### NEW Industrial Air Curtain

###### Description

This measure applies to buildings with exterior entryways that utilize overhead doors. All other air curtain applications, such as through sliding door entryways or conventional foot-traffic entryways, require custom analysis as air curtain designs must often accommodate other factors that may change their effectiveness.

The use of overhead doors within exterior entryways during the heating season leads to the exfiltration of warm air from the upper portion of the door opening and the infiltration of colder air from the lower portion of the door opening. This results in increase heating energy use to compensate for heat losses every time a door is opened. By reducing heat losses, air curtains can also enhance the physical comfort of employees or customers near the entryway as there will be reduced temperature fluctuations when the door is opened and closed. In addition, in some cases excess heating capacity may be installed in buildings to meet this larger heating load. The addition of air curtains to exterior entryways that currently utilize overhead doors will result in energy savings and enhanced personal comfort, and also possibly in reduced equipment sizing and corresponding costs.

The primary markets for this measure are commercial and industrial facilities with overhead doors in exterior entryways, including but not limited to the following building types: retail, manufacturing, and warehouse (non-refrigerated).

*Limitations*

* For use in conditioned spaces with an overhead door in an exterior entryway. This measure does include other door types such doorways to commercial spaces such as retail.
* This measure should only be applied to spaces in which the overhead door separates a conditioned space and an unconditioned space.
* Installation must follow manufacturer recommendations to attain proper air velocity, discharge angle down to the floor level, and unit position.
* Certain heating systems may not be a good fit for air curtains, such as locations with undersized heating capacity. In these cases, the installation of an air curtain may not effectively reduce heating system cycling given the inappropriately sized heating capacity.
* Buildings with slightly positive to slightly negative (~5 Pa to -10 Pa). For all other scenarios, custom analysis is recommended.
* Measure assumes that wind speeds at near ground level are less than or equal to 12 mph for 90% of the heating or cooling season. For areas with more extreme weather, custom analysis is necessary.
* Note: for cost effectiveness, it is recommended that minimum door open times should be approximately 15 hours per week.[[1]](#footnote-1)

This measure was developed to be applicable to the following program types: NC, RF. If applied to other program types, the measure savings should be verified.

The following methodology is highly complex and requires significant data collection. It is hoped that simplifying steps can be made in future iterations based on continued metering and evaluation of installations. Also the data collected through implementing the measure in the way currently drafted will aid in simplifying efforts at a future date.

###### Definition of Efficient Equipment

Overhead air curtains designed for commercial and industrial applications that have been tested and certified in accordance with ANSI/AMCA 220 and installed following manufacturer guidelines. Measure is for standard models without added heating.

###### Definition of Baseline Equipment

No air curtain or other currently installed means to effectively reduce heat loss and air mixing during door openings, such as a vestibule or strip curtain.

###### Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 15 years.[[2]](#footnote-2)

###### Deemed Measure Cost

The incremental capital cost for overhead air curtains for exterior entryways are as follows, with an added average installation cost approximately equal to the capital cost.[[3]](#footnote-3)

|  |  |
| --- | --- |
| **Door Size** | **Capital Cost** |
| 8’w x 8’h | $3,600 |
| 10’w x 10’h | $4,500 |
| 10’w x 12’h | $5,400 |
| 12’w x 14’h | $8,000 |
| 16’w x 16’h | $13,300 |

###### Loadshape

Heating Season: If electric heating, use Commercial Electric Heating Loadshape: C04. Otherwise, N/A

Cooling Season: Commercial Cooling Loadshape C03. Or, if applicable, use Commercial Electric Heating and Cooling Loadshape C05.

