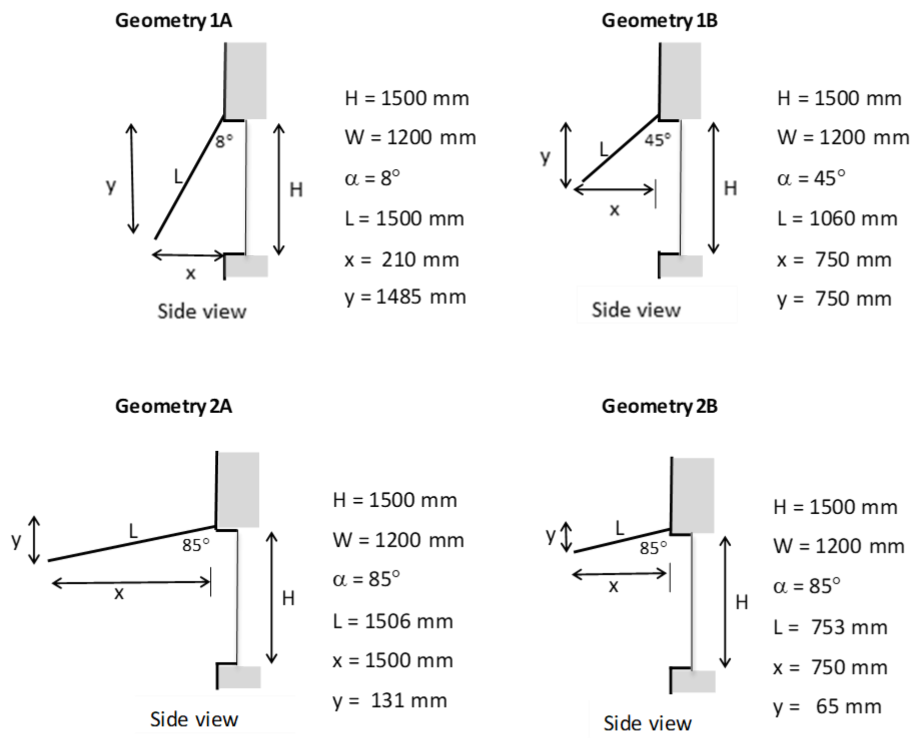


Figure 2: Awnings Geometry and Positions

The following table summarizes positions and dimensions of different awning geometries

Table 6. Positions and Dimensions for Different Awning Geometries

	Geometries 1A+1B Typical Moveable Window Awnings Fully CLOSED (deployed)(1A) and midpoint closed (1B)		Geometries 2A+2B Typical Moveable Window Set Awnings Fully CLOSED (deployed) (2A) and midpoint closed (2B)	
Fixed awnings might have any one of these four geometries.				
	Position 1A	Position 1B	Position 2A	Position 2B
Angle α	8°	45°	85°	85°
Cover length L	1500 mm	1060 mm	1506 mm	753 mm
Projection x-axis	0.14 x H	0.50 x H	1.00 x H	0.50 x H
Projection Drop y-axis	0.99 x H	0.50 x H	0.087 x H	0.043 x H
Fabric width	1.00 x W	1.00 x W	1.00 x W	1.00 x W
H = window recess height (1500 mm)		W = window recess width (1200 mm)		

EP is calculated based on the new schedule for awnings. There are three distinct schedules, based on the awnings type:

In the tables below

- M = Morning
- A = Afternoon
- N = Night

Table 7. permanently-installed, fixed awning

Minneapolis	Cooling Weekday			Cooling Weekend			Heating Weekday			Heating Weekend		
Deployment	M	A	N	M	A	N	M	A	N	M	A	N
Open - no shading												
Closed – each of 1A, 1B, 2A, 2B	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Houston	Cooling Weekday			Cooling Weekend			Heating Weekday			Heating Weekend		
Deployment	M	A	N	M	A	N	M	A	N	M	A	N
Open - no shading												
Closed – each of 1A, 1B, 2A, 2B	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 8. seasonally-installed fixed awning

Minneapolis	Cooling Weekday			Cooling Weekend			Heating Weekday			Heating Weekend		
Deployment	M	A	N	M	A	N	M	A	N	M	A	N
Open - no shading							1.00	1.00	1.00	1.00	1.00	1.00
Closed – each of 1A, 1B, 2A, 2B	1.00	1.00	1.00	1.00	1.00	1.00						
Houston	Cooling Weekday			Cooling Weekend			Heating Weekday			Heating Weekend		
Deployment	M	A	N	M	A	N	M	A	N	M	A	N
Open - no shading							1.00	1.00	1.00	1.00	1.00	1.00
Closed – each of 1A, 1B, 2A, 2B	1.00	1.00	1.00	1.00	1.00	1.00						

Table 9. adjustable awning

Minneapolis	Cooling Weekday			Cooling Weekend			Heating Weekday			Heating Weekend		
Deployment	M	A	N	M	A	N	M	A	N	M	A	N
Open - no shading	0.30	0.20	0.30	0.40	0.30	0.40	0.75	0.65	0.75	0.75	0.65	0.75
Half-Closed – each of 1B, 2B	0.60	0.60	0.60	0.60	0.60	0.60	0.25	0.35	0.25	0.25	0.35	0.25
Closed – each of 1A, 2A	0.10	0.20	0.10	0.00	0.10	0.00	0.0	0.0	0.0	0.0	0.0	0.0
Houston	Cooling Weekday			Cooling Weekend			Heating Weekday			Heating Weekend		
Deployment	M	A	N	M	A	N	M	A	N	M	A	N
Open - no shading	0.30	0.20	0.30	0.30	0.20	0.30	0.65	0.55	0.65	0.65	0.55	0.65
Half-Closed – each of 1B, 2B	0.60	0.60	0.60	0.60	0.60	0.60	0.35	0.45	0.35	0.35	0.40	0.35
Closed – each of 1A, 2A	0.10	0.20	0.10	0.10	0.20	0.10	0.00	0.05	0.00	0.00	0.05	0.00

For permanently-installed fixed awnings, and seasonally-installed fixed awnings each of the four geometries, 1A, 1B, 2A, and 2B, shown in Figure 2, will be considered separately (separate product with individual rating, SHGC, VT). When calculating EP rating indices, for permanent and seasonal schedules each of the four positions is modeled using schedules in Table 5 for permanently-installed fixed awnings (always deployed) and Table 6 for seasonally-installed fixed awnings (no awning in the Winter and deployed in the Summer).

For operable (adjustable) awnings Table 9 lists 3 positions, no shading, half closed and closed, resulting in two rated products; Geometry 1 and Geometry 2 with Open (no awning), Half-Closed (1B for Geometry 1, and 2B for Geometry 2) and Closed (1A for Geometry 1, and 2A for Geometry 2). For each geometry parent-child relationship will be established, where parent record will show EP, while child records will show component properties (e.g., U, SHGC, VT, AL), similar to how results are shown for venetian blinds.

Naming Convention:

Naming of individual products, required for properly importing and calculating EP is listed in Table 10. Each of the fixed and seasonal products are calculated and shown individually. For operable awnings, Geometry 1 and Geometry 2 would be parent records with child records named as per Table 10.

Table 10. Naming of records

<table>
<tr><th colspan="2">Geometry</th><th>Fixed (AY)</th><th>Fixed Seasonal (AS)</th><th>Operable (AO)</th></tr>
<tr><td rowspan="2">1</td><td>1A</td><td>AY1A</td><td>AS1A</td><td rowspan="2">AO1A, AO1B</td></tr>
<tr><td>1B</td><td>AY1B</td><td>AS1B</td></tr>
<tr><td rowspan="2">2</td><td>2A</td><td>AY2A</td><td>AS2A</td><td rowspan="2">AO2A, AO2B</td></tr>
<tr><td>2B</td><td>AY2B</td><td>AS2B</td></tr>
</table>

4.3.2.3 Manual Operation - Window Attachments with 2-D operation

Similar to window attachments with 1 degree freedom in operation, energy use for window attachment with 2-D operation is calculated by summing-up weighting Open, Half-Open and Closed states. Because of the increased complexity of the definition of Open, and Half-Open states for attachments with 2 degrees of freedom (retraction levels and slat angle), multiple deployment states are attached to Open and Half-Open states. Currently, louvered blinds (both horizontal louvered blinds, or Venetian blinds, and vertical louvered blinds) have simulation models available for them. Assignments of different EnergyPlus runs and deployment states for louvered blinds are shown in Table 11.

Table 11. Deployment Information for Louvered blinds and Louvered Shutters

<table>
<tr><th></th><th></th><th>Run No.</th><th>Top Window</th><th>Bottom Window</th></tr>
<tr><td rowspan="2">Open (O)</td><td>Fully-deployed</td><td>1</td><td>0° slat angle</td><td>0° slat angle</td></tr>
<tr><td>Fully-retracted</td><td>2</td><td>No shade</td><td>No shade</td></tr>
<tr><td rowspan="5">Half-Open (H)</td><td>Fully-deployed</td><td>3</td><td>45° slat angle</td><td>45° slat angle</td></tr>
<tr><td>Fully-deployed</td><td>4</td><td>-45° slat angle</td><td>-45° slat angle</td></tr>
<tr><td>Half-deployed</td><td>5</td><td>90° slat angle</td><td>No shade</td></tr>
<tr><td>Half-deployed</td><td>6</td><td>45° slat angle</td><td>No shade</td></tr>
<tr><td>Half-deployed</td><td>7</td><td>-45° slat angle</td><td>No shade</td></tr>
<tr><td>Closed (C)</td><td>Fully-deployed</td><td>8</td><td>90° slat angle</td><td>90° slat angle</td></tr>
</table>

The energy use for louvered blinds is the result of averaging hourly results for two open deployments, five half-open and one closed deployment schedules. Averaging procedure is detailed in Equations to . Numbers in the third column in Table 11 are used in subsequent equations as an index number (1-2 for open, 3-7 for half-open, and 8 for closed).

$$E_O = \frac{\sum_{i=1}^{2}\left(\sum_{\tau_w=S_1}^{S_N}\left(E_{SDO,i}(\tau_w)+E_{SEO,i}(\tau_w)\right)+\sum_{\tau_w=W_1}^{W_N}\left(E_{WDO,i}(\tau_w)+E_{WEO,i}(\tau_w)\right)\right)}{2}$$

$$E_H = \frac{\sum_{i=3}^{7}\left(\sum_{\tau_w=S_1}^{S_N}\left(E_{SDH,i}(\tau_w)+E_{SEH,i}(\tau_w)\right)+\sum_{\tau_w=W_1}^{W_N}\left(E_{WDH,i}(\tau_w)+E_{WEH,i}(\tau_w)\right)\right)}{5}$$

$$E_C = \sum_{\tau_w=S_1}^{S_N}\left(E_{SDC,8}(\tau_w)+E_{SEC,8}(\tau_w)\right)+\sum_{\tau_w=W_1}^{W_N}\left(E_{WDC,8}(\tau_w)+E_{WEC,8}(\tau_w)\right)$$

An example of the application of formula to the calculation of $E_{SEO,1}$ is shown below. Other quantities are calculated in the same manner.

$$E_{SEO,1}(\tau_w) = \sum_{\tau_d=6}^{7}\left(F_{SEMO}\cdot\sum_{\tau_h=5}^{17}E_{O,1}(\tau_w,\tau_d,\tau_h)+F_{SEAO}\cdot\sum_{\tau_h=5}^{17}E_{O,1}(\tau_w,\tau_d,\tau_h)+F_{SENO}\cdot\sum_{\tau_h=5}^{17}E_{O,1}(\tau_w,\tau_d,\tau_h)\right)$$

$E(\tau_w, \tau_d, \tau_h)$ is calculated as follows for each city:

Houston:

$$E_{O,i}(\tau_w,\tau_d,\tau_h)=\left(E_{DXCoil}(\tau_h)_{O,i}+E_{Fan}(\tau_h)_{O,i}\right)_{CS=ON}\cdot SF_E \quad (i=1,2)$$

$$E_{H,i}(\tau_w,\tau_d,\tau_h)=\left(E_{DXCoil}(\tau_h)_{H,i}+E_{Fan}(\tau_h)_{H,i}\right)_{CS=ON}\cdot SF_E \quad (i=3,4,5,6,7)$$

$$E_{C,8}(\tau_w,\tau_d,\tau_h)=\left(E_{DXCoil}(\tau_h)_{C,8}+E_{Fan}(\tau_h)_{C,8}\right)_{CS=ON}\cdot SF_E$$

Minneapolis:

$$E_{O,i}(\tau_w,\tau_d,\tau_h)=\left(E_{Gas}(\tau_h)_{O,i}\right)_{HS=ON}\cdot SF_G+\left(E_{Fan}(\tau_h)_{O,i}\right)_{HS=ON}\cdot SF_E \quad (i=1,2)$$

$$E_{H,i}(\tau_w,\tau_d,\tau_h)=\left(E_{Gas}(\tau_h)_{H,i}\right)_{HS=ON}\cdot SF_G+\left(E_{Fan}(\tau_h)_{H,i}\right)_{HS=ON}\cdot SF_E \quad (i=3,4,5,6,7)$$

$$E_{C,8}(\tau_w,\tau_d,\tau_h)=\left(E_{Gas}(\tau_h)_{C,8}\right)_{HS=ON}\cdot SF_G+\left(E_{Fan}(\tau_h)_{C,8}\right)_{HS=ON}\cdot SF_E$$

4.3.2.4 Automated Operation - Attachments with 1-D operation, Except for Awnings

For these window attachment types, the operation consists of attachment either fully deployed or fully retracted. The performance is calculated in a single EnergyPlus run utilizing the EMS system to deploy or retract the shade for each simulation timestep based on a given deployment schedule. The deployment schedules for Automated window attachments were developed by the AERC Automation working Group and are shown in Tables12 and 13.

Table 12. Deployment Schedule for North (Heating) Climate Zone

	Window Orientation			
	North	South	East	West
June 1 - August 31	Closed All Day	Closed All Day	Closed All Day	Closed All Day
September 1 - May 31	Closed All Day	Open 08:00-16:00	Open 08:00-12:00	Open 12:00-16:00

Table 13. Deployment Schedule for South (Cooling) Climate Zone

	Window Orientation			
	North	South	East	West
April 1 - October 31	Closed All Day	Closed All Day	Closed All Day	Closed All Day
November 1 - March 31	Open 08:00-16:00	Closed All Day	Open 12:00-16:00	Open 08:00-12:00

For automation operation runs for shades with 1-D operation, other than awnings, the energy results for the automation run are equal to the energy use of the shade in the EP calculation:

$E_S = E_{AUTO}$

For automation operation runs for awnings, Closed and Open is defined in Table 9 (Open = no shading, and Closed = 1A and 2A, two separate runs). The E_S is calculated as an average of the EP runs for 1A and 2A awnings

$E_S = (E_{AUTO\text{-}1A} + E_{AUTO\text{-}2A})/2$

4.3.2.5 Automated Operation - Attachments with 2-D operation

For shades with 2-D operation, such as louvered blinds or louvered shutters, the performance is calculated in a same way as for the shades with 1-D operation, in a single EnergyPlus run utilizing the EMS system to fully deploy or retract the shade for each simulation timestep on a deployment schedule shown in Tables 12 and 13. Table 14 lists open and close states for the 2-D shades:

Table 14. Deployment Information for Louvered blinds and Louvered Shutters

		Top Window	**Bottom Window**
Open (O)	Fully-deployed	0° slat angle	0° slat angle
Closed (C)	Fully-deployed	90° slat angle	90° slat angle

For automation operation runs for shades with 2-D operation, the energy results for the automation run are also equal to the energy use of the shade in the EP calculation:

$E_S = E_{AUTO}$

5. Calculation of Final Results

Energy simulation by EnergyPlus is output into csv files, from which E_A, E_B, and E_S is calculated, using formulas detailed above, and depending on the specific window attachment. The following is process outline:

- Selection which calculation is to be performed, E_A, E_B, E_S/EP
- City; Houston or Minneapolis (alternatively could be choice between Cooling and Heating)
- Window attachment type (for E_A and E_B only, no attachment is supplied)
- Number of csv files
- Each csv file name
    - Deployment state (Open, half-open or closed)
    - Slat angle for louvered blinds

Output from software tool:

- E_A, E_B, and/or E_S, as requested
- EP (applicable when E_S is requested)

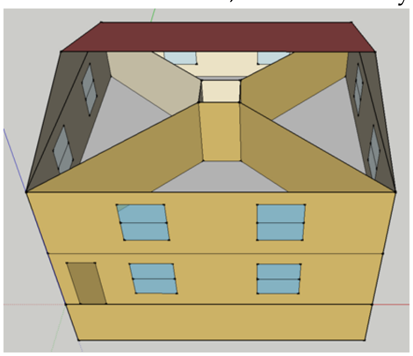
This interface is accomplished through an XML file. XML Schema and example files are included in Appendix E

6. References

ISO. 2011. "ISO 18292: Energy Performance of Fenestration Systems for Residential Buildings – Calculation Procedure". International Standards Organization. Geneva, Switzerland.

