Farm Energy IQ

Farms Today Securing Our Energy Future

Dairy Farm Energy Efficiency

Gary Musgrave, Penn State Extension

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Introductions

Dairy Farm Energy Efficiency

Presentation overview

- Definitions of efficiency and conservation
- The most energy intensive dairy applications
- Methods of reducing energy use in energy intensive operations
- Calculating potential energy savings
- Where assistance may be available
- Sources of additional information

Energy Efficiency vs. Conservation

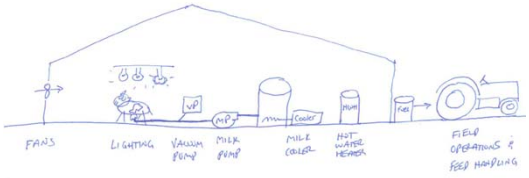
- Energy **efficiency** means using less energy to provide the same service.
- Examples of energy **efficiency** include:
  - Using a heat pump instead of an electric resistance water heater to get the same amount of hot water using less electricity
  - Replacing an incandescent lamp with a compact fluorescent or LED lamp to supply equal light at a fraction of the energy

Energy Efficiency vs. Conservation

- Energy **conservation** is reducing or going without a service to save energy
- Examples of energy **conservation** include:
  - Turning off a light
  - Turning down the thermostat

Energy Use on the Dairy Farm

aka Dan's Dairy Farm



Credit: Dan Ciolkosz, PSU

Energy Efficiency on the Dairy Farm

1. Use a Variable Speed Drive (VSD, also called Variable Frequency Drive) on the milking vacuum pump
2. Add a well water pre-cooler before the milk refrigeration system
3. Recover heat from the refrigeration compressors
4. Tune up the vacuum system
5. Buy more energy efficient ventilation fans
6. Upgrade to more efficient lighting

Energy Efficiency on the Dairy Farm

7. Clean ventilation fans
8. Replace motors with properly sized, energy efficient motors
9. Use a VSD on the milk pump
10. Switch to an energy efficient feed storage and delivery system
11. Use a timer on engine block heaters

Variable Speed Drives (VSD)

So, what is a variable speed drive and what does it look like?

Small variable-frequency drive

Photo credit: Wikipedia, the free encyclopedia

Variable Speed Drives

- VSDs enable electric motors to operate at speeds slower than their nameplate rated speed thus using less energy
- VSDs are also known as variable frequency drives (VFDs) because they control motor speed by varying frequency

Variable Speed Drives

Why should I care about VSDs?

- VSDs can save energy
- Slowing down a fan or pump a little can save a lot of energy
- VSDs can reduce wear and tear on equipment
- VSDs can provide better process control, i.e., ventilate or pump to match needs

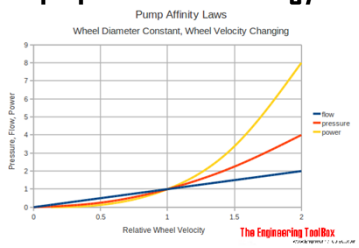
Variable Speed Drives

- VSDs save the most energy–and are most cost-effective—when they are applied to **variable torque loads** such as fans and pumps
- When fan motor speed is cut ½, power consumption is 1/8

Milking Specific Energy Uses

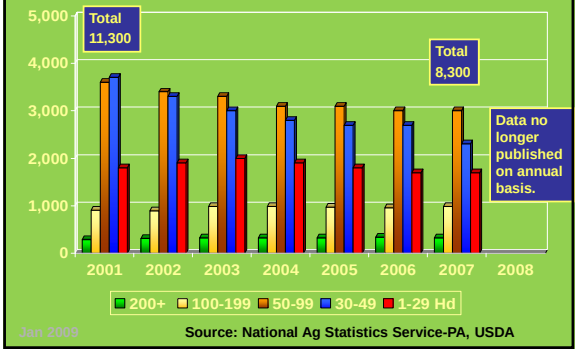
- Milking vacuum pump (#1 opportunity)
  - Without a VSD, vacuum pump operates at full speed; air intake valves admit excess air to meet milking system vacuum requirements. VSDs match vacuum pump operation to the need with no excess air reducing pump operation.
  - **Energy savings are about 50-60%**
  - Tune-up the vacuum pump for optimal efficiency
- Milk pump
  - Pumps milk from receiver to refrigerated tank
  - VSD can be beneficial if milking period is long enough

Pump Speed Affects Energy Use



Note: If pump speed increases *10%*, volume flow increases *10%*, head increases *21%*, and power increases *33%*.

