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Post-Harvest Management: The Economics of Grain Drying

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INTRODUCTION

Kentucky has over 200 million bushels of on-farm grain storage capacity as of 2016. Since 2002, total on-farm grain storage capacity has increased each year (USDA-NASS, 2017). As a producer evaluates there storage capabilities and post-harvest management strategy, investing in a new grain drying system may be a part of that evaluation. Implementing a grain drying system has plenty of advantages such as increasing your harvest windows, harvest quality, efficiency, and marketing. Conversely, it can often be a significant investment requiring some thought out decision-making. Many factors will affect the decision on whether to implement a drying system including dryer ownership and investment cost, access to fuel and electricity, and management and marketing capabilities. Examining these factors closely will allow producers to determine the most profitable system for their operation. This publication describes the types of grain drying systems available to Kentucky producers, how to acquire a grain drying system, federal assistance programs, economic costs, and resources to determine the return on investment of a grain drying system.

TYPE OF DRYERS

Several different grain drying systems are used across Kentucky and throughout the US. The type chosen for a particular operation depends primarily on the daily harvest rate and incoming grain moisture content. Recommended operating conditions for each system are based on an efficient combination of airflow and heat to match the desired amount of moisture removal needed for safe storage (summarized in **Table 1**). Daily drying capacities are estimated for the airflow rate, operating temperature, and harvest moisture for each corresponding system along with the relative initial equipment cost. Available extension publications are also listed to provide more specific information for each system. In general, no/low-temperature bin drying systems offer lower equipment and operating costs but have limited capacity. High-temperature dryers provide higher capacities but must be managed to prevent over-drying grain. By comparison, high-temperature column or tower dryers offer the highest capacities but have higher system costs. The trade-offs between system costs and combined drying and storage capacity often dictate which drying system is used.

Natural Air and Low-Temperature Bin Dryers

Natural air dryers are widely used for corn, soybeans, and wheat when harvest moistures are 18%, 15%, and 15%, respectively. Above these levels, low-temperature drying is needed to control respiration to less than ½% dry matter loss and prevent spoilage. Grain depth for natural air and low temperature drying in Kentucky should be limited (18-ft for corn, 21-ft for soybeans, 11-ft for wheat and 12-ft for grain sorghum) to keep static pressures manageable (less than 4" of water column). All bin dryers should have full perforated floors, a grain spreader, adequately sized fans and adequate roof exhaust vents for good performance.

High-Temperature Bin Dryers

High-temperature bin dryers provide more capacity and are operated in a batch mode (controlled manually or automatically). Grain depths are typically 2 to 4 feet for static beds, up to 6 feet for 'continuous flow'/automatic batch systems, or 6 to 9 feet for stir drying to control static pressure. Multiple axial or centrifugal fans are often used to provide enough airflow for higher capacity systems, so more roof vents are needed than with natural air or low-temperature bin dryers.

Column Dryers

Individual crossflow or rack dryers can provide equal or higher capacities than high-temperature bin dryers and can also be operated in manual or automatic batch or continuous flow modes. Separate wet grain holding is needed in the system so freshly harvested grain can accumulate during the day to allow the harvesting operation to run at full capacity. Similarly, a separate conveyor or small surge bin is needed to handle grain exiting the dryer while wet grain elevators are off-loading trucks from the field. A well-designed system will match the capacities of each piece of equipment to allow for smooth delivery and flow of freshly harvested grain, plus provide for future expansion.

High-temperature, self-contained dryers require larger fans and heaters than bin dryers, so more energy is generally required, although new designs are more efficient than previous models where the flow of grain is uniform and not mixed when passing through the dryer. Column dryers feature vacuum cooling and some 'box' dryers have an optional return duct to recover heat from the process and improve drying efficiency. Alternatively, as with continuous flow bin dryers, hot grain is often moved to a cooling bin where heat from the grain is used to finish drying to the final desired storage moisture level.

Drying Efficiency

Drying efficiency is generally defined as the amount of total energy (electricity + heat) needed to remove the desired amount of water from a bushel of grain (BTU/lb of water). Efficiencies vary with operating conditions (dryer settings, ambient conditions and grain properties) and typical values for each system are shown in **Table 2**.