DOE. 2025. “EnergyPlus 9.5.1: Software Tool for Calculating Energy Performance of Buildings”

Appendix A: Typical US Residential Buildings Assumptions

<table>
<tr><th>PARAMETERS</th><th>Proposed Residential Model Values</th><th>Value inputs in E+</th></tr>
<tr><td>Floor Area
(ft² & dim)</td><td>2400 ft², 34.64ft (W) x 34.64ft (L) x8.5ft (H) x2 stories</td><td>10.55858m(X)*10.55858m(Y)*2.59m(H)*2 stories</td></tr>
<tr><td>House Type</td><td>2-story – One small core zone and four big perimeter zones for each floor, but it has only one HVAC zone.
</td><td>Core zone Area=1.41458m*1.41458m

Refer to Residential model for AERC MEETING (0415).xlsx</td></tr>
<tr><td>Bathrooms</td><td>3</td><td></td></tr>
<tr><td>Bedrooms</td><td>3</td><td></td></tr>
<tr><td>Typical Cities</td><td>Heating: Minneapolis, MN (Climate Zone 6A)
Cooling: Houston, TX (Climate Zone 2A)</td><td>Refer to Residential model for AERC MEETING (0415).xlsx</td></tr>
<tr><td>Foundation</td><td>Unheated Basement for the north heating dominated city, viz. Minneapolis, MN;

Slab-on-grade without insulation for the south cooling dominated city, viz. Houston, TX.</td><td>Basement:
10.55858m(X)*10.55858m(Y)*(-2.13)m(H)</td></tr>
<tr><td>Insulation [a]</td><td>Envelope insulation levels vary with the locations. The following insulation requirements are referred to IECC 1998.
<table>
<tr><td>Location:</td><td>Ceiling R-value</td><td>Wall R-value</td><td>Floor R-value</td><td>Slab/Basement R-value</td></tr>
<tr><td>Houston:</td><td>R-30</td><td>R-13</td><td>R-11</td><td>Slab, R-0</td></tr>
<tr><td>Minneapolis:</td><td>R-49</td><td>R-21</td><td>R-21</td><td>Bsmt, R-11</td></tr>
</table></td><td>Minneapolis:
Exterior Floor: R21
Interior Floor: R21
Exterior Wall: R21
Ceiling: R49
Exterior Roof: R49
Basement wall: R11

Houston:
Exterior Floor: R11
Interior Floor: R11
Exterior Wall: R13
Ceiling: R30
Exterior Roof: R30</td></tr>
<tr><td>Infiltration</td><td>Minneapolis: ACH50=7

Houston: ACH50=10</td><td>Minneapolis baseline window case: ELA=873;

Minneapolis super insulated window case: ELA=669, air infiltration of super insulated window was 0;

Houston baseline window case: ELA=1248;

Houston super insulated window case: ELA=1044, air infiltration of super insulated window was 0;

The converting method from ACH to ELA is described in ELACalculation.xlsx</td></tr>
<tr><td>Internal Mass
Furniture (lb/ft²)</td><td>8.0 lb/ft² of floor area</td><td></td></tr>
<tr><td>Ventilation Air Requirements</td><td>0.15 L/s per square meter of floor space</td><td>0.033456639274582m3/s</td></tr>
</table>

		=0.15*10.55858*10.55858*2
Wall framing system	Wood	
External Doors	U factor: 1.14 W/(m^2.k)	R=0.88
Window Area (% Floor Area)	15.1%. There are two windows (each window with dimension 2*1.4 m*0.75 m) on each orientation each floor.	2*1.4(w)*0.75(h) Refer to Residential model for AERC MEETING (0415).xlsx
Window Type	Double clear wood frame baseline window for both climates; VT=0.639, SHGC=0.601, U=0.472 Btu/hr.ft^2.F, AL=2 cfm/ft^2 Adiabatic window: VT=0, SHGC=0, U=0, AL=0	Baseline window: double clear using CLEAR_3.DAT, wood fixed frame Adiabatic window: custom created super-insulated opaque window without frame Refer to AERC 1 Baseline window B.docx
Window Distribution	8 windows per floor, distributed evenly and centered on the external walls. Each big window was split into the upper and lower small windows.	Refer to Residential model for AERC MEETING (0415).xlsx
Heating Systems	Gas Furnace for Minneapolis, MN; Heat Pump for Houston, TX.	
Heating System Fuels	Gas for Minneapolis, MN; Electricity for Houston, TX.	
Cooling Systems	A/C for Minneapolis, MN; Heat Pump for Houston, TX.	
HVAC System Sizing	For each climate, the HVAC systems were sized based on the base window option (without window attachments).	Houston (HP): Cooling capacity: 13131.31W Heating capacity: 13131.31W Sensible heat ratio: 0.733253 Air flow rate: 0.652m3/s Minneapolis (GAC): Cooling capacity: 10628.64W Heating capacity: 16720.73W Sensible heat ratio: 0.753625 Air flow rate: 0.563m3/s Refer to Doubleclear_basement_Minneapolis, & Doubleclear_slab_Houston
HVAC Efficiencies	Minneapolis (GAC): AFUE= 0.78 for Gas furnace heating (annual fuel utilization efficiency) Houston (HP): HSPF=6.8 for Air-cooled heat pumps heating mode (the converted COP for heating is ~1.99) Both: SEER=10.0 for Air-cooled air conditioners and heat pumps cooling mode (the converted COP for cooling is ~2.70)	(1) EER = 1.12 * SEER - 0.02 * SEER2 (2) EER = COP * 3.41 (3) Avg COP = Heat transferred / electrical energy supplied = (HSPF * 1055.056 J/BTU) / (3600 J/watt-hour) = 0.29307111 HSPF.
Thermostat Settings	Heating: 70°F, Cooling: 75°F No setback	Heating set point: 21.11 °C Cooling set point: 23.89 °C
Internal Loads	Number of People = 3 Hardwire Lights = 1.22 Watts/m^2 Plug-in Lights = 0.478 Watts/m^2 Refrigerator = 91.09 Watts – Design Level Misc. Electrical Equipment = 2.46 Watts/m^2 Clothes Washer = 29.6 Watts – Design Level Clothes Dryer = 222.1 Watts – Design Level Dish Washer = 68.3 Watts – Design Level Misc. Electrical Load = 182.5 Watts – Design Level Gas Cooking range =248.5 Watts – Design Level Misc. Gas Load = 0.297 Watts/m^2 Exterior Lights = 58 Watts – Design Level Garage Lights = 9.5 Watts – Design Level	

	The operation schedules of the all equipment are referred to the PNNL model.	
Weather Data	USA_TX_Houston-Bush.Intercontinental.AP.722430_TMY3.epw USA_MN_Minneapolis-St.Paul.Intl.AP.726580_TMY3_2.epw	All TMY3
Number of Locations	2 typical US cities: Minneapolis, MN for heating; Houston, TX for cooling.	
Calculation Tool	EnergyPlus version 8.5 (LBN's custom version that addresses issue with TIR>0)	
Energy Code	Combination of vintages for each climate zone, but mostly like IECC 1998	
Results extracted from E+	Heating energy use, cooling energy use, fan energy use and total energy use of the house which includes the all energy uses, such as lighting.	
Attachment deployment operations	Refer to (Bickel, 2013)	
Ground temperature	For Minneapolis unheated basement with R11 insulation; For Houston, slab-on-grade with no slab insulation.	
Super insulated window	This window can be regarded as an adiabatic surface without heat transferring.	0.003, !- Thickness {m} 0.000001, !- Solar Transmittance 0.999999, !- Front Reflectance 0.999999, !- Back Reflectance 0.000001, !- Visible Transmittance 0.999999, !- Front Visible Reflectance 0.999999, !- Back Visible Reflectance 0.000000, !- Infrared Transmittance 0.000001, !- Front Infrared Emissivity 0.000001, !- Back Infrared Emissivity 0.00000001; !- Conductivity {W/m-K}

Appendix B: Output Section in IDF File

```
!-   ===========  ALL OBJECTS IN CLASS: OUTPUT:VARIABLE ===========

Output:Variable,*,Site Day Type Index,hourly;

Output:Variable,*,Air System Electric Energy,hourly;

Output:Variable,*,Air System Fan Electric Energy,hourly;

Output:Variable,*,Air System DX Cooling Coil Electric Energy,hourly;

Output:Variable,*,Zone Lights Electric Energy,hourly;

Output:Variable,*,Facility Net Purchased Electric Energy,hourly;

Output:Variable,*,Facility Total Building Electric Demand Power,hourly;

Output:Variable,*,Facility Total HVAC Electric Demand Power,hourly;

Output:Variable,*,Facility Total Electric Demand Power,hourly;

Output:Variable,*,Air System Cooling Coil Total Cooling Energy,hourly;

Output:Variable,*,Air System Heating Coil Total Heating Energy,hourly;

Output:Variable,*,Air System Fan Air Heating Energy,hourly;

Output:Variable,*,Air System Gas Energy,hourly;

Output:Variable,*,Zone Gas Equipment Gas Energy,hourly;

Output:Variable,*,Water Heater Gas Energy,hourly;
```

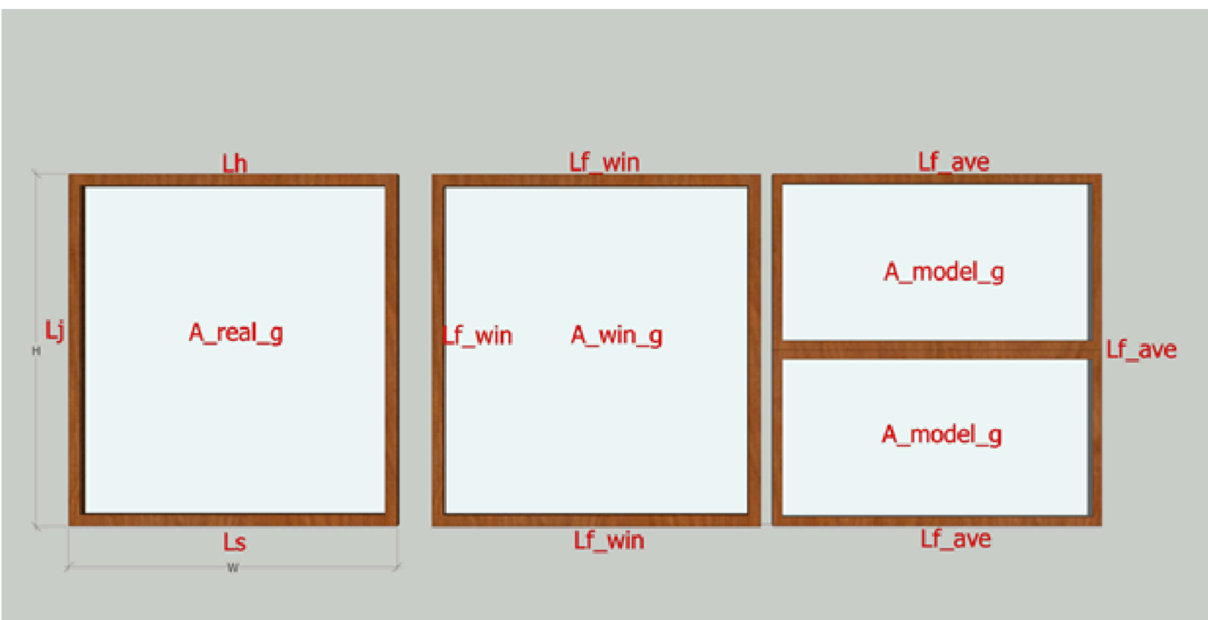
Appendix C: Include Files

C.1 Windows:

Same window configuration file is provided for both climate zones/cities. Also, same window configuration file is used for all windows, however with changes made for construction reference (glazing construction and frame) for different window attachment runs (e.g., For baseline window, construction reference is AERC_Doubleclear_Baseline). For different baseline windows, as their averaged frame width are different, the glazing coordinates should be changed as well. The following sections depict the methodologies of calculating the averaged frame width and changing the fenestration coordinates.

C.1.1 Calculating and exporting the average frame width in WINDOW

As EnergyPlus can't model the half-deployed scenario for a window shade, we used two separate small windows (one at the top and one at the bottom) to replace a single window in simulation. However, this replacement results in a larger frame area for the modelled window because the head and sill are counted twice (as shown in the rightmost drawing of the following picture). So, we will replace the original averaged frame width (L_{f_WIN}) from WINDOW with a new averaged frame width (L_{f_ave}) to make sure the modeled two small windows have the same glazing and frame areas as the original window. The methodology for the averaged frame width calculation is detailed later in this section. The following figure illustrates the original window with original frame dimensions, L_s, L_j, and Lh, then window with the original averaged frame dimension, L_{f_WIN}, as it is exported from WINDOW to IDF file, and resulting 2 windows used in simulation, with the new averaged frame width, L_{f_ave}.



A_{real_g} is the actual window glazing area.

A_{win_g} is the window glazing area normally exported from WINDOW.

A_{model_g} is the window glazing area in E+ simulation.

The first step is to calculate the original averaged frame width (L_{f_WIN}). WINDOW program can calculate L_{f_WIN} according to the below equations.

$$A_{real\_g} = W \cdot H - (L_h \cdot W + L_s \cdot W + 2 \cdot L_j \cdot (H - L_h - L_s)) \quad \text{(C.1)}$$

$$A_{WIN\_g} = W \cdot H - \left(2 \cdot W \cdot L_{f\_WIN} + 2 \cdot L_{f\_WIN} \cdot \left(H - 2 \cdot L_{f\_WIN}\right)\right) \quad \text{(C.2)}$$

Considering that $A_{real\_g} = A_{win\_g}$, and substituting (1) and (2) into this equality, then:

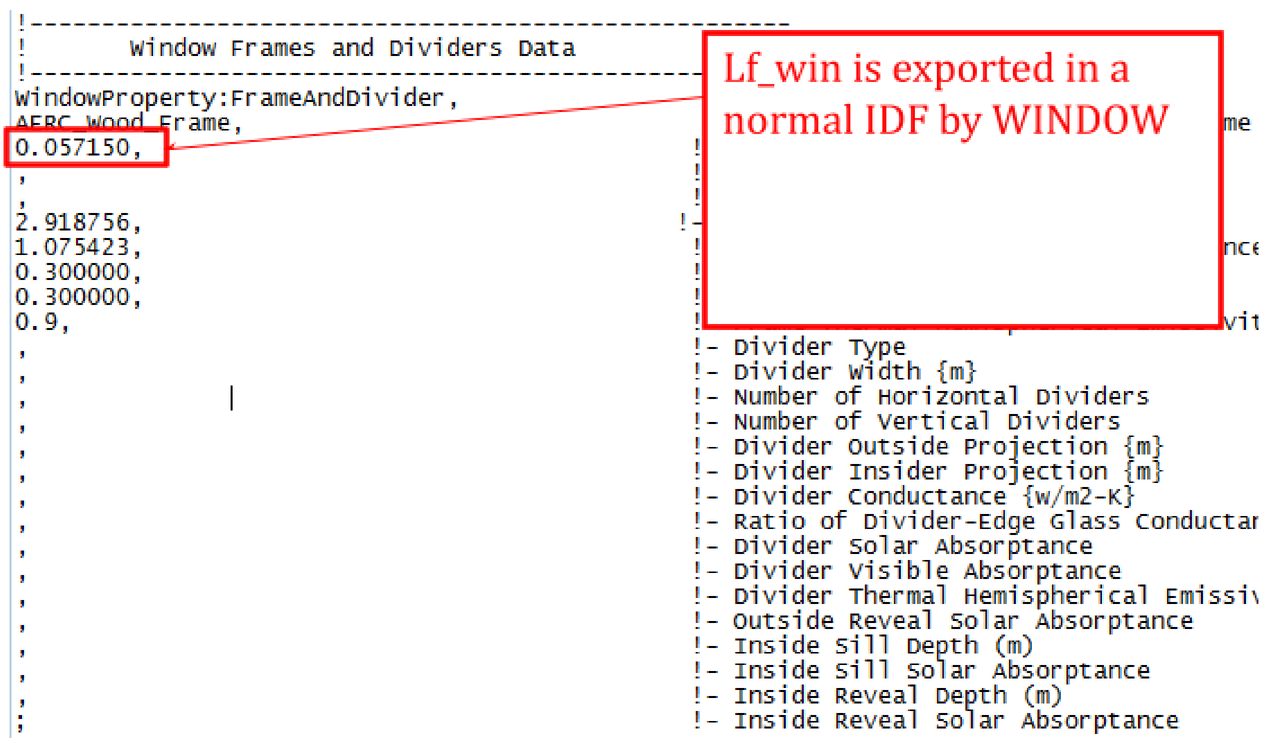
$$W \cdot H - (L_h \cdot W + L_s \cdot W + 2 \cdot L_j \cdot (H - L_h - L_s)) = W \cdot H - \left(2 \cdot W \cdot L_{f\_WIN} + 2 \cdot L_{f\_WIN} \cdot \left(H - 2 \cdot L_{f\_WIN}\right)\right) \quad \text{(C.3)}$$

Or expressed as quadratic equation that can be solved for L_{f_WIN}.

$$4 \cdot L_{f\_WIN}^2 + 2 \cdot (H + W) \cdot L_{f\_WIN} - \left(W \cdot (L_h + L_s) + 2 \cdot L_j \cdot (H - L_h - L_s)\right) = 0 \quad \text{(C.4)}$$

$$L_{f\_WIN} = \frac{-2 \cdot (H + W) \pm \sqrt{4 \cdot (H + W)^2 + 16 \cdot \left(W \cdot (L_h + L_s) + 2 \cdot L_j \cdot (H - L_h - L_s)\right)}}{8} \quad \text{(C.5)}$$

WINDOW program can also export the original averaged frame width (L_{f_WIN}) to a normal IDF file (which is different from the specialized IDF file for EPCalc only, called "AERC EnergyPlus IDF"). An example of L_{f_WIN} exportation for AERC Baseline Window B is shown in the following figure.



The next step is to calculate the new averaged frame width (L_{f_ave}) for the configuration consisting of two windows (top and bottom) with the original averaged frame width (L_{f_WIN}). This calculation was conducted in WINDOW program according to the below equations.

$$A_{Model\_g} = W \cdot H - \left(4 \cdot W \cdot L_{f\_Ave} + 4 \cdot L_{f\_Ave} \cdot \left(\frac{H}{2} - 2 \cdot L_{f\_Ave} \right) \right) \tag{C.6}$$

Considering that $A_{Model\_g} = A_{win\_g}$, and substituting (2) and (6) into this equality, then:

$$W \cdot H - \left(2 \cdot W \cdot L_{f\_WIN} + 2 \cdot L_{f\_WIN} \cdot \left(H - 2 \cdot L_{f\_WIN} \right) \right) = W \cdot H - \left(4 \cdot W \cdot L_{f\_Ave} + 4 \cdot L_{f\_Ave} \cdot \left(\frac{H}{2} - 2 \cdot L_{f\_Ave} \right) \right)$$

(C.7)

Or expressed as quadratic equation that can be solved for L_{f_Ave}.

$$-4 \cdot L_{f\_Ave}^{2} + \left(H + 2 \cdot W \right) \cdot L_{f\_Ave} + 2 \cdot L_{f\_WIN}^{2} - \left(W + H \right) \cdot L_{f\_WIN} = 0 \tag{C.8}$$

$$L_{f\_Ave} = \frac{-\left(H + 2 \cdot W \right) \pm \sqrt{\left(H + 2 \cdot W \right)^{2} + 16 \cdot \left(2 \cdot L_{f\_WIN}^{2} - \left(W + H \right) \cdot L_{f\_WIN} \right)}}{-8} \tag{C.9}$$

There are two roots to the quadratic equation (9), $L_{f\_Ave\_1}$ and $L_{f\_Ave\_2}$, of which one is solution that we are seeking.

$$L_{f\_Ave} = \min\left(L_{f\_Ave\_1}, L_{f\_Ave\_2} \right) \tag{C10}$$

Take the current AERC baseline window B as an example:

W = 1.4 m

H = 1.5 m

Lf_win = 0.057150 m

So Equations (8) and (9) can be written as:

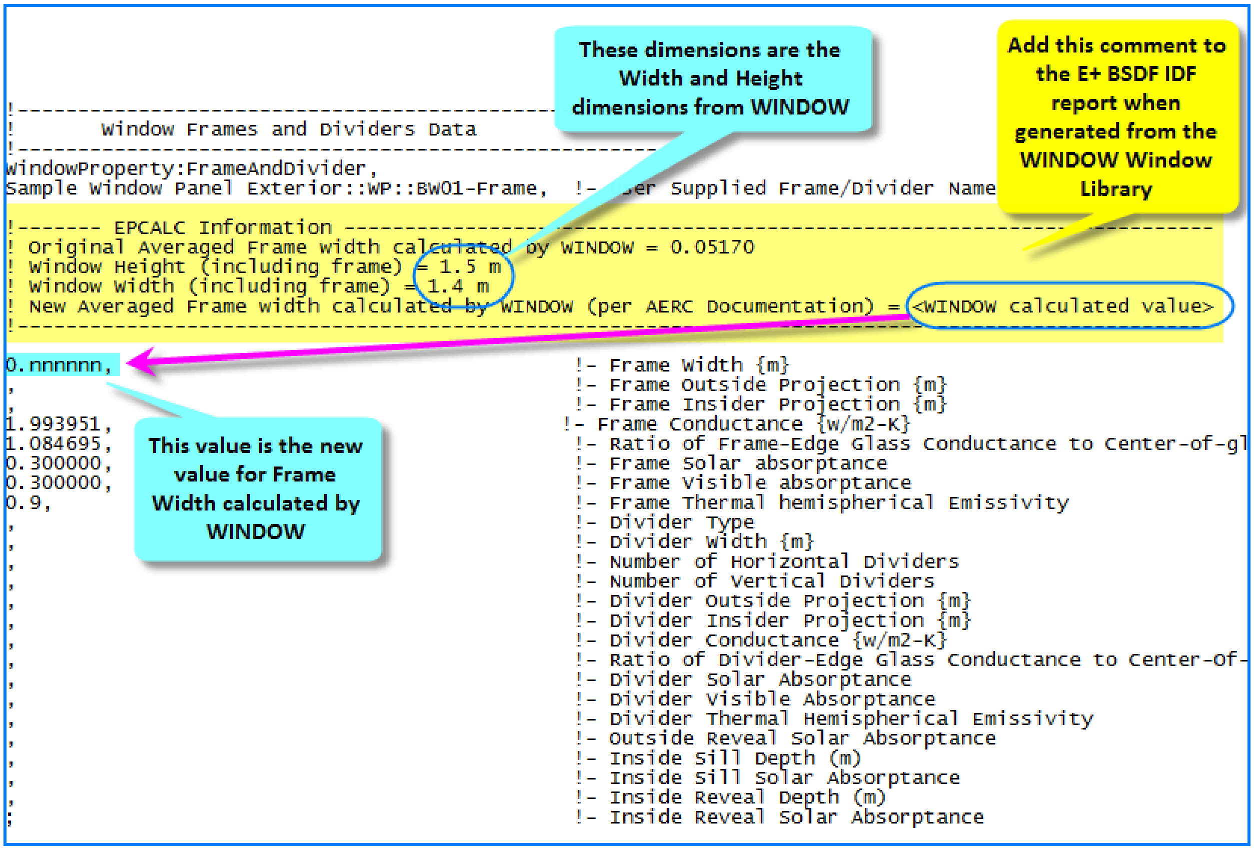
$$-4 \cdot L_{f\_Ave}^{2} + 4.3 \cdot L_{f\_Ave} - 0.1592027 = 0$$

$$L_{f\_Ave} = \frac{-4.3 \pm \sqrt{18.49 - 2.54724}}{-8}$$

$$L_{f\_Ave} = \min\left(0.038395, 1.036605 \right)$$

L_{f_Ave} = 0.038395

This calculation is built into Berkeley Lab WINDOW software tool, which is exported to AERCalc in a new specialized IDF file, called "AERC Energy Plus IDF", where the original frame width, L_{f_WIN}, new averaged frame width L_{f_ave}, and window width and height (W and H, include the frame width), are included in the commented section. New averaged frame width is also inserted in the appropriate IDF field where it is used by EnergyPlus. The following figure illustrates this new AERC EnergyPlus IDF .



