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College of Agricultural Sciences Cooperative Extension

Agricultural and Biological Engineering

Burning Shelled Corn --A Renewable Fuel Source

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Introduction

Contemporary agricultural systems produce sufficient quality and quantity of food for the world's population, with additional resources available so that agricultural products can be utilized for other purposes such as fuel, pharmaceuticals, and chemical feedstocks. **Utilizing corn as a fuel does not compete with the food supply needed for nourishment throughout the world.** While it is recognized that malnutrition is a serious global problem, the world is not experiencing a food production problem. Instead, the world faces political challenges associated with providing the infrastructure systems for food distribution and storage.

Shelled corn is a renewable fuel that can be produced within 180 days, compared to the millennia needed to produce fossil fuels. The use of shelled corn as a fuel source will reduce the United States' dependency on foreign sources of petroleum, while at the same time providing increased financial revenues for agricultural areas throughout this country. Shelled corn is a clean-burning fuel as documented by several government studies concluding that there is less environmental pollution associated with burning shelled corn than fossil fuels. Furthermore, corn is very effective in pulling carbon dioxide from the environment and replacing it with oxygen through photosynthesis during the growing season. Burning shelled corn as a fuel can be a feasible way of dealing with the high prices of conventional fuels such as fuel oil, propane, natural gas, and wood pellets.

No one should attempt to burn shelled corn in any fireplace, stove, furnace, or boiler that is designed for some other fuel. Insist on corn-burning certification on the testing label of the stove or other system before burning corn.

Quality of Shelled Corn

For best results, the quality of shelled corn burned in a corn-burning stove must be specified. Moisture content of the shelled corn should be no higher than 15.5%. If the moisture content is higher than 15.5%, there will be less heat available from each pound of shelled corn. Furthermore, corn with moisture content higher than 15.5% is likely to mold and clump together in the hopper and in the storage area.

The price of shelled corn is based on an industry standard of 15.5% moisture content. Purchasing corn with moisture content less than 15.5% is not recommended unless the lower moisture content is required for efficient combustion of the corn.

The shelled corn needs to be clean, with a minimum of fine particles, cob pieces, husks, and other residue. The presence of fine particles may interfere with proper combustion and cause smoking problems. Cob pieces and other materials may interfere with the flow of the corn into the stove's combustion chamber.

It will probably be necessary to purchase a large amount of corn at a time to get the most economical price for the corn. Proper storage of the corn is essential. The corn should be stored in a clean, dry environment. It should not be stored directly in contact with a concrete or dirt floor. If the corn is in bags, the bags should be placed on a pallet in an area free of rodents, birds, and other varmints. Inspect the corn from time to time to ensure that there are no insect or disease infestations and that the corn does not have a musty odor.

Do not purchase a corn-burning stove or boiler without first identifying a reliable supplier of shelled corn. Contact a grain elevator, feed store, or the Cooperative Extension office in your county to locate a dependable supplier of shelled corn. When discussing price with the supplier, be sure to consider the cost for the delivery of the corn to your home.

EQUIVALENT HEATING VALUES

Fuel	Pounds of Shelled Corn
1 ton of Hard Coal	3,360
1 gallon of Kerosene	21
1 gallon of #2 Fuel Oil	22
1,000,000 BTU of Natural Gas	170
1 gallon of Propane	15
1 full cord of Firewood	2,800
1 ton of Wood Pellets	2,575
1,000 kWH of Electricity	635

Energy Content of Shelled Corn

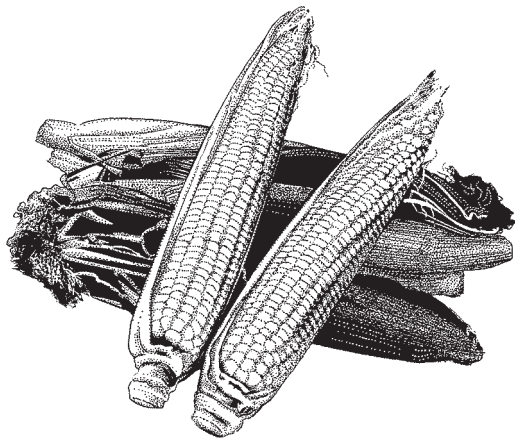
The energy content of shelled corn is not consistent because of biological variability and management factors. The energy content of corn is generally in the range of 8,000 to 8,500 BTU per pound of dry matter. One BTU (British Thermal Unit) is the amount of heat energy needed to heat one pound of water one degree Fahrenheit. The factors that may influence the energy content of corn include variety of corn, weather conditions during growing season, weather conditions at harvest, drying method, and storage conditions.