ACQUIRING A GRAIN DRYER

There are several different financial options to consider when examining the feasibility of investing in a grain drying system. These financial options include cash, a loan to purchase a drying system outright or leasing the equipment of the property. Each of these are highly dependent on the individual operation's financial capabilities. If a loan is the preferred option, the length of the loan should be as close to the taxable depreciation as possible (7 years for a grain dryer). With leasing a dryer, the lease payments are deducted as ordinary business expenses for the life of the lease and at the end of the term length, the lease is bought out and the individual retains ownership. An operator can also benefit from federal assistance programs to help ease the burden of a large long-term loan by making loans more obtainable through less down payment required or more manageable loan interest rates. The best time of the year to acquire a dryer system is in October and November to receive the largest promotional discount from the dealership.

FEDERAL ASSISTANCE PROGRAMS

The two common types of federal assistance programs that apply to grain drying system investments are the USDA Farm Storage Loan Program (FSFL) and the USDA Rural Energy for America Program(REAP). Both have their own eligibility qualification and monetary allocation procedures. Investors should compare both against their specific operations to accurately decide which will be the most beneficial for their situations.

The USDA Farm Storage Facility Loan Program (FSFL) was established in May 2000 and has since issued more than 300,000 loans for on-farm storage and other facilities which is estimated to have increased capacity by approximately 900 million bushels. This loan program provides low-interest financing to producers specifically for building or upgrading grain storage facilities. Although the loan is primarily used for storage systems, operations interested in implanting or upgrading dryer systems are also eligible for both new and used equipment. The FSFL program is an ideal program for established and new farms of small to mid-size operations. With this program producers can borrow up to $500,000 and can receive a term length from 3 to 12 years. This program will also require a down payment of 15% and will waive the three-year production history requirement. More information on the eligibility requirements and loan regulations can be found on the USDA FSFL website at: https://www.fsa.usda.gov/programs-and-services/price-support/facility-loans/farm-storage/

Like the FSFL program the Rural Energy for America Program (REAP) is a loan financing and grant funding program that provides funding to agricultural producers and rural businesses that are interested in investing in renewable energy or energy efficient systems. The loans range from a $5,000 minimum loan to a $25 million maximum loan with up to 85% loan guarantee. The more common term length for this article will have a maximum of 15 years or the useful economic life of the machinery. The grants awarded range from a minimum of $2,500 to a maximum of $500,000 for renewable energy and a minimum of $1,500 to a maximum of $250,000 for energy efficient investments. This program will only support the replacement of a current dryer that is energy-inefficient with a new, energy efficient dryer system. More information about eligibility requirements and loan regulations for the REAP program can be found on the USDA REAP website at: https://www.rd.usda.gov/files/RD_FactSheet_RBS_REAP_RE_EE.pdf

GRAIN DRYING COST CONSIDERATIONS

The investment costs of a new drying system are highly variable depending on dryer type, dryer capacity, and proximity to utilities if three-phase electricity is required. All the above contribute to total ownership and operating costs of grain dryers. Using the cost calculations below, operators can examine the total expenses of implementing a grain dryer system on a yearly basis.

Ownership Costs

The ownership costs (i.e. fixed cost, overhead, indirect cost, or sunk cost) with grain drying systems are the costs that occur regardless of annual usage. These costs include depreciation, interest, taxes, and insurance.

Depreciation

Depreciation is a non-cash expense and is considered a sunk cost and is directly applied to the value lost as the machinery ages and is used. The economic depreciation of machinery is not the same as the tax depreciation. As mentioned above, taxable depreciation for a grain dryer is seven years versus twenty years for economic depreciation. To calculate the depreciation of the grain drying system the purchase price of the dryer, the useful economic life (20 years), and the salvage value are all required. The salvage value of a dryer system is what the dryer is worth once it has reached the economic life. Utilizing the straight-line depreciation method, the average annual economic depreciation is calculated using Equation 1 below.