###### Coincidence Factor

CFSSP = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3%[[4]](#footnote-4)

CFPJM = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8%[[5]](#footnote-5)

Algorithm

###### Calculation of Energy Savings

The following formulas provide a methodology for estimating cooling load (kWh) and heating load (therm) savings associated with the installation of air curtains on exterior entryways such as a single door or loading bay. This algorithm is based on the assumption that therm savings are directly related to the difference in cooling or heating losses due to infiltration or exfiltration through an entryway before and after the installation of an AMCA certified air curtain. Energy savings are assumed to be the result of a reduction of natural infiltration effects due to wind and thermal forces and follow the calculation methodology outlined by the ASHRAE Handbook.[[6]](#footnote-6) The calculation assumes that the air curtain is appropriately sized and commissioned to be effective in mitigating infiltration of winds of up to 12 mph for at a least 90% of the year (based on manufacturer literature and TMY3 wind speed ranges at near ground level for Illinois).[[7]](#footnote-7)  Additionally, this measure assumes the HVAC systems are appropriately balanced such that the maximum pressure differential between indoor air and outdoor air is within the range of 5 Pa < P < -10 Pa.[[8]](#footnote-8) Custom analysis is necessary if building pressurization exceeds this range. However, while effectiveness decreases, some studies suggest that air curtains outperform vestibules and single door construction for negatively pressurized buildings with a P of above -30 Pa.[[9]](#footnote-9)

This algorithm allows either actual inputs or provides estimates if actual data is not available. All weather dependent values are derived from TMY3 data for the closest weather station to those locations defined elsewhere in the Illinois TRM (which are based on 30 year climate normals). If TMY3 weather station data was not available for the data used in the Illinois TRM, the next closest weather station was used. It is assumed that weather variations are negligible between the weather stations located within the same region. This approach was followed as the air curtain algorithm has a number of weather dependent variables which are all calculated in relation to the heating season or cooling season as defined by the balance point temperature deemed appropriate for the facility. All weather dependent data is based on TMY3 data and is listed in tables by both climate zone and balance point temperature, which is then normalized to the Illinois TRM climate zoned HDD/CDD definitions unless otherwise noted.

###### Electric Energy Savings

kWhcooling = [(Qtbc – Qtac) / EER – (HP \* 0.7457)] \* topen \* CD

kWhHPheating = [(Qtbc – Qtac) / HSPF – (HP \* 0.7457)] \* topen \* HD

kWhGasheating = - (HP \* 0.7457) \* topen \* HD

Where:

Qtbc = rate of total heat transfer through the open entryway, before air curtain (kBtu/hr)

Qtac = rate of total heat transfer through the open entryway, after air curtain (kBtu/hr)

(see calculation in ‘Heat Transfer Through Open Entryway with/without Air Curtain’ sections below)

EER = energy efficiency ratio of the cooling equipment (kBtu/kWh)

= Actual. If unknown, use the table C403.2.3(2) in IECC 2012 (or IECC 2015 if through new construction) to assume values based on code estimates

**E** HP = Input power for air curtain (hp)

= Actual value. If actual value not available, use the following estimates based on manufacturer specs

|  |  |
| --- | --- |
| **Door Size** | **Fan HP** |
| 8’w x 8’h | 1 |
| 10’w x 10’h | 1.5 |
| 10’w x 12’h | 4 |
| 12’w x 14’h | 6 |
| 16’w x 16’h | 12 |

0.7457 = unit conversion factor, brake horsepower to electric power (kW/HP)

topen = average hours per day the door is open (hr/day)

= Actual or user defined estimated value.

CD = cooling days per year, total days in year above balance point temperature (day)

= use table below to select the best value for location[[10]](#footnote-10)

|  | CD  (Balance Point Temperature) | | | | |
| --- | --- | --- | --- | --- | --- |
| Climate Zone -  Weather Station/City | 45 oF | 50 oF | 55 oF | 60  oF | 65  oF |
| 1 -Rockford AP / Rockford | 194 | 168 | 148 | 124 | 97 |
| 2 - Chicago O'Hare AP / Chicago | 194 | 173 | 153 | 127 | 95 |
| 3 - Springfield #2 / Springfield | 214 | 194 | 174 | 148 | 114 |
| 4 - Belleville SIU RSCH / Belleville | 258 | 229 | 208 | 174 | 138 |
| 5 - Carbondale Southern IL AP / Marion | 222 | 201 | 181 | 158 | 130 |

