National Food and Energy Council **AT-104**	**END USES:** Crop Drying Moisture Removal Quality Control **OBJECTIVES:** Peak Clipping Strategic Conservation Strategic Load Growth	**APPLICABILITY** Grain Drying Mid-Size Grain Farm Operations **STATUS:** R & D Continuing	**Ag Technical Brief**

This work done under contract with the Electric Power Research Institute.

Crop Drying With Heat Pumps

DESCRIPTION

Drying grain with the use of electrically-powered heat pumps was, as of late 1986, a practice that had been limited to research and development activities. Yet, the utilization of the heat pump, with its high coefficient of performance, is attractive (economically and by performance) for on-farm crop drying. This is especially true where production and storage facilities are compatible with low-temperature drying operations. Such systems raise the ambient temperature about 5 to 15°F, calling for drying periods of from one to several weeks, depending upon initial grain moisture content and associated climatic conditions.

While the FOCUS of this brief is upon low temperature heat pump grain drying, it is important to note that two seasons of limited research work demonstrated successful performance with a high temperature (140 to 220°F), continuous-flow grain drying operation that used heat pumps. High investment cost and limited capacity of such units, however, indicate that high-temperature heat pump systems have limited applications under economic conditions of the late '80s.

Specifications

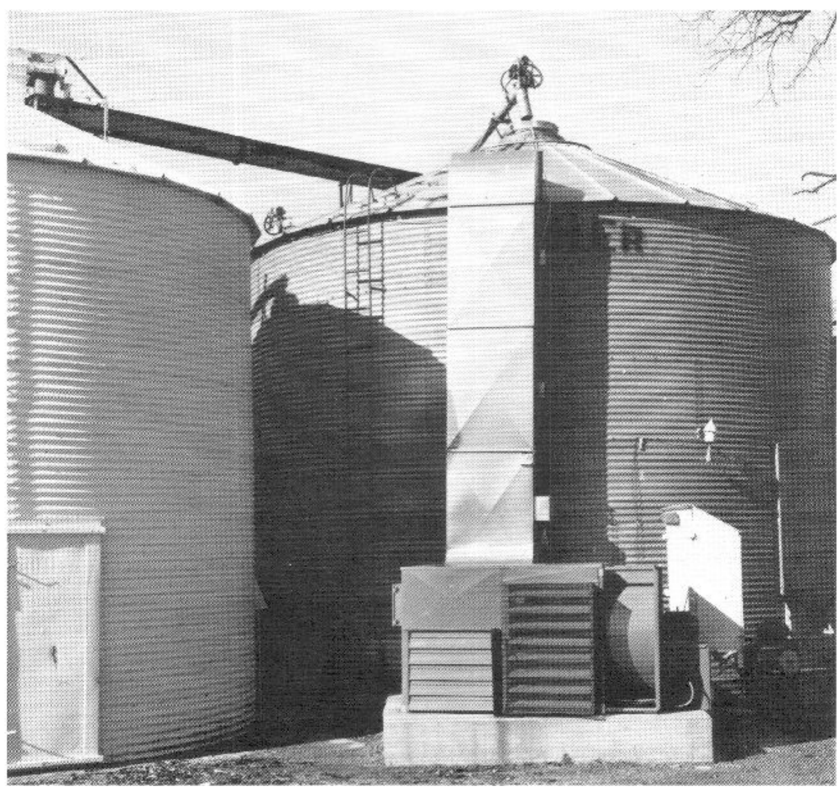
The low temperature, heat pump crop drying system (studied at Purdue University) was installed on a 4,000 bushel drying bin with performance compared to that of a similar size fan system equipped with a 24 kW resistance heater. In each case, approximately 8.8 percentage points of moisture were removed (from approximately 22.8 to 14%). While the amount of water removed from each grain mass was virtually the same, drying time for the heat pump system was three days longer. (If dried to only 15%, the drying time difference would have been only one day.)

The connected load for the heat pump system was 14.6 kW as compared to 30.7 kW for the resistance heat-fan system. Therefore, the electrical demand for the heat pump unit was 52% lower.

