# Farm Energy IQ

Farms Today Securing Our Energy Future

Dairy Farm Energy Efficiency

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NORTHEAST SARE Sustainable Agriculture Research & Education

Farm Energy IQ

# Dairy Farm Energy Efficiency

Gary Musgrave, Penn State Extension

## 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

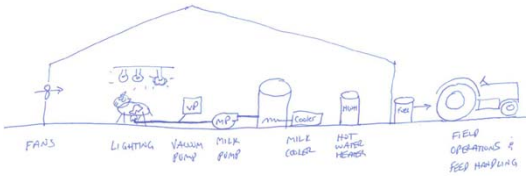
- Energy **efficiency** means using less energy to provide the same service
- Examples of energy **efficiency** include:
  - Using a heat pump instead of an electric resistance water heater to get the same amount of hot water using less electricity
  - Replacing an incandescent lamp with a compact fluorescent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


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

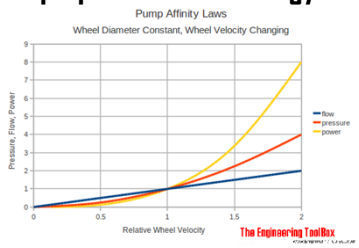
Why should I care about VSDs?

- 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

## 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%*.

## 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

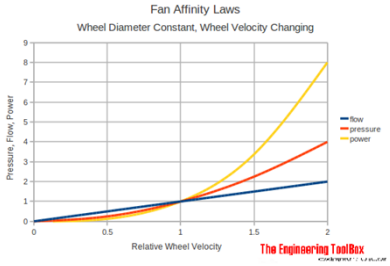
- Intended for free-stall or loose housing barn applications
- Look like big ceiling fans
- Are considerably more efficient than high speed box fans
- A 24-foot HVLS fan, powered by a 1 hp motor, moves as much air as six 48-in. box fans EACH powered by a 1 hp motor

## 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

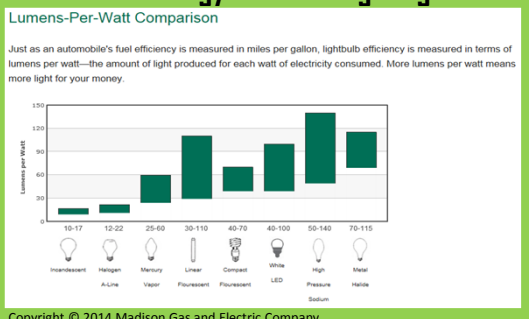



**Note:** When fan speed increases 10%, volume flow increases 10%, head increases 21%, and power consumption increases 33%.

## Ventilation and Cooling Systems for Animal Housing

HVLS fans in a freestall barn

## Energy Efficient Lighting



## Energy Efficient Lighting

Considerations for an upgrade: Cost of upgrade (equipment and installation)

- Maintainability of upgraded equipment
- Suitability of upgraded equipment
- Energy consumption of upgraded equipment compared to replaced equipment
- Utility incentives that may offset some of the equipment costs

## 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

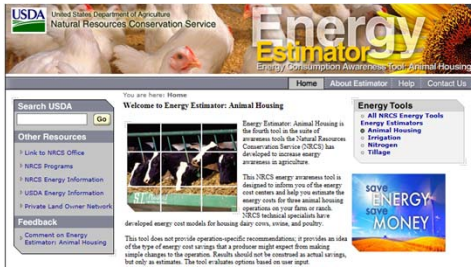
- Start by reading your own electric meter
- Conduct frequent meter readings. Note irregular activities conducted since the previous meter reading to help identify large electric using processes
- The same theory holds true for other energy sources

## 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 - Efficiency

The first page looks like this:



# Reducing Energy Use - Efficiency

**Step 1: Getting Started**

**Instructions:**

1. Enter your ZIP code.
2. Select an Animal Type.
3. Click **Next** to continue.

ZIP code: *

Animal Type: * Select Animal Type

* Required Input

Next >>

Last Modified: 11/05/2012

# Reducing Energy Use - Efficiency

**Step 2: Dairy Cow Housing Systems**

The NRCS technical specialists have developed the Energy Estimator: Animal Housing to provide you with energy use and cost estimates for your dairy operation. Characterize the size of your dairy and provide some information on energy fuel sources you use in your dairy operation, then click next.

**Instructions:**

1. Enter your total number of Confined Cows.
2. Enter your total Annual Milk Production.
3. Enter your unit Energy Cost for electricity.
4. Click **Next** to continue or **Back** to the previous page.

**Herd and Milk Production**

Enter your total number of Confined Cows: *

Enter your total Annual Milk Production: * Lbs

**Energy Cost**

Enter your unit Energy Cost for electricity: * $ 0.10 /kWh

* Required Input

<< Back Next >>

**Required input (*): Enter Annual Milk Production between 45,000 and 18,000,000.**

Last Modified: 11/30/2011

# 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 0.10

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 Vapor * | 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 |

## 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

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## Dairy Farm Energy Efficiency

Questions?