HSPF = Heating System Performance Factor of heat pump equipment

= Actual. If unknown, use the table C403.2.3(2) in IECC 2012 (or IECC 2015 if through new construction) to assume values based on code estimates

HD = heating days per year, total days in year above balance point temperature (day)

= use table below to select an appropriate value[[11]](#footnote-11):

|  | HD | | | | |
| --- | --- | --- | --- | --- | --- |
| Climate Zone -  Weather Station/City | 45 oF | 50 oF | 55 oF | 60  oF | 65  oF |
| 1 -Rockford AP / Rockford | 142 | 160 | 183 | 204 | 228 |
| 2 - Chicago O'Hare AP / Chicago | 150 | 166 | 192 | 219 | 253 |
| 3 - Springfield #2 / Springfield | 125 | 142 | 167 | 194 | 230 |
| 4 - Belleville SIU RSCH / Belleville | 101 | 115 | 134 | 156 | 180 |
| 5 - Carbondale Southern IL AP / Marion | 103 | 123 | 148 | 174 | 205 |

***Heat Transfer Through Open Entryway without Air Curtain (Cooling Season)***

Qtbc = 4.5 \* CFMtot \*(hoc – hic) / (1,000 Btu/kBtu)

Where:

4.5 = unit conversion factor with density of air: 60 min/hr \* 0.075 lbm/ft3 (lb\*min/(ft\*hr))

CFMtot = Total air flow through entryway (cfm), see calculation below

hoc = average enthalpy of outside air during the cooling season (Btu/lb)

= use the below table to determine the approximate outdoor air enthalpy associated with an indoor temperature setpoint and climate zone.[[12]](#footnote-12)

|  |  |  |  |
| --- | --- | --- | --- |
|  | hoc | | |
| Climate Zone -  Weather Station/City | 67 oF | 72 oF | 77 oF |
| 1 -Rockford AP / Rockford | 31.6 | 33.0 | 35.3 |
| 2 - Chicago O'Hare AP / Chicago | 32.0 | 33.6 | 35.4 |
| 3 - Springfield #2 / Springfield | 32.9 | 34.6 | 36.6 |
| 4 - Belleville SIU RSCH / Belleville | 33.5 | 35.0 | 36.4 |
| 5 - Carbondale Southern IL AP / Marion | 34.6 | 36.2 | 37.7 |

hic = average enthalpy of indoor air, cooling season (Btu/lb)

= use the below table to determine the approximate indoor air enthalpy associated with an indoor temperature setpoint in indoor relative humidity.

|  |  |  |  |
| --- | --- | --- | --- |
|  | hic | | |
| Relative Humidity (%) | 67 oF | 72 oF | 77 oF |
| 60 | 25.5 | 28.5 | 31.8 |
| 50 | 23.9 | 26.6 | 29.5 |
| 40 | 22.3 | 24.7 | 27.3 |

= an estimate 26.6 Btu/lb associated with the 72 oF and 50% indoor relative humidity case can be used as an approximation if no other data is available. For other indoor temperature setpoints and RH, enthalpies may be interpolated.

The total airflow through the entryway, CFMtot, includes both infiltration due to wind as well as thermal forces, as follows:

CFMtot = sqrt[ (CFMw)2 + (CFMt2) ]

Where:

CFMw = Infiltration due to the wind (cfm)

CFMt = Infiltration due to thermal forces (cfm)

The infiltration due to the wind is calculated as follows:

CFMw = (vwc \* Cwc)\* Cv \* Ad \* (88 fpm/mph)

Where:

vwc = average wind speed during the cooling season based on entryway orientation (mph)

= use the below table to for the wind speed effects based on climate zone and entryway orientation[[13]](#footnote-13):

