Energy Facts: Reducing Energy Requirements for Harvesting, Drying and Storing Grain
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ENERGY FACTS

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Reducing Energy Requirements for Harvesting, Drying and Storing Grain

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Drying grain with heated air requires large amounts of energy. Energy is used as a heat source to evaporate moisture, and it also runs conveyors and fans. By far the most energy is used to evaporate moisture. While the most positive way to reduce the energy needed to dry grain is to reduce the amount of moisture evaporated, other practices in planting, harvesting, handling, drying and storing grain can also reduce the total energy requirements for a given system. The approximate energy requirements for producing an acre of shelled corn is shown in Table 1.

SYSTEM EFFICIENCY

A grain-handling system moves grain from harvest to utilization and includes machinery, equipment, structures and methods. An efficient system should:

1. provide the needed capacity to complete harvest in a reasonable amount of time.
2. maintain grain quality.
3. utilize available fuels with reasonable efficiency.
4. provide some flexibility in methods of drying, handling and cooling grain.
5. utilize harvesting, handling and marketing methods and techniques for reducing total energy needs.

DRYING EFFICIENCY

Evaporating a pound of water from grain with a grain-drying unit requires from 1,300 to 3,000 BTUs per pound. The variation is due to several factors, including rate of airflow, temperature and humidity of the drying air, type of drying unit, management of dryer, condition of grain and weather. In general, low airflows combined with limited additional heat, use BTUs efficiently but reduce drying capacity. However, for heated air dryers, substantially increasing the drying-air temperature will result in the most efficient moisture removal.

Each 20 °F increase in temperature approximately doubles the capacity of the air to carry moisture; thus, 120 °F air will carry approximately twice the moisture of 100 °F air, and air at 180 °F will carry approximately 16 times as much moisture as air at 100 °F. High-temperature drying increases the efficient use of heat for moisture evaporation. Thus, using, the highest drying temperature compatible with the type of dryer, rate of airflow and grain quality improves efficiency.

HEAT SOURCES

Bottled gas is the most common fuel for drying grain. It is easy to regulate, is suitable for a range of burner sizes, permits a fairly wide heat modulation for a given heating unit and burns clean so that the products of combustion can be released into the air used for drying.

Table 1 — Approximate energy requirements for corn per acre.*

Operation	Gallons gasoline
Moldboard plow	2.60
Disk (once over)	.90
Harrow	.40
Plant	.90
Spray	.15
Anhydrous ammonia application	1.60
Combine	1.80
Transport	.40
Subtotal	8.75 (= 1,050,000 BTUs)
Drying (13 percentage points of moisture removed—100 bu/A, 2,300 BTUs/lb of water removed)	32.70 gal (LP gas) = 2,990,000 BTUs
TOTAL BTUs REQUIRED	4,040,000 BTUs

**These are average figures based on calculations and samplings of farming practices. The individual figures can easily vary from 10 to 50 percent for a particular farm. Energy requirements for the fertilization and irrigating corn will normally be up to two times as much as required for drying.*

Natural gas has the same characteristics as bottled gas and is a good heat source where available. It is also still the least expensive heat source.

Fuel oil heater units are now being provided by some manufacturers after being off the market for a number of years. In general, fuel oil heating units require more management and maintenance than gas burners and do not provide as wide a heat range for a given unit. Certain products of combustion might lead to difficulties.

Solar heat, although widely publicized, provides limited BTUs for drying grain at a relatively high cost and maintenance requirement. It can serve as a supplemental, but not as a primary heat source in Michigan.

Wood or corn cobs can be used as a supplemental heat source for some types of drying units, but they have some limitations. A chamber or furnace is required that prevents products of combustion from entering the drying air. A method for controlling and regulating the amount of heat is also necessary.

Electrical heaters are not recommended heat sources for medium- or high-temperature dryers, but can be used for low-temperature drying in combination with high-temperature dryers for corn at moisture contents below 23 percent.

Farm drying units, from the standpoint of temperature, fall into these general categories:

- Natural-air—ambient temperature + 2 °F from the fan—bin dryers
- Low-temperature—60 ° to 90 °F—bin dryers
- Medium-temperature—90 ° to 120 °F—bin dryers
- High-temperature—140 ° to 200 °F—bin or column dryers
- Ultra-high-temperature—250 ° to 550 °—concurrent flow dryers

Approximately 1.1 BTUs are required to raise 1 CFM of air 1 °F. The total heat required depends upon both airflow and drying-air temperature. Heater capacities commonly range from 300,000 for low-temperature dryers to 5 million BTUs per hour for high-temperature, high-capacity farm dryers. Bottled or natural gas and fuel oil are the only suitable fuels for high- and medium-temperature drying units. The amount of heat per unit of fuel is shown in Table 2.

Table 2 — Approximate BTUs per unit of fuel.