Equation 1: Annual Depreciation Calculation

$$\text{Depreciation} = \frac{\text{Purchase Price} - \text{Salvage Value}}{\text{Useful Economic Life}}$$

Example: *If an 85,000 bu/capacity grain dryer has a purchase price of $75,000, a salvage value of $10,000, and a useful economic life of 20 years, then the estimated annual depreciation would be: ($50,000 - $10,000) / 20yrs = $3,250. Drying 85,000 bushels annually would equal $0.04/bu depreciation cost ($3,250/85,000 bu).*

Interest

In this case, interest is not the interest rate of the loan but is the opportunity cost of capital. This is a non-cash cost that represents the expected return if the capital used to invest in a grain dryer was used to purchase the best alternative instead. Because the value of a grain dryer system decreases throughout the time of ownership, the average value must be determined. The interest is calculated by multiplying the average value by the interest rate as shown in Equation 2. The appropriate interest rate to use is determined by the expected rate on borrowed capital or the rate of return on the next best investment.

Equation 2: Annual Interest Calculation

$$\text{Average Value} = \frac{\text{Purchase Price} + \text{Salvage Value}}{2}$$

$$\text{Interest} = \text{Average Value x Interest Rate}$$

Example: *Using the same grain dryer in the depreciation example, the average value is: ($75,000 + $10,000) / 2 = $42,500. If the interest rate is 6%, then the annual interest cost of owning the grain dryer would be $42,500 x 0.06 = $2,550 or $0.03/bu.*

Operating Costs

Operating costs for a drying system occur when the system is used. Energy costs (electricity and fuel) represent the majority of the operating cost to run the dryer, augers, and conveyors. These costs are also dependent on the type of dryer system the operation requires. Some dryer systems are more energy efficient than others in addition to requiring less labor for handling the grain. Other operating costs include labor, repairs and maintenance, shrinkage from drying and additional handling.

Energy Costs

Electricity

Depending on the type of dryer, electricity accounts for 2%-4% of the total energy required to dry grain (Edwards, 2014). Three-phase electricity is often required for grain drying systems due to the high demand for unrestricted energy needed to power the large motors. Investment in three-phase electricity can be costly depending on the farms location to a power station. By installing three-phase electricity, the farm is subject to commercial electricity rates rather than residential rates (contact local utility company to negotiate three-phase power and the potential to keep residential rates). **Figure 1** depicts Kentucky average electricity price for October - December (typical drying months) in cents per kilowatt-hour from 2001 to 2016. Utilizing the spreadsheet tool by Edwards (2014), the electrical cost to operate a dryer system in Kentucky is roughly $0.001-$0.002/bu point. Even though electricity prices have increased steadily since 2001, the electric cost to operating a dryer system is relatively constant since it is a small portion of the overall energy consumption.

Fuel

Fuel cost is the highest for operating a high-temperature grain dryer. Approximately 96% to 98% of the energy needed to dry grain comes from fuel. Most dryers run on propane, however some producers in Kentucky have access to natural gas, which also power grain dryers. The U.S. Energy Information Administration reports monthly propane and natural gas prices by state and is available online at: www.eia.gov. **Figure 2** depicts historical propane prices in Kentucky from 1994 – 2016. In addition, **Figure 3** represents historical natural gas prices in Kentucky from 1989-2016 (U.S. Energy Information Administration, 2017). Fuel cost will vary substantially based on dryer system due to energy efficiency differences shown in **Table 2**. Utilizing the spreadsheet tool by Edwards (2014) and 2016-2017 average Kentucky energy prices (electric and propane), on-farm energy costs ($ per bu. point) are calculated for various dryer types and presented in **Table 3.**

Additional Operating Costs

Additional operating costs to consider are repair and maintenance. This article will assume that repair and maintenance are calculated as 3% of the total investment. For example, using the purchase price from the earlier equations ($75,000 x 0.03) is $2,250 in annual repairs and maintenance. If a producer expects to dry 85,000 bu, divide the annual cost by the capacity ($2,250 / 85,000 bu.) which results in a cost of $0.026/bu. Shrinkage costs are also incurred from drying and additional handling. The additional shrinkage from mechanical drying versus field drying and additional handling is 1.676% according to Edwards (2014). Therefore, to determine the shrinkage cost, multiply 1.676% by the grain price at drying. In 2016, the corn price was $3.75/bu at drying, therefore the shrinkage cost was $3.75/bu x 0.01675 = $0.06/bu.

