Farm Energy IQ

Farm Energy Efficiency Principles

TOM MANNING, NEW JERSEY AGRICULTURAL EXPERIMENT STATION, RUTGERS UNIVERSITY

What is energy efficiency? Broadly defined, efficiency means making the best use of resources in performing a task. Energy efficiency is defined as the ratio of work done or useful energy developed to the energy supplied to the process. Efficiency is often expressed as a percentage.

Improving energy efficiency benefits the environment, lowers energy costs, and can simplify and improve operations. This fact sheet includes information on the energy efficiency of different technologies, a summary of common energy savings methods in agriculture, and some basic information on energy units and conversions.

The laws of thermodynamics dictate that every process is less than 100% efficient. In other words, every time energy is converted to perform a task, a certain amount of that energy is lost, in the sense that it is no longer available to perform the task. Improving energy performance means minimizing the losses associated with a process or system. Table 1 shows the efficiency of different energy conversion processes.

Table 1 - Energy Conversion Efficiencies

Conversion process	Energy efficiency
Electric heaters	95-100% (virtually all energy is converted into heat)
Electric motors	70–99.99% (above 200W); 30–60% (small ones < 10W)
Water turbine	up to 90% (practically achieved)
Electrolysis of water	50–70% (80–94% theoretical maximum)
Wind turbine	up to 59% (theoretical limit, 30 – 40% more typical)
Fuel cell	40–60%, up to 85%
Gas turbine	up to 40%
Household refrigerators	low-end systems ~ 20%; high end systems ~ 40–50%
Solar cell	6–40% (15-20% currently)
Combustion engine	10–50% (Gasoline engine: 15-25%)

Light-emitting diode (LED)	4.2–14.9%, up to 35%
High-pressure sodium lamps	12.0–22.0%
Metal halide lamps	9.5–17.0%
Fluorescent lamps	8.0–15.6%
Photosynthesis	up to 6%
Incandescent light bulb	0.7–5.1%

In addition to the general principle of using only as much energy as needed there are some basic approaches that can guide improvements in energy efficiency.

Understanding the energy needs and uses of the operation: Energy use is a complex issue and there are typically many options for solving energy-related problems. A good understanding of the energy requirements of an operation helps in evaluating energy solutions. Reviewing and tabulating utility and fuel bills is critical to understanding current energy use. Cooperative Extension resources and published or online information can help determine the typical energy requirements of similar operations and efficient solutions. Energy audits and energy monitoring can further describe and quantify energy use and help identify potential energy conservation measures.

Sizing systems appropriately, using energy efficient designs: Most equipment that uses energy works optimally when it is sized to deliver the amount of energy needed. For example, an oversized air conditioner often causes excessive temperature swings, is louder than appropriately sized equipment, requires more maintenance because it cycles on and off frequently, is unable to control humidity, and has a higher initial cost. In addition to economic and comfort issues, these problems typically result in higher energy use. Similarly, structures that are larger than necessary cost more to build and the larger surface area typically results in higher heating and cooling loads.

Using high performance equipment: Although high efficiency cooling, heating, lights, and other equipment often cost more initially than similar less efficient devices, energy cost savings attributed to the efficient equipment often quickly makes up for the cost differential. Equipment labels and nameplates provide information that can help compare the relative energy efficiency of equipment.

Maintaining equipment and systems: Many maintenance problems have a direct impact on energy use. Leaking pipes and compressed air systems, underinflated tires, dirty light bulbs, slipping fan belts, broken windows, dirty filters and dusty condenser coils are just some of the many maintenance issues that waste energy. Regular maintenance and timely repair of problems as they arise extends equipment life and improves energy performance.

Ensuring that structures are well insulated and weather tight: Heating and cooling costs are often a substantial portion of the total energy use of a facility. Insulation, caulking, and weather stripping are typically the energy saving measures with greatest impact on energy use for heating and cooling.

Using functional and efficient controls: Well-calibrated, accurate control equipment provides more precise management of equipment and environments. A space that maintains a consistent temperature will typically use less energy than a space with large temperature swings and provides a better environment for humans, animals or plants. In the worst cases, inefficient controls can cause equipment to work at cross purposes, for example, by running heating and cooling systems at the same time.

Making energy decisions appropriate for the location and specific activities of the operation: Optimal energy solutions are site specific. Good decisions about energy-using equipment and systems depend on a careful assessment of the needs of the operation, the timing and duration of energy use, and resources available at the site.

CHECKLIST FOR ENERGY CONSERVATION

Every farm is unique, so it's not really possible to have a standard approach that applies to all farms. However, the following checklist shows some common things that can be done to improve energy efficiency on the farm.

Field Operations

- ✓ *Reduce number of operations*
- ✓ *Match implement to tractor size*
- ✓ *Operate tractors at optimal speeds*
- ✓ *Combine field operations*
- ✓ *Improve field efficiency*
- ✓ *Minimize depth of tillage*
- ✓ *Take advantage of crop conditions*
- ✓ *Maintain machinery*
- ✓ *Consider alternative implements for similar operations*

Electric Motors (Pumps, Fans, Conveyor belts)

- ✓ *Install high efficiency motors*
- ✓ *Use variable frequency drive (VFD) controls*
- ✓ *Replace standard V-belts with high-efficiency belts*

Pumps

- ✓ *Repair air leaks*
- ✓ *Use large headers*
- ✓ *Maintain minimum necessary pressure*
- ✓ *Use synthetic lubricants*

Lighting

- ✓ *Use efficient fixtures (bulbs and ballasts)*
- ✓ *Design lighting for desired light levels*
- ✓ *Maintain fixtures and lamps*
- ✓ *Use occupancy sensors and other intelligent controls*
- ✓ *<u>Grow lighting for greenhouses:</u>*
  - ✓ *Schedule for off-peak hours*
  - ✓ *Stagger lighting schedules to minimize peak loads*
  - ✓ *Arrange lights in accordance with manufacturer's recommendations*
  - ✓ *Adjust intensity to crop needs*

Heating and Cooling

- ✓ *Insulate heated and cooled spaces*
- ✓ *Use strip doors and loading dock seals*
- ✓ *Use high efficiency boilers, furnaces and cooling equipment*
- ✓ *Maintain boilers, filters, and steam systems*
- ✓ *Run heating and cooling systems only as needed and never simultaneously*
- ✓ *Use multiple appropriately sized units (boilers, compressors, etc.) instead of a single large unit*
- ✓ *Install radiant heat where appropriate (not recommended for greenhouses)*
- ✓ *Use heat or energy recovery for ventilation air*
- ✓ *Consider automated controls*

COMMON ENERGY UNIT CONVERSIONS

Energy Unit Conversions

British thermal unit (Btu)	1	0.00095
Watt-hour	0.293	0.000278
Joule	1,055.06	1
Calorie (Cal)	252.164	0.239
Therm	1/100,000	9.48×10^{-9}

Common Conversions

From:	*To:*	*Multiply by*
hp (mech)	W	745.7
hp (boiler)	Btu/h	33,445.7
ft	m	0.3048
gal	L	3.79
lb	kg	0.454

This project supported by the Northeast Sustainable Agriculture Research and Education (SARE) program. SARE is a program of the National Institute of Food and Agriculture, U.S. Department of Agriculture. Significant efforts have been made to ensure the accuracy of the material in this report, but errors do occasionally occur, and variations in system performance are to be expected from location to location and from year to year.

Any mention of brand names or models in this report is intended to be of an educational nature only, and does not imply any endorsement for or against the product.

The organizations participating in this project are committed to equal access to programs, facilities, admission and employment for all persons.