Number of PA Milk Operations by Size



Milking Vacuum Pump Calculations

- The chart above suggests that the greatest number of dairy farms in PA have 50 to 99 head
- So, for a sample calculation, let's try 75 head
- Data for the calculation:
  - 75 head
  - Three milking periods per day, three hours each
  - 7.5 horsepower vacuum pump running at 5.6 kW

Milking Vacuum Pump Calculations

- Annual vacuum pump hours
  - 3 hours per milking
  - 3 times per day
  - 365 days per year
  - Equals 3,285 vacuum pump hours per year
- Annual vacuum pump energy
  - 3,285 vacuum pump hours per year
  - 5.6 kW pump motor
  - Equals 18,396 kilowatt-hours (kWh) per year

Milking Vacuum Pump Calculations

- The cost of 18,396 kWh at $0.10 per kWh is $1,840/yr
- A vacuum pump with a VSD uses about ½ the energy consumed by an uncontrolled pump, saving about $920 per year
- A VSD costs about $550. Therefore, cost is recovered in less than a year and saves more than $900 per year thereafter.
- Utility rebates may be available

Milking Vacuum Pump Calculations

Ventilation and Cooling Systems for Animal Housing

- Generally, efficiency increases with the fan diameter
- Box fan efficiencies range widely from 8.7 to 33 cubic feet per minute (cfm) per watt for 24-in. to 54-in. diameter
- Check out Univ. of Illinois Bioenvironmental and Structural Systems Laboratory (BESS) to compare fan efficiency http://bess.illinois.edu/search.asp

Ventilation and Cooling Systems for Animal Housing

Typical Efficiency and High Efficiency Fans

Fan diameter	Efficiency range*	High efficiency*
24"	8.7 to 19.4 cfm/watt	16 cfm/watt and higher
36"	12.7 to 23.7 cfm/watt	20 cfm/watt and higher
48"	13.5 to 27.0 cfm/watt	20 cfm/watt and higher
50 to 54"	16.1 to 33.0 cfm/watt	23 cfm/watt and higher

* @ 0.05" water static pressure, 230V single phase electrical power

For a 48-in. fan, average efficiency is 17 cfm/watt. A high efficiency fan moves 20 cfm/watt—a nearly 20% efficiency increase!

Source: University of Wisconsin Extension Fact Sheet A3784-6

Ventilation and Cooling Systems for Animal Housing

High-volume, low-speed (HVLS) fans

- Intended for free-stall or loose housing barn applications
- Look like big ceiling fans
- Are considerably more efficient than high speed box fans
- A 24-foot HVLS fan, powered by a 1 hp motor, moves as much air as six 48-in. box fans EACH powered by a 1 hp motor

Ventilation and Cooling Systems for Animal Housing

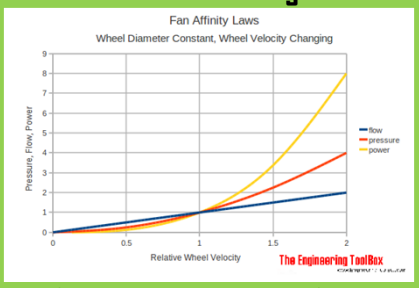
Farmers using HVLS fans report:

- Drier floors
- Fewer flies
- Reduced bird traffic in barns

Ventilation and Cooling Systems for Animal Housing

HVLS fans in a freestall barn

Ventilation and Cooling Systems for Animal Housing



Note: When fan speed increases 10%, volume flow increases 10%, head increases 21%, and power consumption increases 33%.

Energy Efficient Lighting

Energy efficient light sources produce more light for the same amount of electricity than do less efficient sources.

