Hybrid Tunnel Ventilation
Combination of Exhaust Fans with Directional ECV Fans

ENGINEERING FLOWCHART

DOES IT MOVE?

- **NO**
  - SHOULD IT?
    - **NO**
      - NO PROBLEM
    - **YES**
      - YES

- **YES**
  - SHOULD IT?
    - **YES**
      - NO PROBLEM
    - **NO**
Adult Facility Ventilation

- Freestall (lactating, dry cows & prefresh heifers)
- Parlor
- Holding & Connecting Links
- Active Ventilation is **NOT** a Seasonal Luxury

Goals of Hybrid Ventilation

Three Legged Stool

- Fresh Air (dynamically balanced inlet & exhaust)
- ECV (Effective Cow-Cooling Velocity)
- Ambient Temperature Drop by High Pressure Fog (supplement as needed with soakers)
Hybrid Tunnel Ventilation Components

- Roof Insulation
- Dynamic Inlet
- Recirculating Fans w/wo Baffles
- Shutter Tie Bar Stabilization
- Exhaust Fans
- Control System (component staging & enviro management)

Other Considerations

- Barn Location & Orientation
- Prevailing Winds
- Lagoon Location
- Flume Vents
- Connecting Links
- Curtain or Polycarb Side Walls
Other Advantages

• Bird Control $170/100 Hd Cost (feed, milk loss not including disease potential)
• Fly Control (reduced costs, environmental safety)
• Keep Cows in TNZ (20-65°F reduced maintenance cost)
• Seasonal Manure Handling Challenges

Under Roof Insulation

• Reduces Heating of Barn Air by Convection
• Reduces Thermal Loading from Infrared Radiation
• Reduced IR to Cows
• Reduced IR to Building Components Concrete, Steel
Does Insulation Matter?

- Metal roof with no insulation adds 5.5 F by convection to a building environment


Inlets

- Must be Balanced with Fan CFM Capacity
- 1.5 sq ft Opening per 1000 CFM Exhaust Fan Capacity
- Unbalanced Inlet will Increase Facility SP (Static Pressure)
- As SP Increases Fan Performance Decreases
- Air Flow Ratio of Fans
Baffles

- Increase Air Velocity by Reducing Cross Sectional Area
- Velocity = Total Fan CFM ÷ Cross Sectional Area
- Must be Designed to **NOT** Increase SP
- Should Be Located Less than 50 Ft Apart
- Air Follows Path of Least Resistance
- Feeder Lanes & Scrape Alleys Highest Velocities
- Block LDPP Lighting Patterns if Not Translucent

Exhaust Fans

- Determine the Desired Air Exchange Rate of Barn
- Total CFM = Cross Sectional Area X Target FPM
- Role of Exhaust Fan Cones
- Air Flow Ratio > 0.80 = (cfm @ 0.20 SP ÷ cfm @ 0.05 SP)
- CFM/Watt > 19
Energy Efficiency

- CFM/Watt
- AFR (air flow ratio)
- Conflict Between These Two Factors

Air Flow Ratios

![Graph showing air flow ratios against static pressure.](image)
Why Are These Shutters Fluttering?

Shutter Fluttering

- Fan Belts are Not Tight
- Dirty Fan Blades and Shutters
- Shutters not Tie Barred
- Wind Direction (puts static pressure back against the fans & also impacts inlet)
- Long Cones or Restrictive Exhaust Hood
- Inlet Not Adequately Sized for the Fan Capacity Running (high static pressure)
- Exhaust Obstruction
Manometer
Cones & Zone of Influence

- Long Exhaust Cones
- Intake Influence Zone is 1.5X the Fans Diameter
- Restricted Intake Zone of Influence adds Static Pressure
40% Reduction in Potential CFM Capacity
Air Exchange Strategy
Dilution is the Solution to Pollution

