



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



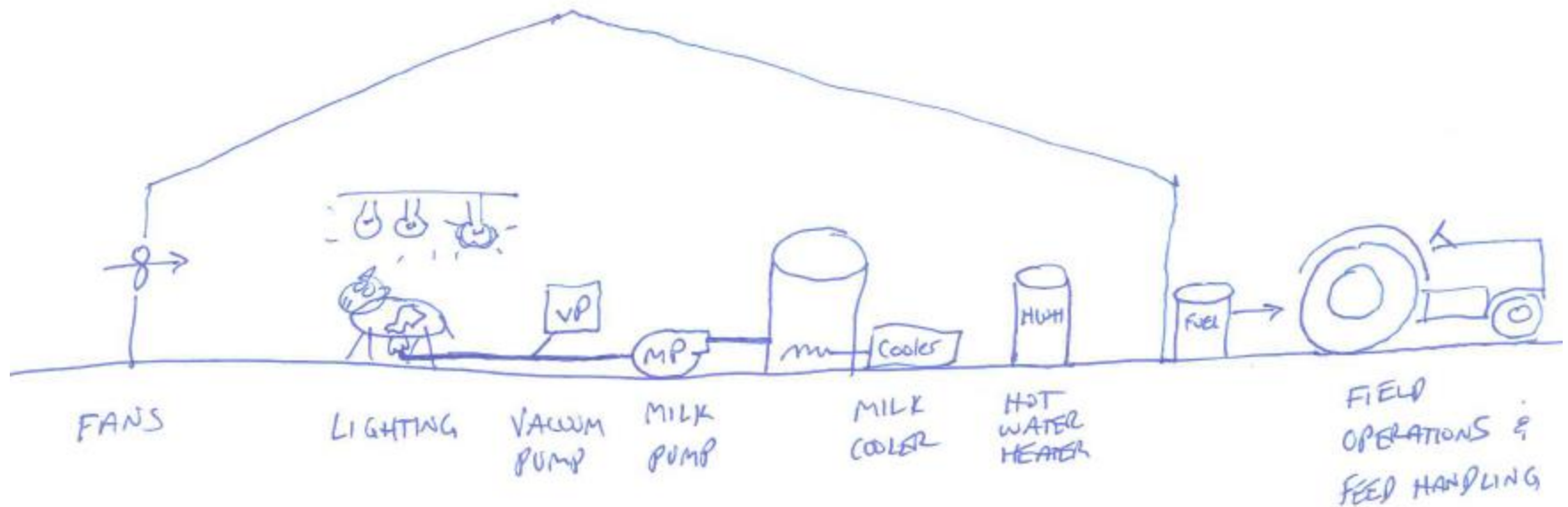
Energy Efficiency vs. Conservation

- 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?



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 $\frac{1}{2}$, power consumption is $\frac{1}{8}$



