Managing Variable Costs on Dairy Farms Through Energy Use Assessment and Conservation
Acknowledgements

Program Support
• Project supported by USDA/NIFA under Award Number 2012-49200-20032
• North Central Risk Management Center

Expertise and Input
• SDSU Extension
  – Steve Pohl
  – Alvaro Garcia
  – Tracey Erickson
  – Heidi Caroll
• University of Minnesota Extension
  – Kevin Janni
  – Jim Paulson
• South Dakota Dairy Producers
• Minnesota Milk Producers
Sponsors and Supporters

- Host farms, producers and staff
- Participants
Where is the risk?

• Inefficient use and management of the environmental control system can lead to

  ↑ Energy Use and Electricity Cost

  ↓ Cow Comfort and Milk Production
Energy Use on a Dairy

Energy Consumption

- Ventilation – 24%
- Lighting – 17%
- Electric Water Heating – 5%
- Milk Cooling – 26%
- Milk Harvesting – 18%
- Other – 10%

Considerations

- High Cost
- High Volatility
- Energy Use Changes
  - Lower Carbon Footprint
  - Economic Incentives


Energy Use and Milk Production

Energy Sources
- Feed
- Lighting
- Ventilation

Feed Efficiency → ????

Energy Intensity → Energy Used per Lb of Milk Produced
Heat Stress

- Energy use patterns during periods of heat stress
  - Milking system
  - Lighting
  - Ventilation fan use
  - Mixing fan use
  - Addition of evaporative cooling
Clickers!
What percent of days is the THI above 68 in a typical Midwestern Summer?

1. 30%
2. 40%
3. 50%
4. 60%
5. 70%
6. 80%
7. 90%
What is the estimated economic impact of heat stress to the dairy industry?

1. Similar to mastitis
2. Similar to reproduction
3. More than mastitis
4. More than reproduction
5. Less than mastitis or reproduction
6. More than mastitis and reproduction
Workshop Outline

Understanding the Impacts of Heat Stress on the Cow

Identifying and Evaluating Energy Use Changes

Understanding the Basics of the Environmental Control System
IMPACTS OF HEAT STRESS
Impacts of Heat Stress

- Incidence of Heat Stress
- Economics of Heat Stress
- Cattle Response to Heat Stress
Environmental Control System Basics

- Ventilation Concepts
- Evaporative Cooling
- Convective Cooling
- Control System
Identifying and Evaluating Energy Use Changes
Electrical Energy Used Per Lb of Milk Produced

Temperature, F

2011  2012  2013

kWh/lb milk produced

0.00  0.01  0.02  0.03  0.04  0.05  0.06

0  20  40  60  80  100
Heat Stress Management Plan

- Setting a baseline
- Observations and measurements
- Comparison to baseline
Summer Workshops: 
Evaluating Heat Stress and Energy Use on Dairies

- July – Southwest Minnesota
- Late July – Central Minnesota
- August – East Central South Dakota

Stay tuned for more details...
How do cows respond to heat stress?

A. Pant - ↑ BT - ↑ Resp - ↑ standing

B. ↑ BT - ↑ Resp – Pant - ↑ standing

C. ↑ Resp - Pant - ↑ standing - ↑ BT

D. ↑ Resp - ↑ BT - ↑ standing - Pant

E. ↑ Resp - ↑ standing - ↑ BT Pant
### Effect of THI on Behavior

<table>
<thead>
<tr>
<th>Activity</th>
<th>63.6 THI</th>
<th>71.6 THI</th>
<th>56.3 THI</th>
<th>73.8 THI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lying time, hr/d</td>
<td>8.65&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9.12&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10.93&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.91&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Standing in stall, hr/d</td>
<td>4.27</td>
<td>3.47</td>
<td>3.41</td>
<td>3.95</td>
</tr>
<tr>
<td>Standing in alley, hr/d</td>
<td>3.20&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.18&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.55&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.48&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a,b</sup> Different superscripts are different ($P<.05$)

Cook et al, ASABE 2007
Effects of Heat Stress on Rumination
Embryo Loss for Different THI

Summer vs. Winter:
- 3.7 times more likely to lose embryo
- 5.4 times more likely to lose embryo if twins

(Lopez-Gatius et al., 2004)

Adapted from Garcia-Ispierto et al., 2006
Total dry matter intake and pounds of dry matter required for maintenance with increasing environmental temperature (dew point = 30)

Slide compliments Bilby, 2012
Higher producing cows suffer the most from heat stress.
How about cooling dry cows?
How much does cooling dry cows increase milk production the next lactation

A. None
B. 0-5 lbs/cow/d
C. 5-10 lbs/cow/d
D. >10 lbs/c/d
Cooling Dry Cows Increases Milk

Slide compliments G. Dahl
Tao et al., *J. Dairy Sci.* 94:5976–5986
How much more do calves from cooled cows milk once they begin lactating?