Total Annual Cost

Total annual cost is the sum of the annual operating and ownership costs listed above. Total annual costs will vary by dryer systems due to efficiency differences, investment cost, and management practices. Table 4 provides of break-down of annual operating costs by dryer systems based on drying 85,000 bushels of corn from 20% moisture content to 15% moisture content using 2017 average Kentucky energy prices, the additional operating costs assumptions, and corn price of $3.75/bu. Table 5 provides the total annual cost for each dryer system by combining the annual operating costs with the ownership costs of the dryers. For simplicity, it is assumed that the natural air and low temperature dryer cost $8,000 each and the other dryer systems cost $75,000 with an annual ownership cost of $640 and $5,800 (depreciation and interest) respectively, or $0.01/bu and $0.07/bu.

ECONOMIC BENEFITS OF INVESTING IN A GRAIN DRYING SYSTEM

Kentucky corn and soybean cash prices follow a consistent seasonal pattern during the September to August marketing-year. Figure 4 shows the percentage change in corn and soybean price from September harvest through the following August for the 2010 to 2016 marketing-years. The seasonal increase in corn price is 14% from September to June with prices then declining into the new crop harvest. Soybeans also have a seasonal price increase of 11% from September to May.

The best time to sell stored grain depends upon current prices, managers' expectations of any further price increase, and the cost of storing an additional month. The opportunity cost of the stored grain will drive this decision. This non-cash cost reflects the lost benefit of selling corn and soybeans at harvest and using that revenue to pay debt. If the annual opportunity cost of storing grain is 8%, the monthly opportunity cost would be 0.67% per month. While this seems like a minor cost, the cumulative effect is significant. At $3.75 corn and $9.50 soybeans, the opportunity cost would be $0.025 and $0.063 per bushel per month for corn and soybeans, respectively.

Why does this matter? Consider the decision to sell soybeans in May or store until July to obtain the largest forecasted price increase. The maximum appreciation for soybeans is 11% if sold in July; however, soybean sales in May is more profitable when the opportunity cost of stored grain is included. Storing soybeans two additional months has an opportunity cost greater than the additional revenue.

An additional economic benefit from having a dryer system is the ability to harvest at higher moisture content, which limits harvest loss compared to field dry down. Data from the Midwest suggests combine losses of 10 percent with corn harvested at 15 percent moisture compared to harvesting at 26 percent moisture and incurring 1-3 percent losses (Willcutt, 2001). Furthermore, weather risks increase as grain remains in the field to dry down. Severe weather events late in the year can significantly affect overall grain yield at harvest.

Grain drying and storage are a powerful asset that managers can use to improve farm profitability. To increase farm profitability, managers need to understand the monthly cost of storage and the potential for additional revenue from storing another month.

DETERMINING RETURN ON INVESTMENT

The long term price appreciaiton captured via marketing and yield loss avoidance must be enough to justfiy the investment in a grain dryer. Various methods can assist in determine return on you grain dryer investment and the price appreciation/yield loss avoidance required long term to make the purchase a viable investment. The two most commonly used of these methods are net Present Value (NPV) and Internal Rate of Return (IRR). NPV analyzes the profitability of an investment and compares the present value of the expected benefits to the expected costs. NPV is a dollar value that estimates how much value is created from undertaking an investment. If the NPV of an investment is positive then the investment is economically feasible. If the NPV of an investment is negative, then the investment is not economically feasible and should not be pursued. Instead of a dollar representation of value creation, IRR determines the percent return of an investment. If the IRR of the investment is greater than a producer's required rate of return, then the investment is economically feasible. If the IRR of the investment is less than a producer's required rate of return, then the investment is not economically feasible and should not be pursued. However, if investing in a grain dryer is economically feasible based on either or both methods above does not mean it is financially feasible. Determine if the financials of the farm can support a long-term, capital-intensive investment such as a grain dryer.

