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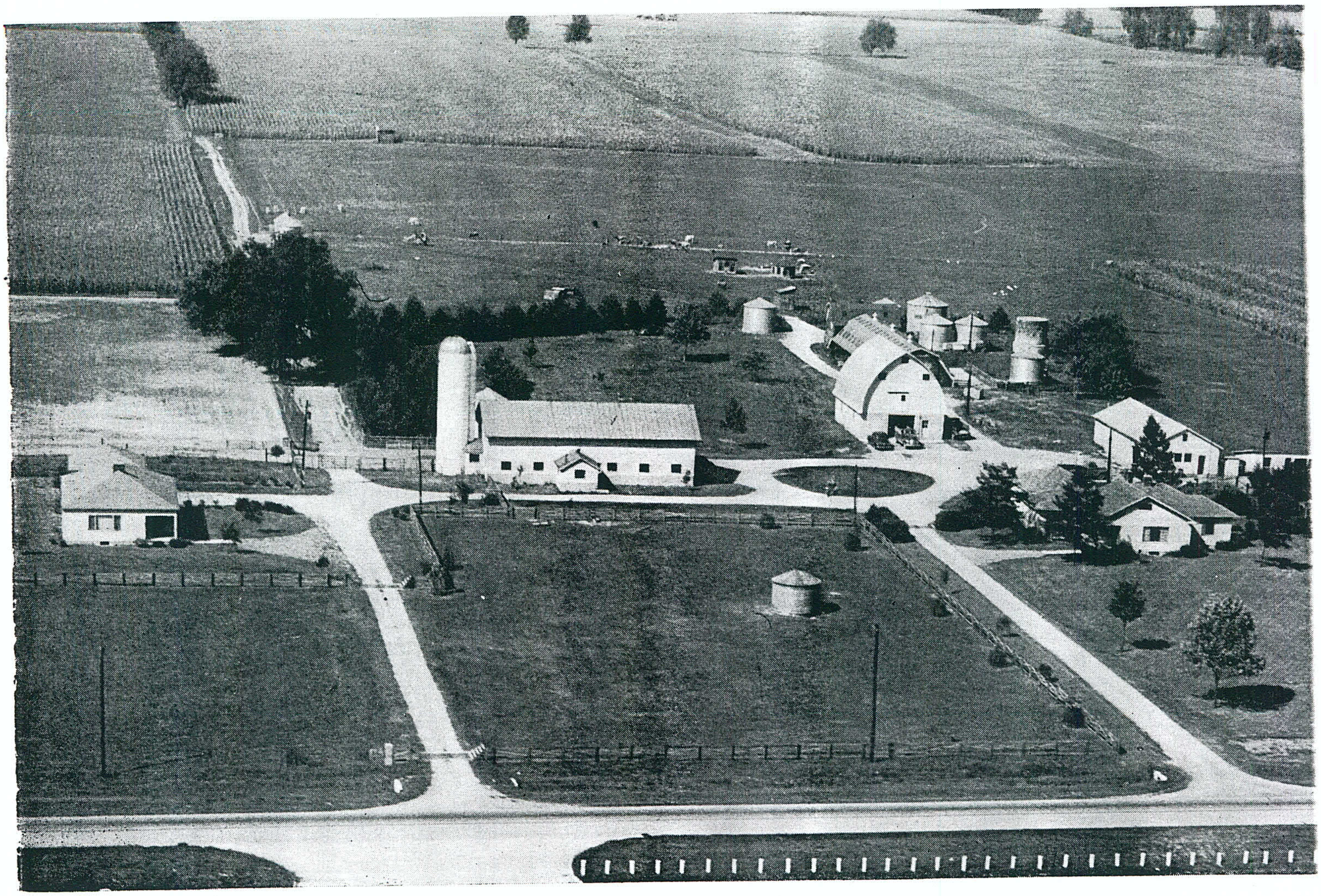
An Economic Analysis of Drying Wheat and Corn *on Indiana Farms*



PURDUE UNIVERSITY

Agricultural Experiment Station, Lafayette, Indiana
in cooperation with Farmer Cooperative Service, and Agricultural Marketing Service,
United States Department of Agriculture

SUMMARY CONTINUED

mental work to estimate costs and returns. The budget analysis indicated that:

1. Yearly fixed costs could be estimated by multiplying the original installation cost figure by 13 percent for Type A; 14 percent for Type B; and 9 percent for each of Types C and D.

2. Variable costs per 100 pounds of water removed approximated: Type A—56.2 cents (shelled corn) and 52.8 cents (wheat); Type B—45.4 cents (ear corn); Type C—17 cents (ear corn); Type D—24.3 cents (shelled corn) and 27.7 cents (wheat).