Efficiency is measured in lumens (amount of light) per watt. Approximate efficiency for each type of light:

- Incandescent: 14 lumens/watt
- Compact fluorescent: 60 lumens/watt
- Linear Fluorescent T-8 with electronic ballast: 90 lumens/watt.
- LED: 50-100 lumens/watt

Energy Efficient Lighting

Considerations for an upgrade:

- Cost of upgrade (equipment and installation)
- Maintenance needs
- Suitability of upgraded equipment for application (e.g., vapor tight fixtures, high bay)
- Energy of upgraded equipment compared to replaced equipment
- Utility incentives available to offset a portion of equipment costs
- Options are increasing and LED prices are falling

Engine Block Heaters

- The typical engine block heater takes just 1 to 2 hours to raise a tractor engine to starting temperature
- A simple 24-hour clock timer can automatically turn the heater on at the desired time.
- The energy savings from running the engine block heater unnecessarily will usually pay for the clock timer in 1 to 3 months

Getting a Handle on Energy Use – Keeping Track

- Energy use is difficult to control or reduce until you know how much energy each process uses
- For liquid fuels, it is sometimes a bit easier since they are purchased periodically through some effort on the farmer's part
- Electricity, on the other hand, takes a bit more determination to really know how much is used where

Getting a Handle on Energy Use – Keeping Track

- Start by reading your own electric meter
- Conduct frequent meter readings. Note irregular activities conducted since the previous meter reading to help identify large electric using processes
- The same theory holds true for other energy sources

Getting a Handle on Energy Use – Keeping Track

- Food consumption in a household is usually pretty steady, but if you have a house full of guests, there will be a jump in consumption.
- Likewise with tractor fuel. If you are prepping a new field, consumption will be higher than usual
- The point is, if you keep track of energy use, you may find opportunities to conserve.

Reducing Energy Use – Fuel Cost and Efficiency Improvements

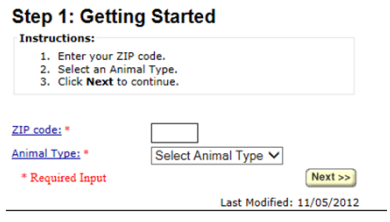
This USDA tool can estimate fuel costs and the benefits of changing/upgrading some of your energy using systems:

http://ahat.sc.egov.usda.gov/

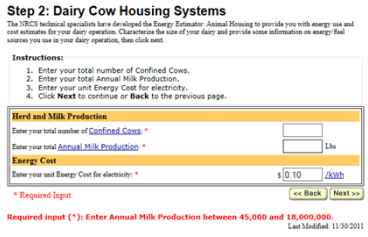
Reducing Energy Use - Efficiency

The first page looks like this:

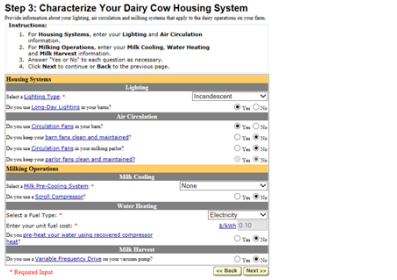
Reducing Energy Use - Efficiency



Reducing Energy Use - Efficiency



Reducing Energy Use - Efficiency



Step 3: Characterize Your Dairy Cow Housing System

Provide information about your lighting, air circulation and milking systems that apply to the dairy operations on your farm.

Instructions:

1. For **Housing Systems**, enter your **Lighting** and **Air Circulation** information.
2. For **Milking Operations**, enter your **Milk Cooling**, **Water Heating** and **Milk Harvest** information.
3. Answer "Yes or No" to each question as necessary.
4. Click **Next** to continue or **Back** to the previous page.