For other baseline windows which may have different frame widths, WINDOW program will calculate L_{f_Ave} using equations (9) and (10) and export L_{f_Ave} as shown in the above figure.

C.1.2 Changing the fenestration coordinates in window configuration file

The whole window area, consisting of the glass area and the frame area, is given by specifying the window width (W, includes the frame width) and the height (H, includes the frame width). However, in Energyplus, window coordinates describe vision portion of glazing system only, so full window area is obtained by adding frame width to glazing area. The fenestration coordinates can be calculated by using the window width (W), the window height (H) and the new averaged frame width (**L_{f_Ave}**). The methodology is detailed in this section.

For each window in a typical building, the coordinates of the vertices for the vision area of glazing are calculated starting with lower left corner. The remaining three vertices are then calculated based on the fixed coordinates of the lower-left corner point, the window width

(W), height (H) and the new averaged frame width (L_{f_Ave}). However, it is worth noting that the coordinate calculation method is different for different oriented windows. The calculation methods for different orientations are illustrated in sections below.

C.1.2.1 Template for IDF snippet for windows

An IDF snippet for the definition of each window is required. There are 8 windows on each orientation. Template for the IDF snippet is illustrated as follows:

```
FenestrationSurface:Detailed,
  Window_OriF_N_Pos.unit1, !- Name
  Window,               !- Surface Type
  AERC_Doubleclear_Baseline,     !- Construction Name
  Wall_OriW_F.unit1,      !- Building Surface Name
  ,                     !- Outside Boundary Condition Object
  ,                     !- View Factor to Ground
  ,                     !- Shading Control Name
  AERC_Wood_Frame,        !- Frame and Divider Name
  1,                     !- Multiplier
  4,                     !- Number of Vertices
  X1,     Y1,     Z1,              !- X,Y,Z ==> Vertex 1 {m}
  X2,     Y2,     Z2,              !- X,Y,Z ==> Vertex 2 {m}
  X3,     Y3,     Z3,              !- X,Y,Z ==> Vertex 3 {m}
  X4,     Y4,     Z4;              !- X,Y,Z ==> Vertex 4 {m}
```

Where OriF_N_Pos stand for:

- Ori = Orientation (ldf– front side (South), ldb – back side (North), sdr – right side (East), sdl – left side (West))
- F = Floor number (1 – first floor, 2 – second floor)
- N = Window number on each floor and orientation (1 – left side window, 2 – right side window)
- Pos = Window position(Bot – bottom window, Top – top window)
- W = Wall number of each perimeter zone on each floor (1 – external wall on which the windows were installed)

For example, Window_ldf1_2_Bot.unit1 means the right bottom window on the first floor on the south orientation; Wall_sdr1_2.unit1 means the external wall on the second floor of east orientation

C.1.2.2 South facing windows:

There are eight south facing windows (named as Window_ldfF_N_Pos.unit1).

where, the coordinates of the lower-left corner vertice (X1, Y1, Z1) are fixed as follows:

X1= values for each of south facing windows are listed in table below

Y1=Y2=Y3=Y4=0.00,

Z1 values for each of south facing windows are listed in table below

The coordinates of the remaining three vertices are calculated based on the window width (W), the window height (H) and the new averaged frame width (L_{f_Ave}) using the below formulas:

X2=X1+(W-2* L_{f_Ave})
Z2=Z1
X3=X+(W-2* L_{f_Ave})
Z3=Z+(H/2-2* L_{f_Ave})
X4=X1
Z4=Z+(H/2-2* L_{f_Ave})

For baseline window B, the coordinates of the lower-left corner vertices of the eight south facing windows are listed as follows:

Fenestration Name	Building Surface Name	X1	Y1	Z1
Window_ldf1_1_Bot.unit1	Wall_ldf1_1.unit1	2.50	0.00	0.60
Window_ldf1_1_Top.unit1	Wall_ldf1_1.unit1	2.50		1.35
Window_ldf1_2_Bot.unit1	Wall_ldf1_1.unit1	6.60		0.60
Window_ldf1_2_Top.unit1	Wall_ldf1_1.unit1	6.60		1.35
Window_ldf2_1_Bot.unit1	Wall_ldf1_2.unit1	2.50		3.20
Window_ldf2_1_Top.unit1	Wall_ldf1_2.unit1	2.50		3.95
Window_ldf2_2_Bot.unit1	Wall_ldf1_2.unit1	6.60		3.20
Window_ldf2_2_Top.unit1	Wall_ldf1_2.unit1	6.60		3.95

The coordinates of the lower-left corner vertices of the eight south facing windows are fixed in the E+ model and will be used for different baseline windows. With the coordinates of the lower-left corner vertices, the coordinates of the remaining vertices of each south facing window can be calculated using Equations above.

Take the current AERC baseline window B as an example:

W = 1.4 m

H = 1.5 m

L_{f_Ave} = 0.038395 m

the coordinates of the eight south facing windows are calculated and the values are listed in the below table.

Fenestration Name	Building Surface	Vertices	X	Y	Z
Window_ldf1_1_Bot.unit1	Wall_ldf1_1.unit1	1	2.50000	0.00000	0.60000
		2	3.82321	0.00000	0.60000
		3	3.82321	0.00000	1.27321
		4	2.50000	0.00000	1.27321
Window_ldf1_1_Top.unit1	Wall_ldf1_1.unit1	1	2.50000	0.00000	1.35000
		2	3.82321	0.00000	1.35000
		3	3.82321	0.00000	2.02321

		4	2.50000	0.00000	2.02321
Window_ldf1_2_Bot.unit1	Wall_ldf1_1.unit1	1	6.60000	0.00000	0.60000
		2	7.92321	0.00000	0.60000
		3	7.92321	0.00000	1.27321
		4	6.60000	0.00000	1.27321
Window_ldf1_2_Top.unit1	Wall_ldf1_1.unit1	1	6.60000	0.00000	1.35000
		2	7.92321	0.00000	1.35000
		3	7.92321	0.00000	2.02321
		4	6.60000	0.00000	2.02321
Window_ldf2_1_Bot.unit1	Wall_ldf1_2.unit1	1	2.50000	0.00000	3.20000
		2	3.82321	0.00000	3.20000
		3	3.82321	0.00000	3.87321
		4	2.50000	0.00000	3.87321
Window_ldf2_1_Top.unit1	Wall_ldf1_2.unit1	1	2.50000	0.00000	3.95000
		2	3.82321	0.00000	3.95000
		3	3.82321	0.00000	4.62321
		4	2.50000	0.00000	4.62321
Window_ldf2_2_Bot.unit1	Wall_ldf1_2.unit1	1	6.60000	0.00000	3.20000
		2	7.92321	0.00000	3.20000
		3	7.92321	0.00000	3.87321
		4	6.60000	0.00000	3.87321
Window_ldf2_2_Top.unit1	Wall_ldf1_2.unit1	1	6.60000	0.00000	3.95000
		2	7.92321	0.00000	3.95000
		3	7.92321	0.00000	4.62321
		4	6.60000	0.00000	4.62321

C.1.2.3 North facing windows:

There are also eight north facing windows (named as Window_ldbF_N_Pos.unit1).

Coordinates of the lower-left corner vertice (X1, Y1, Z1) are fixed as follows:

X1= values for each of north facing windows are listed in table below

Y1=Y2=Y3=Y4=10.55858,

Z1= values for each of north facing windows are listed in table below

The coordinates of the remaining three vertices can be calculated based on the window width (W), the window height (H) and the new averaged frame width (L_{f_Ave}) using the formulas below:

X2=X1-(W-2* L_{f_Ave})
Z2=Z1
X3=X1-(W-2* L_{f_Ave})
Z3=Z1+(H/2-2* L_{f_Ave})
X4=X1
Z4=Z1+(H/2-2* L_{f_Ave})

The coordinates of the lower-left corner vertices of the eight north facing windows are listed as follows:

Fenestration Name	Building Surface Name	X1	Y1	Z1
Window_ldb1_1_Bot.unit1	Wall_ldb1_1.unit1	8.00	10.55858	0.60
Window_ldb1_1_Top.unit1	Wall_ldb1_1.unit1	8.00		1.35
Window_ldb1_2_Bot.unit1	Wall_ldb1_1.unit1	3.90		0.60
Window_ldb1_2_Top.unit1	Wall_ldb1_1.unit1	3.90		1.35
Window_ldb2_1_Bot.unit1	Wall_ldb1_2.unit1	8.00		3.20
Window_ldb2_1_Top.unit1	Wall_ldb1_2.unit1	8.00		3.95
Window_ldb2_2_Bot.unit1	Wall_ldb1_2.unit1	3.90		3.20
Window_ldb2_2_Top.unit1	Wall_ldb1_2.unit1	3.90		3.95

The coordinates of the remaining vertices of each north facing window are calculated using above equation.

For AERC baseline window B, the coordinates of the eight north facing windows are as follows

Fenestration Name	Building Surface	Vertices	X	Y	Z
Window_ldb1_1_Bot.unit1	Wall_ldb1_1.unit1	1	8.00000	10.55858	0.60000
		2	6.67679	10.55858	0.60000
		3	6.67679	10.55858	1.27321
		4	8.00000	10.55858	1.27321
Window_ldb1_1_Top.unit1	Wall_ldb1_1.unit1	1	8.00000	10.55858	1.35000
		2	6.67679	10.55858	1.35000
		3	6.67679	10.55858	2.02321
		4	8.00000	10.55858	2.02321
Window_ldb1_2_Bot.unit1	Wall_ldb1_1.unit1	1	3.90000	10.55858	0.60000
		2	2.57679	10.55858	0.60000
		3	2.57679	10.55858	1.27321
		4	3.90000	10.55858	1.27321
Window_ldb1_2_Top.unit1	Wall_ldb1_1.unit1	1	3.90000	10.55858	1.35000
		2	2.57679	10.55858	1.35000
		3	2.57679	10.55858	2.02321
		4	3.90000	10.55858	2.02321
Window_ldb2_1_Bot.unit1	Wall_ldb1_2.unit1	1	8.00000	10.55858	3.20000
		2	6.67679	10.55858	3.20000
		3	6.67679	10.55858	3.87321
		4	8.00000	10.55858	3.87321
Window_ldb2_1_Top.unit1	Wall_ldb1_2.unit1	1	8.00000	10.55858	3.95000
		2	6.67679	10.55858	3.95000
		3	6.67679	10.55858	4.62321
		4	8.00000	10.55858	4.62321
Window_ldb2_2_Bot.unit1	Wall_ldb1_2.unit1	1	3.90000	10.55858	3.20000

		2	2.57679	10.55858	3.20000
		3	2.57679	10.55858	3.87321
		4	3.90000	10.55858	3.87321
Window_ldb2_2_Top.unit1	Wall_ldb1_2.unit1	1	3.90000	10.55858	3.95000
		2	2.57679	10.55858	3.95000
		3	2.57679	10.55858	4.62321
		4	3.90000	10.55858	4.62321

C.1.2.4 East facing windows:

There are also eight east facing windows (named as Window_sdrF_N_Pos.unit1).

Coordinates of the lower-left corner vertice (X1, Y1, Z1) are fixed as follows:

X1= X2=X3=X4= 10.55858,

Y1= values for each of east facing windows are listed in table below

Z1= values for each of east facing windows are listed in table below

The coordinates of the remaining three vertices are calculated based on the window width (W), the window height (H) and the new averaged frame width (L_{f_Ave}) using the below formulas:

Y2= Y1+(W-2* L_{f_Ave})

Z2=Z1

Y3= Y1+(W-2* L_{f_Ave})

Z3= Z1+(H/2-2* L_{f_Ave})

Y4=Y1

Z4= Z1+(H/2-2* L_{f_Ave})

The coordinates of the lower-left corner vertices of the eight east facing windows are listed as follows:

Fenestration Name	Building Surface Name	X1	Y1	Z1
Window_sdr1_1_Bot.unit1	Wall_sdr1_1.unit1	10.55858	2.50	0.60
Window_sdr1_1_Top.unit1	Wall_sdr1_1.unit1		2.50	1.35
Window_sdr1_2_Bot.unit1	Wall_sdr1_1.unit1		6.60	0.60
Window_sdr1_2_Top.unit1	Wall_sdr1_1.unit1		6.60	1.35
Window_sdr2_1_Bot.unit1	Wall_sdr1_2.unit1		2.50	3.20
Window_sdr2_1_Top.unit1	Wall_sdr1_2.unit1		2.50	3.95
Window_sdr2_2_Bot.unit1	Wall_sdr1_2.unit1		6.60	3.20
Window_sdr2_2_Top.unit1	Wall_sdr1_2.unit1		6.60	3.95

The coordinates of the remaining vertices of each east facing window are calculated using above equations.

For AERC baseline window B, the full set of coordinates for the eight east facing windows are listed in the table below.

Fenestration Name	Building Surface	Vertices	X	Y	Z
Window_sdr1_1_Bot.unit1	Wall_sdr1_1.unit1	1	10.55858	2.50000	0.60000
		2	10.55858	3.82321	0.60000
		3	10.55858	3.82321	1.27321
		4	10.55858	2.50000	1.27321
Window_sdr1_1_Top.unit1	Wall_sdr1_1.unit1	1	10.55858	2.50000	1.35000
		2	10.55858	3.82321	1.35000
		3	10.55858	3.82321	2.02321
		4	10.55858	2.50000	2.02321
Window_sdr1_2_Bot.unit1	Wall_sdr1_1.unit1	1	10.55858	6.60000	0.60000
		2	10.55858	7.92321	0.60000
		3	10.55858	7.92321	1.27321
		4	10.55858	6.60000	1.27321
Window_sdr1_2_Top.unit1	Wall_sdr1_1.unit1	1	10.55858	6.60000	1.35000
		2	10.55858	7.92321	1.35000
		3	10.55858	7.92321	2.02321
		4	10.55858	6.60000	2.02321
Window_sdr2_1_Bot.unit1	Wall_sdr1_2.unit1	1	10.55858	2.50000	3.20000
		2	10.55858	3.82321	3.20000
		3	10.55858	3.82321	3.87321
		4	10.55858	2.50000	3.87321
Window_sdr2_1_Top.unit1	Wall_sdr1_2.unit1	1	10.55858	2.50000	3.95000
		2	10.55858	3.82321	3.95000
		3	10.55858	3.82321	4.62321
		4	10.55858	2.50000	4.62321
Window_sdr2_2_Bot.unit1	Wall_sdr1_2.unit1	1	10.55858	6.60000	3.20000
		2	10.55858	7.92321	3.20000
		3	10.55858	7.92321	3.87321
		4	10.55858	6.60000	3.87321
Window_sdr2_2_Top.unit1	Wall_sdr1_2.unit1	1	10.55858	6.60000	3.95000
		2	10.55858	7.92321	3.95000
		3	10.55858	7.92321	4.62321
		4	10.55858	6.60000	4.62321

C.1.2.5 West facing windows:

There are also eight west facing windows (named as Window_sdlF_N_Pos.unit1).

where, the coordinates of the lower-left corner vertice (X1, Y1, Z1) are fixed as follows:

X1=X2=X3=X4=0.00,

Y1=values for each of west facing windows are listed in table below

Z1=values for each of west facing windows are listed in table below

The coordinates of the remaining three vertices are calculated based on the window width (W), the window height (H) and the new averaged frame width (L_{f_Ave}) using the below formulas:

Y2= Y1-(W-2* L_{f_Ave})

Z2=Z1

Y3= Y1-(W-2* L_{f_Ave})

Z3= Z1+(H/2-2* L_{f_Ave})

Y4=Y1

Z4= Z1+(H/2-2* L_{f_Ave})

The coordinates of the lower-left corner vertices of the eight west facing windows are listed as follows:

Fenestration Name	Building Surface Name	X	Y	Z
Window_sdl1_1_Bot.unit1	Wall_sdl1_1.unit1	0.00	8.00	0.60
Window_sdl1_1_Top.unit1	Wall_sdl1_1.unit1		8.00	1.35
Window_sdl1_2_Bot.unit1	Wall_sdl1_1.unit1		3.90	0.60
Window_sdl1_2_Top.unit1	Wall_sdl1_1.unit1		3.90	1.35
Window_sdl2_1_Bot.unit1	Wall_sdl1_2.unit1		8.00	3.20
Window_sdl2_1_Top.unit1	Wall_sdl1_2.unit1		8.00	3.95
Window_sdl2_2_Bot.unit1	Wall_sdl1_2.unit1		3.90	3.20
Window_sdl2_2_Top.unit1	Wall_sdl1_2.unit1		3.90	3.95

The coordinates of the remaining vertices of each west facing window are calculated using above equations.

For AERC baseline window B, the coordinates of the eight west facing windows are listed in the table below.

Fenestration Name	Building Surface	Vertices	X	Y	Z
Window_sdl1_1_Bot.unit1	Wall_sdl1_1.unit1	1	0.00000	8.00000	0.60000
		2	0.00000	6.67679	0.60000
		3	0.00000	6.67679	1.27321
		4	0.00000	8.00000	1.27321
Window_sdl1_1_Top.unit1	Wall_sdl1_1.unit1	1	0.00000	8.00000	1.35000
		2	0.00000	6.67679	1.35000
		3	0.00000	6.67679	2.02321
		4	0.00000	8.00000	2.02321

Window_sdl1_2_Bot.unit1	Wall_sdl1_1.unit1	1	0.00000	3.90000	0.60000
		2	0.00000	2.57679	0.60000
		3	0.00000	2.57679	1.27321
		4	0.00000	3.90000	1.27321
Window_sdl1_2_Top.unit1	Wall_sdl1_1.unit1	1	0.00000	3.90000	1.35000
		2	0.00000	2.57679	1.35000
		3	0.00000	2.57679	2.02321
		4	0.00000	3.90000	2.02321
Window_sdl2_1_Bot.unit1	Wall_sdl1_2.unit1	1	0.00000	8.00000	3.20000
		2	0.00000	6.67679	3.20000
		3	0.00000	6.67679	3.87321
		4	0.00000	8.00000	3.87321
Window_sdl2_1_Top.unit1	Wall_sdl1_2.unit1	1	0.00000	8.00000	3.95000
		2	0.00000	6.67679	3.95000
		3	0.00000	6.67679	4.62321
		4	0.00000	8.00000	4.62321
Window_sdl2_2_Bot.unit1	Wall_sdl1_2.unit1	1	0.00000	3.90000	3.20000
		2	0.00000	2.57679	3.20000
		3	0.00000	2.57679	3.87321
		4	0.00000	3.90000	3.87321
Window_sdl2_2_Top.unit1	Wall_sdl1_2.unit1	1	0.00000	3.90000	3.95000
		2	0.00000	2.57679	3.95000
		3	0.00000	2.57679	4.62321
		4	0.00000	3.90000	4.62321

A complete EnergyPlus window configuration inc file for the current AERC baseline window B was attached at the end of this document as Appendix F.

