Ventilation in Dairy Production

Introduction

On average, 15% of the electricity consumption in a dairy operation is attributed to ventilation (Figure 1). This equates to 16,680 kWh for a 100 cow dairy.

![Typical Consumption for 100 Cow Dairy: 111,000 kWh](image)

**Figure 1. Electricity Usage and Distribution**

Assuming the cost of electricity is $0.10 per kWh, this equates to $1,665 per year. Electricity prices over the last five years have been unpredictable ranging from $0.06 to $0.15 per kWh (Figure 2). This equates to a range of $999 to $2,498 per year for a 100 cow dairy.

![Price of Electricity from 2008 to 2012](image)

**Figure 2. Alberta Price for Electricity from 2008 to 2012**

Source: Alberta Agriculture and Rural Development

Ventilation systems for confined dairy facilities are used to maintain desirable environmental conditions inside the barns. There are usually two types of ventilation, natural and mechanical. As dairy cattle can withstand high temperature fluctuations without affecting their performance, many dairy barns use natural ventilation systems. However, mechanical ventilation systems (Figure 3) can be used in these facilities as well.

Unlike natural ventilation systems, mechanical ventilation systems consume energy. Based on the techniques used, a number of different mechanical ventilation systems are commercially available. In barn settings, proper design, sizing, control selections, locations, modifications and maintenance can make a significance difference in energy consumption and reduce the operating costs.

![Mechanical Ventilation on Livestock Barn](image)

**Figure 3. Mechanical Ventilation on Livestock Barn**

Source: www.jdmfg.com

Animal Requirements

Proper sizing of fans is important to meet the optimal environmental requirements. Summer and winter design temperatures are usually considered in sizing the fans. Winter ventilation rates are considerably lower than the summer ventilation rates. Winter design temperatures are used to determine the minimum ventilation requirements while summer design temperatures are used to determine maximum ventilation requirements. Moisture removal is the primary function of ventilation in winter and heat removal is the primary function of ventilation in summer.

Table 1 shows the parameters and their recommended minimum and maximum ventilation levels for a dairy operation. In general, mature dairy cows do not show significant reduction in the performance when there are wide fluctuations in the environmental conditions. A small loss in milk yield occurs when the temperature and humidity range are between 2 - 24°C and 40 - 80%. Increase in feed consumption occurs when the temperature drops below 10°C to compensate for the heat losses.

![Ventilation in Dairy Production](image)
be more efficient than the ones with either on/off or multi speed control (Teitel 2008). Typically the speed is varied as a function of barn moisture and temperature. Variable speed ventilation systems adjust their speed as needed and maintain the desirable barn conditions more accurately with optimal energy consumption.

Factors Affecting Ventilation Efficiency

Factors affecting ventilation efficiency are motor type; construction material; fan drive (direct coupled or belt driven); fan housing; using shutters, guards, cones and deflectors; inlet and exhaust location and size; thermostat location and maintenance. Installing discharge cones or wind hood deflectors can increase the efficiency up to 15%. Exhausting against the prevailing wind situation is not desirable. The recommended location of the thermostat is near the exhaust fan, especially when the operating temperature is equal or below the thermostat’s final settings. Keeping the fan in good condition through maintenance is very important for reducing energy costs. Poor maintenance can reduce the fan efficiency by 50% or more. Ventilation fans should be inspected periodically to remove the dust built up on the fan and motors should be serviced regularly.

Ventilation rates can affect the temperature and humidity levels in the barn. Therefore, using appropriate monitors and controllers may optimize the ventilation rates, increase animal performance and reduce energy consumption. Related items such as timers, thermostats, variable speed drive controls, humidity controllers, etc. are commercially available. Installing such monitoring and controlling equipment will help maintain desirable barn conditions.