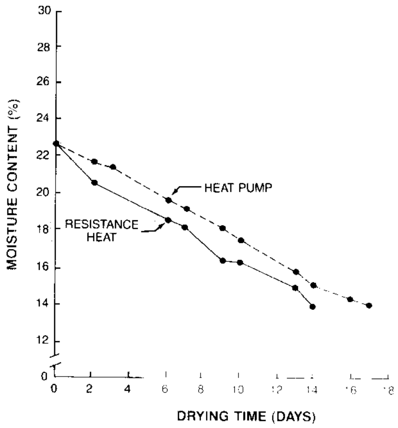
The cost (operating) of removing each percentage point of moisture per bushel was 0.181 kWh for the heat pump and 0.293 kWh for the resistance-fan system. Thus, an operating cost saving of 38% was realized. See tables for specific data comparisons.

Applicability

Heat pump grain drying systems could be used wherever resistance type, low-temperature—or natural air crop drying—systems are normally used. If and when the heat pump system is adaptable to multiple use



Low-temperature heat pump installed on 4000-bushel drying bin on which test data were obtained. (Purdue University)



Corn moisture reduction during same drying period when using heat pump and electric resistance crop drying systems at West Lafayette, IN.

(i.e. drying two crops and/or heating nearby buildings during winter months) its applicability and feasibility will be enhanced.

Implementation Considerations

The coefficient of performance (C.O.P.) of the heat pump system used for grain drying should be calculated on a seasonal basis for the complete system, including the fan and heater, if used in comparison with resistance units (where C.O.P. = 1). The seasonal system C.O.P., as shown in the table, is appropriate.

The relative cost of different types of energy will have a direct bearing upon operating costs and total system costs once the heat pump crop dryer becomes commercially available and total capital investment data for a few such systems are known.

EVALUATION

Availability

In late 1986 there were no known manufacturers of heat pump systems designed for low-temperature crop drying.

Cost Per Unit

At the time research was conducted in the early '80s, it was estimated that when compared to low-temperature drying with electric resistance drying systems, the savings in energy by the heat pump system would about offset the increased capital cost of that system (as compared to resistance-fan systems).

Reliability

While the low-temperature heat pump system unit under study performed well, there is insufficient experience to predict long-term reliability at this time.

Utility System Benefits

Once heat pump crop drying units are commercially-produced and available at reasonable cost, electric utilities can benefit through reduced electrical demand and from strategic growth in electric crop drying and/or multiple-use farm systems that include crop drying.

Customer Benefits

The operating costs for drying grain are less with the heat pump, as compared to electric resistance units. With alternate uses of the heat pump units, during nondrying periods, the prorated investment costs could be reduced so as to make both applications energy-use and cost effective. Thus, the customer may benefit in several ways.

Customer Acceptance

When equipment is available, acceptance will be based upon prudent decisions and traditional values such as investment costs, relative operating costs, equipment use flexibility, and need for and quality of local service.

Utility Programs

No programs now exist because such equipment is not available.

COMMENTS

Technical information in this brief is adapted from papers listed below which, in turn, represent results from a Purdue University study funded by the U.S. Department of Energy and Westinghouse Electric Corporation.

At least one equipment manufacturer continues to pursue research and the development of heat pump crop dryers. Until such time as those results are publicized, possibly in late 1987, interested parties are referred to "Grain Drying with Heat Pumps", George H. Foster, NFEC Conference Paper, July 31, 1984 (available from NFEC); and/or "Heat Pumps for Low-Temperature Grain Drying", Hogan, M.D., et al. Transactions of ASAE 26(4) 1234-1238. Also see Ag Tech Briefs #102 and #103.

Table 1. Comparison of the Energy Used by the Heat Pump and Resistance Heat Dryers

Item	Heat Pump kWh	Resistance Heat kWh
Energy Used by:		
Fan	3813	3024
Heat Source	2289	7091
Grain Stirrers	171	136
Total	6273	10251
Energy Used:		
Per kg Water Removed	0.557	0.905
Per Bushel Per Percentage Point of Moisture	0.181	0.293

Table 2. Heat Pump and Electric Resistance Unit Seasonal Average Performance

Performance Indicator	Heat Pump	Resistance Heater
Heat Source COP	4.83	1.0
System COP	2.36	1.0
Heat Rejection Rate, kW	25.2	21.6
Heat Source Power, kW	5.2	21.6
Fan Power, kW	9.4	9.1
System Power, kW	14.6	30.7
Temperature Rise, °F	12.9	9.4
Airflow, cfm	8420	9940