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Entryway Orientation | | | |
| Climate Zone -Weather Station/Citytion/City | N | E | S | W |
| 1 -Rockford AP / Rockford | 4.2 | 4.1 | 4.7 | 4.8 |
| 2 - Chicago O'Hare AP / Chicago | 4.7 | 4.5 | 5.4 | 4.6 |
| 3 - Springfield #2 / Springfield | 4.1 | 3.7 | 6.0 | 5.0 |
| 4 - Belleville SIU RSCH / Belleville | 3.3 | 2.7 | 3.8 | 4.2 |
| 5 - Carbondale Southern IL AP / Marion | 3.1 | 2.9 | 4.4 | 3.8 |

Cwc = wind speed correction factor due to wind direction in cooling season, (%)

= because wind direction is not constant, a wind speed correction factor is used to adjust for the amount of time during the cooling season prevailing winds can be expected to impact the entryway. Use the following table to determine the correct wind speed correction factor for cooling applications.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Entryway Orientation | | | |
| Climate Zone -Weather Station/Citytion/City | N | E | S | W |
| 1 -Rockford AP / Rockford | 0.18 | 0.13 | 0.30 | 0.31 |
| 2 - Chicago O'Hare AP / Chicago | 0.18 | 0.17 | 0.36 | 0.26 |
| 3 - Springfield #2 / Springfield | 0.17 | 0.12 | 0.46 | 0.21 |
| 4 - Belleville SIU RSCH / Belleville | 0.21 | 0.15 | 0.35 | 0.16 |
| 5 - Carbondale Southern IL AP / Marion | 0.18 | 0.15 | 0.37 | 0.11 |

Note that correction factors do not add up to 1 (100%). This is attributed to periods of calm winds.

Cv = effectiveness of openings,

= 0.3, assumes diagonal wind20

Ad = area of the doorway (ft2)

= user defined

The infiltration due to thermal forces is calculated as follows:

CFMt = Ad \* Cdc \* (60 sec/min) \* sqrt[2 \* g \* H/2 \* (Toc - Tic) / (459.7 + Toc)]

Where:

Cdc = the discharge coefficient during the cooling season[[14]](#footnote-14)

= 0.4 + 0.0025 \* |Tic – Toc|

= 0.42, Illinois average at indoor air temp of 72oF

Note, values for Cdc show little variation due to balance point temperature, indoor air temperature, and climate zone. As such, if estimating results, the Illinois average value may be used as a simplification.

g = acceleration due to gravity

= 32.2 ft/sec2

H = the height of the entryway (ft)

= user input

Tic = Average indoor air temperature during cooling season

= User input, can assume indoor cooling temperature set-point

Toc = Average outdoor temp during cooling season (oF)

= the average outdoor temperature is dependent on the CD period and zone. As such, the following table may be used for average outdoor temperature during the cooling period[[15]](#footnote-15):

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Toc | | | | |
| Climate Zone -  Weather Station/City | 62 oF | 67 oF | 72 oF | 77  oF | 82  oF |
| 1 -Rockford AP / Rockford | 72.9 | 76.0 | 79.2 | 82.5 | 85.5 |
| 2 - Chicago O'Hare AP / Chicago | 72.9 | 76.0 | 79.4 | 82.8 | 85.5 |
| 3 - Springfield #2 / Springfield | 73.7 | 76.7 | 79.9 | 83.4 | 86.4 |
| 4 - Belleville SIU RSCH / Belleville | 74.9 | 77.7 | 81.0 | 84.3 | 86.9 |
| 5 - Carbondale Southern IL AP / Marion | 75.1 | 77.7 | 80.9 | 84.7 | 87.4 |

459.7 = conversion factor from oF to oR

= calculation requires absolute temperature for values not calculated as a difference of temperatures.

