ENERGY-RELATED AGRICULTURAL BEST PRACTICES

Grain Drying

For Grain Farms

Farms can use less energy, save money, and be more resilient through equipment upgrades that pay for themselves

There are several measures and technologies available to help grain farms reduce energy use and save money. Grain farms include corn, soybeans, small grain (wheat, rye, oats) and more.

Grain Drying Best Practices

Grain drying systems are often a crucial tool after harvest to reduce moisture for short-term economic benefits when delivering the crop to market, as well as to help preserve the grain for longer-term storage to eliminate supply chain / delivery issues and strategically increase profit margins based on market conditions. As important as a grain drying system can be for a farm, it is often one of the most energy-intensive system within the entire operation. If improvements can be made that reduce energy needs for the grain drying system, it can make a substantial difference in reducing energy use and variable costs, and likely increase profitability for the farm operation.

1. Types of Grain Drying Systems

Grain dryers are generally divided into batch and continuous flow type dryers. Dryers can be operated at high temperatures using propane or natural gas to heat the air. Continuous flow dryers are usually described by the air flow path in relation to the grain flow hence grain dryers have names that include cross flow, concurrent flow, counter flow, and mixed flow.

Batch Bin Dryers are the simplest dryer requiring a storage bin with a perforated floor and a blower to move heated air through the grain. The grain is screened and dried in layers of 2 to 3 feet at a time. The largest disadvantage of this dryer type is over drying of grain; in order to get the grain on top dry, the grain on the bottom is often over dried. This reduces grain weight and increases energy use.

Continuous Flow Counter-Flow Bin Dryers have the grain and air flow in opposite directions, and are one of the more popular continuous flow dryers. Typically, a round bin is used that has a perforated floor and a sweep auger. Heated air is pushed up through the grain while the sweep auger removes grain as the control system indicates the grain has reached the desired moisture. Hot grain is typically moved to a cooling bin when it is discharged from the dryer. One advantage of this dryer type is that wet grain can be piled on top of the drying grain, eliminating the need for a separate wet holding bin.

Continuous Flow Cross-Flow Dryers are one of the more popular continuous flow dryers. In this type of dryer, the air flow is generally perpendicular to the grain flow. The grain flows by gravity down a 10 to 16 inch column as the heated air blows across the grain column. The energy efficiency is a function of the plenum air temperature and the air flow rate with the highest efficiency occurring at high plenum temperatures and low air flow rates. In practice high efficiency is not achieved due to grain quality issues. The lower the air flow rate the higher the grain moisture content difference between the grain kernels on the inside versus the outside of the column. Many manufacturers have developed methods to mix the grain as it flows down the column to lessen the moisture variation at the dryer discharge.

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Continuous Flow Mixed-Flow Dryers are column dryers that have air flow in both counter and concurrent directions. These dryers often have multiple zones and can use higher air temperatures without crop damage than cross-flow dryers because like the concurrent flow dryers, all grain kernels are exposed to the same air temperatures. The dryers are usually self-cleaning and have energy efficiency similar to a counter-flow dryer, using about 40% less energy than a cross-flow dryer without heat recovery. One major advantage compared to a dryer with a screen column like a cross-flow dryer is the ability to use the dryer for a wide variety of different grains; from small rape seed to corn or soybeans. This type of dryer has a higher capital cost.

When selecting a new dryer, the efficiency (as measured by Btu/lb water removed) should be higher than the existing dryer. If the farm operation's existing bins are in good condition and wish to be utilized, those bins could be adapted to high-efficiency by installing a Shivvers system. If an operation wishes to adopt an entirely new continuous flow drier system, considerations should be made for mixed flow, heat recovery, vacuum cooling, and other energy saving features, as budget allows.

2. In-bin Cooling

Bin cooling is where the hot grain is delivered directly from the dryer to the final storage bin for cooling. Cooling is started as soon as enough hot grain has been put in the bin to maintain an air seal over the entire floor. The bin cooling process allows grain to 'slow-cool' in bins used for final storage. This increases dryer performance and results in reduced kernel stress cracks. Another form of bin cooling is dryeration, where the grain is left to temper in a drying bin prior to fan operation and then subsequent transfer to a storage bin. Dryeration yields slightly higher grain quality, but the added step slows the process.

Significant energy savings for bin cooling are due to reduced moisture removal in the dryer, which shortens the total batch time. Grain is discharged from the dryer at a higher moisture content (2–2 1/2 points higher in the case of dryeration, 1–1 1/2 points in a bin cooling system). That moisture is then removed during the bin cooling process.

