BURNING SHELLED CORN AS FUEL

Burning shelled corn as a fuel can be a feasible way of dealing with the high prices of more conventional fuels such as fuel oil, propane, natural gas, coal, and firewood. 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 infrastructure systems for food distribution and storage.

Contemporary agricultural systems can produce sufficient quality and quantity of food for the world's population, with additional resources available so that agricultural products can be used as fuel, pharmaceuticals, and chemical feedstocks. Shelled corn is a fuel that can be produced within 180 days, compared to the millennia needed to produce fossil fuels.

Heat Energy Content of Shelled Corn — The combustion energy content of shelled corn is a critical factor in making energy comparisons of fuels.

Corn Energy Equivalents — This table provides a method of calculating how much shelled corn would be required to replace the fuel currently being used for heating.

EnergySelector — EnergySelector is a user-friendly decision-aide to easily compare the heating values available from any two energy sources.

Shopping for a Corn-Burning Stove? — Questions to ask when considering the purchase of a corn-burning stove.

Locating a Supplier of Shelled Corn — Do not purchase a corn-burning stove without first identifying a reliable supplier of shelled corn.

Quality of Shelled Corn — For best results, the quality of shelled corn burned in a corn-burning stove must be specified.

Storage Requirements of Shelled Corn — Proper storage of shelled corn is important for good performance of a corn-burning stove.

Disposal of Corn Ash — A plan for the proper disposal of corn ash needs to be developed before purchasing a corn-burning stove.

LISTING OF MANUFACTURERS OF CORN BURNING STOVES AND BOILERS:

Click on the desired image below:

Note: The inclusion of a manufacturer on these lists does not constitute an endorsement nor does the omission of a manufacturer from the lists constitute a lack of endorsement.

For more information please contact:

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814-863-1031 (FAX)

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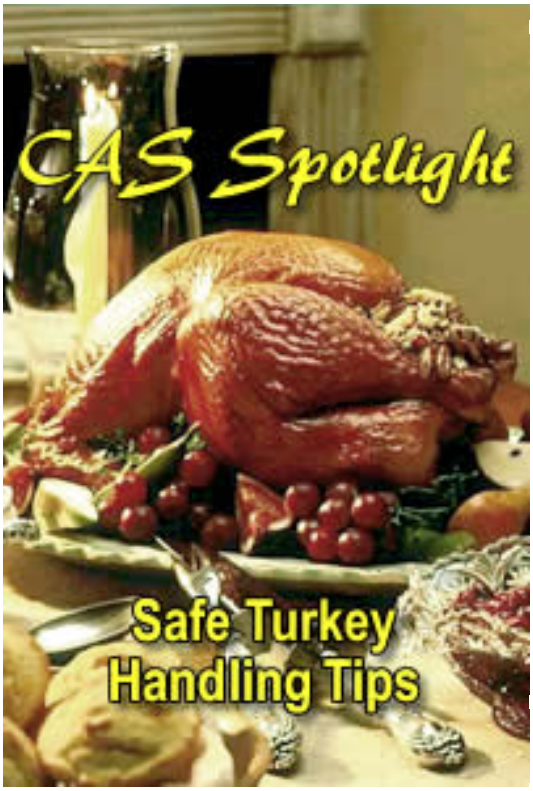

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201 Agricultural Administration Building
University Park, PA 16802
Penn State is committed to affirmative action, equal opportunity, and the diversity of its workforce.
Contact us with comments, questions and feedback .
Wednesday, November 22, 2006 15:38

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Ag Engineering has brochures pertaining to groundwater videos and ag safety.

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Ag Engineering has circulars available in both agricultural safety and health and horse facilities.

Newsletter
The Ag Safety and Health newsletter is produced six times a year 

Check out the latest edition.

To view ABE fact sheets, idea plans, newsletters, circulars, and brochures you will need

NRAES Natural Resources, Agriculture and Engineering Services (NRAES) also has planning material that may be of interest. The NRAES website

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- Managing Agricultural Emergencies
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Meet the Extension Faculty

Telephone: (814)865-7685

Extension Directory A listing of Agricultural and Biological Engineering Department faculty expertise and extension programs.

OMPEC Organic Materials Processing and Education Center. Learn about OMPEC, Penn State's program for composting food waste, landscape debris and manure to produce a useable product.

is: www.nraes.org

 Please e-mail us with your questions, comments or suggestions to the department.