CONCLUSION

Although implementing a dryer system typically involves a large initial capital outlay, the advantages of drying grain can make sense for a variety of operations. Every operation will differ both finically and in production capabilities so decision-makers must take into considerations their individual ownership and operating cost. Returns in a drying operation is dependent on the current price and opportunity cost of the investment. Using this information, the net present value and internal rate of return can be calculated to estimate the most profitable dryer type and investment strategy necessary for a dynamic producer base.

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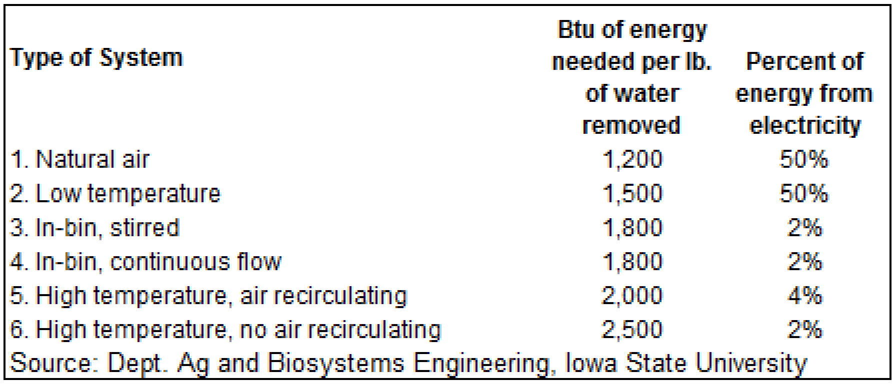
Appendix

Table 1. Comparison of corn drying systems for Kentucky conditions.

Dryer type	Drying capacity bu/day	Airflow rate cfm/bu	Operating temp. °F	Corn harvest moisture %wb	Relative initial cost	UK publication
Bin dryers						
No heat	150	1 2	Outside air	16% 18%	Low	AEN-23
Low temp.	250	1 2	Outside air +5 - 10	16% 19%	Low	AEN-22
In bin, stirred	3,000	8-12	120-140	26%	Low	AEN-62
In-bin, continuous flow	8,000	15-50	160-180	30%	Medium	AEN-63
Column dryers						
Recirculating	8,000	75 - 125	180-220	30%	High	AEN-64
Automatic batch	10,000	75 - 125	180-240	30%	High	AEN-65
Continuous flow	20,000	75 - 125	180-240	30%	High	AEN-65

Table 2. Amount of energy (Btu/lb) and portion supplied by electricity (%) for each grain drying system shown.



Type of System	Btu of energy needed per lb. of water removed	Percent of energy from electricity
1. Natural air	1,200	50%
2. Low temperature	1,500	50%
3. In-bin, stirred	1,800	2%
4. In-bin, continuous flow	1,800	2%
5. High temperature, air recirculating	2,000	4%
6. High temperature, no air recirculating	2,500	2%

Source: Dept. Ag and Biosystems Engineering, Iowa State University

Table 3. On-farm energy costs estimates for Kentucky in 2016 and 2017 ($ per bu point).

Dryer System	2017			2016
	Electric	Propane	**Total**	**Total**
Natural Air	0.012	-	**0.012**	**0.012**
Low Temperature	0.014	0.015	**0.029**	**0.027**
In bin, stirred or continuous flow	0.001	0.033	**0.034**	**0.030**
High Temperature, air recirculation	0.002	0.036	**0.038**	**0.034**
High Temperature, no air recirculation	0.001	0.047	**0.048**	**0.042**