3. Stirrator

Stirrators are used in continuous flow bin dryers. The stirrator moves grain vertically as a stirring device rotates in a circular path slowly around the bin. This lifts dry grain from near the bin floor and allows higher moisture grain to replace it. The stirrator is run continuously when drying but operators need to be careful because excessive stirring causes fines to accumulate on the perforated floor and block air flow, increasing drying times. The largest disadvantage of stirring mechanisms is maintenance and mechanical breakdowns.

4. Moisture Sensing Controls

Central computerized controls will automatically manage the drying process based on the operator's specifications. This includes constantly adjusting the heater operation, the fan operation, monitoring the target transfer moisture conditions, engaging the grain removal process, unloading into the transfer auger system, and monitoring in-bin cooling. This automation is used to optimize the drying process and maximize the energy savings potential of the overall drying system and each of the drying system's energy saving components.

Table 1. Summary of grain drying recommendations.

	Grain Dryer	In-bin Cooling (aerated floors)	Stirrator	Grain dryer controls	Preventative Maintenance – Crop Storage	Preventative Maintenance – Grain Dryer
Description	High efficiency grain dryer, must be higher BTU/lb water removed than existing dryer. HE systems include Shivvers, mixed flow, dryers with heat recovery, vacuum cooling, etc.	Perforated floors in holding bins for in-bin cooling and can increase dryer capacity by 10–20%	Added to a bin dryer to decrease drying time	Moisture sensor controls in bins used for in bin cooling or with a bin dryer	Check temperature and humidity sensors annually	Seasonal preventative maintenance (clean screens, remove fines, inspect bin floors, etc.)
General Operational Requirements	Higher cost items require higher annual production to justify cost.	Does not apply to dryers with vacuum cooling	Only applies to farms with bin dryers.	All farms benefit from moisture controls	n/a	n/a
Potential Energy Savings	5–50%	10–15%	20–30%	5–20%	0%	1–5%
Typical Simple Payback	9–18 years	4–12 years	3–9 years	5–12 years	n/a	1–3 years

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	Grain Dryer	In-bin Cooling (aerated floors)	Stirrator	Grain dryer controls	Preventative Maintenance – Crop Storage	Preventative Maintenance – Grain Dryer
Possible Barriers	High cost. New equipment requires new training and learning curve.	Existing bin may not accommodate perforated floors.	Some farms report significant operational issues and reportedly abandon the stirrators.	Cost.	Equipment access (which should be corrected).	Equipment access (which should be corrected).
Non-Energy Benefits	Faster drying time, improved grain quality	Improved grain quality and increased throughput / capacity of dryer	Post drying grain condition	Improved grain quality	Avoid product spoilage.	Avoid product spoilage due to uneven airflow; avoid equipment operational issues.
Industry Information and References	U-Wisc, 2019.	Purdue, AE-107.	Farmshow, Vol. 10, Issue 6, Page 16, 1986.	U-Wisc, Extension Bulletin A3784-8.		GrainNet, 2019.

Table Notes:

1. *The column for **"Potential Energy Savings"** represents the potential savings as a percentage of the total energy use for each technology category. E.g., if "refrigeration" as an end use was 20% of a farmer's electricity usage, and if the above table showed a Potential Energy Savings of 25%, then the net effect would be a 5% overall electricity energy savings (20% * 25% = 5%). An individual farmer can then predict the **Economic Benefit** through annual cost savings by taking 5% of their annual bill. So, if a farmer's annual electricity bill is $10,000 then the potential cost savings for implementing HE Refrigeration would be 5% * $10,000 = $500.*
2. *"Simple Payback" is defined as the installation costs divided by the potential energy cost savings. An individual farmer can then predict the **Expected Implementation Cost** by taking the cost savings from item #1 above and multiplying it by the Simple Payback for the Technology being investigated. So, if the HE Refrigeration had a Typical Simple Payback of 3.0 years, then the estimated implementation cost would be $500 * 3.0 = $1,500.*

References:

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- *Stirring Device. University of Wisconsin-Madison, Madison, WI. Available at http://www.ruralenergy.wisc.edu/Information.aspx?Q=AM&Def=IMGSD_G_P2.*

Resources

Energy efficiency resources are being developed for farmers by Cornell Cooperative Extension and the New York State Energy Research and Development Authority, in collaboration with topic-experts in New York State. Visit AgEnergyNY.org to find cost-saving resources for farms:

- Recommendations for energy-efficient technologies
- Conservation practices to optimize energy use
- Easy access to funding resources

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Ready to get started?

Visit AgEnergyNY.org to learn more and to get advice on energy efficiency and farm operations, learn about available grants and incentives, or obtain a free energy audit of your farm operations.

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