PENN STATE

College of Agricultural Sciences

Agricultural and Biological Engineering

Energy Strategies

ENERGY ALTERNATIVES

- Energy Cost Calculator

  To make an "apples-to-apples" comparison of various forms of energy, the comparisons must be made on basis of Dollars per Million BTUs.

- EnergySelector

  EnergySelector is a user-friendly decision-aide to easily compare the heating values available from any two energy sources.

- Burning Shelled Corn--A Renewable Fuel

  Burning shelled corn as a fuel can be a feasible way of dealing with the high prices of conventional fuels.

ENERGY EFFICIENCY -- SAVING ENERGY AND DOLLARS TOO!

- In the Home Under Construction...
- On the Farm Under Construction...
- In your Cars and Trucks

  There are many simple measures that have the combined effect of substantially increasing our miles per gallon. Not only will we conserve precious energy resources, but we will also save dollars at the same time. Let's take a look at some of these simple measures...

ENERGY ISSUES

- Financial Assistance for Paying Energy Bills

  Pennsylvania has an established network of Universal Service Programs for helping those in need to gain access to affordable energy.

- Options for Paying Your Energy Bills

  Utility companies offer a choice of how your monthly energy bills are calculated and a choice of how you can pay your bills

- Soy-Diesel vs. Bio-Diesel

  The terms "soy-diesel" and "bio-diesel" are not synonymous. Although burning bio-diesel is beneficial, the limitations of burning soy-diesel must be clearly understood.

- Deregulation of Electricity Generation in Pennsylvania

The deregulation of electricity generation provides electricity customers with far more options in terms of how they purchase and use electricity.

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PENN STATE College of Agricultural Sciences

Agricultural and Biological Engineering

EnergySelector

Energy Selectors

With the rising prices of energy, more and more people are questioning what is the best fuel for heating purposes. A frequently asked question this year is:"Would it be cheaper for me to burn shelled corn than propane?" This question is very timely considering that the price of propane is high and going even higher, while the price of shelled corn is quite low because of the bountiful harvest.

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

To obtain the EnergySelector of interest to you, simply choose the two energy sources to be compared from the drop-down menus below. (Note that there is no difference, for example, between a "corn vs. propane" comparison and a "propane vs. corn" comparison.)

Corn Natural Gas

Select

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HEAT ENERGY CONTENT OF SHELLED CORN

The energy content of shelled corn is not a constant value because of biological variability and management factors. Generally the energy content of corn is in the range of 8,000 to 8,500 BTU per pound of dry matter. A BTU (British Thermal Unit) is a unit measure of energy. One BTU 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**, based on bomb calorimeter studies. The term "dry matter" refers to material that is "bone dry." The standard moisture content of shelled corn is 15.5 % moisture on a wet basis. This means that each pound of shelled corn will actually consist of 0.845 pound of dry matter and 0.155 pound of water. Using a median energy content value of 8,250 BTU per pound of dry matter, the energy content of one pound of shelled corn at 15.5% moisture is then 6,971 BTU (8,250 BTU per pound dry matter x 0.845). This figure needs to be further reduced because of the energy required to vaporize the 0.155 pound of water in the shelled corn. The energy to evaporate the water is approximately 163 BTU (1,050 BTU per pound water x 0.155). The net energy content of a pound of shelled corn with a moisture content of 15.5 % is then 6,808 BTU, a reduction of nearly 17.5 % when the moisture content is taken into account. The actual energy content of shelled corn would be even 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. I have seen figures as high as 10,000 BTU per pound or 560,000 BTU per bushel used in some analyses. Whenever these exaggerated energy contents are used in any analysis, there will be considerable distortion in the results.

In all the EnergySelectors at this web site, the energy content for shelled corn is assumed to be of 6,800 BTU per pound of shelled corn for all the analysis, along with an assumed combustion efficiency of 75%. Whenever reviewing commercial literature, be especially cautious of the recommendations and conclusions if the analyses are based on an energy content of the corn higher than 7,000 BTU per pound of shelled corn.

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CORN ENERGY EQUIVALENTS

The corn energy equivalent table below provides an efficient 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.