- Summer Rate:
  1 Complete Air Exchange/Min
- Winter Rate:
  1 Complete Air Exchange/15 Min (may change based on animal size, density & barn length)
- Winter-Summer Transition Ventilation: Staging should be no more than 2X the previous setting for CFM output

THI & ECV

- THI Considerations (Temp/Humidity/ECV)
- Current Accepted Dairy THI does not Consider ECV
- Feed lots consider Temp, %RH, Solar Gain & Wind Speed
- Feed Lots Credit for 1.1 ↓ THI per 1 mph Wind Speed
- ECVs of 5-7 mph Reduces THI by 5.5-7.7 Points
- **Stress Threshold**: Respiration rate exceeds 60 BPM. Milk yield losses begin. Repro losses detectable. Rectal Temperature exceeds 38.5°C (101.3°F)

- **Mild-Moderate Stress**: Respiration Rate Exceeds 75 BPM. Rectal Temperature exceeds 39°C (102.2°F)

- **Moderate-Severe Stress**: Respiration Rate Exceeds 85 BPM. Rectal Temperature exceeds 40°C (104°F)
  - Death Rates Rise

- **Severe Stress**: Respiration Rate 120-140 BPM. Rectal Temperature exceeds 41°C (106°F)
Integrated Dynamic Controls

RH & HPF or Pad System

Cooling Potential

Smith et al: (2008)
Control = no cooling system, FRT-500 = head to tail airflow at 500 CFM, FRT-750 = head to tail airflow at 750 CFM, FRT-900 = head to tail airflow at 900 CFM, SIDE-500 = right side airflow at 500 CFM, SIDE-750 = right side airflow at 750 CFM, and SIDE-900 = right side airflow at 900 CFM.

Figure 3. Average Vaginal Temperature of Cows Treated with Different Cooling Systems.
Cyclone Fan

- Designed Specifically to Create Max ECV to Cool Cows
- Creates Laminar Air Flow
- Can be Paired with HPF
- High CFM/Watt (including entrained air)
- Can be VFD Controlled
- Reduce SP Experienced by Exhaust Fans
- De-Stratefy Air in Barn
Simulated Cyclone ECV Pattern

ECV Coverage Comparisons

<table>
<thead>
<tr>
<th>Fan</th>
<th>Coverage</th>
<th>ECV Comparison</th>
<th>Cost/KW</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Width</td>
<td>Length</td>
<td>Sq Ft</td>
</tr>
<tr>
<td>36” Basket</td>
<td>8</td>
<td>24</td>
<td>192</td>
</tr>
<tr>
<td>50” Panel</td>
<td>12</td>
<td>36</td>
<td>432</td>
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<tr>
<td>72” Cyclone</td>
<td>24</td>
<td>72</td>
<td>1728</td>
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</table>
4 Row Tail-Tail
### Combined Average 2,4 & 6 Ft Level

<table>
<thead>
<tr>
<th></th>
<th>FL</th>
<th>FA</th>
<th>I-TT</th>
<th>SA</th>
<th>O-TT</th>
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<tbody>
<tr>
<td>Ave</td>
<td>305</td>
<td>425</td>
<td>526</td>
<td>478</td>
<td>370</td>
<td>450</td>
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<tr>
<td>Max</td>
<td>785</td>
<td>819</td>
<td>1416</td>
<td>840</td>
<td>855</td>
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<tr>
<td>Min</td>
<td>0</td>
<td>108</td>
<td>0</td>
<td>203</td>
<td>46</td>
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</table>

4 Row H-H Freestall
Entrained Air

Tunnel with 12 Ft Baffle
Cyclone Mis-Installation

Air Flow Counter Current
Connecting Link

Performance Tools & Standards

• What are Your Ventilation Performance Goals?
• Velocity Meter
• Temp & Humidity Meter
• Light Meter
• Manometer for SP measurement
• CFM/Watt Exhaust Fans
• CFM of a Fan & ECV Created
• Air Flow Ratios
## 10 Year Annualized Comparison