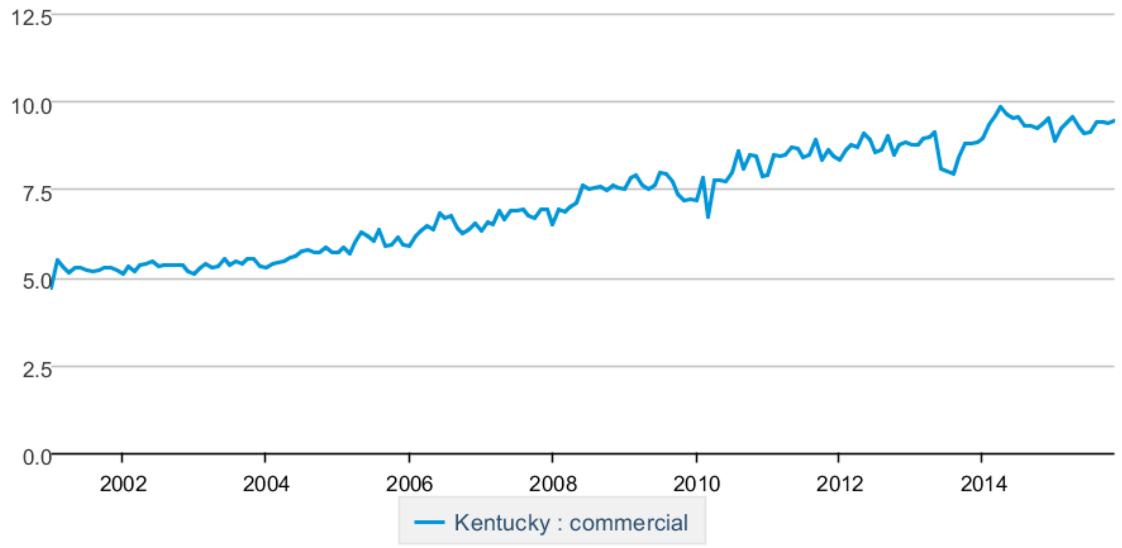
Table 4**.** Annual operating cost ($/bu) and for drying 85,000 bushels of corn from 20% moisture content to 15% moisture content (5 bu points) using 2017 average Kentucky energy prices, the additional operating costs assumptions and corn price of $3.75/bu.

	Energy Cost	Shrinkage	Repairs	Cost of Drying ($/bu)	Annual Operating Cost of Drying 85,000 bushels
Natural Air	$0.06	$0.06	$0.03	$0.15	$12,750
Low Temperature	$0.15	$0.06	$0.03	$0.24	$20,400
In bin, stirred or continuous flow	$0.17	$0.06	$0.03	$0.26	$22,100
High Temperature, air recirculation	$0.19	$0.06	$0.03	$0.28	$23,800
High Temperature, no air recirculation	$0.24	$0.06	$0.03	$0.33	$28,050

Table 5. Total annual cost per bushel and for drying 85,000 bu of corn based on dryer system.

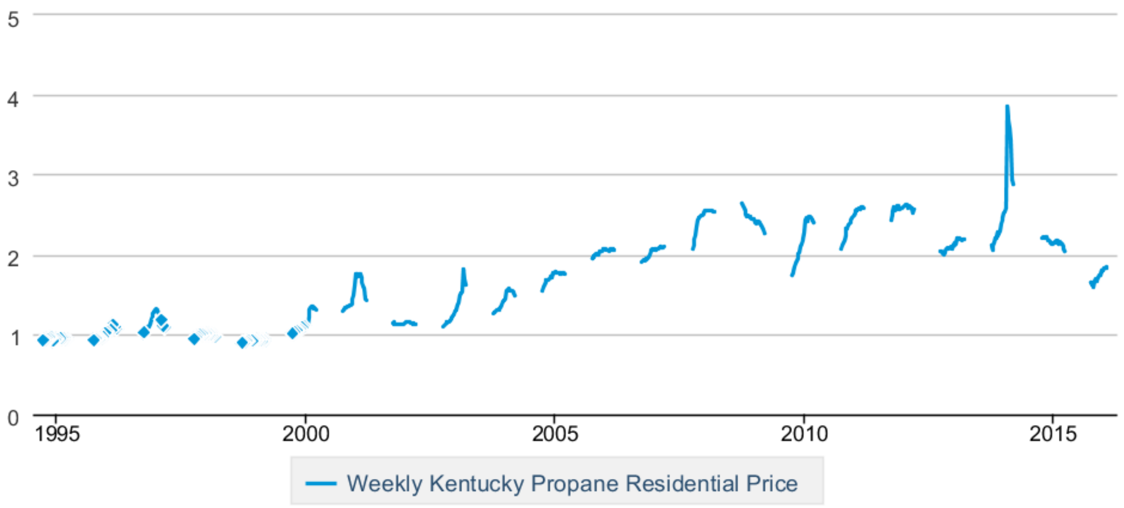
	Annual Operating Cost ($/bu)	Annual Ownership Cost ($/bu)	Total Annual Cost ($/bu)	Total Annual Cost of Drying 85,000 bushels
Natural Air	$0.15	$0.01	$0.16	$13,600
Low Temperature	$0.24	$0.01	$0.25	$21,250
In bin, stirred or continuous flow	$0.26	$0.07	$0.33	$28,050
High Temperature, air recirculation	$0.28	$0.07	$0.35	$29,750
High Temperature, no air recirculation	$0.33	$0.07	$0.40	$34,000