Housing Systems

Lighting

Select a Lighting Type: * — Incandescent

Do you use Long-Day Lighting in your barns? * — Yes / No

Air Circulation

Do you use Circulation Fans in your barn? — Yes / No

Do you keep your barn fans clean and maintained? — Yes / No

Do you use Circulation Fans in your milking parlor? — Yes / No

Do you keep your parlor fans clean and maintained? — Yes / No

Milking Operations

Milk Cooling

Select a Milk Pre-Cooling System: * — None

Do you use a Scroll Compressor? — Yes / No

Water Heating

Select a Fuel Type: * — Electricity

Enter your unit fuel cost: * — $/kWh @ 10

Do you pre-heat your water using recovered compressor heat? — Yes / No

Milk Harvest

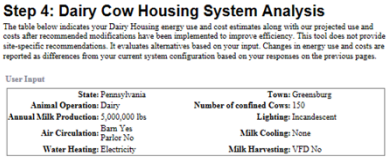
Do you use a Variable Frequency Drive on your vacuum pump? — Yes / No

* Required Input

<< Back | Next >>

Reducing Energy Use - Efficiency

This is a summary of the analysis inputs:



Step 4: Dairy Cow Housing System Analysis

The table below indicates your Dairy Housing energy use and cost estimates along with our projected use and costs after recommended modifications have been implemented to improve efficiency. This tool does not provide site-specific recommendations. It evaluates alternatives based on your input. Changes in energy use and costs are reported as differences from your current system configuration based on your responses on the previous pages.

User Input

State: Pennsylvania	**Town:** Greensburg
Animal Operation: Dairy	**Number of confined Cows:** 150
Annual Milk Production: 5,000,000 lbs	**Lighting:** Incandescent
Air Circulation: Barn Yes, Parlor No	**Milk Cooling:** None
Water Heating: Electricity	**Milk Harvesting:** VFD No

Reducing Energy Use - Efficiency

The results:

Annual Dairy Cow Housing System Analysis

Description	Estimated Annual Energy Use (Units)	Unit	Estimated Annual Energy Cost ($)	Estimated Annual Energy Savings ($)
Lighting				
Your Lighting	**20,700**	kWh	**$2,070**	
Change to T8 *	3,500	kWh	$350	$1,720
Change to Compact Fluorescent *	5,200	kWh	$520	$1,550
Change to High Pressure Sodium	5,800	kWh	$580	$1,490
Change to Halide *	6,200	kWh	$620	$1,450
Change to Mercury Vaper *	12,000	kWh	$1,200	$870
Change to Halogen	14,700	kWh	$1,470	$600
Air Circulation				
Your Freestall Barn	**20,700**	kWh	**$2,070**	
Clean and maintain circulation fans	12,400	kWh	$1,240	$830

Reducing Energy Use - Efficiency

Further results:

Description	Estimated Annual Energy Use (Units)	Unit	Estimated Annual Energy Cost ($)	Estimated Annual Energy Savings ($)
Milking Operations				
Your Milk Cooling	**50,000**	kWh	**$5,000**	
Add Water-Cooled Plate Cooler, VFD, and Scroll Compressor	24,500	kWh	$2,450	$2,550
Add Water-Cooled Plate Cooler and VFD	29,000	kWh	$2,900	$2,100
Add Water-Cooled Plate Cooler and Scroll Compressor	29,500	kWh	$2,950	$2,050
Add Water-Cooled Plate Cooler	35,000	kWh	$3,500	$1,500
Add Scroll Compressor	42,500	kWh	$4,250	$750
Your Water Heating	**50,000**	kWh	**$5,000**	
Pre-heat water using recovered compressor heat	25,000	kWh	$2,500	$2,500
Your Milk Harvest	**40,000**	kWh	**$4,000**	
Use a Variable Frequency Drive on your vacuum pump	22,000	kWh	$2,200	$1,800

Shifting Energy Use to Lower Cost Time Periods

- Some electric utilities offer pricing schemes that reflect actual cost of the electric at the time it is used.
- Such offerings require special metering that records electric use by hour.
- To benefit economically, you have to avoid the highest cost time periods, usually early morning and mid- to late afternoon.

Taking Advantage of Incentives for Energy Efficiency

- Many dairy farm efficiency measures are included in utility rebate programs
- Check www.dsireusa.org for the latest program information

Dairy Farm Energy Efficiency

Summary

- You know the difference between efficiency and conservation
- You know the most energy intensive dairy applications
- You are aware of methods for reducing energy use in those applications
- And, you have a tool to calculate potential energy savings

Farm Energy IQ

Dairy Farm Energy Efficiency

Questions?