***Heat Transfer Through Open Entryway with Air Curtain (Cooling Season)***

Qtac = Qtbc \* (1 – E)

Where:

E = the effectiveness of the air curtain (%)

= 0.60[[16]](#footnote-16)

###### Summer Coincident Peak Demand Savings

ΔkW = (ΔkWhcooling / (CD \*24)) \* CF

Where:

CFSSP = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3%[[17]](#footnote-17)

CFPJM = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8%[[18]](#footnote-18)

###### Natural Gas Savings

Natural gas savings, therms, associated with reduced infiltration through an entryway during the heating season are calculated by determining the difference between heat loss through the entryway before and after the installation of the air curtain.

therms = (Qbc - Qac) \* topen \* HD / η

Where:

Qbc = rate of sensible heat transfer through the open entryway, before air curtain (therm/hr)

Qac = rate of sensible heat transfer through the open entryway, after air curtain (therm/hr)

topen = average hours per day the door is open (hr/day)

= Actual or estimated user input value

HD = heating days per year, total days in year above balance point temperature (day)

= use table below to select an appropriate value[[19]](#footnote-19):

|  | HD | | | | |
| --- | --- | --- | --- | --- | --- |
| Climate Zone -  Weather Station/City | 45 oF | 50 oF | 55 oF | 60  oF | 65  oF |
| 1 -Rockford AP / Rockford | 142 | 160 | 183 | 204 | 228 |
| 2 - Chicago O'Hare AP / Chicago | 150 | 166 | 192 | 219 | 253 |
| 3 - Springfield #2 / Springfield | 125 | 142 | 167 | 194 | 230 |
| 4 - Belleville SIU RSCH / Belleville | 101 | 115 | 134 | 156 | 180 |
| 5 - Carbondale Southern IL AP / Marion | 103 | 123 | 148 | 174 | 205 |

η = efficiency of heating equipment

= Actual. If unknown, assume 0.8

***Heat Transfer Through Open Entryway without Air Curtain (Heating Season)***

Qbc = (1.08 Btu/(hr\*oF\*cfm)) \* CFMtot \* (Tih – Toh) / (100,000 Btu/therm)

Where:

1.08 = sensible heat transfer coefficient (specific heat of air and unit conversions)

CFMtot = Total air flow through entryway (cfm)

Tih = Average indoor air temperature during heating season

= User input, can assume indoor heating temperature set-point

Toh = Average outdoor temp during heating season (oF)

= use table below, based on binned data from TMY3 & balance point temperature

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Avg Outdoor Air Temp - Heating Season | | | | |
| Climate Zone -  Weather Station/City | 45 oF | 50 oF | 55 oF | 60  oF | 65  oF |
| 1 -Rockford AP / Rockford | 26.3 | 28.8 | 31.6 | 34.2 | 37.3 |
| 2 - Chicago O'Hare AP / Chicago | 29.4 | 31.2 | 34.0 | 36.8 | 40.3 |
| 3 - Springfield #2 / Springfield | 29.4 | 31.5 | 34.6 | 37.7 | 41.6 |
| 4 - Belleville SIU RSCH / Belleville | 31.7 | 33.6 | 36.2 | 39.2 | 42.3 |
| 5 - Carbondale Southern IL AP / Marion | 32.5 | 34.9 | 37.8 | 40.7 | 44.0 |

The total airflow through the entryway, CFMtot, includes both infiltration due to wind as well as thermal forces, as follows:

CFMtot = sqrt[ (CFMw)2 + (CFMt2) ]

Where:

CFMw = Infiltration due to the wind (cfm)

CFMt = Infiltration due to thermal forces (cfm)

The infiltration due to the wind is calculated as follows:

CFMw = (vwh \* Cwh)\* Cv \* Ad \* (88 fpm/mph)

Where:

vwh = average wind speed during the heating season (mph)

= similar to cooling season wind speed assumptions, use the following table to determined average wind speed based on entryway orientation:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Entryway Orientation | | | |
| Climate Zone -Weather Station/Citytion/City | N | E | S | W |
| 1 -Rockford AP / Rockford | 5.0 | 4.6 | 4.9 | 5.6 |
| 2 - Chicago O'Hare AP / Chicago | 5.5 | 5.2 | 4.9 | 5.1 |
| 3 - Springfield #2 / Springfield | 5.0 | 4.9 | 5.3 | 5.1 |
| 4 - Belleville SIU RSCH / Belleville | 4.3 | 3.4 | 3.5 | 5.3 |
| 5 - Carbondale Southern IL AP / Marion | 4.6 | 3.2 | 4.2 | 4.4 |