It needs to be emphasized that the energy content of shelled corn is in the range of 8,000 to 8,500 BTU **per pound of dry matter.** The net energy content of shelled corn with a moisture content of 15.5 % is then 6,800 BTU per pound, a reduction of nearly 17.5 % when the effect of the moisture content is taken into account.

The energy content of shelled corn used in all the analyses reported in this fact sheet and on the Internet web site is based on a value of 6,800 BTU per pound with a combustion efficiency of 75%. The actual energy content of shelled corn would be lower if pieces of cob, husk, or stalks are mixed in with the shelled corn.

Unfortunately, some manufacturers of corn stoves use the energy content figures of 8,000 to 8,500 BTU per pound as though these figures were the energy content of the actual shelled corn itself. They frequently multiply energy content by the number of pounds in a bushel (56 pounds) and then report an energy content of 448,000 to 476,000 BTU per bushel of shelled corn. Figures as high as 10,000 BTU per pound (or 560,000 BTU per bushel) are used in some analyses. Whenever these exaggerated energy contents are used in any analysis, there will be considerable distortion in the results.

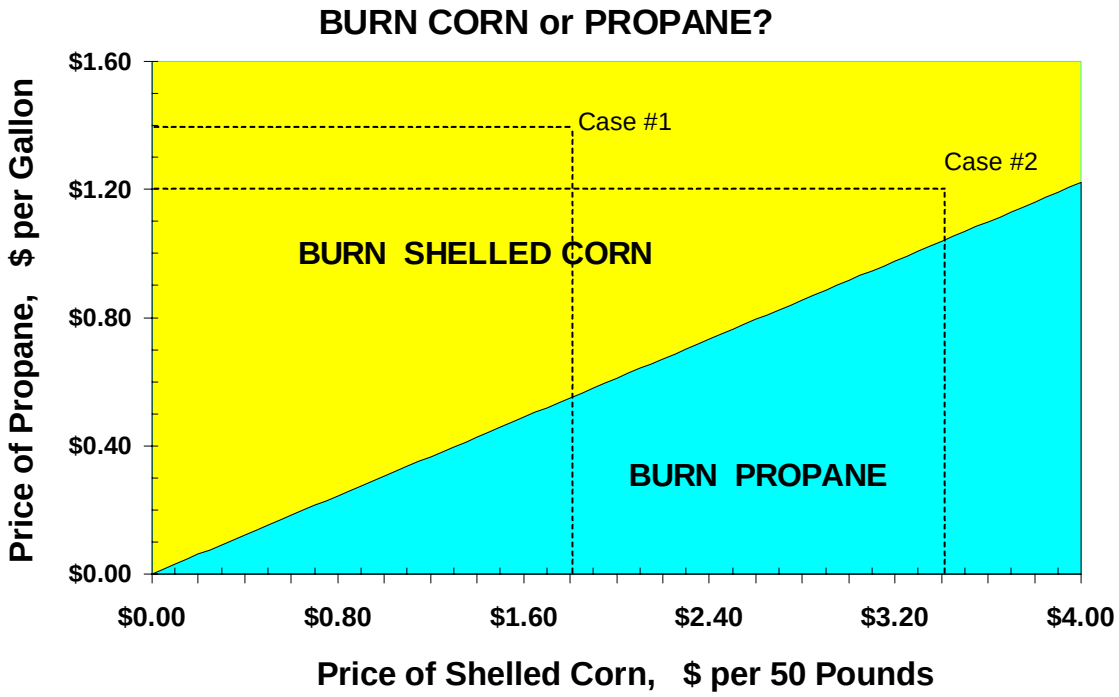
The energy equivalency table above provides a simple way to calculate how much corn would be required to replace the fuel currently being used. For example, if a person uses two tons of hard coal per heating season, then that person would need to use about 6720 pounds of shelled corn (2 x 3,360) to obtain the same heating value. Likewise, a person using 400 gallons of #2 fuel oil would need to use about 8,800 pounds of shelled corn (400 x 22) for the equivalent amount of heat.



Economics of Burning Shelled Corn

Whenever the price of corn is low and the price of conventional energy sources is high, a frequently asked question is “Would it be cheaper for me to burn shelled corn than to buy propane (or any other fuel) to burn?”