**Comparison of Current State High Loss-Low Ownership Cost vs. Low Loss High Ownership Cost**

<table>
<thead>
<tr>
<th>Cost Component</th>
<th>High Loss-Low Input</th>
<th>Low Loss-High Input</th>
<th>Net Ownership Advantage</th>
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</thead>
<tbody>
<tr>
<td>Installation Cost</td>
<td>$14,600</td>
<td>$16,500</td>
<td>$(1,900)</td>
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<tr>
<td>Replacement Factor Value</td>
<td>$10,000</td>
<td>$10,000</td>
<td>$0</td>
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<tr>
<td>Amortized Value (including Rent)</td>
<td>$7,500</td>
<td>$7,500</td>
<td>$0</td>
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<tr>
<td>Total Operating &amp; Ownership Costs</td>
<td>$8,400</td>
<td>$8,400</td>
<td>$0</td>
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<tr>
<td>Total Operating &amp; Ownership Costs &amp; Cost</td>
<td>$9,300</td>
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**Note:** The Net Ownership Advantage is calculated as the difference between the Total Operating & Ownership Costs of the High Loss-Low Ownership Cost scenario and the Low Loss-High Ownership Cost scenario.
### High Loss/Low Investment

<table>
<thead>
<tr>
<th>Tax code</th>
<th>Dry Cow</th>
<th>Pregnant</th>
<th>Calving</th>
<th>Total cow</th>
<th>Cost to Operate (High compared to Low based on Call)</th>
<th>Summer Cost of Operation</th>
<th>Spring/Full Crop</th>
<th>Winter Cost of Operation</th>
<th>Total Purchase Cost/F Cows</th>
<th>Total Yearly Maintenance</th>
</tr>
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<tbody>
<tr>
<td></td>
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<tr>
<td>Existing S&amp;F Loss</td>
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<td>675</td>
<td>11</td>
<td>3,498</td>
<td>$6,000</td>
<td>$2,000</td>
<td>$7,200</td>
<td>$8,200</td>
<td>$10,000</td>
<td>$6,000</td>
</tr>
<tr>
<td>39’ Center Pen</td>
<td>4</td>
<td>655</td>
<td>10</td>
<td>3,498</td>
<td>$5,000</td>
<td>$2,000</td>
<td>$7,200</td>
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<tr>
<td>48’ Good Day</td>
<td>4</td>
<td>715</td>
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<tr>
<td>Attachment Equipment &amp;<em>#</em>#_#</td>
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**Opportunity Costs of Current Performance**

**Milk:**
- **Reproduction & Culling**
  - **Lameness**
    - **Annualized Cost of Ownership**
      - 5.0% Interest
- **10 Year Low Loss/High Investment**
- **Annual Cost of Heat Abatement**
  - ($123,039) Cumulative Productivity Cost
  - ($134,970) Annual Total Costs

### 10 Year Low Loss/High Investment

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2.1 Years to Pay Back Investment

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<td>-</td>
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<tr>
<td>Inst. Cost</td>
<td>$28</td>
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<tr>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Ventilation</td>
<td>Uniformly Deliver</td>
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<tr>
<td>• Air Exchange CFM</td>
<td></td>
</tr>
<tr>
<td>• Effective Cow Side Velocity or ECV (Air Velocity FPM between 2-6’ of Ht)</td>
<td></td>
</tr>
<tr>
<td>• Direct Cow Cooling by Soaking (holding areas, return &amp; feed lanes)</td>
<td></td>
</tr>
<tr>
<td>• Ambient Temperature Drop with HPF (when Ambient RH% Conditions Present Opportunity)</td>
<td></td>
</tr>
<tr>
<td>• Maximize the Opportunity for Dairy Cattle to be in Their TNZ (20°- 65°F) 24/7/365.</td>
<td></td>
</tr>
</tbody>
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Questions?

That’s alota of Bull!

Thank You!