Cwh = wind speed correction factor due to wind direction in heating season, (%)

= because wind direction is not constant, a wind speed correction factor is used to adjust for the amount of time during the heating season prevailing winds can be expected to impact the entryway. Use the following table to determine the correct wind speed correction factor for the heating applications.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Entryway Orientation | | | |
| Climate Zone -Weather Station/Citytion/City | N | E | S | W |
| 1 -Rockford AP / Rockford | 0.18 | 0.13 | 0.30 | 0.31 |
| 2 - Chicago O'Hare AP / Chicago | 0.21 | 0.10 | 0.26 | 0.39 |
| 3 - Springfield #2 / Springfield | 0.21 | 0.14 | 0.27 | 0.34 |
| 4 - Belleville SIU RSCH / Belleville | 0.31 | 0.15 | 0.22 | 0.29 |
| 5 - Carbondale Southern IL AP / Marion | 0.31 | 0.11 | 0.27 | 0.18 |

Note that correction factors do not add up to 1 (100%). This is attributed to periods of calm winds.

Cv = effectiveness of openings,

= 0.3, assumes diagonal wind24

Ad = area of the doorway (ft2)

= user input

The infiltration due to thermal forces is calculated as follows:

CFMt = Ad \* Cdh \* (60 sec/min) \* sqrt[2 \* g \* H/2 \* (Tih – Toh) / (459.7 + Tih)]

Where:

Cdh = the discharge coefficient during the heating season

= 0.4 + 0.0025 \* |Tih – Toh|

= 0.49, Illinois average at indoor air temp of 72oF

Note, values for Cdh show little variation due to balance point temperature, indoor air temperature, and climate zone. As such, if estimating results, the Illinois average value may be used as a simplification.

g = acceleration due to gravity

= 32.2 ft/sec2

H = the height of the entryway (ft)

= user defined

***Heat Transfer Through Open Entryway without Air Curtain (Heating Season)***

Qac = Qbc \* (1 – E)

Where:

E = the effectiveness of the air curtain (%)

= 0.60[[20]](#footnote-20)

###### Water and Other Non-Energy Impact Descriptions and Calculation

N/A

###### Deemed O&M Cost Adjustment Calculation

The air curtain would need to be regularly serviced and commissioned to ensure that it is appropriately operating. We should come up with a suitable service cost for this.

###### Measure Code: CI-MSC-AIRC-V01-160601

1. Spentzas, Steve, et. al, “1009: Commercial and Industrial Air Curtains – Public Project Report,” Nicor Gas Emerging Technology Program (Oct 2014): 9 [↑](#footnote-ref-1)
2. Navigant Consulting Inc, Measures and Assumptions for Demand Side Management (DSM) Planning: Appendix C: Substantiation Sheets, “Air Curtains – Single Door,” Ontario Energy Board, (April 2009): C-137.

   2014 Database for Energy-Efficient Resources, EUL/RUL (Effective/Remaining Useful Life) Values, February 4, 2014. [↑](#footnote-ref-2)
3. Based on manufacturer interviews and air curtain specification sheets. [↑](#footnote-ref-3)
4. Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility’s peak hour is divided by the maximum AC load during the year. [↑](#footnote-ref-4)
5. Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year [↑](#footnote-ref-5)
6. ASHRAE, “Ventilation and Infiltration,” in 2013 ASHRAE Handbook – Fundamentals (2013): Ch 16.1 - 16.37 [↑](#footnote-ref-6)
7. National Solar Radiation Data Base – 1991 – 2005 Update: Typical Meteorological year 3. <http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html> [↑](#footnote-ref-7)
8. Spentzas, Steve, et. al, “1009: Commercial and Industrial Air Curtains – Public Project Report,” Nicor Gas Emerging Technology Program (Oct 2014): 10

