Example 1: Cross-ventilated barn with cooling pads

Assumptions:
- 8-row, 800-head freestall
- Dimensions of 210 ft. by 420 ft.
- Baffle height of 8 ft. and one baffle per two rows of stalls
- Design velocity under the baffle of 528 fpm
- Cooling pads result in 0.05 inches of static pressure at air velocity of 400 fpm
- Performance test results show exhaust fan moving 31,000 CFM at 0.12 inches of static pressure

Calculate cross-sectional area:
\[ A_{cs} = 8 \text{ ft.} \times 420 \text{ ft.} = 3,360 \text{ sq. ft.} \]

Calculate volumetric flow rate to meet design velocity and air exchange per cow:
Calculate airflow based on velocity: \( Q = 3,360 \text{ sq. ft.} \times 528 \text{ fpm} = 1,774,080 \text{ CFM} \)
Calculate airflow based on number of cows:
\( Q = 800 \text{ cows} \times 1,000 \text{ CFM/cow} = 800,000 \text{ CFM} \)
Choose larger: 1,774,080 CFM

Size inlets:
1,774,080 CFM/400 fpm = 4,435 sq. ft.
Find inlet height: 4,435 sq. ft./420 ft. = 10.56 ft. high

Estimate static pressure:
Calculate static pressure per baffle (equation 5 in the companion summary article):
\[ S.P._{\text{baffle}} = \left( \frac{528 \text{ fpm}}{4,000} \right)^2 = 0.0174 \text{ inches of water/baffle} \]
Sum static pressures: 0.05 in. at inlet + 0.0174 in./baffle * 4 baffles = 0.12 inches of water

Consider fans needed:
Number of fans = 1,774,000 CFM/31,000 CFM/fan = 57 fans

Example 2: Estimating the annual electrical cost of operating circulation fans in Madison, Wisconsin

Assumptions:
- 40 circulation fans with 1 hp motors in naturally ventilated barn
- 1 hp motor consumes 1 kW of power
- Electricity costs $0.11/kWh
- Set point temperature is 68 °F
- In typical meteorological year, Madison has 1,682 hours with a temperature at or above 68 °F

Annual electrical costs \( [$] = \text{(hours over set point [hours/yr])} \times \text{(number of fans)} \times \text{(electrical use per fan [kW/fan])} \times \text{(cost of electricity [$/kWh])} \)
= 1,682 hours/year * 40 fans * 1 kW/fan * $0.11/kWh = $7,400.80/year

Example 3: Estimating the annual water use of a sprinkler system operating in a holding area in Madison, Wisconsin

Assumptions:
- Holding area is 400 square feet
- Water is applied at a rate of 0.025 gal per sq. ft. per cycle
- System uses valved nozzles, so water is not wasted between cycles
- Cycles are set to operate 1 minute in: 15 minutes at temperature 68 – 77 °F, 10 minute cycles at temperatures 78 – 88 °F, and 5 minute cycles at temperatures above 88 °F
- Typical meteorological year has 994 hours from 68 – 78 °F, 566 hours from 78 – 88 °F, and 61 hours > 88 °F

Water per cycle [gal] = square feet * application per square foot = 400 square feet * 0.025 gal per square foot per cycle = 10 gal per cycle

Number of cycles is found by dividing the number of hours by the cycle duration

<table>
<thead>
<tr>
<th>Range</th>
<th>Number of hours/yr</th>
<th>Number of cycles/yr</th>
<th>Gallons of water/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>68 – 78 °F</td>
<td>1,171</td>
<td>4,684</td>
<td>46,840</td>
</tr>
<tr>
<td>79 – 88 °F</td>
<td>389</td>
<td>2,334</td>
<td>23,340</td>
</tr>
<tr>
<td>&gt; 88 °F</td>
<td>61</td>
<td>732</td>
<td>7,320</td>
</tr>
</tbody>
</table>

Annual water use in holding area: 77,500

(note: water can be saved in the holding area by staging sprinklers so they do not operate in the empty portion (or only installing sprinklers in the 75% closest to the parlor, which is occupied a higher percentage of the time). Significant water could also be saved by staging the sprinklers to turn on at THI setpoints instead of temperature setpoints).