<u>Baseline Window Configuration Include File:</u>

```
FenestrationSurface:Detailed,
  Window_ldf1_1_Bot.unit1, !- Name
  Window,                  !- Surface Type
  AERC_Doubleclear_Baseline,   !- Construction Name
  Wall_ldf1_1.unit1,       !- Building Surface Name
  ,                        !- Outside Boundary Condition Object
  ,                        !- View Factor to Ground
  ,                        !- Shading Control Name
  AERC_Wood_Frame,         !- Frame and Divider Name
  1,                       !- Multiplier
  4,                       !- Number of Vertices
  2.500000000000, 0.000000000000, 0.600000000000,  !- X,Y,Z ==> Vertex 1 {m}
  3.823210000000, 0.000000000000, 0.600000000000,  !- X,Y,Z ==> Vertex 2 {m}
  3.823210000000, 0.000000000000, 1.273210000000,  !- X,Y,Z ==> Vertex 3 {m}
  2.500000000000, 0.000000000000, 1.273210000000;  !- X,Y,Z ==> Vertex 4 {m}

FenestrationSurface:Detailed,
  Window_ldf1_1_Top.unit1, !- Name
  Window,                  !- Surface Type
  AERC_Doubleclear_Baseline,   !- Construction Name
  Wall_ldf1_1.unit1,       !- Building Surface Name
  ,                        !- Outside Boundary Condition Object
  ,                        !- View Factor to Ground
  ,                        !- Shading Control Name
  AERC_Wood_Frame,         !- Frame and Divider Name
  1,                       !- Multiplier
  4,                       !- Number of Vertices
  2.500000000000, 0.000000000000, 1.350000000000,  !- X,Y,Z ==> Vertex 1 {m}
  3.823210000000, 0.000000000000, 1.350000000000,  !- X,Y,Z ==> Vertex 2 {m}
  3.823210000000, 0.000000000000, 2.023210000000,  !- X,Y,Z ==> Vertex 3 {m}
  2.500000000000, 0.000000000000, 2.023210000000;  !- X,Y,Z ==> Vertex 4 {m}
```

B: Baseline window run:
Glazing construction name is AERC_Doubleclear_Baseline. Frame construction name is AERC_Wood_Frame for both top and bottom "half" of the baseline window.

```
!     Window Material/Construction file with spectral data in IDF format
Construction:ComplexFenestrationState,
AERC_DoubleClear_Baseline,                    !- name
LBNLWindow,                          !- basis type
None,                            !- basis symmetry type
ThermParam_Glz_10001,                    !- window thermal model
CFS_Glz_10001_Basis,                   !- basis matrix name
CFS_Glz_10001_TfSol,                   !- Tfsol
CFS_Glz_10001_RbSol,                    !- Rbsol
CFS_Glz_10001_Tfvis,                   !- Tfvis
CFS_Glz_10001_Rbvis,                   !- Rbvis
Glass_102_Layer,                     !- layer 1 name
CFS_Glz_10001_Layer_1_fAbs,              !- fAbs
CFS_Glz_10001_Layer_1_bAbs,              !- bAbs
Gap_1_Glz_10001_Layer_1,               !- gap 1 name
,
,
Glass_102_Layer,                     !- layer 2 name
CFS_Glz_10001_Layer_2_fAbs,              !- fAbs
CFS_Glz_10001_Layer_2_bAbs;              !- bAbs
```

…

Adiabatic Window Configuration Include File:

```
FenestrationSurface:Detailed,
  Window_Idf1_1_Bot.unit1, !- Name
  Window,                  !- Surface Type
  Adiabatic_Window,        !- Construction Name
  Wall_Idf1_1.unit1,       !- Building Surface Name
  ,                        !- Outside Boundary Condition Object
  ,                        !- View Factor to Ground
  ,                        !- Shading Control Name
  ,                        !- Frame and Divider Name
  1,                       !- Multiplier
  4,                       !- Number of Vertices
  2.500000000000, 0.000000000000, 0.600000000000,  !- X,Y,Z ==> Vertex 1 {m}
  3.823210000000, 0.000000000000, 0.600000000000,  !- X,Y,Z ==> Vertex 2 {m}
  3.823210000000, 0.000000000000, 1.273210000000,  !- X,Y,Z ==> Vertex 3 {m}
  2.500000000000, 0.000000000000, 1.273210000000;  !- X,Y,Z ==> Vertex 4 {m}

FenestrationSurface:Detailed,
  Window_Idf1_1_Top.unit1, !- Name
  Window,                  !- Surface Type
  Adiabatic_Window,        !- Construction Name
  Wall_Idf1_1.unit1,       !- Building Surface Name
  ,                        !- Outside Boundary Condition Object
  ,                        !- View Factor to Ground
  ,                        !- Shading Control Name
  ,                        !- Frame and Divider Name
  1,                       !- Multiplier
  4,                       !- Number of Vertices
  2.500000000000, 0.000000000000, 1.350000000000,  !- X,Y,Z ==> Vertex 1 {m}
  3.823210000000, 0.000000000000, 1.350000000000,  !- X,Y,Z ==> Vertex 2 {m}
  3.823210000000, 0.000000000000, 2.023210000000,  !- X,Y,Z ==> Vertex 3 {m}
  2.500000000000, 0.000000000000, 2.023210000000;  !- X,Y,Z ==> Vertex 4 {m}
```

A: Adiabatic window run: Glazing construction name is Adiabatic_window. Frame and divider construction name is blank (keep a comma) for both top and bottom "half" of the baseline window.

Adiabatic Window Construction Include File (Window_construction_adiabatic.inc):

```
!-------------------------------------------------
!     Window Glass Layers
!-------------------------------------------------

 WindowMaterial:Glazing,
  Super_Insulated_Glass,   !- Name
  SpectralAverage,         !- Optical Data Type
  ,                        !- Window Glass Spectral Data Set Name
  0.003,                   !- Thickness {m}
  0.000001,                !- Solar Transmittance at Normal Incidence
  0.999999,                !- Front Side Solar Reflectance at Normal Incidence
  0.999999,                !- Back Side Solar Reflectance at Normal Incidence
  0.000001,                !- Visible Transmittance at Normal Incidence
  0.999999,                !- Front Side Visible Reflectance at Normal Incidence
  0.999999,                !- Back Side Visible Reflectance at Normal Incidence
  0.000000,                !- Infrared Transmittance at Normal Incidence
  0.000001,                !- Front Side Infrared Hemispherical Emissivity
  0.000001,                !- Back Side Infrared Hemispherical Emissivity
  0.00000001               !- Conductivity {W/m-K}

!-------------------------------------------------
!     Window Construction
!-------------------------------------------------
 Construction,
  Adiabatic_window,        !- Name
  Super_Insulated_Glass;   !- Outside Layer
```

Half-Deployed Window Configuration Include File:

```
FenestrationSurface:Detailed,
  Window_Idf1_1_Bot.unit1, !- Name
  Window,                  !- Surface Type
  AERC_Doubleclear_Baseline,  !- Construction Name
  Wall_Idf1_1.unit1,       !- Building Surface Name
  ,                        !- Outside Boundary Condition Object
  ,                        !- View Factor to Ground
  ,                        !- Shading Control Name
  AERC_Wood_Frame,         !- Frame and Divider Name
  1,                       !- Multiplier
  4,                       !- Number of Vertices
  2.500000000000, 0.000000000000, 0.600000000000, !-
  3.823210000000, 0.000000000000, 0.600000000000, !- X,Y,Z ==> Vertex 2 {m}
  3.823210000000, 0.000000000000, 1.273210000000, !- X,Y,Z ==> Vertex 3 {m}
  2.500000000000, 0.000000000000, 1.273210000000; !- X,Y,Z ==> Vertex 4 {m}

FenestrationSurface:Detailed,
  Window_Idf1_1_Top.unit1, !- Name
  Window,                  !- Surface Type
  AERC_Doubleclear_Attachment,  !- Construction Name
  Wall_Idf1_1.unit1,       !- Building Surface Name
  ,                        !- Outside Boundary Condition Object
  ,                        !- View Factor to Ground
  ,                        !- Shading Control Name
  AERC_Wood_Frame,         !- Frame and Divider Name
  1,                       !- Multiplier
  4,                       !- Number of Vertices
  2.500000000000, 0.000000000000, 1.350000000000, !- X,Y,Z ==> Vertex 1 {m}
  3.823210000000, 0.000000000000, 1.350000000000, !- X,Y,Z ==> Vertex 2 {m}
  3.823210000000, 0.000000000000, 2.023210000000, !- X,Y,Z ==> Vertex 3 {m}
  2.500000000000, 0.000000000000, 2.023210000000; !- X,Y,Z ==> Vertex 4 {m}
```

H: Attachments half deployed: Glazing Construction for "Bot" window unit AERC_Doubleclear_Baseline. Glazing Construction for "Top" window unit is AERC_Doubleclear_Attachment, which is user-specified. Frame construction name is AERC_Wood_Frame for both top and bottom "half" of the baseline window.

Fully-Deployed Window Configuration Include File :

```
FenestrationSurface:Detailed,
  Window_Idf1_1_Bot.unit1, !- Name
  Window,                  !- Surface Type
  AERC_Doubleclear_Attachment,   !- Construction Name
  Wall_Idf1_1.unit1,       !- Building Surface Name
  ,                        !- Outside Boundary Condition Object
  ,                        !- View Factor to Ground
  ,                        !- Shading Control Name
  AERC_Wood_Frame,         !- Frame and Divider Name
  1,                       !- Multiplier
  4,                       !- Number of Vertices
  2.500000000000, 0.000000000000, 0.600000000000,  !- X,Y,Z ==> Vertex 1 {m}
  3.823210000000, 0.000000000000, 0.600000000000,  !- X,Y,Z ==> Vertex 2 {m}
  3.823210000000, 0.000000000000, 1.273210000000,  !- X,Y,Z ==> Vertex 3 {m}
  2.500000000000, 0.000000000000, 1.273210000000;  !- X,Y,Z ==> Vertex 4 {m}
```

```
FenestrationSurface:Detailed,
  Window_Idf1_1_Top.unit1, !- Name
  Window,                  !- Surface Type
  AERC_Doubleclear_Attachment,   !- Construction Name
  Wall_Idf1_1.unit1,       !- Building Surface Name
  ,                        !- Outside Boundary Condition Object
  ,                        !- View Factor to Ground
  ,                        !- Shading Control Name
  AERC_Wood_Frame,         !- Frame and Divider Name
  1,                       !- Multiplier
  4,                       !- Number of Vertices
  2.500000000000, 0.000000000000, 1.350000000000,  !- X,Y,Z ==> Vertex 1 {m}
  3.823210000000, 0.000000000000, 1.350000000000,  !- X,Y,Z ==> Vertex 2 {m}
  3.823210000000, 0.000000000000, 2.023210000000,  !- X,Y,Z ==> Vertex 3 {m}
  2.500000000000, 0.000000000000, 2.023210000000;  !- X,Y,Z ==> Vertex 4 {m}
```

S: Attachments fully deployed: Glazing Construction is AERC_Doubleclear_Attachment, which is user-specified. Frame construction name is AERC_Wood_Frame for both top and bottom "half" of the baseline window.

C.2 Zone Infiltration:

The method of calculating air infiltration for the house with baseline windows, adiabatic windows and baseline windows with attachments consists of the following steps:

(1) Calculate the ELA of the whole house with baseline windows, ELA_H

(2) Calculate the ELA of all baseline windows, ELA_W

(3) Calculate the ELA of the whole house with adiabatic windows (no window infiltration), ELA_{HO}

(4) Calculate the ELA of all windows with attachment, ELA_{WA}

(5) Calculate the ELA of the whole house with windows and attachments, ELA_{HWA}

C.2.1 Calculating the ELA of the whole house with baseline windows, ELA_H

$$ELA_H = \frac{Q_{50}\left[\frac{\Delta P_4}{\Delta P_{50}}\right]^n}{\left[\frac{2\Delta P_4}{\rho}\right]^{0.5}} \times 10000 \quad \text{(I.1)}$$

$$Q_{50} = \frac{V_H \cdot ACH_{50}}{3600} \quad \text{(I.2)}$$

Where:

ELA_H = Effective leakage area of the whole house with baseline windows, (cm^2)

Q_{50} = Total house infiltration at 50 Pa, (m^3/s)

ΔP_{50} = 50 Pa test pressure for windows, (Pa)

ΔP_4 = 4 Pa used as baseline for comparison, (Pa)

n = 0.65; Flow exponent [-]

ρ = 1.29; Air density at standard temp. & press., (kg/m^3)

V_H = The volume of the house, (m^3)

ACH_{50} = Air changes per hour at 50 Pa

C.2.2 Calculating the ELA of all baseline windows, ELA_W

$$ELA_W = \frac{Q_{W75}\left[\frac{\Delta P_4}{\Delta P_{75}}\right]^n}{\left[\frac{2\Delta P_4}{\rho}\right]^{0.5}} \times 10000 \quad (I.3)$$

$$Q_{W75} = q_{W75} \cdot A_W \quad (I.4)$$

Where:

ELA_W = Effective leakage area of all baseline windows, (cm^2)

Q_{W75} = Total baseline window infiltration at 75 Pa, (m^3/s)

ΔP_{75} = 75 Pa test pressure for windows, (Pa)

q_{W75} = 0.01016 $m^3/(s \cdot m^2)$ (2.0 cfm/ft^2); The infiltration per unit area of baseline window at 75 Pa, ($m^3/s{\cdot}m^2$)

A_w = Total window area, (m^2)

C.2.3 Calculating the ELA of the whole house without windows, ELA_{HO}

$$ELA_{HO} = ELA_H - ELA_W \quad (I.5)$$

C.2.4 Calculating the ELA of windows with attachments, ELA_{WA}

$$ELA_{WA} = \frac{Q_{WA75}\left[\frac{\Delta P_4}{\Delta P_{75}}\right]^n}{\left[\frac{2\Delta P_4}{\rho}\right]^{0.5}} \cdot 10000 \quad (I.6)$$

$$Q_{WA75} = q_{WA75} \cdot A_W \quad (I.7)$$

Where:

ELA_{WA} = Effective leakage area of all windows with attachment, (cm^2)

Q_{75WA} = Total infiltration of the windows with attachment at 75 Pa, (m^3/s)

q_{WA75} = The measured air infiltration per unit area of the window with attachment at 75 Pa, also known as air leakage measurement; [$m^3/(s \cdot m^2)$]

Conversion of measured air leakage from IP units (cfm/sf^2) to SI units (m^3/(s · m^2)) is given by. This quantity is specified as input data in AERCalc for infiltration of window attachment product (baseline window plus window attachment):

$$q_{WA75}(SI) = 0.00508 \cdot q_{WA75}(IP)$$

Where the conversion factor 0.00508 is the result of the following conversion action: (ft to m)/(min to sec), or 0.3048/60.

C.2.5 Calculating the ELA of the whole house with window and attachment, ELA_{HWA}

$$ELA_{HWA} = ELA_{HO} + ELA_{WA} \quad \text{(I.8)}$$

Numerical values for the typical house and baseline window in AERCalc air:

$$V_H = 577.6288 \text{ m}^3 \quad \text{(I.9)}$$

$$ACH_{50}\_cooling=10 \text{ 1/hr} \quad \text{(I.10)}$$

$$ACH_{50}\_heating=7 \text{ 1/hr} \quad \text{(I.11)}$$

$$q_{W75} = 0.01016 \text{ m}^3/(\text{s} \cdot \text{m}^2) \quad \text{(I.12)}$$

$$A_w = 33.6 \text{ m}^2 \quad \text{(I.13)}$$

For cooling climate:

$$ELA_{HO} = 1,044 \text{ cm}^2$$

$$ELA_{HWA} = 1,044 + ELA_{WA} \text{ cm}^2 \quad \text{(I.14)}$$

For example, if the measured air infiltration of the window with attachment is 1 cfm/sf^2, then:

ELA_{HWA} equals to 1146 cm^2, this value should be inputted in the ELA filed of EnergyPlus IDF files for cooling simulation.

$$ELA_{WA} = \frac{1 \cdot 0.00508 \cdot 33.6 \cdot \left[\frac{4}{75}\right]^{0.65}}{\left[\frac{8}{1.29}\right]^{0.5}} \cdot 10000 = 101.977 cm^2$$

Therefore,

$$ELA_{HWA} = 1,044 + 101.977 = 1,145.997 cm^2$$

For heating climate calculation:

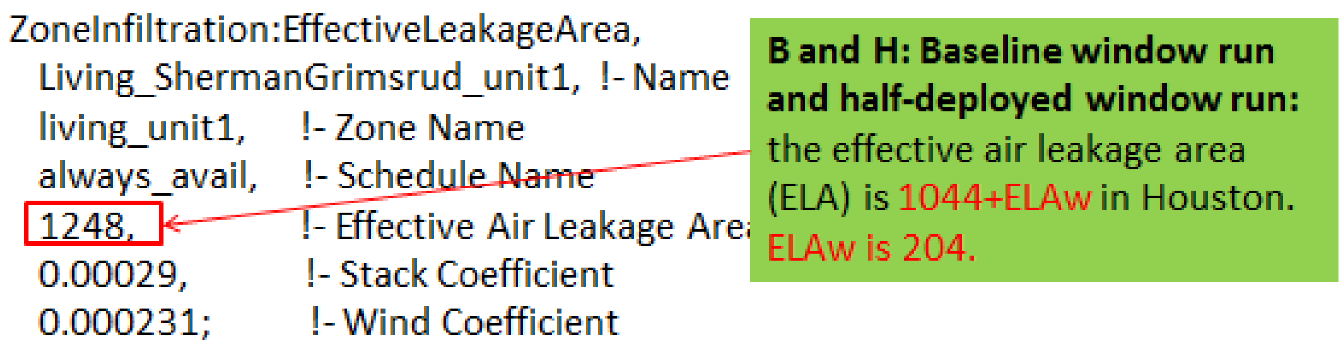
$$ELA_{H0} = 669 \text{ cm}^2$$

$$ELA_{HWA} = 669 + ELA_{WA} \text{ (cm}^2\text{)} \quad (I.15)$$

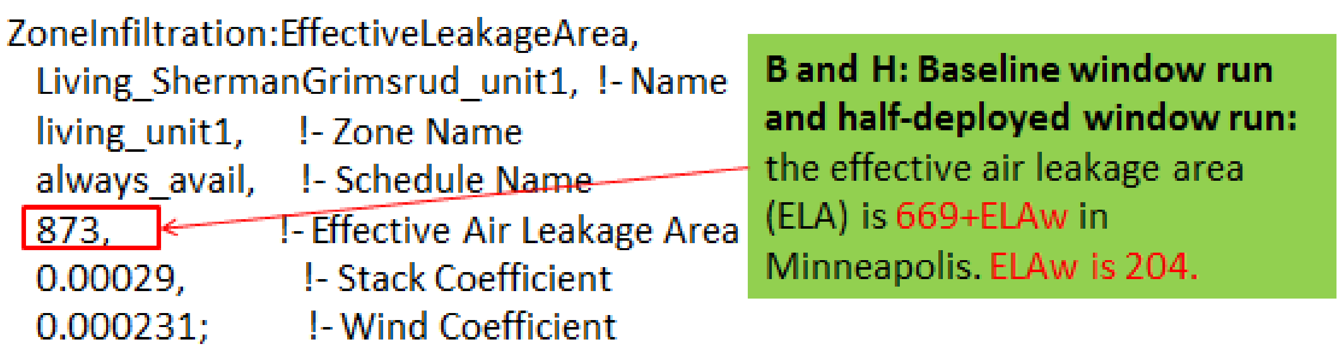
For the same example the infiltration for the house with window attachments will be:

$$ELA_{HWA} = 669 + 101.977 = 770.997 cm^2$$

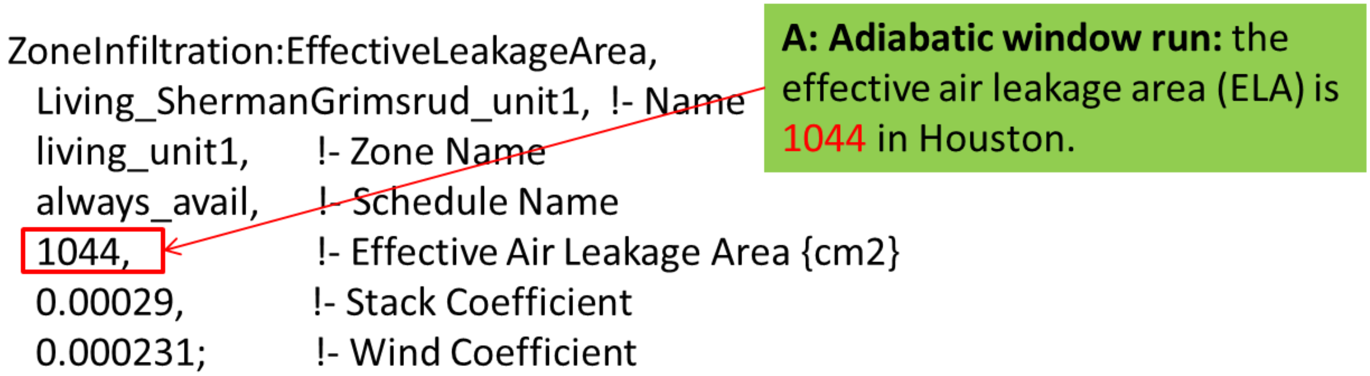
Baseline window and half-deployed window infiltration include file for Houston (Air_infiltration_baseline_Houston.inc):