Fuel	Unit	BTU
LP gas (propane)	Gallon	91,500
Natural gas	Cubic foot	1,000
#2 fuel oil	Gallon	140,000
Electricity	Kilowatt	3,413
Wood, corn cobs	Pound	6,500-9,000
Coal	Pound	13,000
Solar energy*	Per sq. foot collector area	150-220

**These figures are average for October and November. Actual usable BTUs for heating drying air in Michigan will be less than this amount due to cloudy days and collector efficiency.*

EFFICIENT ENERGY USE

Although the drying unit is the focal point for reducing energy requirements for drying grain, there are management and technology practices in the grain flow path from harvest to utilization that can reduce the energy requirements. There is need also to consider methods and components that will permit the adjustment of drying practices to reduce the amount of fuel required for drying grain. Following are suggestions that will contribute to the efficient use of energy.

Select Planting Dates and Hybrids

Early planting dates and the selection of early- or medium-maturity corn can reduce harvest moisture by several percentage points without necessarily reducing yield. *Corn Hybrids Compared*, MSU Cooperative Extension Bulletin E-431, available from your county Extension office, is a good guide for comparing yields and moistures.

Adjust Combine Frequently

Frequent adjustment of the combine reduces broken kernels, cornstalks and leaves in corn, as well as corn losses out the end of the combine. Clean corn permits better airflow in the dryer and storage bin. Combines should be adjusted with a change in varieties, a change in fields and every half-day in the same field during the early part of harvest.

Harvest Below 30 Percent Moisture

Harvesting above 30 percent moisture not only increases the moisture to be removed and energy requirements, but also results in greater kernel damage, which can reduce corn quality. The amount of water and the estimated heat required for drying grain is shown in Table 3. Drying from 26 percent moisture to 16 percent moisture, rather than from 30 percent initial moisture, reduces the BTU requirements by 8,770 BTUs per bushel (33,120 − 24,350), or about 24 percent.

Follow Recommended Practices

Most drying equipment provides recommendations for drying-air temperatures and grain depths, if variable. Generally, these recommendations are based on drying efficiency considering both BTUs and drying capacity. Exceeding the recommendation will usually increase the total BTUs used to dry grain. If there is a question about grain depths or drying temperatures, ask the manufacturer for his heat recommendations.

Avoid Overdrying Grain

The two general situations where overdrying results are: (1) drying to a lower moisture content than

Table 3 — Amount of moisture removed and approximate number of BTUs required per bushel to dry corn.

Initial moisture content	Final moisture content							
	12%		14%		16%		18%	
%	Lbs. water	BTU*	Lbs. water	BTU	Lbs. water	BTU	Lbs. water	BTU
30	14.40	33,120	12.80	29,440	11.2	25,760	9.8	22,540
28	12.44	28,610	10.89	25,040	9.4	21,620	8.0	18,400
26	10.59	24,350	9.08	20,810	7.6	17,480	6.2	14,260
24	8.84	20,330	7.37	16,950	5.9	13,570	4.5	10,350
22	7.18	16,514	5.74	13,200	4.3	9,890	2.7	6,210
20	5.60	12,880	4.20	9,660	2.8	6,440	1.4	3,220
18	4.10	9,430	2.73	6,280	1.4	3,220		
16	2.32	5,336	.99	2,270				

**A range of 1,500 to 3,000 BTUs may be required to evaporate a pound of water. 2,300 BTU/lb was used for these calculations.*

necessary for storage, and (2) using excessively high-air temperatures in deep bins which results in overdrying of grain in the lower part of the storage before the grain in the upper part of the bin dries to the desired moisture content.

General recommended storage moisture contents of corn are:

—Over 12 months—small bins with no aeration—13 percent
—10 to 12 months—with aeration—14 to 15 percent
—Less than 10 months—with aeration—15 percent
—Short term (3 to 5 months)—with aeration—15.5 to 16 percent
—Winter storage (2 to 3 months)—with aeration—16.5 to 18 percent

All moistures are based on adequate cooling of grain in the dryer (or storage), aeration in storage and regular inspection of the grain.

Clean Grain

Debris and fines in grain increase the static pressures in the drying unit and storage bin. Fines and debris can also cause pockets in grain dryers or bins which are more dense and take longer to dry or cool. Although removal of fines from grain is often somewhat difficult to do without interrupting the flow rate, removal of even a part of the fines is desirable.

Use Dryeration

The dryeration process takes advantage of grain heat to remove some of the moisture from the grain. Grain is taken from the dryer hot (130° to 140°F), held in a steeping bin for several hours, then cooled with outside air using an airflow of .5 to 1 CFM per bushel. The grain heat increases the temperature sufficiently so that 2 to 3 percent of the moisture will be removed from the grain during the dryeration process. Thus grain taken from a drying unit at 17 to 18 percent moisture can be dried to 15 percent moisture in the dryeration process with a substantial savings of energy and often with an improvement in grain quality.

It is strongly recommended that grain cooled in a steeping bin be removed from that steeping bin and stored in a different bin, because of condensation that occurs in the bin during the cooling. The condensation collects on bin walls and causes an increase in moisture in the grain in contact with or near the bin wall and can result in mold growth and grain spoilage during storage.