A. 0 lbs/cow/d
B. 0-5 lbs/cow/d
C. 5-10 lbs/cow/d
D. >10 lbs/cow/d
Milk production from cows who were cooled or hot in utero

![Graph showing milk production over weeks of lactation]

- **CL**: 68.17 lbs
- **HT**: 58.27 lbs

**trt**: $P = 0.108$

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Adapted from Geoff Dahl
UNDERSTANDING THE BASICS OF THE ENVIRONMENTAL CONTROL SYSTEM
Environmental System Tool Kit

- Exhaust Fans
  Source: extension.umn.edu

- Mixing Fans
  Source: uwex.edu

- Shade or Lighting
  Source: uwex.edu

- Evaporative Cooling
  Source: uwex.edu

Adjustable Controls
Basic Ventilation Concepts

• Air exchange between inside & outside
  – Bring in fresh air, remove excess heat and moisture
  – 500 CFM/1250 lb cow in hot weather (MWPS-32)

• To have air exchange you need
  – Inlets and outlets
  – Something to cause air exchange
    • Exhaust fans in tunnel and cross-ventilated barns
    • Wind in natural ventilation
Ventilation does not...

A. Dilute dust and gases
B. Decrease the barn air temperature lower than outside
C. Bring in fresh air
D. Exhaust heat and moisture
Ventilation Systems

http://www.faromor.com/english/ventilation-systems/power/cross-flow-ventilation

www.milproduction.com
Air Distribution Concepts

• Air distribution throughout barn
  – Airflow pattern
  – Uniform conditions versus dead spots?

• Air velocity at animal level
  – 200-400 ft/min (1-2 m/s) to use fan output
  – 570-800 ft/min (2.9-4.0 m/s) for humid air

• Air is lazy – it takes the easiest path

• Air flows around solid obstructions
Air Velocities at High Ventilation Rate (cross-flow)

- Velocity at Inlet: 350 fpm or 4 mph
- Velocity at Baffle: 587 fpm or 6.67 mph
- Velocity at Feed Rail: 180 fpm or 2.01 mph

Air Exchange Rate for the Building: 64 Seconds

Source: Steve Pohl, SDSU & John F. Smith, KSU
Cooling / Mixing Fan/ Airflow Characteristics

• Fan output (cfm) **not as important** as the air velocity produced at cow level
  – Good throw of air
  – Maintain desired air velocity
  – Direct air where cows should be
Evaporative Cooling Concepts

• Sprinkling cows
• Putting very fine mist into the air
• Using evaporative cooling pads to pre-cool ventilation air
• Each method
  – Has variations in practice
  – Is conceptually different
  – Trades sensible heat for evaporating water into the air and higher humidity
What is my priority area for cooling?

A. Travel lanes
B. Lactating cows
C. Holding pen
D. Hospital cow pen
Control System

• Adjust ventilating system
  – Fans,
  – Inlets and
  – Cooling equipment

• Make decisions and adjustments using
  – Measured inputs (ex. temperature) and
  – User inputs
  – Program logic

• Your automated employee
IDENTIFYING AND EVALUATING ENERGY USE CHANGES
Energy Use Changes

• Energy Audits
  – Identifies energy use by sector or area
  – Most programs include alternatives
    • Infrastructure
    • System Components
    • Management Practices

• Review of your existing system
  – Is my system operating properly?
  – Am I getting everything out of my current system?
Setting a Baseline

• Baseline measurements identify
  – System functionality before a change occurs
  – Means of measuring future efficiency

• Can take multiple forms
  – Observations
  – Records
  – Measurements

• Write it down!
Evaluating Energy Use Changes
Example Method

• Gather monthly milk production, energy use, and temperature data from prior year(s)
• Divide monthly energy use values by milk production for the same time period
• Plot the energy use per milk production numbers calculated previously against average temperature or THI values for the same period
Electrical Energy Used Per Lb of Milk Produced

Temperature, F

kWh/lb milk produced

- 2011
- 2012
- 2013
YOUR TURN
Realigning Mixing Fans

Making the Change

Evaluating the Change
Fan Maintenance Schedule

Making the Change

Evaluating the Change
Airflow Patterns

Making the Change

Evaluating the Change

\[ V = \frac{Q}{A} \]

Shut the door
KEY POINTS
Where is the risk?

• Inefficient use and management of the environmental control system can lead to

  ↑ Energy Use and Electricity Cost

  ↓ Cow Comfort and Milk Production
Summer Workshops:
Evaluating Heat Stress and Energy Use on Dairies

• On-farm workshops Summer 2014
• Will cover costs of heat stress, ventilation basics, and in-barn activities to assess the environmental control system

Stay tuned for more details...
What energy use change are you planning to try (or recommend)?

A. Fan maintenance  
B. Monitor bunching  
C. Track temperatures  
D. Realign mixing fans  
E. Monitor airflow patterns  
F. Review energy bills