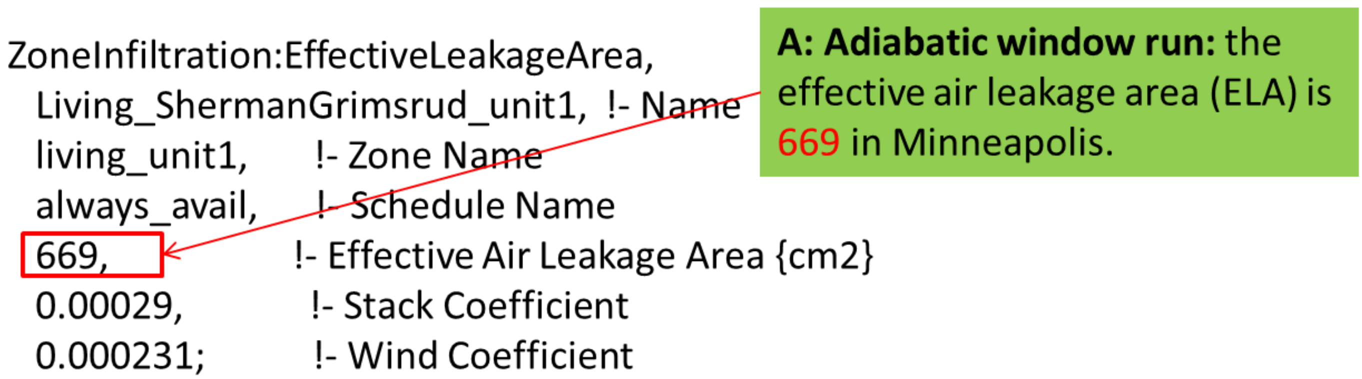
Baseline window and half-deployed window infiltration include file for Minneapolis (Air_infiltration_baseline_Minneapolis.inc):



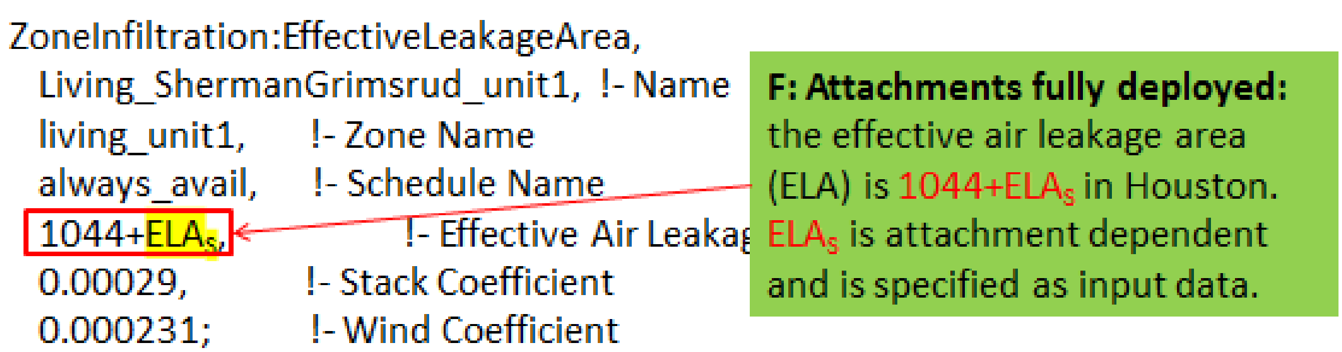
Adiabatic window infiltration include file for Houston (Air_infiltration_adiabatic_Houston.inc):



Adiabatic window infiltration include file for Minneapolis (Air_infiltration_adiabatic_Minneapolis.inc):



Fully-deployed window infiltration include file for Houston (Air_infiltration_user_input_Houston.inc):



Fully-deployed window infiltration include file for Minneapolis
(Air_infiltration_user_input_Minneapolis.inc):

```
ZoneInfiltration:EffectiveLeakageArea,
  Living_ShermanGrimsrud_unit1,  !- Name
  living_unit1,      !- Zone Name
  always_avail,      !- Schedule Name
  669+ELAS,                !- Effective Air Leakage
  0.00029,          !- Stack Coefficient
  0.000231;         !- Wind Coefficient
```

F: Attachments fully deployed: the effective air leakage area (ELA) is 669+ELA_S in Houston. ELA_S is attachment dependent and is specified as input data.

Note 1: ELA_S in annotations above was replaced with ELA_{WA} notation in equations preeding these annotations.

Note 2: In AERCalc, users are required to input the measured air leakage (AL) of the window with attachment, but in EnergyPlus the infiltration is calculated based on the effective leakage area of the whole house including the windows with attachments. Thus, it is necessary to convert the user-input air leakage to the effective leakage area of the whole house (ELA_{HWA})at the back-end before starting simulation. In addition to this conversion, unit conversion will often be required, since most common way of reporting AL is in IP units of cfm/sf^2. The methodology of converting AL into ELA_{HWA} was illustrated in above.

C.3 HVAC:

HVAC System for Houston

- Red highlight: System_autosize_Houston.inc
- Yellow highlight: System_sizing_Houston.inc

```
Sizing:System,
  Central System_unit1,     !- AirLoop Name
  Sensible,                 !- Type of Load to Size On
  autosize,                    !- Design Outdoor Air Flow Rate {m3/s}
  0.652,                    !- Design Outdoor Air Flow Rate {m3/s}
  1,                        !- Central Heating Maximum System Air Flow Ratio
  7,                        !- Preheat Design Temperature {C}
  0.008,                    !- Preheat Design Humidity Ratio {kgWater/kgDryAi
  11,                       !- Precool Design Temperature {C}
  0.008,                    !- Precool Design Humidity Ratio {kgWater/kgDryAi
  12,                       !- Central Cooling Design Supply Air Temperature
  50,                       !- Central Heating Design Supply Air Temperature
  NonCoincident,            !- Type of Zone Sum to Use
  No,                       !- 100% Outdoor Air in Cooling
  No,                       !- 100% Outdoor Air in Heating
  0.008,                    !- Central Cooling Design Supply Air Humidity Rat
  0.008,                    !- Central Heating Design Supply Air Humidity Rat
  designday,                !- Cooling Supply Air Flow Rate Method
  ,                         !- Cooling Supply Air Flow Rate {m3/s}
  ,                         !- Cooling Supply Air Flow Rate Per Floor Area {m
  ,                         !- Cooling Fraction of Autosized Cooling Supply A
  ,                         !- Cooling Supply Air Flow Rate Per Unit Cooling
  designday,                !- Heating Supply Air Flow Rate Method
  ,                         !- Heating Supply Air Flow Rate {m3/s}
  ,                         !- Heating Supply Air Flow Rate Per Floor Area {m
  ,                         !- Heating Fraction of Autosized Heating Supply A
  ,                         !- Heating Fraction of Autosized Cooling Supply A
  ,                         !- Heating Supply Air Flow Rate Per Unit Heating
  ZoneSum,                  !- System Outdoor Air Method
  0.5,                      !- Zone Maximum Outdoor Air Fraction {dimensionle
  CoolingDesignCapacity,    !- Cooling Design Capacity Method
  autosize,                 !- Cooling Design Capacity {W}
  9485.25,                 !- Cooling Design Capacity {W}
  ,                         !- Cooling Design Capacity Per Floor Area {W/m2}
  ,                         !- Fraction of Autosized Cooling Design Capacity
  HeatingDesignCapacity,    !- Heating Design Capacity Method
  autosize,                  !- Heating Design Capacity {W}
  7126.4,                  !- Heating Design Capacity {W}
  ,                         !- Heating Design Capacity Per Floor Area {W/m2}
  ,                         !- Fraction of Autosized Heating Design Capacity
  ;                         !- Central Cooling Capacity Control Method
```

1, for baseline window run, this field keeps autosize, for other runs, viz. adiabatic window run, shade fully deployed run and shade half deployed run, this field replaces with 0.652

2, for baseline window run, this field keeps autosize, for other runs, this field replaces with 9485.25

3, for baseline window run, this field keeps autosize, for other runs, this field replaces with 7126.4

```
AirTerminal:SingleDuct:Uncontrolled,
  ZoneDirectAir_unit1,      !- Name
  always_avail,             !- Availability Schedule Name
  Zone Inlet Node_unit1,    !- Zone Supply Air Node Name
  autosize;                    !- Maximum Air Flow Rate {m3/s}
  0.652;                    !- Maximum Air Flow Rate {m3/s}
```

4, for baseline window run, this field keeps autosize, for other runs, this field replaces with 0.652

```
Coil:Cooling:DX:SingleSpeed,
  DX Cooling Coil_unit1,    !- Name
  always_avail,             !- Availability Schedule Name
  autosize,                 !- Gross Rated Total Cooling Capacity
  13131.31,                 !- Gross Rated Total Cooling Capacity
  autosize,                 !- Gross Rated Sensible Heat Ratio
  0.733253,                 !- Gross Rated Sensible Heat Ratio
  2.70,                     !- Gross Rated Cooling COP {W/W}
  autosize,                     !- Rated Air Flow Rate {m3/s}
  0.652,                     !- Rated Air Flow Rate {m3/s}
  ,                         !- Rated Evaporator Fan Power Per Volu
  Cooling Coil Air Inlet Node_unit1,   !- Air Inlet Node Name
  Heating Coil Air Inlet Node_unit1,   !- Air Outlet Node Name
  HPACCoolCapFT,            !- Total Cooling Capacity Function of
  HPACCoolCapFFF,           !- Total Cooling Capacity Function of
  HPACCOOLEIRFT,            !- Energy Input Ratio Function of Temp
  HPACCOOLEIRFFF,           !- Energy Input Ratio Function of Flow
  HPACCOOLPLFFPLR;          !- Part Load Fraction Correlation Curv
```

5, for baseline window run, this field keeps autosize, for other runs, this field replaces with 13131.31

6, for baseline window run, this field keeps autosize, for other runs, this field replaces with 0.733253

7, for baseline window run, this field keeps autosize, for other runs, this field replaces with 0.652

```
Fan:OnOff,
  Supply Fan_unit1,          !- Name
  always_avail,              !- Availability Schedule Name
  0.7,                       !- Fan Total Efficiency
  400,                       !- Pressure Rise {Pa}
  autosize,                      !- Maximum Flow Rate {m3/s
  0.652,                     !- Maximum Flow Rate {m3/s}
  0.8,                       !- Motor Efficiency
  1,                         !- Motor In Airstream Fraction
  air loop inlet node_unit1,   !- Air Inlet Node Name
  cooling coil air inlet node_unit1,  !- Air Outlet Node
  ,                          !- Fan Power Ratio Function of
  ,                          !- Fan Efficiency Ratio Functi
  General;                   !- End-Use Subcategory
```

8, for baseline window run, this field keeps autosize, for other runs, this field replaces with 0.652

```
Coil:Heating:DX:SingleSpeed,
    Main DX Heating Coil_unit1,   !- Name
    always_avail,              !- Availability Schedule Name
    autosize,                  !- Rated Total Heating Capacity {W}
    13131.31,                  !- Rated Total Heating Capacity {W}
    1.99,                      !- Rated COP {W/W}
    autosize,                      !- Rated Air Flow Rate {m3/s}
    0.652,                     !- Rated Air Flow Rate {m3/s}
    ,                          !- Rated Evaporator Fan Power Per Vo
    Heating Coil Air Inlet Node_unit1,   !- Air Inlet Node Name
    Supp Heating Coil Air Inlet Node_unit1,   !- Air Outlet Node N
    HPACHeatCapFT,             !- Total Heating Capacity Function o
    HPACHeatCapFFF,            !- Total Heating Capacity Function o
    HPACHeatEIRFT,             !- Energy Input Ratio Function of Te
    HPACHeatEIRFFF,            !- Energy Input Ratio Function of Fl
    HPACCOOLPLFFPLR,           !- Part Load Fraction Correlation Cu
    Defrost_EIR_FT,            !- Defrost Energy Input Ratio Functi
    -17.78,                    !- Minimum Outdoor Dry-Bulb Temperat
    ,                          !- Outdoor Dry-Bulb Temperature to T
    5.0,                       !- Maximum Outdoor Dry-Bulb Temperat
    200.0,                     !- Crankcase Heater Capacity {W}
    10.0,                      !- Maximum Outdoor Dry-Bulb Temperat
    ReverseCycle,              !- Defrost Strategy
    OnDemand,                  !- Defrost Control
    ,                          !- Defrost Time Period Fraction
    ;                          !- Resistive Defrost Heater Capacity
```

9, for baseline window run, this field keeps autosize, for other runs, this field replaces with 13131.31

10, for baseline window run, this field keeps autosize, for other runs, this field replaces with 0.652

```
Coil:Heating:Electric,
    Supp Heating Coil_unit1, !- Name
    always_avail,            !- Availability Schedule Name
    1,                       !- Efficiency
    autosize,                  !- Nominal Capacity {W}
    7910.07,                 !- Nominal Capacity {W}
    Supp Heating Coil Air Inlet Node_unit1,  !- Air Inlet Node Name
    Air Loop Outlet Node_unit1;  !- Air Outlet Node Name

!-   ===========  ALL OBJECTS IN CLASS: AIRLOOPHVAC ===========

  AirLoopHVAC,
    Central System_unit1,    !- Name
    ,                        !- Controller List Name
    availability list,       !- Availability Manager List Name
    autosize,                    !- Design Supply Air Flow Rate {m3/s}
    0.652,                     !- Design Supply Air Flow Rate {m3/s}
    Air Loop Branches_unit1, !- Branch List Name
    ,                        !- Connector List Name
    Air Loop Inlet Node_unit1,  !- Supply Side Inlet Node Name
    Return Air Mixer Outlet_unit1,  !- Demand Side Outlet Node Name
    Zone Equipment Inlet Node_unit1,  !- Demand Side Inlet Node Names
    Air Loop Outlet Node_unit1;  !- Supply Side Outlet Node Names
```

11, for baseline window run, this field keeps autosize, for other runs, this field replaces with 7910.07

12, for baseline window run, this field keeps autosize, for other runs, this field replaces with 0.652

```
AirLoopHVAC:UnitaryHeatPump:AirToAir,
    Heat Pump_unit1,          !- Name
    always_avail,             !- Availability Schedule Name
    Air Loop Inlet node_unit1,  !- Air Inlet Node Name
    Air Loop Outlet Node_unit1,  !- Air Outlet Node Name
    autosize,                    !- Supply Air Flow Rate During Cooling Ope
    0.652,                    !- Supply Air Flow Rate During Cooling Operat
    autosize,                    !- Supply Air Flow Rate During Heating Ope
    0.652,                    !- Supply Air Flow Rate During Heating Operat
    0.0,                      !- Supply Air Flow Rate When No Cooling or Heat
    living_unit1,             !- Controlling Zone or Thermostat Location
    Fan:OnOff,                !- Supply Air Fan Object Type
    Supply Fan_unit1,         !- Supply Air Fan Name
    Coil:Heating:DX:SingleSpeed,  !- Heating Coil Object Type
    Main DX Heating Coil_unit1,  !- Heating Coil Name
    Coil:Cooling:DX:SingleSpeed,  !- Cooling Coil Object Type
    DX Cooling Coil_unit1,    !- Cooling Coil Name
    Coil:Heating:Electric,    !- Supplemental Heating Coil Object Type
    Supp Heating Coil_unit1,  !- Supplemental Heating Coil Name
    50,                       !- Maximum Supply Air Temperature from Supplem
    10,                       !- Maximum Outdoor Dry-Bulb Temperature for Su
    BlowThrough,              !- Fan Placement
    fan_cycle;                !- Supply Air Fan Operating Mode Schedule Name
```

13, for baseline window run, this field keeps autosize, for other runs, this field replaces with 0.652

14, for baseline window run, this field keeps autosize, for other runs, this field replaces with 0.652

```
Branch,
    Air Loop Main Branch_unit1,  !- Name
    autosize,                    !- Maximum Flow Rate {m3/s}
    0.652,                    !- Maximum Flow Rate {m3/s}
    ,                         !- Pressure Drop Curve Name
    AirLoopHVAC:UnitaryHeatPump:AirtoAir,  !- Component 1 Object Type
    Heat Pump_unit1,          !- Component 1 Name
    Air Loop Inlet Node_unit1,  !- Component 1 Inlet Node Name
    Air Loop Outlet Node_unit1, !- Component 1 Outlet Node Name
    ACTIVE;                   !- Component 1 Branch Control Type
```

15, for baseline window run, this field keeps autosize, for other runs, this field replaces with 0.652

```
Pump:VariableSpeed,
    Mains Pressure_unit1,     !- Name
    Mains Inlet Node_unit1,   !- Inlet Node Name
    Mains Pressure Outlet Node_unit1,  !- Outlet Node Name
    autosize,                 !- Design Maximum Flow Rate {m3/s}
    0.000009,                 !- Design Maximum Flow Rate {m3/s}
    179352,                   !- Design Pump Head {Pa}
    autosize,                 !- Design Power Consumption {W}
    0.9,                      !- Motor Efficiency
    0,                        !- Fraction of Motor Inefficiencies
    0,                        !- Coefficient 1 of the Part Load P
    1,                        !- Coefficient 2 of the Part Load P
    0,                        !- Coefficient 3 of the Part Load P
    0,                        !- Coefficient 4 of the Part Load P
    0,                        !- Design Minimum Flow Rate {m3/s}
    Intermittent;             !- Pump Control Type
```