Table 2 has performance targets for different fan sizes with and without cones. VER 10 is the ventilating efficiency expressed in ft³/min/W at 0.10 inch water column (w.c.) static pressure. Exhaust fans in barns usually operate at negative 0.10 inch w.c. static pressure. This can change depending on the design of the facility as well as the maintenance issues such as dirt build-up and damaged fan blades along with wind pressure affecting the exhaust. Airflow ratio is the ratio of airflow 0.2 inch to 0.05 inch w.c static pressure. In Table 2, it is evident that larger fans have higher efficiency. It is also evident from the same table that larger fans with cones are more efficient.
The number of fans and sizes of the fans will depend on the minimum and maximum ventilation requirement given in Table 1. As mentioned previously, proper sizing of fans will save energy costs.

**Table 2. Recommended Energy Performance Efficiency**

<table>
<thead>
<tr>
<th>Fan Size (in)</th>
<th>Cone</th>
<th>Performance Targets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>VER 10</td>
</tr>
<tr>
<td>10 &amp; 12</td>
<td>N</td>
<td>8.0</td>
</tr>
<tr>
<td>14 &amp; 16</td>
<td>N</td>
<td>8.0</td>
</tr>
<tr>
<td>18 &amp; 20</td>
<td>Y</td>
<td>10.5</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>11.0</td>
</tr>
<tr>
<td>24</td>
<td>Y</td>
<td>15.0</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>12.0</td>
</tr>
<tr>
<td>36</td>
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<td>17.0</td>
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<tr>
<td></td>
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</tr>
<tr>
<td>48</td>
<td>Y</td>
<td>18.0</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>17.0</td>
</tr>
</tbody>
</table>

Source: ASABE (2008)

**Calculating Operating Cost and Savings**

Operating cost savings from using energy efficient ventilation fans can be estimated using the following equation (ASABE 2008):

\[
EOCS = \frac{AFR_1}{FE_1} - \frac{AFR_2}{FE_2} \times AOH \times ER \times 0.001
\]

**Case Study**

<table>
<thead>
<tr>
<th>Fan</th>
<th>AFR (_1) – 15,340 ft(^3)/min at 0.1 inch Static Pressure</th>
<th>AFR (_2) – 15,500 ft(^3)/min at 0.1 inch Static Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FE (_1) – 15.6 ft(^3)/min/W at 0.1 inch Static Pressure</td>
<td>FE (_2) – 12.9 ft(^3)/min/W at 0.1 inch Static Pressure</td>
</tr>
<tr>
<td>AOH – 8,760 hours per year (h/yr) for the fan</td>
<td>AOH (_1) \times ER \times 0.001) = ((15,340/15.6) \times 8,760 \text{ hr/yr} \times 0.10 \times 0.001) = $861.40</td>
<td></td>
</tr>
<tr>
<td>ER – $0.10 kWh charged by electric power supplier</td>
<td>ER (_2) \times 0.001) = ((15,500/12.9) \times 8,760 \text{ hr/yr} \times 0.10 \times 0.001) = $1,052.56</td>
<td></td>
</tr>
</tbody>
</table>

This means savings of $191 per year. Payback period may be estimated using EOCS and considering average servicing or motor replacement costs.

**Summary**

Ventilation systems are important for maintaining the optimum performance in confined feeding operations (CFO). Dairy barns use natural as well as mechanical ventilation systems. Mechanical ventilations systems consume considerable energy to operate. Energy efficiency of the ventilation fans depend on a number of factors. Summer and winter design temperatures as well as number of animals and type of operation determines the maximum and minimum ventilation rates required for a CFO. Sizes and number of fans for the facility will in turn depend on the building size, configuration as well as minimum and maximum ventilations rates. Different types of ventilation systems are commercially available. Multi-speed, intermittent, variable speeds, belt driven and direct coupled are some of the examples. Choosing a suitable type of ventilation system can reduce the operating costs. Motor type, construction materials and modifications such as installing cone, housing, hoods and wind deflectors can affect the efficiency. In addition, periodic maintenance including dusting off can improve the energy efficiency of the fans. Installing controllers such as thermostat, moisture control and variable speed drive can optimize energy consumption. Replacing existing inefficient fans with the newer, more efficient fans using the energy efficiency guidelines can conserve energy.
References

Teitel, M. A Levi, V.Chao, M.Barrak, E.Barlev, D. Shmvel.

http://www.asabe.org/

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