EQUIVALENT HEATING VALUES

Fuel Currently Used	Equal to	Pounds of Shelled Corn
1 ton of Hard Coal	=	3,360
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

Burning Shelled Corn as Fuel

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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. Below you will find questions that are designed to help you gather the necessary information for making an informed decision. The answers to these questions may vary from model to model, and are also dependent on personal preferences and the anticipated location 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 UL or CSA 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?
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. How often will the supply hopper need to be filled when the stove is burning at full capacity?
5. 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? Must an additive (such as oyster shells) be burned along with the corn to ease the cleaning requirements?
6. Are sugars from burning corn likely to accumulate in the combustion chamber? If so, what is the recommended way to remove the sugars?
7. Where can shelled corn be purchased in this area? Be sure to have a plan for storing the shelled corn you purchase for the heating season and perhaps beyond. (See the link on the web site to “Storage Requirements of Shelled Corn.”)
8. What is the recommended moisture content for the shelled corn in order to get good fuel combustion?
9. What type of exhaust ventilation system must be provided for the corn-burning stove? What are the local code requirements and insurance requirements for handling the combustion exhaust?
10. What size corn-burning stove is needed for the intended application? Is the house layout appropriate for the convective movement of the heated air throughout the whole house? You need to decide if the stove is intended to be the primary heat source for the building or if it is intended to serve as a supplementary or

back-up source.

11. Can the corn-burning stove be connected with an existing hot water or hot air distribution system?
12. How much experience does the dealer have with installing and servicing corn-burning stoves and boilers?
13. Which stove models are intended for residential applications and which models are for commercial and industrial applications?
14. What warranty comes with the stove? Under what conditions will the warranty be voided?

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LOCATING A SUPPLIER OF SHELLED CORN

Do not purchase a corn-burning stove or boiler without first identifying a reliable supplier of shelled corn. To find suppliers of shelled corn, contact the feed and seed stores in your area as well as any feed mills and grain elevators. The Extension Office in your county or the land-grant university in your state may also be able to identify suppliers of shelled corn. If you know any farmers, contact them directly to inquire if they or other farmers they know will sell shelled corn to you on a direct basis. Be sure that the moisture content of the shelled corn that you buy is no higher than 15.5 % for good combustion characteristics and for safe storage of the corn. (See the link for "Quality of Shelled Corn" on the homepage of the web site.)

Generally, it will be cheaper to buy the corn directly from a farmer than from a feed mill or elevator. Probably the most expensive place to buy shelled corn is from a fireplace/hearth shop where the corn is sold in cute little decorated bags. In many cases, it will be necessary to purchase a large amount of corn at a time to get the cheapest price for the corn. You may find it is necessary to purchase 25 bushels (1,400 pounds) to 100 bushels (5,600 pounds) to negotiate the cheapest price. Whenever discussing price, be sure to consider the cost for the delivery of the corn to your home.

The price of corn fluctuates throughout regions of the U. S. and throughout each year. It is impossible for any supplier to provide a firm price for corn over an extended period of time, unless you buy the corn on a futures contract. You may be able to negotiate a price that is a fixed number of cents higher than the price of corn on the commodity market at the time of your purchase.

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QUALITY OF SHELLED CORN

For best results, the quality of shelled corn to be burned in a corn-burning stove or boiler must be specified.

Moisture Content - The moisture content of the shelled corn should be no higher than 15.5%. Higher moisture contents will result in the growth of mold and mildew in the corn, thereby leading to spoilage of the corn. The growth of fungi will likely create problems of the corn clumping together in the storage area and the corn may not feed properly through the distribution system into the combustion chamber of the stove or boiler. There is also the danger of the fungal spores causing or aggravating respiratory problems with the people exposed to the spores.

Whenever the moisture content of the corn is above 15.5%, then there will be less heat available from each pound of shelled corn. For each one percent increase in moisture content above 15.5%, there will be a corresponding reduction of about 90 BTU of heat per pound of shelled corn.

Some models of corn-burning stoves and boilers may require that the moisture content of the shelled corn be as low as 13% to get efficient combustion of the corn. Be sure to ask the dealer or manufacturer about the recommended moisture content of shelled corn for efficient combustion.

Cleanliness of Shelled Corn - The shelled corn needs to be clean, with a minimum of broken kernels and foreign materials (cob pieces, husks, stalks, stones, and other residue). Small pieces of corn kernels may interfere with proper combustion and likely cause some smoking problems. The foreign materials tend to clog the flow of the shelled corn into the stove's combustion chamber. Specify U. S. Grade #2 to get the shelled corn with just a small amount of broken corn and foreign materials (BCFM). If there are problems associated with burning Grade #2, then it may be necessary to specify U. S. Grade #1 which will have even less BCFM. However, Grade #1 corn will be considerably more expensive than Grade #2.