16, for baseline window run, this field keeps autosize, for other runs, this field replaces with 0.000009

```
WaterHeater:Mixed,
  Water Heater_unit1,        !- Name
  0.196841372,               !- Tank Volume {m3}
  dhw_setpt,                 !- Setpoint Temperature Schedule Name
  2,                         !- Deadband Temperature Difference {deltaC}
  50,                        !- Maximum Temperature Limit
  Cycle,                     !- Heater Control Type
  autosize,                  !- Heater Maximum Capacity {W
  5500,                      !- Heater Maximum Capacity {W
  0,                         !- Heater Minimum Capacity {W
  0,                         !- Heater Ignition Minimum Fl
  ,                          !- Heater Ignition Delay {s}
  electricity,               !- Heater Fuel Type
  1,                         !- Heater Thermal Efficiency
  ,                          !- Part Load Factor Curve Name
  ,                          !- Off Cycle Parasitic Fuel Consumption Rate {W}
  ,                          !- Off Cycle Parasitic Fuel Type
  ,                          !- Off Cycle Parasitic Heat Fraction to Tank
  ,                          !- On Cycle Parasitic Fuel Consumption Rate {W}
  ,                          !- On Cycle Parasitic Fuel Type
  ,                          !- On Cycle Parasitic Heat Fraction to Tank
  Zone,                      !- Ambient Temperature Indicator
  ,                          !- Ambient Temperature Schedule Name
  living_unit1,              !- Ambient Temperature Zone Name
  ,                          !- Ambient Temperature Outdoor Air Node Name
  1.3306616,                 !- Off Cycle Loss Coefficient to Ambient Temperature {W/K}
  1,                         !- Off Cycle Loss Fraction to Zone
  1.3306616,                 !- On Cycle Loss Coefficient to Ambient Temperature {W/K}
  1,                         !- On Cycle Loss Fraction to Zone
  0,                         !- Peak Use Flow Rate {m3/s}
  ,                          !- Use Flow Rate Fraction Sch
  ,                          !- Cold Water Supply Temperat
  Water Heater use inlet node_unit1,  !- Use Side Inlet
  Water Heater use outlet node_unit1,  !- Use Side Outle
  1,                         !- Use Side Effectiveness
  ,                          !- Source Side Inlet Node Nam
  ,                          !- Source Side Outlet Node Na
  1,                         !- Source Side Effectiveness
  autosize,                  !- Use Side Design Flow Rate {m3/s}
  0.000009,                  !- Use Side Design Flow Rate {m3/s}
  0,                         !- Source Side Design Flow Rate {m3/s}
  1.5;                       !- Indirect Water Heating Recovery Time {hr}
```

17, for baseline window run, this field keeps autosize, for other runs, this field replaces with 5500

18, for baseline window run, this field keeps autosize, for other runs, this field replaces with 0.000009

```
PlantLoop,
  DHW Loop_unit1,            !- Name
  Water,                     !- Fluid Type
  ,                          !- User Defined Fluid Type
  DHW Loop Operation_unit1,!- Plant Equipment Operatio
  DHW Supply Outlet Node_unit1,  !- Loop Temperature S
  100,                       !- Maximum Loop Temperature
  0,                         !- Minimum Loop Temperature
  autosize,                  !- Maximum Loop Flow Rate {
  0.000009,                  !- Maximum Loop Flow Rate {
  0,                         !- Minimum Loop Flow Rate {
  autocalculate,             !- Plant Loop Volume {m3}
  0.006851,                  !- Plant Loop Volume {m3}
  Mains Inlet Node_unit1,    !- Plant Side Inlet Node Name
  DHW Supply Outlet Node_unit1,  !- Plant Side Outlet
  DHW Supply Branches_unit1,  !- Plant Side Branch Lis
  DHW Supply Connectors_unit1,  !- Plant Side Connecto
  DHW Demand Inlet Node_unit1,  !- Demand Side Inlet N
  Mains Makeup Node_unit1, !- Demand Side Outlet Node
  DHW Demand Branches_unit1,  !- Demand Side Branch Li
  DHW Demand Connectors_unit1,  !- Demand Side Connect
  Optimal;                   !- Load Distribution Scheme
```

19, for baseline window run, this field keeps autosize, for other runs, this field replaces with 0.000009

20, for baseline window run, this field keeps autocalculate, for other runs, this field replaces with 0.006851

HVAC System for Minneapolis

- Red highlight: System_autosize_Minneapolis.inc
- Yellow highlight: System_sizing_Minneapolis.inc

```
Sizing:System,
  Central System_unit1,     !- AirLoop Name
  Sensible,                 !- Type of Load to Size On
  autosize,                    !- Design Outdoor Air Flow Rate {m3/s}
  0.563,                    !- Design Outdoor Air Flow Rate {m3/s}
  1,                        !- Central Heating Maximum System Air Flow
  7,                        !- Preheat Design Temperature {C}
  0.008,                    !- Preheat Design Humidity Ratio {kgWater/
  11,                       !- Precool Design Temperature {C}
  0.008,                    !- Precool Design Humidity Ratio {kgWater/
  12,                       !- Central Cooling Design Supply Air Tempe
  50,                       !- Central Heating Design Supply Air Tempe
  NonCoincident,            !- Type of Zone Sum to Use
  No,                       !- 100% Outdoor Air in Cooling
  No,                       !- 100% Outdoor Air in Heating
  0.008,                    !- Central Cooling Design Supply Air Humid
  0.008,                    !- Central Heating Design Supply Air Humid
  designday,                !- Cooling Supply Air Flow Rate Method
  ,                         !- Cooling Supply Air Flow Rate {m3/s}
  ,                         !- Cooling Supply Air Flow Rate Per Floor
  ,                         !- Cooling Fraction of Autosized Cooling S
  ,                         !- Cooling Supply Air Flow Rate Per Unit C
  designday,                !- Heating Supply Air Flow Rate Method
  ,                         !- Heating Supply Air Flow Rate {m3/s}
  ,                         !- Heating Supply Air Flow Rate Per Floor
  ,                         !- Heating Fraction of Autosized Heating S
  ,                         !- Heating Fraction of Autosized Cooling S
  ,                         !- Heating Supply Air Flow Rate Per Unit H
  ZoneSum,                  !- System Outdoor Air Method
  0.5,                      !- Zone Maximum Outdoor Air Fraction {dime
  CoolingDesignCapacity,    !- Cooling Design Capacity Method
  autosize,                  !- Cooling Design Capacity {W}
  7979.19,                  !- Cooling Design Capacity {W}
  ,                         !- Cooling Design Capacity Per Floor Area
  ,                         !- Fraction of Autosized Cooling Design Ca
  HeatingDesignCapacity,    !- Heating Design Capacity Method
  autosize,                 !- Heating Design Capacity {W}
  15123.09,                 !- Heating Design Capacity {W}
  ,                         !- Heating Design Capacity Per Floor Area
  ,                         !- Fraction of Autosized Heating Design Ca
  ;                         !- Central Cooling Capacity Control Method
```

1, for baseline window run, this field keeps autosize, for other runs, viz. adiabatic window run, shade fully-deployed run and shade half-deployed run, this field replaces with 0.563

2, for baseline window run, this field keeps autosize, for other runs, this field replaces with 7979.19

3, for baseline window run, this field keeps autosize, for other runs, this field replaces with 15123.09

```
AirTerminal:SingleDuct:Uncontrolled,
  ZoneDirectAir_unit1,       !- Name
  always_avail,              !- Availability Schedule Name
  Zone Inlet Node_unit1,     !- Zone Supply Air Node Name
  autosize;                    !- Maximum Air Flow Rate {m3/s}
  0.563;                     !- Maximum Air Flow Rate {m3/s}
```

4, for baseline window run, this field keeps autosize, for other runs, this field replaces with 0.563

```
Coil:Cooling:DX:SingleSpeed,
  DX Cooling Coil_unit1,    !- Name
  always_avail,             !- Availability Schedule Name
  autosize,                 !- Gross Rated Total Cooling Capacity {W}
  10628.64,                 !- Gross Rated Total Cooling Capacity {W}
  autosize,                 !- Gross Rated Sensible Heat Ratio
  0.753625,                 !- Gross Rated Sensible Heat Ratio
  2.70,                     !- Gross Rated Cooling COP {W/W}           SEER=
  autosize,                    !- Rated Air Flow Rate {m3/s}
  0.563,                    !- Rated Air Flow Rate {m3/s}
  ,                         !- Rated Evaporator Fan Power Per Volume Flow
  Cooling Coil Air Inlet Node_unit1,  !- Air Inlet Node Name
  Heating Coil Air Inlet Node_unit1,  !- Air Outlet Node Name
  Cool-Cap-FT,              !- Total Cooling Capacity Function of Tempera
  ConstantCubic,            !- Total Cooling Capacity Function of Flow Fr
  Cool-EIR-FT,              !- Energy Input Ratio Function of Temperature
  ConstantCubic,            !- Energy Input Ratio Function of Flow Fracti
  Cool-PLF-fPLR;            !- Part Load Fraction Correlation Curve Name
```

5, for baseline window run, this field keeps autosize, for other runs, this field replaces with 10628.64

6, for baseline window run, this field keeps autosize, for other runs, this field replaces with 0.753625

7, for baseline window run, this field keeps autosize, for other runs, this field replaces with 0.563

```
Fan:OnOff,
  Supply Fan_unit1,           !- Name
  always_avail,               !- Availability Schedule
  0.7,                        !- Fan Total Efficiency
  400,                        !- Pressure Rise {Pa}
  autosize,                   !- Maximum Flow Rate {m3/
  0.563,                   !- Maximum Flow Rate {m3/s}
  0.8,                        !- Motor Efficiency
  1,                          !- Motor In Airstream Fra
  air loop inlet node_unit1,  !- Air Inlet Node Name
  cooling coil air inlet node_unit1,  !- Air Outlet
  ,                           !- Fan Power Ratio Functi
  ,                           !- Fan Efficiency Ratio F
  General;                    !- End-Use Subcategory
```

8, for baseline window run, this field keeps autosize, for other runs, this field replaces with 0.563

```
AirLoopHVAC,
  Central System_unit1,      !- Name
  ,                          !- Controller List Name
  availability list,         !- Availability Manager List Name
  autosize,                  !- Design Supply Air Flow Rate {m3,
  0.563,                  !- Design Supply Air Flow Rate {m3/s}
  Air Loop Branches_unit1, !- Branch List Name
  ,                          !- Connector List Name
  Air Loop Inlet Node_unit1,   !- Supply Side Inlet Node Name
  Return Air Mixer Outlet_unit1,   !- Demand Side Outlet Node I
  Zone Equipment Inlet Node_unit1,   !- Demand Side Inlet Node
  Air Loop Outlet Node_unit1;   !- Supply Side Outlet Node Nam
```

9, for baseline window run, this field keeps autosize, for other runs, this field replaces with 0.563

```
!-   ===========  ALL OBJECTS IN CLASS: AIRLOOPHVAC:UNITARYHEAT

  AirLoopHVAC:UnitaryHeatCool,
    ACandF_unit1,              !- Name
    always_avail,              !- Availability Schedule Name
    air loop inlet node_unit1,   !- Unitary System Air Inlet Nod
    air loop outlet node_unit1,   !- Unitary System Air Outlet N
    fan_cycle,                 !- Supply Air Fan Operating Mode S
    80,                        !- Maximum Supply Air Temperature
    autosize,                  !- Cooling Supply Air Flow Rate {m
    0.563,                  !- Cooling Supply Air Flow Rate {m3/s
    autosize,                  !- Heating Supply Air Flow Rate {m
    0.563,                  !- Heating Supply Air Flow Rate {m3/s
    0,                         !- No Load Supply Air Flow Rate {m
    living_unit1,              !- Controlling Zone or Thermostat I
    Fan:OnOff,                 !- Supply Fan Object Type
    Supply Fan_unit1,          !- Supply Fan Name
    BlowThrough,               !- Fan Placement
    Coil:Heating:gas,          !- Heating Coil Object Type
    Main gas Heating Coil_unit1,   !- Heating Coil Name
    Coil:Cooling:DX:SingleSpeed,   !- Cooling Coil Object Type
    DX Cooling Coil_unit1,     !- Cooling Coil Name
    None;                      !- Dehumidification Control Type
```

10, for baseline window run, this field keeps autosize, for other runs, this field replaces with 0.563

11, for baseline window run, this field keeps autosize, for other runs, this field replaces with 0.563

```
  Branch,
    Air Loop Main Branch_unit1,   !- Name
    autosize,                  !- Maximum Flow Rate {m3/s}
    0.563,                  !- Maximum Flow Rate {m3/s}
    ,                          !- Pressure Drop Curve Name
    AirLoopHVAC:UnitaryHeatCool,   !- Component 1 Object Type
    ACandF_unit1,              !- Component 1 Name
    Air Loop Inlet Node_unit1,   !- Component 1 Inlet Node Name
    Air loop outlet node_unit1,   !- Component 1 Outlet Node Name
    ACTIVE;                    !- Component 1 Branch Control Type

!-   ===========  ALL OBJECTS IN CLASS: OUTDOORAIR:NODE =========

  OutdoorAir:Node,
    outside air inlet node_unit1,   !- Name
    0.914355407629293;         !- Height Above Ground {m}

  OutdoorAir:Node,
    outdoor air node_unit1,    !- Name
    1;                         !- Height Above Ground {m}
```

12, for baseline window run, this field keeps autosize, for other runs, this field replaces with 0.563

```
!-   ===========  ALL OBJECTS IN CLASS: COIL:HEATING:GAS ========

  Coil:Heating:Gas,
    Main gas heating coil_unit1,   !- Name
    always_avail,              !- Availability Schedule Name
    0.78,                      !- Gas Burner Efficiency
    autosize,                  !- Nominal Capacity {W}
    16720.73,                  !- Nominal Capacity {W}
    heating coil air inlet node_unit1,   !- Air Inlet Node Name
    air loop outlet node_unit1;   !- Air Outlet Node Name
```

13, for baseline window run, this field keeps autosize, for other runs, this field replaces with 16720.73

```
Pump:VariableSpeed,
  Mains Pressure_unit1,     !- Name
  Mains Inlet Node_unit1,   !- Inlet Node Name
  Mains Pressure Outlet Node_unit1,  !- Outlet Node Name
  autosize,                 !- Design Maximum Flow Rate {m3/s}
  0.000009,                 !- Design Maximum Flow Rate {
  179352,                   !- Design Pump Head {Pa}
  autosize,                 !- Design Power Consumption {
  0.9,                      !- Motor Efficiency
  0,                        !- Fraction of Motor Ineffici
  0,                        !- Coefficient 1 of the Part
  1,                        !- Coefficient 2 of the Part
  0,                        !- Coefficient 3 of the Part
  0,                        !- Coefficient 4 of the Part Load I
  0,                        !- Design Minimum Flow Rate {m3/s}
  Intermittent;             !- Pump Control Type
```

14, for baseline window run, this field keeps autosize, for other runs, this field replaces with 0.000009

```
WaterHeater:Mixed,
  Water Heater_unit1,       !- Name
  0.196841372,              !- Tank Volume {m3}
  dhw_setpt,                !- Setpoint Temperature Schedul
  2,                        !- Deadband Temperature Differe
  50,                       !- Maximum Temperature Limit {C
  Cycle,                    !- Heater Control Type
  autosize,                 !- Heater Maximum Capacity
  11137.8,                  !- Heater Maximum Capacity
  0,                        !- Heater Minimum Capacity
  0,                        !- Heater Ignition Minimum
  ,                         !- Heater Ignition Delay {s
  naturalgas,               !- Heater Fuel Type
  0.8,                      !- Heater Thermal Efficienc
  ,                         !- Part Load Factor Curve N
  ,                         !- Off Cycle Parasitic Fuel Con
  ,                         !- Off Cycle Parasitic Fuel Typ
  ,                         !- Off Cycle Parasitic Heat Fra
  ,                         !- On Cycle Parasitic Fuel Cons
  ,                         !- On Cycle Parasitic Fuel Type
  ,                         !- On Cycle Parasitic Heat Frac
  Zone,                     !- Ambient Temperature Indicato
  ,                         !- Ambient Temperature Schedule
  living_unit1,             !- Ambient Temperature Zone Nam
  ,                         !- Ambient Temperature Outd
  1.3306616,                !- Off Cycle Loss Coefficie
  1,                        !- Off Cycle Loss Fraction
  1.3306616,                !- On Cycle Loss Coefficien
  1,                        !- On Cycle Loss Fraction t
  0,                        !- Peak Use Flow Rate {m3/s
  ,                         !- Use Flow Rate Fraction S
  ,                         !- Cold Water Supply Temperatur
  Water Heater use inlet node_unit1,  !- Use Side Inlet No
  Water Heater use outlet node_unit1,  !- Use Side Outlet
  1,                        !- Use Side Effectiveness
  ,                         !- Source Side Inlet Node Name
  ,                         !- Source Side Outlet Node Name
  1,                        !- Source Side Effectiveness
  autosize,                 !- Use Side Design Flow Rate {m
  0.000009,                 !- Use Side Design Flow Rate {m
  0,                        !- Source Side Design Flow Rate
  1.5;                      !- Indirect Water Heating Recov
```

15, for baseline window run, this field keeps autosize, for other runs, this field replaces with 11137.8

16, for baseline window run, this field keeps autosize, for other runs, this field replaces with 0.000009

```
PlantLoop,
  DHW Loop_unit1,              !- Name
  Water,                       !- Fluid Type
  ,                            !- User Defined Fluid Type
  DHW Loop Operation_unit1,!- Plant Equipment Operati
  DHW Supply Outlet Node_unit1,  !- Loop Temperature
  100,                         !- Maximum Loop Temperatur
  0,                           !- Minimum Loop Temperatur
  autosize,                    !- Maximum Loop Flow Rate
  0.000009,                    !- Maximum Loop Flow Rate
  0,                           !- Minimum Loop Flow Rate {m3/s}
  autocalculate,               !- Plant Loop Volume {m3}
  0.006851,                    !- Plant Loop Volume {m3}
  Mains Inlet Node_unit1,      !- Plant Side Inlet Node Name
  DHW Supply Outlet Node_unit1,  !- Plant Side Outlet
  DHW Supply Branches_unit1,   !- Plant Side Branch Li
  DHW Supply Connectors_unit1,   !- Plant Side Connect
  DHW Demand Inlet Node_unit1,   !- Demand Side Inlet
  Mains Makeup Node_unit1,     !- Demand Side Outlet Node
  DHW Demand Branches_unit1,   !- Demand Side Branch L
  DHW Demand Connectors_unit1,   !- Demand Side Connect
  Optimal;                     !- Load Distribution Scheme
```

17, for baseline window run, this field keeps autosize, for other runs, this field replaces with 0.000009

18, for baseline window run, this field keeps autocalculate, for other runs, this field replaces with 0.006851

Appendix D: Cooling and Heating Season Definition

Table D1. Cooling and Heating Season Definition for Heating and Cooling EP

Minneapolis			Houston		
	Start	End		Start	End
Winter	November 1	January 31	Winter	December 1	February 28
Spring	February 1	April 30	Spring	March 1	May 31
Summer	May 1	July 31	Summer	June 1	August 31
Autumn	August 1	October 31	Autumn	September 1	November 30
Heating	September 15	March 16	Heating	October 16	April 14
Cooling	March 17	September 14	Cooling	April 15	October 15