The answer to the question is “it just depends.” The “Energy Selector” shown on the next page compares the costs of heating with shelled corn and propane. To use the chart, just find the point on the chart where the price of shelled corn (on the horizontal scale) and the price of propane (on the vertical scale) intersect. The location of the intersection point



on the graph gives the answer to the question of whether it is cheaper to burn shelled corn or propane. Consider Case #1 that was typical in autumn of 2000 when the price of corn was relatively low because of an abundant harvest and conventional fuel prices were very high. Then corn had a value of $1.80 per 50 pounds and the price of propane was $1.40 per gallon. For this case, the two points intersect in the "Burn Corn" territory. So just on the basis of values of heats of combustion, it was cheaper to burn corn than propane for this example.

Consider Case #2 in autumn 2002 when the price of shelled corn was high because of a severe drought during the growing season and the price of energy was relatively stable but at a high level. For this situation, the value of shelled corn was $3.40 per 50 pounds and the price of propane was $1.20 per gallon. The intersection of these two points is still in the "Burn Corn" territory.

The assumed values to develop the Energy Selector shown above were the heating value of shelled corn (6,800 BTU per pound), heating value of propane (91,600 BTU per gallon), combustion efficiency of corn (75%), and combustion efficiency of propane (85%).

You need to recognize that there are additional costs associated with burning corn in place of propane. Additional expenses include combustion system as well as handling and storage facilities for the corn. These expenses are not trivial and must be considered before any final plans are made to burn shelled corn instead of propane.

Energy Selector is a user-friendly decision-aide to compare the heating values available from two energy sources. The input data used for developing each Energy Selector include the heat contents of the two energy sources being compared as well as their combustion efficiencies .

You can develop Energy Selectors to compare many different fuels at the web site **http://BurnCorn.cas.psu.edu** The assumptions concerning energy contents of the fuels and their combustion efficiencies are incorporated into the Energy Selectors that you can develop. If you do not have access to the web site, contact the Cooperative Extension office in your county for assistance.

Burning shelled corn yields far less residue than ashes from burning firewood or cinders from burning coal. The corn ash (after cooling) can be safely applied to garden areas, flower beds, lawns, and fields.

Shopping For a Corn-Burning Stove or Boiler? — Questions to Ask

As you consider the purchase of a corn-burning stove or boiler, you will undoubtedly have many questions. Questions designed to help you gather the necessary information for making an informed decision are listed below. The answers to these questions may vary from model to model. Some answers may depend on personal preferences and the anticipated placement and function of the stove. However, satisfactory answers to all questions should be received from the dealer before committing to a purchase.

1. Does the corn-burning stove have corn-burning certification on the testing label?
2. Does the operator's manual for the stove state that 100% shelled corn can be burned or must the corn be mixed with wood pellets for good combustion? Is a calcium additive (such as oyster shells) required for effective combustion?
3. Are there any other fuels that can be burned in the corn-burning stove? If so, what adjustments or stove modifications are required to burn some other fuel?
4. What are the maintenance requirements of the corn-burning stove compared to other stoves? How often do clinkers need to be knocked loose and removed?
5. Are sugars from burning corn likely to accumulate in the combustion chamber? If so, what is the best way to remove the sugars?
6. What is the recommended moisture content for shelled corn to get good fuel combustion?
7. What type of exhaust ventilation system must be provided for the corn-burning stove?
8. What size corn-burning stove or boiler is needed for the intended application?
9. Can the corn-burning stove or boiler be connected with an existing hot water or hot air distribution system?
10. How much experience does the dealer have with installing and servicing corn-burning stoves and boilers?
11. Which stove models are intended for residential applications and which models are for commercial and industrial applications?
12. What warranty comes with the stove? Under what conditions will the warranty be voided?

Summary

In addition to the economic benefits of burning shelled corn as a renewable fuel, other important benefits include:

- Reduces environmental pollution associated with burning conventional fossil fuel
- Reduces the dependency of the United States on imported fuel
- Increases income to agricultural producers, thus providing more economic development activity in rural America

Additional information on burning shelled corn is available at the web site **http://BurnCorn.cas.psu.edu** The web site includes a list of all known manufacturers of corn-burning stoves and boilers in U. S. and Canada. Please note that the inclusion of a manufacturer on this list does not constitute an endorsement nor does the omission of a manufacturer from the list constitute a lack of endorsement.

For a listing of our other Fact Sheets that are available contact:
Agricultural & Biological Engineering Department
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Telephone: (814)865-7685 FAX: (814)863-1031
www.abe.psu.edu/factsheets

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