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STORAGE REQUIREMENTS OF CORN

Proper storage of shelled corn is important for good performance of a corn-burning stove or boiler. The corn must 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 stacked on a pallet in an area free of rodents, birds, squirrels, and other varmints. If the corn is stored in bulk containers, the containers should not sealed shut because there must be some air circulation around and through the corn. Inspect the corn from time to time to ensure that there are no insect or disease infestations and that the corn does not develop a musty odor.

Shelled corn is generally sold by the bushel or by weight. One bushel of shelled corn with a moisture content of 15.5 % weighs 56 pounds and requires a storage volume of 1.25 cubic feet. One hundred pounds of shelled corn (about 1.8 bushels) requires a storage volume of 2.25 cubic feet.

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DISPOSAL OF CORN ASH

A plan for proper disposal of corn ash needs to be developed before purchasing a corn-burning stove or boiler. Burning shelled corn yields less ash residue than burning firewood or cinders from burning coal. Corn ash has some modest value as a fertilizer and as a liming agent, with no evidence of heavy metals or any other contaminants. The corn ash (after cooling) can be safely applied to garden areas, flower beds, lawns, and fields.

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MANUFACTURERS OF CORN-BURNING STOVES AND BOILERS

FOR RESIDENTIAL APPLICATIONS

Amaizablaze/Nesco, Inc.
P. O. Box 3498
Cookeville, TN 38502
931-372-0130
http://www.cornstoves.info

American Energy Systems, Inc.
150 Michigan Street SE
Hutchinson, MN 55350
800-495-3196
http://www.hearthdirect.com

America's Heat/LMF Mfg.
601 Woods Avenue
Lock Haven, PA 17745
800-582-4317
http://www.americasheat.com

Big M Manufacturing Co.
Box 319A
928 East 1090 N. Road
Taylorville, IL 62568
217-824-9372

Bixby Energy Systems
14295 James Road
Rogers, Minnesota 55374
877-500-2800
http://www.bixbyenergy.com

CANECO Manufacturing Inc.
Box 9042, Sub.40
London, ON
N6E 1V0 Canada
519-686-7298
http://www.cornstove.ca

CornGlo Industries, LLC
P.O. Box 548
3990 Highway 25E
Beanstation, TN 37708
865-993-4436
www.cornglo.com

Country Flame Technologies, Inc.
1200 E. Industrial Park Drive
Mt. Vernon, MO 65712
417-466-7161
http://www.countryflame.com

Dansons Group, Inc.
26319 Township Road 531
Acheson, Alberta
Canada T7X 5A3
877-303-3135
http://www.dansons.com

Eagle Manufacturing, Inc.
1120 East 2nd Street
Webster City, IA 50595
515-832-4655
http://www.eaglemfginc.com

Golden Grain Corn Stove
P.O. Box 5000
Sterling, CO 80751
800-634-6097
http://www.goldengrainstove.com

Grain Stoves, Inc.
R.R. 3
Blyth, Ontario
Canada NOM 1HO
519-523-9897
http://www.grainstovesinc.com

Harman Stove Company
352 Mountain House Road
Halifax, PA 17032
717-362-1422
http://harmanstoves.com

Ja-Ran Enterprises, Inc.
3541 Babcock Road
Lexington, MI 48450
810-359-7985
http://www.ja-ran.com

K-C Cornburners, Inc.
1433 Northstar Drive
Zumbrota, MN 55992
507-732-4666
http://kccornburners.com

Kernelburner
46304 Jeffery Street
Hartford, SD 57033
605-528-4700
http://www.kernelburner.com

Kozy Heat Fireplaces
204 Industrial Park Drive
Lakefield, MN 56150
800-253-4904
www.kozyheat.com

LDJ Manufacturing
1833 Hwy 163
Pella, IA 50219
866-535-7667
http://www.ldj-products.com

Lennox Hearth Products
1110 West Taft Avenue
Orange, CA 92865
714-921-6100
http://www.earthstove.com

Nature-Heat
P. O. Box 205
Cedar Falls, IA 50613
319-277-2074
http://www.nature-heat.com

Pinnacle Stove Sales, Inc.
1089 Highway 97 North
Quesnel, B. C.
Canada V2J 2Y3
250-992-5050
http://www.pinnaclestove.com

RJM Manufacturing, Inc.
1875 Olson Drive
Chippewa Falls, WI 54729
715-720-1794
http://www.energyking.com

Sedore Multi-Fuel Stoves and Furnaces
P. O. Box 103
Oro, Ontario L0L 2X0
705-487-1921
http://www.sedoremultifuelstoves.com

Snow Flame, Inc.
4076 Haywood Road
Mills River, NC 28742
828-891-1006
http://www.snowflame.com

United States Stove Company
108 Garner Road
Bridgeport, AL 35740
423-837-2100
http://www.usstove.com

Note: 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.