Appendix E: ESCalc XML Schema

ESCalc XML schema describes interface between AERCalc and calculation module ESCalc.


```
<?xml version="1.0" encoding="UTF-8"?>
<!-- edited with XMLSpy v2016 rel. 2 sp1 (x64) (http://www.altova.com) by D. Charlie Curcija (Lawrence Berkeley National
Laboratory) -->
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" xmlns:vc="http://www.w3.org/2007/XMLSchema-versioning"
elementFormDefault="qualified" attributeFormDefault="unqualified" version="1.1" vc:minVersion="1.1">
  <xs:element name="ESCalc">
    <xs:complexType>
      <xs:sequence>
        <xs:element name="Input" minOccurs="0">
          <xs:annotation>
            <xs:documentation>ESCalc Inputs</xs:documentation>
          </xs:annotation>
          <xs:complexType>
            <xs:sequence>
              <xs:element name="Selection" maxOccurs="3">
                <xs:annotation>
                  <xs:documentation>Selection of calculation type. EA: Adiabatic Windows Run; EB: Baseline WIndows Runb;
ES: Window Attachment Run</xs:documentation>
                </xs:annotation>
                <xs:simpleType>
                  <xs:restriction base="xs:string">
                    <xs:minLength value="2"/>
                    <xs:maxLength value="2"/>
                  </xs:restriction>
                </xs:simpleType>
              </xs:element>
              <xs:element name="Climate">
                <xs:annotation>
                  <xs:documentation>Selection of climate. Cooling: Houston climate data and assumptions; Heating:
Minneapolis climate data and assumptions</xs:documentation>
                </xs:annotation>
                <xs:simpleType>
                  <xs:restriction base="xs:string">
                    <xs:minLength value="7"/>
                    <xs:maxLength value="7"/>
                  </xs:restriction>
                </xs:simpleType>
              </xs:element>
              <xs:element name="AttachmentType" minOccurs="0">
                <xs:annotation>
                  <xs:documentation>Selection of Attachment type. RollerShades; CellularShades; SolarScreens;
AppliedFilms;  VenetianBlinds; VerticalBlinds; WindowPanels; and PleatedShades</xs:documentation>
                </xs:annotation>
                <xs:simpleType>
                  <xs:restriction base="xs:string">
                    <xs:minLength value="12"/>
                    <xs:maxLength value="14"/>
                  </xs:restriction>
                </xs:simpleType>
              </xs:element>
              <xs:element name="NoCSVFiles" type="xs:integer">
                <xs:annotation>
                  <xs:documentation>Number of supplied CSV IDF files. 1 file for EA, EB, or ES for fixed attachments; 2 files
for 1D shades; and 7 files for 2D shades</xs:documentation>
                </xs:annotation>
              </xs:element>
              <xs:element name="CSVFile" maxOccurs="7">
                <xs:complexType>
                  <xs:sequence>
                    <xs:element name="CSVFileName" type="xs:string">
                      <xs:annotation>
                        <xs:documentation>Arbitrary CSV File name for each E+ run</xs:documentation>
                      </xs:annotation>
```

```
                    </xs:element>
                    <xs:element name="DeploymentState" minOccurs="0">
                      <xs:annotation>
                        <xs:documentation>Deployment State: Open (only for 1-D and 2-D shades), Half (only for 1-D and
2-D shades), or Full (for all shades)</xs:documentation>
                      </xs:annotation>
                      <xs:simpleType>
                        <xs:restriction base="xs:string">
                          <xs:minLength value="4"/>
                          <xs:maxLength value="4"/>
                        </xs:restriction>
                      </xs:simpleType>
                    </xs:element>
                    <xs:element name="SlatAngle" type="xs:integer" minOccurs="0">
                      <xs:annotation>
                        <xs:documentation>Slat Angle for Louvered Blinds: 0, -45, 45, 90</xs:documentation>
                      </xs:annotation>
                    </xs:element>
                  </xs:sequence>
                </xs:complexType>
              </xs:element>
            </xs:sequence>
          </xs:complexType>
        </xs:element>
        <xs:element name="Output" minOccurs="0">
          <xs:annotation>
            <xs:documentation>ESCalc Outputs</xs:documentation>
          </xs:annotation>
          <xs:complexType>
            <xs:sequence>
              <xs:element name="E_HVAC" type="xs:float"/>
              <xs:element name="EP" type="xs:float" minOccurs="0"/>
            </xs:sequence>
          </xs:complexType>
        </xs:element>
      </xs:sequence>
    </xs:complexType>
  </xs:element>
</xs:schema>
```


The following Figure shows schematic presentation of the Schema.

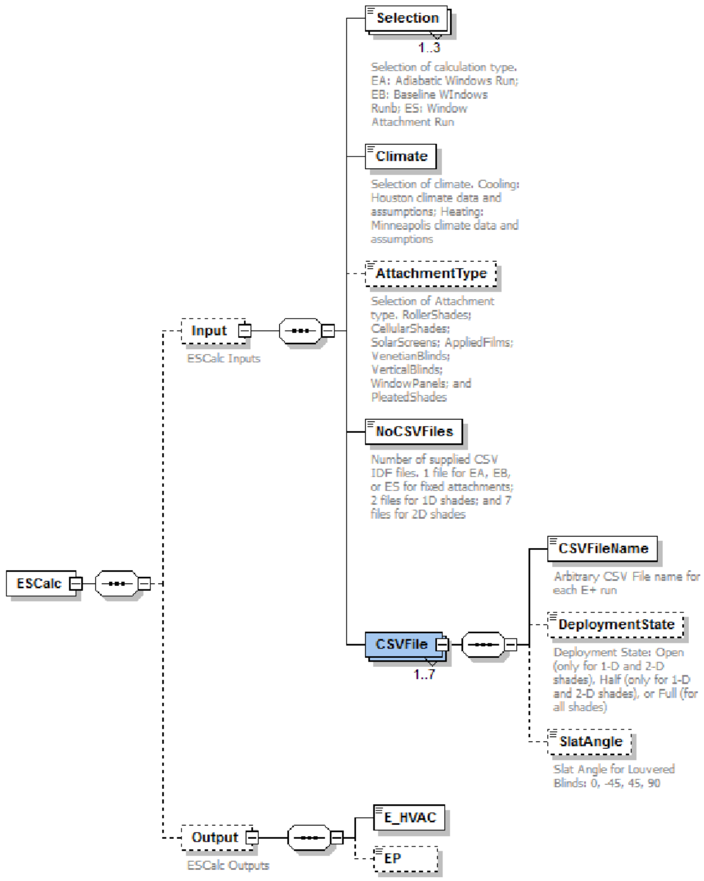


Figure E1. Schematic Presentation of the ESCalc Schema

Examples of the schema for fixed window attachment and venetian blinds products are shown next, respectively:

<u>Example of a fixed window attachment XML file:</u>

```
<?xml version="1.0" encoding="UTF-8"?>
<!-- edited with XMLSpy v2016 rel. 2 sp1 (x64) (http://www.altova.com) by D. Charlie Curcija (Lawrence Berkeley National
Laboratory) -->
<!-- Based on XML schema ESCalc.xsd.-->
<ESCalc xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:noNamespaceSchemaLocation="ESCalc_v3.xsd">
  <Input>
    <Selection>ES</Selection>
    <Climate>Houston</Climate>
    <AttachmentType>SolarScreens</AttachmentType>
    <NoCSVFiles>1</NoCSVFiles>
    <CSVFile>
      <CSVFileName>Test-File-Name-1_SS</CSVFileName>
    </CSVFile>
  </Input>
  <Output>
    <E_HVAC>115.92</E_HVAC>
    <EP>53.2</EP>
  </Output>
```

</ESCalc>

Example of venetian blind window attachment XML file:


```
<?xml version="1.0" encoding="UTF-8"?>
<!-- edited with XMLSpy v2016 rel. 2 sp1 (x64) (http://www.altova.com) by D. Charlie Curcija (Lawrence Berkeley National
Laboratory) -->
<!-- Based on XML schema ESCalc.xsd.-->
<ESCalc xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:noNamespaceSchemaLocation="ESCalc_v3.xsd">
  <Input>
    <Selection>ES</Selection>
    <City>Minneapolis</City>
    <AttachmentType>VenetianBlinds</AttachmentType>
    <NoCSVFiles>7</NoCSVFiles>
    <CSVFile>
      <CSVFileName>Test-File-Name-2_VB_Open_0</CSVFileName>
      <DeploymentState>Full</DeploymentState>
      <SlatAngle>0</SlatAngle>
    </CSVFile>
    <CSVFile>
      <CSVFileName>Test-File-Name-2_VB_Full_-45</CSVFileName>
      <DeploymentState>Full</DeploymentState>
      <SlatAngle>-45</SlatAngle>
    </CSVFile>
    <CSVFile>
      <CSVFileName>Test-File-Name-2_VB_Full_45</CSVFileName>
      <DeploymentState>Full</DeploymentState>
      <SlatAngle>45</SlatAngle>

    </CSVFile>
    <CSVFile>
      <CSVFileName>Test-File-Name-2_VB_Full_90</CSVFileName>
      <DeploymentState>Full</DeploymentState>
      <SlatAngle>90</SlatAngle>
    </CSVFile>
    <CSVFile>
      <CSVFileName>Test-File-Name-2_VB_Half_-45</CSVFileName>
      <DeploymentState>Half</DeploymentState>
      <SlatAngle>-45</SlatAngle>
    </CSVFile>
    <CSVFile>
      <CSVFileName>Test-File-Name-2_VB_Half_45</CSVFileName>
      <DeploymentState>Half</DeploymentState>
      <SlatAngle>45</SlatAngle>
    </CSVFile>
    <CSVFile>
      <CSVFileName>Test-File-Name-2_VB_Half_90</CSVFileName>
      <DeploymentState>Half</DeploymentState>
      <SlatAngle>90</SlatAngle>
    </CSVFile>
  </Input>
  <Output>
    <E_HVAC>127.32</E_HVAC>
    <EP>34.6</EP>
  </Output>
</ESCalc>
```