Figure 1. Average retail price of electricity by month for Kentucky (cents per kilowatt-hour)



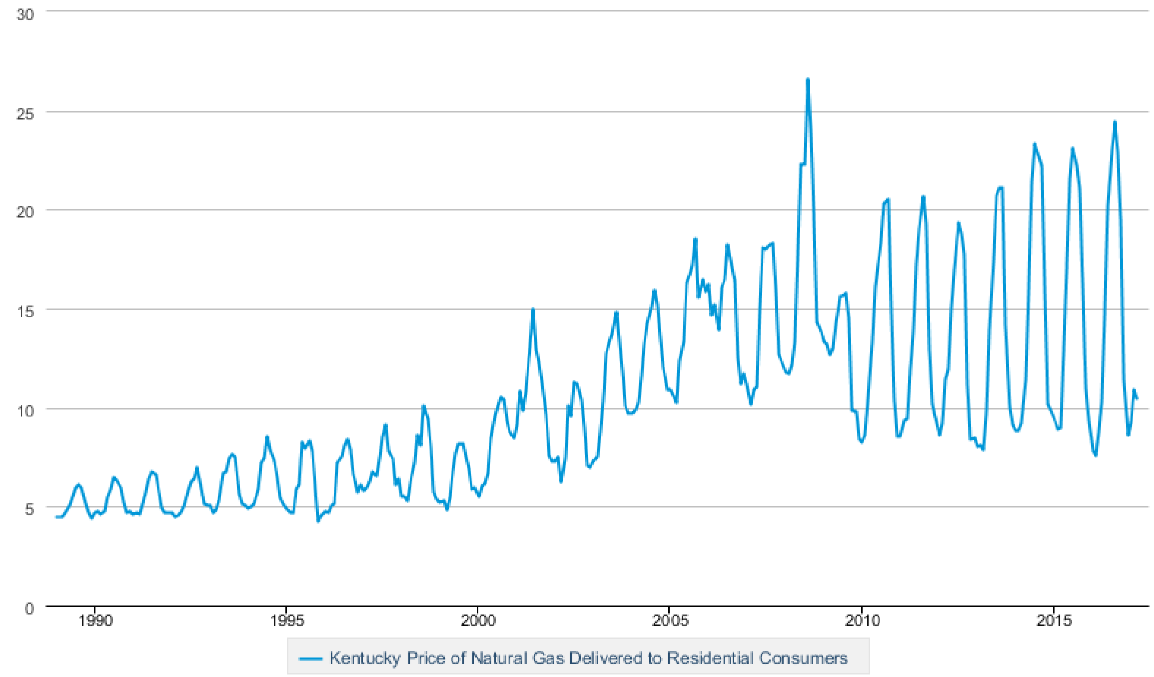
Source: U.S. Energy Information Administration average monthly prices from October-December

Figure 2. Average residential propane price by week for Kentucky (dollars per gallon)



Source: U.S. Energy Information Administration

Figure 3. Average residential natural gas price by month for Kentucky (dollars per 1000 ft^3)



Source: U.S. Energy Information Administration

Figure 4. Kentucky monthly cash price as a percent of September price (USDA NASS: 2010-2016 market year)