Cool in the Storage Bin

More and more operators of grain dryers are doing all or a part of the cooling of grain from high-temperature dryers in the storage bin. This process has the advantage of increasing the throughput of the drying unit and reduces energy requirements by utilizing grain heat combined with an airflow of unheated air to remove from .5 to 1 percent of moisture from grain. An airflow of .25 CFM per bushel or greater is needed for cooling warm grain, and the air should be forced up through the grain. The cooling process differs from aeration of cooled grain in both the amount of airflow (.1 CFM per bushel for aeration) and the direction of airflow. This method differs from dryeration, in that grain is subject to cooling air immediately upon placement in the storage bin.

One disadvantage is the increased condensation occurring in the bin during cooling. Extra care should be taken to make sure all grain around the bin walls is dry, and grain should be inspected at least weekly while in storage.

Use Natural-Air Drying Where Applicable

Natural-air drying can be used in bins 12 to 16 feet deep to finish dry or to dry grain below 20 percent moisture. The heat from the fan motor will increase the air temperature about two degrees. This small temperature rise with an airflow of 2.5 to 3 CFM per bushel provides a slow but positive drying rate that will reduce grain moisture 3 to 5 percent in 20 to 30 days. Natural air (a form of solar-heated air) is often used for drying edible beans, wheat and ear corn. A faster drying rate takes place when outside air temperatures are above 60 °F.

Use Combination or Step Drying Methods and Equipment

Research work at the University of Minnesota has utilized a combination of high-temperature and low-temperature drying methods to reduce energy requirements. Grain is dried from 26 to 28 percent moisture down to 21 and 22 percent moisture in a high-temperature drying unit then transferred to 10,000- to 12,000-bushel bins with a maximum depth of about 16 feet. The storage bins are equipped with large fan units (15 to 20 horsepower) that will provide 1.5 to 2 CFM per bushel of air and a heater unit that will give a 5° to 7 °F temperature rise which will dry the grain down to 15 to 16 percent moisture in 30 days. An additional investment in equipment is required. The economics of a combination drying system is not favorable at today's fuel costs, but this could change if fuel prices increase drastically. This system or the combination of high temperature and natural air may be the best solution to on-farm drying and storage if fuel supplies become limited or farm operators are faced with quotas. By purchasing all new bins constructed to permit the addition of a false floor at a later time, farm operators insure themselves of being able to change to this method of drying at a later date or moving in this direction gradually as fuel prices increase.

Dry to Utilization

Grain dried and stored on the farm for feed does not require drying below 18 to 20 percent moisture if it is fed out by mid-March. A number of Michigan farmers are presently following this practice. Grain must be cooled as it goes into storage. Continuous aeration is recommended until grain temperatures in storage are reduced to 35 °F or lower. Grain at 35 °F temperature and 20 percent moisture will remain in good condition during the winter months (Table 4).

Use Moisture Tester Regularly

Knowing the grain moisture going into and coming out of a drying unit and adjusting grain flow and drying temperatures accordingly can save 10 percent or more in fuel for many farm operators. Regular testing with a moisture tester is recommended.

Limit Grain Depth When Batch Drying in Storage Bins

The static pressure or resistance to airflow through grain increases with grain depth, and as the static pressures increase, the CFM of air from the fan decreases. Limiting the depth of grain in the bins causes higher airflows per bushel which results in less overdrying of the bottom layers and more rapid drying of the batch.

Table 4 — Maximum time for storing shelled corn at various corn moistures and air temperatures.

Air temperature °F	Corn moisture content			
	15%	20%	25%	30%
	Days			
75°	116	12.1	4.3	2.6
70°	155	16.1	5.8	3.5
65°	207	21.5	7.8	4.6
60°	259	27	9.6	5.8
55°	337	35	12.5	7.5
50°	466	48	17	10
45°	725	75	27	16
40°	906	94	34	20
35°	1,140	118	42	25

Use Grain-Stirring Devices

Field experience shows that when a grain-stirring device is used there is more uniform drying through the bin, increased airflow through the grain, some increase in drying rate and more efficient use of heat because a higher temperature can be used for drying. When stirring devices are used in bins with 6 feet or more of grain, overall efficiency per pound of water removed probably changes very little when power to run the stirring devices is included. However, with good management, overdrying could be reduced on many farms, resulting in a fuel savings.

Good Management Practices

There is no substitute for good management practices to reduce the energy requirements for drying and handling grain and maintaining grain quality. Such practices as cooling grain in the storage bin, storing grain at 15 to 16 percent moisture or higher for short periods are recommended if:

- grain is harvested below 30 percent moisture.
- combines are adjusted regularly in the field.
- grain moisture is checked in and out of the dryer.
- temperature-sensing devices are used in large bins.
- proper aeration methods are followed.
- grain is inspected regularly.

If farm operators know and control the moisture content of their grain, the energy requirements for drying can be reduced and grain quality maintained.

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