   Wang, Liangzhu, “Investigation of the Impact of Building Entrance Air Curtain on Whole Building Energy Use,” Air Movement and Control International, Inc. (2013). 4 [↑](#footnote-ref-8)
9. Wang, Liangzhu, “Investigation of the Impact of Building Entrance Air Curtain on Whole Building Energy Use,” Air Movement and Control International, Inc. (2013). 4 [↑](#footnote-ref-9)
10. National Solar Radiation Data Base – 1991 – 2005 Update: Typical Meteorological year 3. <http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html>

    Note that cooling days (CD) are calculated by first determining its value from the TMY3 data associated with the appropriate weather station as defined by and used elsewhere in the Illinois TRM. Using the TMY3 outdoor air dry bulb hourly data, the annual hours are totaled for every hour that the outdoor air dry bulb temperature is above a designated zero heat loss balance point temperature or base temperature for cooling. For commercial and industrial (C&I) buildings, a base temperature for heating of 55 oF is designated in the Illinois TRM, but building specific base temperatures are recommended for large C&I projects. Additionally, the TRM uses a 30-year normal data for degree-days while the CD calculation was based on TMY3 data; in order to account for this, calculations of CD were also normalized by the ratio of CDD to align the calculated values more closely with the TRM. [↑](#footnote-ref-10)
11. Note that Heating Days (HD) are calculated following the same approach outlined in the Cooling Days section. [↑](#footnote-ref-11)
12. Average enthalpies were estimated following ASHRAE guidelines for perfect gas relationships for dry air associated with hourly TMY3 data.18 Enthalpies were then averaged for all values associated with a dry-bulb outdoor air temperature that exceeded the indoor air temperature setpoint. Other enthalpy values may be interpolated for indoor air temperature setpoints not represented in the table. Note that while outdoor air enthalpies increase with higher temperature setpoints, the change in enthalpy from indoor to outdoor will decrease. [↑](#footnote-ref-12)
13. Average wind speeds are calculated based on the TMY3 wind speed data. Because this data is collected at an altitude of 33 ft, wind speed is approximated for a 5 ft level based on ASHRAE Handbook guidelines using the urban/suburban parameters for adjusting wind speed based on altitude ( = 1200,  = 0.22).

    ASHRAE, “Airflow Around Buildings,” in 2013 ASHRAE Handbook – Fundamentals (2013): p 24.3 [↑](#footnote-ref-13)
14. ASHRAE, “Ventilation and Infiltration,” in 2013 ASHRAE Handbook – Fundamentals (2013): p 16.13 [↑](#footnote-ref-14)
15. Based on binned data from TMY3 & adjusted bracketed thermostat setpoint temperatures. Interpolate other values as needed. [↑](#footnote-ref-15)
16. Assumed conservative estimate based on referenced study results and ASHRAE 2004 effectiveness range of 60-80% for air curtains. Jaramillo, Julian, et. Al. “Application of Air Curtains in Refrigerated Chambers,” International Refrigeration and Air-Conditioning Conference, Purdue University e-Pubs (July 14-17, 2008): <http://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=1972&context=iracc>

    ASHRAE, “Room Air Distribution Equipment,” in 2004 ASHRAE Handbook – HVAC Systems and Equipment (2004): p 17.8 [↑](#footnote-ref-16)
17. Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility’s peak hour is divided by the maximum AC load during the year. [↑](#footnote-ref-17)
18. Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year [↑](#footnote-ref-18)
19. Note that Heating Days (HD) are calculated following the same approach outlined in the Cooling Days section. [↑](#footnote-ref-19)
20. Assumed conservative estimate based on referenced study results and ASHRAE 2004 effectiveness range of 60-80% for air curtains. Jaramillo, Julian, et. Al. “Application of Air Curtains in Refrigerated Chambers,” International Refrigeration and Air-Conditioning Conference, Purdue University e-Pubs (July 14-17, 2008): <http://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=1972&context=iracc>

    ASHRAE, “Room Air Distribution Equipment,” in 2004 ASHRAE Handbook – HVAC Systems and Equipment (2004): p 17.8 [↑](#footnote-ref-20)