Milking Specific Energy Uses

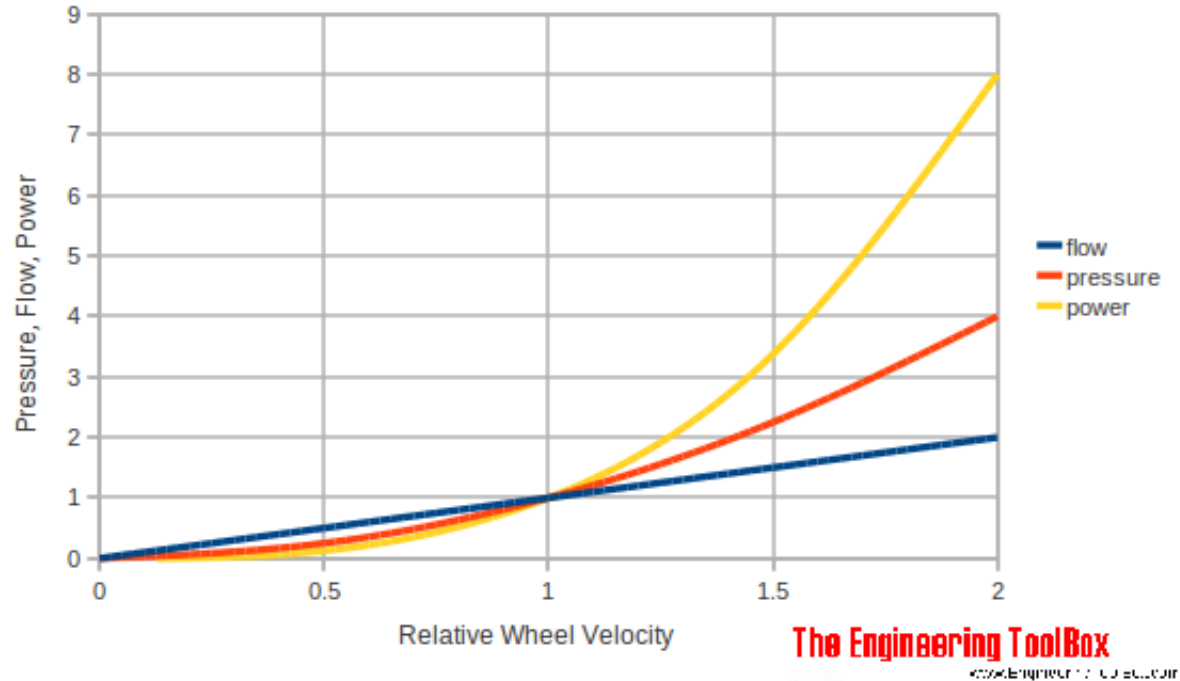
- Milking vacuum pump (#1 opportunity)
 - Without a VSD, vacuum pump operates at full speed; air intake valves admit excess air to meet milking system vacuum requirements. VSDs match vacuum pump operation to the need with no excess air reducing pump operation.
 - **Energy savings are about 50-60%**
 - 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

Pump Affinity Laws

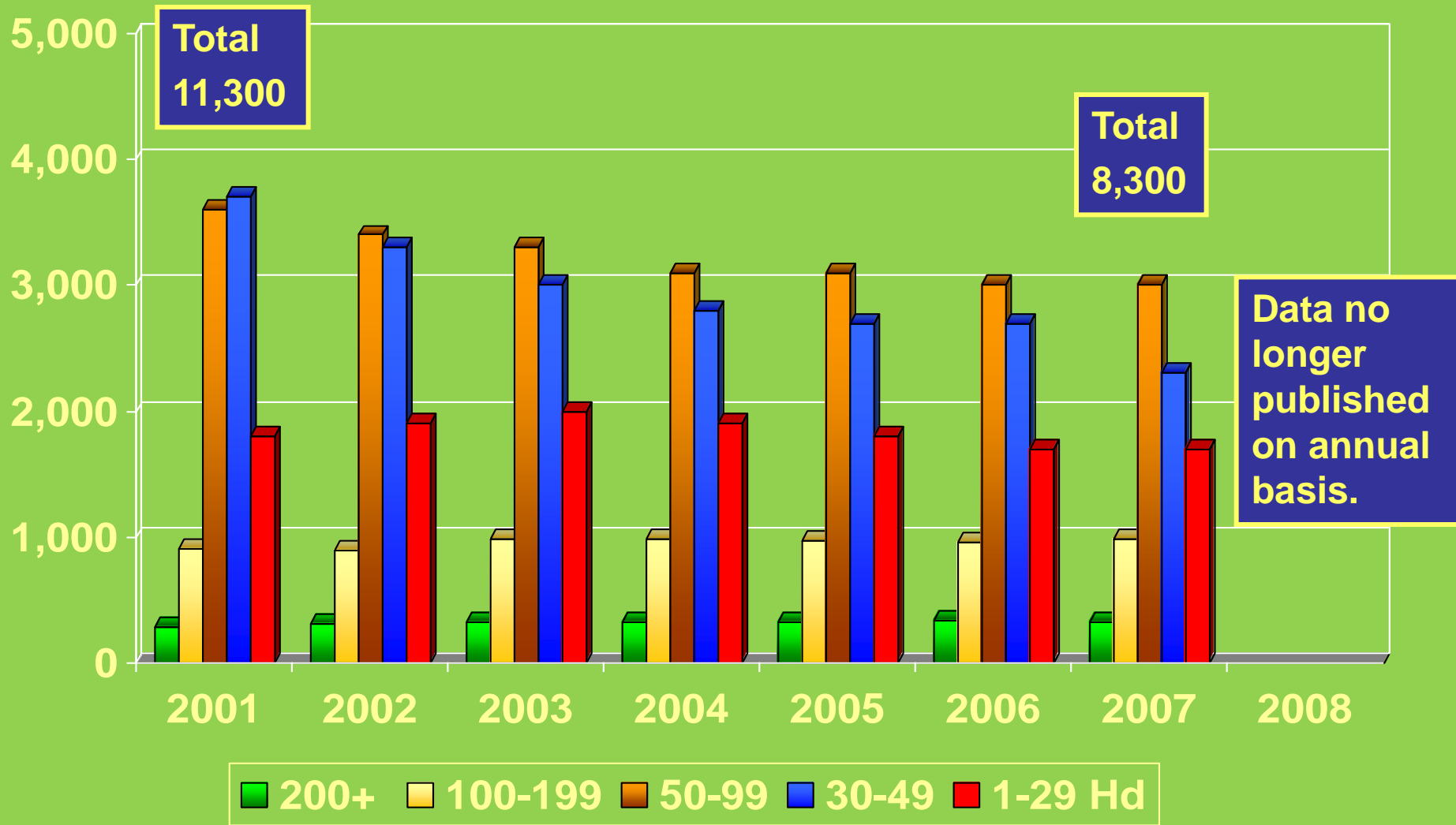
Wheel Diameter Constant, Wheel Velocity Changing