Burning Shelled Corn as Fuel

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MANUFACTURERS OF CORN-BURNING STOVES AND BOILERS

FOR COMMERCIAL APPLICATIONS

(100,000 TO 500,000 BTU/HOUR)

America's Heat/LMF Mfg.
601 Woods Avenue
Lock Haven, PA 17745
800-582-4317
http://www.americasheat.com

Big M Manufacturing Co.
(A-Maize-Ing Heat)
Box 319A
928 East 1090 N. Road
Taylorville, IL 62568
217-824-9372

Eagle Manufacturing, Inc.
1120 East 2nd Street
Webster City, IA 50595
515-832-4655
http://www.eaglemfginc.com

Golden Grain Corn Stove
P.O. Box 5000
Sterling, CO 80751
800-634-6097
http://www.goldengrainstove.com

Ja-Ran Enterprises, Inc.
3541 Babcock Road
Lexington, MI 48450
810-359-7985
http://www.ja-ran.com

K-C Cornburners, Inc.
1433 Northstar Drive
Zumbrota, MN 55992
507-732-4666
http://kccornburners.com

Kernelburner
25198 421st Ave.
Alexandria, SD 57311
605-239-4690
http://www.kernelburner.com

LDJ Manufacturing
1833 Hwy 163
Pella, IA 50219
866-535-7667
http://www.ldj-products.com

Nature-Heat
P. O. Box 205
Cedar Falls, IA 50613
319-277-2074
http://www.nature-heat.com

Pinnacle Stove Sales, Inc.
1089 Highway 97 North
Quesnel, B. C.
Canada V2J 2Y3
250-992-5050
http://www.pinnaclestove.com

Quality Manitoban Products
Box 398
Morris, MB Canada
204-746-6894
http://www.topline-dist.com

RJM Manufacturing, Inc.
1875 Olson Drive
Chippewa Falls, WI 54729
715-720-1794
http://www.energyking.com

Solagen
33993 Lawrence Road
Deer Island, OR 97054
503-366-4210
http://www.solageninc.com

Year-A-Round Corporation
110 West Lind Street
P.O. Box 2075
Mankato, MN 56002
800-418-9390
http://www.year-a-round.com

Note: 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.

Burning Shelled Corn as Fuel

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MANUFACTURERS OF CORN-BURNING STOVES AND BOILERS

FOR INDUSTRIAL APPLICATIONS

(500,000 BTU/HOUR AND LARGER)

Advanced Recycling Equipment, Inc.
850 Washington Road
St. Marys, PA 15857
800-611-6599
http://advancedrecyclingequip.com

RIMACO
P. O. Box 41
Beavertown, PA 17813
570-658-7491
http://www.ricemachineryco.com

Smart Building Products
1658 Route 300
Newburgh, NY 12550
Ph:845-566-9329
http://www.smartbuildingproducts.com

Year-A-Round Corporation
110 West Lind Street
P.O. Box 2075
Mankato, MN 56002
800-418-9390
http://www.year-a-round.com

Note: 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.

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Penn State University is committed to the concept of affirmative action to ensure equal opportunity in all aspects of employment for those historically excluded and to foster diversity in the University community. The University has a comprehensive Affirmative Action Plan which sets forth programs and goals for increasing the representation of historically excluded groups.

Mission

The Affirmative Action Office is a service organization that supports and enhances the University's commitment to diversity, providing expert advice and leadership to colleges, departments, faculty and staff in their efforts to recruit and retain a diverse workforce and ensure an environment free from discrimination and harassment.

Vision

To provide quality services in support of the University's vision to foster an academic community that provides leadership for constructive participation in a diverse, multicultural world.

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Contact

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Questions regarding web issues, please contact Cindy Harter, cih1@psu.edu

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