Appendix F: EnergyPlus Window configuration file for baseline window B

```
!- Window_configuration_baseline.inc
!- There are 4 seperated windows on each floor each orientation

 FenestrationSurface:Detailed,
  Window_ldf1_1_Bot.unit1, !- Name
  Window,                  !- Surface Type
  AERC_Doubleclear_Baseline,       !- Construction Name
  Wall_ldf1_1.unit1,       !- Building Surface Name
  ,                        !- Outside Boundary Condition Object
  ,                        !- View Factor to Ground
  ,                        !- Shading Control Name
  AERC_Wood_Frame,         !- Frame and Divider Name
  1,                       !- Multiplier
  4,                       !- Number of Vertices
  2.500000000000,0.000000000000,0.600000000000,  !- X,Y,Z ==> Vertex 1 {m}
  3.823210000000,0.000000000000,0.600000000000,  !- X,Y,Z ==> Vertex 2 {m}
  3.823210000000,0.000000000000,1.273210000000,  !- X,Y,Z ==> Vertex 3 {m}
  2.500000000000,0.000000000000,1.273210000000;  !- X,Y,Z ==> Vertex 4 {m}

 FenestrationSurface:Detailed,
  Window_ldf1_1_Top.unit1, !- Name
  Window,                  !- Surface Type
  AERC_Doubleclear_Baseline,       !- Construction Name
  Wall_ldf1_1.unit1,       !- Building Surface Name
  ,                        !- Outside Boundary Condition Object
  ,                        !- View Factor to Ground
  ,                        !- Shading Control Name
  AERC_Wood_Frame,         !- Frame and Divider Name
  1,                       !- Multiplier
  4,                       !- Number of Vertices
  2.500000000000,0.000000000000,1.350000000000,  !- X,Y,Z ==> Vertex 1 {m}
  3.823210000000,0.000000000000,1.350000000000,  !- X,Y,Z ==> Vertex 2 {m}
  3.823210000000,0.000000000000,2.023210000000,  !- X,Y,Z ==> Vertex 3 {m}
  2.500000000000,0.000000000000,2.023210000000;  !- X,Y,Z ==> Vertex 4 {m}

 FenestrationSurface:Detailed,
  Window_ldf1_2_Bot.unit1, !- Name
  Window,                  !- Surface Type
  AERC_Doubleclear_Baseline,       !- Construction Name
  Wall_ldf1_1.unit1,       !- Building Surface Name
  ,                        !- Outside Boundary Condition Object
  ,                        !- View Factor to Ground
  ,                        !- Shading Control Name
  AERC_Wood_Frame,         !- Frame and Divider Name
  1,                       !- Multiplier
  4,                       !- Number of Vertices
  6.600000000000,0.000000000000,0.600000000000,  !- X,Y,Z ==> Vertex 1 {m}
  7.923210000000,0.000000000000,0.600000000000,  !- X,Y,Z ==> Vertex 2 {m}
  7.923210000000,0.000000000000,1.273210000000,  !- X,Y,Z ==> Vertex 3 {m}
  6.600000000000,0.000000000000,1.273210000000;  !- X,Y,Z ==> Vertex 4 {m}

 FenestrationSurface:Detailed,
  Window_ldf1_2_Top.unit1, !- Name
  Window,                  !- Surface Type
  AERC_Doubleclear_Baseline,       !- Construction Name
  Wall_ldf1_1.unit1,       !- Building Surface Name
  ,                        !- Outside Boundary Condition Object
  ,                        !- View Factor to Ground
  ,                        !- Shading Control Name
  AERC_Wood_Frame,         !- Frame and Divider Name
  1,                       !- Multiplier
  4,                       !- Number of Vertices
```

```
    6.600000000000,0.000000000000,1.350000000000,  !- X,Y,Z ==> Vertex 1 {m}
    7.923210000000,0.000000000000,1.350000000000,  !- X,Y,Z ==> Vertex 2 {m}
    7.923210000000,0.000000000000,2.023210000000,  !- X,Y,Z ==> Vertex 3 {m}
    6.600000000000,0.000000000000,2.023210000000;  !- X,Y,Z ==> Vertex 4 {m}

  FenestrationSurface:Detailed,
    Window_ldb1_1_Bot.unit1, !- Name
    Window,                  !- Surface Type
    AERC_Doubleclear_Baseline,       !- Construction Name
    Wall_ldb1_1.unit1,       !- Building Surface Name
    ,                        !- Outside Boundary Condition Object
    ,                        !- View Factor to Ground
    ,                        !- Shading Control Name
    AERC_Wood_Frame,         !- Frame and Divider Name
    1,                       !- Multiplier
    4,                       !- Number of Vertices
    8.000000000000,10.558580000000,0.600000000000,  !- X,Y,Z ==> Vertex 1 {m}
    6.676790000000,10.558580000000,0.600000000000,  !- X,Y,Z ==> Vertex 2 {m}
    6.676790000000,10.558580000000,1.273210000000,  !- X,Y,Z ==> Vertex 3 {m}
    8.000000000000,10.558580000000,1.273210000000;  !- X,Y,Z ==> Vertex 4 {m}

  FenestrationSurface:Detailed,
    Window_ldb1_1_Top.unit1, !- Name
    Window,                  !- Surface Type
    AERC_Doubleclear_Baseline,       !- Construction Name
    Wall_ldb1_1.unit1,       !- Building Surface Name
    ,                        !- Outside Boundary Condition Object
    ,                        !- View Factor to Ground
    ,                        !- Shading Control Name
    AERC_Wood_Frame,         !- Frame and Divider Name
    1,                       !- Multiplier
    4,                       !- Number of Vertices
    8.000000000000,10.558580000000,1.350000000000,  !- X,Y,Z ==> Vertex 1 {m}
    6.676790000000,10.558580000000,1.350000000000,  !- X,Y,Z ==> Vertex 2 {m}
    6.676790000000,10.558580000000,2.023210000000,  !- X,Y,Z ==> Vertex 3 {m}
    8.000000000000,10.558580000000,2.023210000000;  !- X,Y,Z ==> Vertex 4 {m}

  FenestrationSurface:Detailed,
    Window_ldb1_2_Bot.unit1, !- Name
    Window,                  !- Surface Type
    AERC_Doubleclear_Baseline,       !- Construction Name
    Wall_ldb1_1.unit1,       !- Building Surface Name
    ,                        !- Outside Boundary Condition Object
    ,                        !- View Factor to Ground
    ,                        !- Shading Control Name
    AERC_Wood_Frame,         !- Frame and Divider Name
    1,                       !- Multiplier
    4,                       !- Number of Vertices
    3.900000000000,10.558580000000,0.600000000000,  !- X,Y,Z ==> Vertex 1 {m}
    2.576790000000,10.558580000000,0.600000000000,  !- X,Y,Z ==> Vertex 2 {m}
    2.576790000000,10.558580000000,1.273210000000,  !- X,Y,Z ==> Vertex 3 {m}
    3.900000000000,10.558580000000,1.273210000000;  !- X,Y,Z ==> Vertex 4 {m}

  FenestrationSurface:Detailed,
    Window_ldb1_2_Top.unit1, !- Name
    Window,                  !- Surface Type
    AERC_Doubleclear_Baseline,       !- Construction Name
    Wall_ldb1_1.unit1,       !- Building Surface Name
    ,                        !- Outside Boundary Condition Object
    ,                        !- View Factor to Ground
    ,                        !- Shading Control Name
    AERC_Wood_Frame,         !- Frame and Divider Name
    1,                       !- Multiplier
    4,                       !- Number of Vertices
    3.900000000000,10.558580000000,1.350000000000,  !- X,Y,Z ==> Vertex 1 {m}
    2.576790000000,10.558580000000,1.350000000000,  !- X,Y,Z ==> Vertex 2 {m}
    2.576790000000,10.558580000000,2.023210000000,  !- X,Y,Z ==> Vertex 3 {m}
```

```
  3.900000000000,10.558580000000,2.023210000000;  !- X,Y,Z ==> Vertex 4 {m}

 FenestrationSurface:Detailed,
  Window_sdr1_1_Bot.unit1, !- Name
  Window,                  !- Surface Type
  AERC_Doubleclear_Baseline,       !- Construction Name
  Wall_sdr1_1.unit1,       !- Building Surface Name
  ,                        !- Outside Boundary Condition Object
  ,                        !- View Factor to Ground
  ,                        !- Shading Control Name
  AERC_Wood_Frame,         !- Frame and Divider Name
  1,                       !- Multiplier
  4,                       !- Number of Vertices
  10.558580000000,2.500000000000,0.600000000000,  !- X,Y,Z ==> Vertex 1 {m}
  10.558580000000,3.823210000000,0.600000000000,  !- X,Y,Z ==> Vertex 2 {m}
  10.558580000000,3.823210000000,1.273210000000,  !- X,Y,Z ==> Vertex 3 {m}
  10.558580000000,2.500000000000,1.273210000000;  !- X,Y,Z ==> Vertex 4 {m}

 FenestrationSurface:Detailed,
  Window_sdr1_1_Top.unit1, !- Name
  Window,                  !- Surface Type
  AERC_Doubleclear_Baseline,       !- Construction Name
  Wall_sdr1_1.unit1,       !- Building Surface Name
  ,                        !- Outside Boundary Condition Object
  ,                        !- View Factor to Ground
  ,                        !- Shading Control Name
  AERC_Wood_Frame,         !- Frame and Divider Name
  1,                       !- Multiplier
  4,                       !- Number of Vertices
  10.558580000000,2.500000000000,1.350000000000,  !- X,Y,Z ==> Vertex 1 {m}
  10.558580000000,3.823210000000,1.350000000000,  !- X,Y,Z ==> Vertex 2 {m}
  10.558580000000,3.823210000000,2.023210000000,  !- X,Y,Z ==> Vertex 3 {m}
  10.558580000000,2.500000000000,2.023210000000;  !- X,Y,Z ==> Vertex 4 {m}

 FenestrationSurface:Detailed,
  Window_sdr1_2_Bot.unit1, !- Name
  Window,                  !- Surface Type
  AERC_Doubleclear_Baseline,       !- Construction Name
  Wall_sdr1_1.unit1,       !- Building Surface Name
  ,                        !- Outside Boundary Condition Object
  ,                        !- View Factor to Ground
  ,                        !- Shading Control Name
  AERC_Wood_Frame,         !- Frame and Divider Name
  1,                       !- Multiplier
  4,                       !- Number of Vertices
  10.558580000000,6.600000000000,0.600000000000,  !- X,Y,Z ==> Vertex 1 {m}
  10.558580000000,7.923210000000,0.600000000000,  !- X,Y,Z ==> Vertex 2 {m}
  10.558580000000,7.923210000000,1.273210000000,  !- X,Y,Z ==> Vertex 3 {m}
  10.558580000000,6.600000000000,1.273210000000;  !- X,Y,Z ==> Vertex 4 {m}

 FenestrationSurface:Detailed,
  Window_sdr1_2_Top.unit1, !- Name
  Window,                  !- Surface Type
  AERC_Doubleclear_Baseline,       !- Construction Name
  Wall_sdr1_1.unit1,       !- Building Surface Name
  ,                        !- Outside Boundary Condition Object
  ,                        !- View Factor to Ground
  ,                        !- Shading Control Name
  AERC_Wood_Frame,         !- Frame and Divider Name
  1,                       !- Multiplier
  4,                       !- Number of Vertices
  10.558580000000,6.600000000000,1.350000000000,  !- X,Y,Z ==> Vertex 1 {m}
  10.558580000000,7.923210000000,1.350000000000,  !- X,Y,Z ==> Vertex 2 {m}
  10.558580000000,7.923210000000,2.023210000000,  !- X,Y,Z ==> Vertex 3 {m}
  10.558580000000,6.600000000000,2.023210000000;  !- X,Y,Z ==> Vertex 4 {m}

 FenestrationSurface:Detailed,
```

```
  Window_sdl1_1_Bot.unit1, !- Name
  Window,                  !- Surface Type
  AERC_Doubleclear_Baseline,       !- Construction Name
  Wall_sdl1_1.unit1,       !- Building Surface Name
  ,                        !- Outside Boundary Condition Object
  ,                        !- View Factor to Ground
  ,                        !- Shading Control Name
  AERC_Wood_Frame,         !- Frame and Divider Name
  1,                       !- Multiplier
  4,                       !- Number of Vertices
  0.000000000000,8.000000000000,0.600000000000,  !- X,Y,Z ==> Vertex 1 {m}
  0.000000000000,6.676790000000,0.600000000000,  !- X,Y,Z ==> Vertex 2 {m}
  0.000000000000,6.676790000000,1.273210000000,  !- X,Y,Z ==> Vertex 3 {m}
  0.000000000000,8.000000000000,1.273210000000;  !- X,Y,Z ==> Vertex 4 {m}

 FenestrationSurface:Detailed,
  Window_sdl1_1_Top.unit1, !- Name
  Window,                  !- Surface Type
  AERC_Doubleclear_Baseline,       !- Construction Name
  Wall_sdl1_1.unit1,       !- Building Surface Name
  ,                        !- Outside Boundary Condition Object
  ,                        !- View Factor to Ground
  ,                        !- Shading Control Name
  AERC_Wood_Frame,         !- Frame and Divider Name
  1,                       !- Multiplier
  4,                       !- Number of Vertices
  0.000000000000,8.000000000000,1.350000000000,  !- X,Y,Z ==> Vertex 1 {m}
  0.000000000000,6.676790000000,1.350000000000,  !- X,Y,Z ==> Vertex 2 {m}
  0.000000000000,6.676790000000,2.023210000000,  !- X,Y,Z ==> Vertex 3 {m}
  0.000000000000,8.000000000000,2.023210000000;  !- X,Y,Z ==> Vertex 4 {m}

 FenestrationSurface:Detailed,
  Window_sdl1_2_Bot.unit1, !- Name
  Window,                  !- Surface Type
  AERC_Doubleclear_Baseline,       !- Construction Name
  Wall_sdl1_1.unit1,       !- Building Surface Name
  ,                        !- Outside Boundary Condition Object
  ,                        !- View Factor to Ground
  ,                        !- Shading Control Name
  AERC_Wood_Frame,         !- Frame and Divider Name
  1,                       !- Multiplier
  4,                       !- Number of Vertices
  0.000000000000,3.900000000000,0.600000000000,  !- X,Y,Z ==> Vertex 1 {m}
  0.000000000000,2.576790000000,0.600000000000,  !- X,Y,Z ==> Vertex 2 {m}
  0.000000000000,2.576790000000,1.273210000000,  !- X,Y,Z ==> Vertex 3 {m}
  0.000000000000,3.900000000000,1.273210000000;  !- X,Y,Z ==> Vertex 4 {m}

 FenestrationSurface:Detailed,
  Window_sdl1_2_Top.unit1, !- Name
  Window,                  !- Surface Type
  AERC_Doubleclear_Baseline,       !- Construction Name
  Wall_sdl1_1.unit1,       !- Building Surface Name
  ,                        !- Outside Boundary Condition Object
  ,                        !- View Factor to Ground
  ,                        !- Shading Control Name
  AERC_Wood_Frame,         !- Frame and Divider Name
  1,                       !- Multiplier
  4,                       !- Number of Vertices
  0.000000000000,3.900000000000,1.350000000000,  !- X,Y,Z ==> Vertex 1 {m}
  0.000000000000,2.576790000000,1.350000000000,  !- X,Y,Z ==> Vertex 2 {m}
  0.000000000000,2.576790000000,2.023210000000,  !- X,Y,Z ==> Vertex 3 {m}
  0.000000000000,3.900000000000,2.023210000000;  !- X,Y,Z ==> Vertex 4 {m}

 FenestrationSurface:Detailed,
  Window_ldf2_1_Bot.unit1, !- Name
  Window,                  !- Surface Type
  AERC_Doubleclear_Baseline,       !- Construction Name
```

```
  Wall_Idf1_2.unit1,       !- Building Surface Name
  ,                      !- Outside Boundary Condition Object
  ,                      !- View Factor to Ground
  ,                      !- Shading Control Name
  AERC_Wood_Frame,         !- Frame and Divider Name
  1,                      !- Multiplier
  4,                      !- Number of Vertices
  2.500000000000,0.000000000000,3.200000000000,  !- X,Y,Z ==> Vertex 1 {m}
  3.823210000000,0.000000000000,3.200000000000,  !- X,Y,Z ==> Vertex 2 {m}
  3.823210000000,0.000000000000,3.873210000000,  !- X,Y,Z ==> Vertex 3 {m}
  2.500000000000,0.000000000000,3.873210000000;  !- X,Y,Z ==> Vertex 4 {m}

 FenestrationSurface:Detailed,
  Window_Idf2_1_Top.unit1, !- Name
  Window,                  !- Surface Type
  AERC_Doubleclear_Baseline,       !- Construction Name
  Wall_Idf1_2.unit1,       !- Building Surface Name
  ,                      !- Outside Boundary Condition Object
  ,                      !- View Factor to Ground
  ,                      !- Shading Control Name
  AERC_Wood_Frame,         !- Frame and Divider Name
  1,                      !- Multiplier
  4,                      !- Number of Vertices
  2.500000000000,0.000000000000,3.950000000000,  !- X,Y,Z ==> Vertex 1 {m}
  3.823210000000,0.000000000000,3.950000000000,  !- X,Y,Z ==> Vertex 2 {m}
  3.823210000000,0.000000000000,4.623210000000,  !- X,Y,Z ==> Vertex 3 {m}
  2.500000000000,0.000000000000,4.623210000000;  !- X,Y,Z ==> Vertex 4 {m}

 FenestrationSurface:Detailed,
  Window_Idf2_2_Bot.unit1, !- Name
  Window,                  !- Surface Type
  AERC_Doubleclear_Baseline,       !- Construction Name
  Wall_Idf1_2.unit1,       !- Building Surface Name
  ,                      !- Outside Boundary Condition Object
  ,                      !- View Factor to Ground
  ,                      !- Shading Control Name
  AERC_Wood_Frame,         !- Frame and Divider Name
  1,                      !- Multiplier
  4,                      !- Number of Vertices
  6.600000000000,0.000000000000,3.200000000000,  !- X,Y,Z ==> Vertex 1 {m}
  7.923210000000,0.000000000000,3.200000000000,  !- X,Y,Z ==> Vertex 2 {m}
  7.923210000000,0.000000000000,3.873210000000,  !- X,Y,Z ==> Vertex 3 {m}
  6.600000000000,0.000000000000,3.873210000000;  !- X,Y,Z ==> Vertex 4 {m}

 FenestrationSurface:Detailed,
  Window_Idf2_2_Top.unit1, !- Name
  Window,                  !- Surface Type
  AERC_Doubleclear_Baseline,       !- Construction Name
  Wall_Idf1_2.unit1,       !- Building Surface Name
  ,                      !- Outside Boundary Condition Object
  ,                      !- View Factor to Ground
  ,                      !- Shading Control Name
  AERC_Wood_Frame,         !- Frame and Divider Name
  1,                      !- Multiplier
  4,                      !- Number of Vertices
  6.600000000000,0.000000000000,3.950000000000,  !- X,Y,Z ==> Vertex 1 {m}
  7.923210000000,0.000000000000,3.950000000000,  !- X,Y,Z ==> Vertex 2 {m}
  7.923210000000,0.000000000000,4.623210000000,  !- X,Y,Z ==> Vertex 3 {m}
  6.600000000000,0.000000000000,4.623210000000;  !- X,Y,Z ==> Vertex 4 {m}

 FenestrationSurface:Detailed,
  Window_Idb2_1_Bot.unit1, !- Name
  Window,                  !- Surface Type
  AERC_Doubleclear_Baseline,       !- Construction Name
  Wall_Idb1_2.unit1,       !- Building Surface Name
  ,                      !- Outside Boundary Condition Object
  ,                      !- View Factor to Ground
```

```
  ,                  !- Shading Control Name
  AERC_Wood_Frame,        !- Frame and Divider Name
  1,                   !- Multiplier
  4,                   !- Number of Vertices
  8.000000000000,10.558580000000,3.200000000000,  !- X,Y,Z ==> Vertex 1 {m}
  6.676790000000,10.558580000000,3.200000000000,  !- X,Y,Z ==> Vertex 2 {m}
  6.676790000000,10.558580000000,3.873210000000,  !- X,Y,Z ==> Vertex 3 {m}
  8.000000000000,10.558580000000,3.873210000000;  !- X,Y,Z ==> Vertex 4 {m}

 FenestrationSurface:Detailed,
  Window_ldb2_1_Top.unit1, !- Name
  Window,                 !- Surface Type
  AERC_Doubleclear_Baseline,      !- Construction Name
  Wall_ldb1_2.unit1,      !- Building Surface Name
  ,                  !- Outside Boundary Condition Object
  ,                  !- View Factor to Ground
  ,                  !- Shading Control Name
  AERC_Wood_Frame,        !- Frame and Divider Name
  1,                   !- Multiplier
  4,                   !- Number of Vertices
  8.000000000000,10.558580000000,3.950000000000,  !- X,Y,Z ==> Vertex 1 {m}
  6.676790000000,10.558580000000,3.950000000000,  !- X,Y,Z ==> Vertex 2 {m}
  6.676790000000,10.558580000000,4.623210000000,  !- X,Y,Z ==> Vertex 3 {m}
  8.000000000000,10.558580000000,4.623210000000;  !- X,Y,Z ==> Vertex 4 {m}

 FenestrationSurface:Detailed,
  Window_ldb2_2_Bot.unit1, !- Name
  Window,                 !- Surface Type
  AERC_Doubleclear_Baseline,      !- Construction Name
  Wall_ldb1_2.unit1,      !- Building Surface Name
  ,                  !- Outside Boundary Condition Object
  ,                  !- View Factor to Ground
  ,                  !- Shading Control Name
  AERC_Wood_Frame,        !- Frame and Divider Name
  1,                   !- Multiplier
  4,                   !- Number of Vertices
  3.900000000000,10.558580000000,3.200000000000,  !- X,Y,Z ==> Vertex 1 {m}
  2.576790000000,10.558580000000,3.200000000000,  !- X,Y,Z ==> Vertex 2 {m}
  2.576790000000,10.558580000000,3.873210000000,  !- X,Y,Z ==> Vertex 3 {m}
  3.900000000000,10.558580000000,3.873210000000;  !- X,Y,Z ==> Vertex 4 {m}

 FenestrationSurface:Detailed,
  Window_ldb2_2_Top.unit1, !- Name
  Window,                 !- Surface Type
  AERC_Doubleclear_Baseline,      !- Construction Name
  Wall_ldb1_2.unit1,      !- Building Surface Name
  ,                  !- Outside Boundary Condition Object
  ,                  !- View Factor to Ground
  ,                  !- Shading Control Name
  AERC_Wood_Frame,        !- Frame and Divider Name
  1,                   !- Multiplier
  4,                   !- Number of Vertices
  3.900000000000,10.558580000000,3.950000000000,  !- X,Y,Z ==> Vertex 1 {m}
  2.576790000000,10.558580000000,3.950000000000,  !- X,Y,Z ==> Vertex 2 {m}
  2.576790000000,10.558580000000,4.623210000000,  !- X,Y,Z ==> Vertex 3 {m}
  3.900000000000,10.558580000000,4.623210000000;  !- X,Y,Z ==> Vertex 4 {m}

 FenestrationSurface:Detailed,
  Window_sdr2_1_Bot.unit1, !- Name
  Window,                 !- Surface Type
  AERC_Doubleclear_Baseline,      !- Construction Name
  Wall_sdr1_2.unit1,      !- Building Surface Name
  ,                  !- Outside Boundary Condition Object
  ,                  !- View Factor to Ground
  ,                  !- Shading Control Name
  AERC_Wood_Frame,        !- Frame and Divider Name
  1,                   !- Multiplier
```

```
  4,                     !- Number of Vertices
  10.558580000000,2.500000000000,3.200000000000,  !- X,Y,Z ==> Vertex 1 {m}
  10.558580000000,3.823210000000,3.200000000000,  !- X,Y,Z ==> Vertex 2 {m}
  10.558580000000,3.823210000000,3.873210000000,  !- X,Y,Z ==> Vertex 3 {m}
  10.558580000000,2.500000000000,3.873210000000;  !- X,Y,Z ==> Vertex 4 {m}

 FenestrationSurface:Detailed,
  Window_sdr2_1_Top.unit1, !- Name
  Window,                !- Surface Type
  AERC_Doubleclear_Baseline,       !- Construction Name
  Wall_sdr1_2.unit1,       !- Building Surface Name
  ,                      !- Outside Boundary Condition Object
  ,                      !- View Factor to Ground
  ,                      !- Shading Control Name
  AERC_Wood_Frame,         !- Frame and Divider Name
  1,                     !- Multiplier
  4,                     !- Number of Vertices
  10.558580000000,2.500000000000,3.950000000000,  !- X,Y,Z ==> Vertex 1 {m}
  10.558580000000,3.823210000000,3.950000000000,  !- X,Y,Z ==> Vertex 2 {m}
  10.558580000000,3.823210000000,4.623210000000,  !- X,Y,Z ==> Vertex 3 {m}
  10.558580000000,2.500000000000,4.623210000000;  !- X,Y,Z ==> Vertex 4 {m}

 FenestrationSurface:Detailed,
  Window_sdr2_2_Bot.unit1, !- Name
  Window,                !- Surface Type
  AERC_Doubleclear_Baseline,       !- Construction Name
  Wall_sdr1_2.unit1,       !- Building Surface Name
  ,                      !- Outside Boundary Condition Object
  ,                      !- View Factor to Ground
  ,                      !- Shading Control Name
  AERC_Wood_Frame,         !- Frame and Divider Name
  1,                     !- Multiplier
  4,                     !- Number of Vertices
  10.558580000000,6.600000000000,3.200000000000,  !- X,Y,Z ==> Vertex 1 {m}
  10.558580000000,7.923210000000,3.200000000000,  !- X,Y,Z ==> Vertex 2 {m}
  10.558580000000,7.923210000000,3.873210000000,  !- X,Y,Z ==> Vertex 3 {m}
  10.558580000000,6.600000000000,3.873210000000;  !- X,Y,Z ==> Vertex 4 {m}

 FenestrationSurface:Detailed,
  Window_sdr2_2_Top.unit1, !- Name
  Window,                !- Surface Type
  AERC_Doubleclear_Baseline,       !- Construction Name
  Wall_sdr1_2.unit1,       !- Building Surface Name
  ,                      !- Outside Boundary Condition Object
  ,                      !- View Factor to Ground
  ,                      !- Shading Control Name
  AERC_Wood_Frame,         !- Frame and Divider Name
  1,                     !- Multiplier
  4,                     !- Number of Vertices
  10.558580000000,6.600000000000,3.950000000000,  !- X,Y,Z ==> Vertex 1 {m}
  10.558580000000,7.923210000000,3.950000000000,  !- X,Y,Z ==> Vertex 2 {m}
  10.558580000000,7.923210000000,4.623210000000,  !- X,Y,Z ==> Vertex 3 {m}
  10.558580000000,6.600000000000,4.623210000000;  !- X,Y,Z ==> Vertex 4 {m}

 FenestrationSurface:Detailed,
  Window_sdl2_1_Bot.unit1, !- Name
  Window,                !- Surface Type
  AERC_Doubleclear_Baseline,       !- Construction Name
  Wall_sdl1_2.unit1,       !- Building Surface Name
  ,                      !- Outside Boundary Condition Object
  ,                      !- View Factor to Ground
  ,                      !- Shading Control Name
  AERC_Wood_Frame,         !- Frame and Divider Name
  1,                     !- Multiplier
  4,                     !- Number of Vertices
  0.000000000000,8.000000000000,3.200000000000,  !- X,Y,Z ==> Vertex 1 {m}
  0.000000000000,6.676790000000,3.200000000000,  !- X,Y,Z ==> Vertex 2 {m}
```

```
  0.000000000000,6.676790000000,3.873210000000,  !- X,Y,Z ==> Vertex 3 {m}
  0.000000000000,8.000000000000,3.873210000000;  !- X,Y,Z ==> Vertex 4 {m}

 FenestrationSurface:Detailed,
  Window_sdl2_1_Top.unit1, !- Name
  Window,                  !- Surface Type
  AERC_Doubleclear_Baseline,       !- Construction Name
  Wall_sdl1_2.unit1,       !- Building Surface Name
  ,                        !- Outside Boundary Condition Object
  ,                        !- View Factor to Ground
  ,                        !- Shading Control Name
  AERC_Wood_Frame,         !- Frame and Divider Name
  1,                       !- Multiplier
  4,                       !- Number of Vertices
  0.000000000000,8.000000000000,3.950000000000,  !- X,Y,Z ==> Vertex 1 {m}
  0.000000000000,6.676790000000,3.950000000000,  !- X,Y,Z ==> Vertex 2 {m}
  0.000000000000,6.676790000000,4.623210000000,  !- X,Y,Z ==> Vertex 3 {m}
  0.000000000000,8.000000000000,4.623210000000;  !- X,Y,Z ==> Vertex 4 {m}

 FenestrationSurface:Detailed,
  Window_sdl2_2_Bot.unit1, !- Name
  Window,                  !- Surface Type
  AERC_Doubleclear_Baseline,       !- Construction Name
  Wall_sdl1_2.unit1,       !- Building Surface Name
  ,                        !- Outside Boundary Condition Object
  ,                        !- View Factor to Ground
  ,                        !- Shading Control Name
  AERC_Wood_Frame,         !- Frame and Divider Name
  1,                       !- Multiplier
  4,                       !- Number of Vertices
  0.000000000000,3.900000000000,3.200000000000,  !- X,Y,Z ==> Vertex 1 {m}
  0.000000000000,2.576790000000,3.200000000000,  !- X,Y,Z ==> Vertex 2 {m}
  0.000000000000,2.576790000000,3.873210000000,  !- X,Y,Z ==> Vertex 3 {m}
  0.000000000000,3.900000000000,3.873210000000;  !- X,Y,Z ==> Vertex 4 {m}

 FenestrationSurface:Detailed,
  Window_sdl2_2_Top.unit1, !- Name
  Window,                  !- Surface Type
  AERC_Doubleclear_Baseline,       !- Construction Name
  Wall_sdl1_2.unit1,       !- Building Surface Name
  ,                        !- Outside Boundary Condition Object
  ,                        !- View Factor to Ground
  ,                        !- Shading Control Name
  AERC_Wood_Frame,         !- Frame and Divider Name
  1,                       !- Multiplier
  4,                       !- Number of Vertices
  0.000000000000,3.900000000000,3.950000000000,  !- X,Y,Z ==> Vertex 1 {m}
  0.000000000000,2.576790000000,3.950000000000,  !- X,Y,Z ==> Vertex 2 {m}
  0.000000000000,2.576790000000,4.623210000000,  !- X,Y,Z ==> Vertex 3 {m}
  0.000000000000,3.900000000000,4.623210000000;  !- X,Y,Z ==> Vertex 4 {m}
```