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



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Select Options for the High Performance AC Vector Drive, 1/2 to 15hp, Single or 3 Phase Delta VFD-E

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Choose HP/kW Rating [show help for this option](#)

Choose Input Voltage [show help for this option](#)

Configured Price \$547.30

Configured Part Number VFD055E23A

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!



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

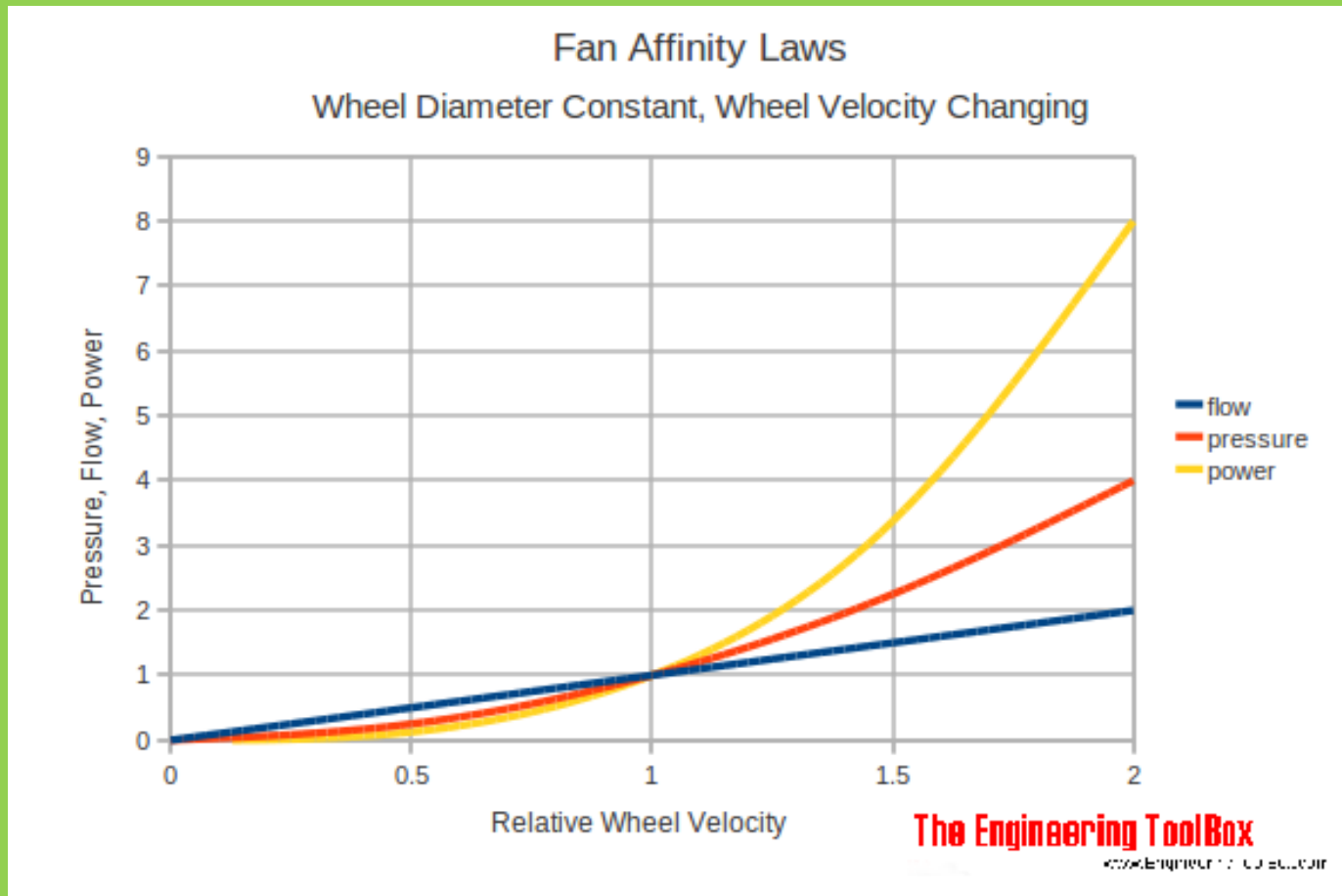


Ventilation and Cooling Systems for Animal Housing



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

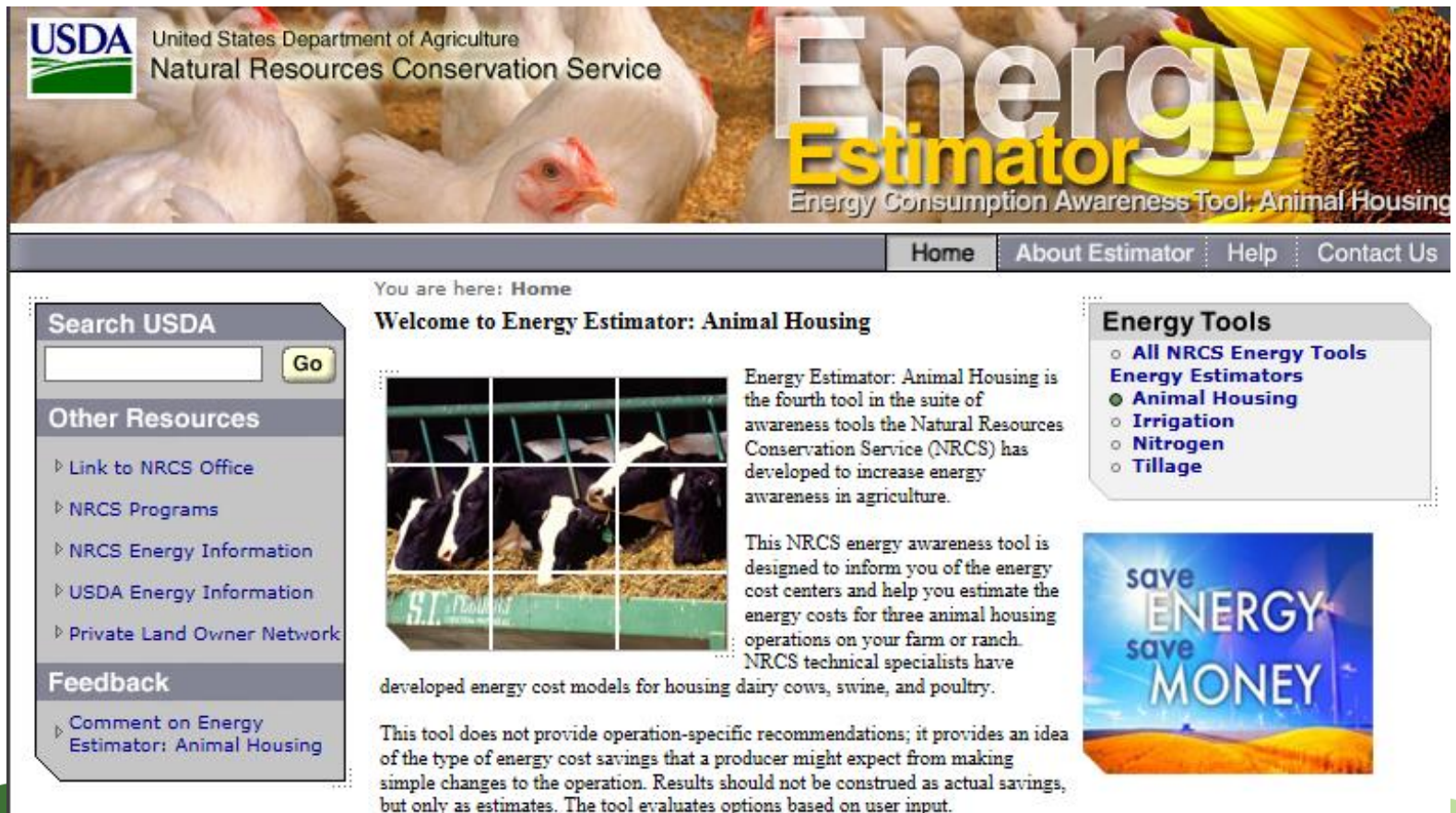
This USDA tool can estimate fuel costs and the benefits of changing/upgrading some of your energy using systems:

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



Reducing Energy Use - Efficiency

The first page looks like this:



The screenshot shows the homepage of the USDA Energy Estimator: Animal Housing tool. At the top, there is a banner with the USDA logo and the text "United States Department of Agriculture Natural Resources Conservation Service". The main title "Energy Estimator" is prominently displayed in large, stylized letters, with "Energy" in white and "Estimator" in yellow. Below the title, it says "Energy Consumption Awareness Tool: Animal Housing".

The navigation menu includes "Home", "About Estimator", "Help", and "Contact Us". The breadcrumb trail indicates "You are here: Home".

The main content area features a welcome message: "Welcome to Energy Estimator: Animal Housing". Below this is a photo of cows in a barn. The text explains that the tool is the fourth in a suite of awareness tools developed by NRCS to increase energy awareness in agriculture. It is designed to inform users of energy cost centers and help estimate energy costs for three animal housing operations: dairy cows, swine, and poultry. NRCS technical specialists have developed energy cost models for these operations.

A sidebar on the left contains a "Search USDA" box with a "Go" button, "Other Resources" (including links to NRCS Office, Programs, Energy Information, and Private Land Owner Network), and "Feedback" (including a link to comment on the tool).

On the right, there is an "Energy Tools" section with a list of tools: "All NRCS Energy Tools Energy Estimators", "Animal Housing" (which is selected), "Irrigation", "Nitrogen", and "Tillage". Below this is a graphic that says "save ENERGY save MONEY" with a wind turbine and sun in the background.

This tool does not provide operation-specific recommendations; it provides an idea of the type of energy cost savings that a producer might expect from making simple changes to the operation. Results should not be construed as actual savings, but only as estimates. The tool evaluates options based on user input.

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: *

\$ /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 <input type="button" value="v"/>
Do you use Long-Day Lighting in your barns?	<input checked="" type="radio"/> Yes <input type="radio"/> No
Air Circulation	
Do you use Circulation Fans in your barn?	<input checked="" type="radio"/> Yes <input type="radio"/> No
Do you keep your barn fans clean and maintained ?	<input type="radio"/> Yes <input checked="" type="radio"/> No
Do you use Circulation Fans in your milking parlor?	<input type="radio"/> Yes <input checked="" type="radio"/> No
Do you keep your parlor fans clean and maintained ?	<input type="radio"/> Yes <input checked="" type="radio"/> No
Milking Operations	
Milk Cooling	
Select a Milk Pre-Cooling System : *	None <input type="button" value="v"/>
Do you use a Scroll Compressor ?	<input type="radio"/> Yes <input checked="" type="radio"/> No
Water Heating	
Select a Fuel Type : *	Electricity <input type="button" value="v"/>
Enter your unit fuel cost: *	\$/kWh 0.10
Do you pre-heat your water using recovered compressor heat ?	<input type="radio"/> Yes <input checked="" type="radio"/> No
Milk Harvest	
Do you use a Variable Frequency Drive on your vacuum pump?	<input type="radio"/> Yes <input checked="" type="radio"/> No
* Required Input	<input style="border: 1px solid black; padding: 2px 5px;" type="button" value=" << Back "/> <input style="border: 1px solid black; padding: 2px 5px;" type="button" value=" 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

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



Dairy Farm Energy Efficiency

Questions?