3. For each 2 percent increase in initial moisture level, drying costs increase about 1 cent, 1¼ cents and ½ cent for Types A, B and C respectively. Type D costs vary somewhat less. Variability in budgeted costs of drying per bushel is reflected in these examples:

Volume (dry bushels per farm)	Initial capital investment per farm ($)	Initial Moisture (%)	Budgeted total cost per dry bushel ($)
Type A: (shelled corn)			
4,000	$2,000	24	$.100
8,000	3,000	24	.084
15,000	4,500	24	.074
Type A: (wheat)			
2,000	2,000	18	.146
5,000	2,000	18	.068
10,000	3,000	18	.055
Type B: (ear corn)			
3,000	2,000	24	.143
8,000	2,000	24	.084
15,000	2,000	24	.068
Type C: (ear corn)			
2,000	800	24	$0.050
4,000	1,000	24	0.036
6,000	1,200	24	0.032
Type D: (shelled corn)			
200	500	20	0.236
600	500	20	0.086
600	600	20	0.101
1,000	600	20	0.065
2,000	600	20	0.038
Type D: (wheat)			
200	500	16	0.231
600	500	16	0.081
600	600	16	0.096
1,000	600	16	0.060
2,000	600	16	0.033

4. To the individual farmer, the economy of drying grain depends on the initial moisture level of the grain, market prices, discount schedules in his area and his volume of drying.

5. Other benefits from drying which may accrue to individual farmers include: avoidance of field losses by earlier harvest, reduced risk of substantial crop loss in very wet years, reduced investment needed for storage under government programs, reduced insect problems in storage, more certainty of meeting qualifications for storage, reduced amount of harvesting during disagreeable weather, assurance of a quality feed supply, planting of wheat immediately following corn, and use with picker-sheller.

6. Negative factors associated with farm drying include: equipment may not be needed every year; present dryers may become obsolete, discount schedules may change; it is possible to over-dry grain; alternative investments may yield higher or more certain returns, and dryers may be of little use on livestock farms.

7. To generalize whether drying grain is profitable or not on Indiana farms is difficult. Each farmer must budget his probable costs and returns in order to make a wise decision.

mercial producers. Seed corn must be dried at a lower temperature to preserve germination and must meet more rigid specifications for marketing than commercial corn.

To increase the accuracy of information received from farmers, only those farmers who did dry grain in 1953 were studied. Since 1953 was an exceptionally dry year, 60 farmers originally listed did no drying that year. Besides, 15 of the mail questionnaires returned were incomplete and could not be included in the sample. This left a sample of 100.

These 100 farmers were visited and asked detailed questions concerning their drying installation and its operation. Twenty farmers were not at home but were asked to fill out and return the questionnaire. Total usable schedules resulting numbered 78. Therefore, the farm sample on which the analysis was based was a purposive one. An attempt was made to obtain a complete enumeration of farmers owning drying equipment. The partial enumeration which resulted was as complete as it was possible to obtain under the circumstances.

Survey Farms Had Large Acreages

Forty-two of the 92 counties in Indiana were represented by at least one farm in the 78 farms studied (Figure 1). These farms were grouped according to type of drying equipment used as follows:

Type A—Drying shelled corn and/or wheat with heated air.

Type B—Drying ear corn with heated air.

Type C—Drying ear corn with unheated air.

Type D—Drying shelled corn and/or wheat with unheated air.

Of the 78 survey farms, 30 were in each of the Types A and C and nine were in each of the types B and D. Type A installations were most frequent in the Northern Area (20 of 30) while Type C installations were most frequent in the Southern Area (18 of 30). Most of the Type B and D installations studied were in the Central Area.[4]

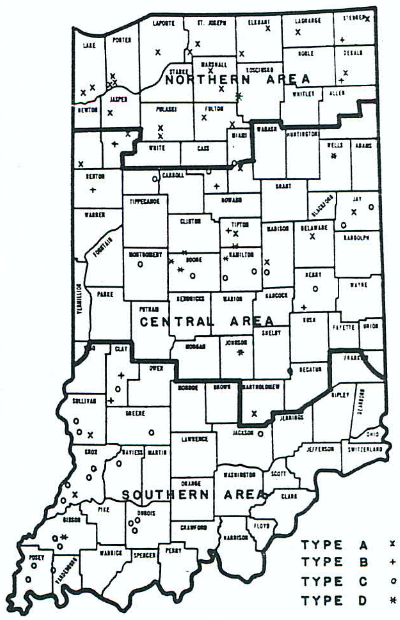


Figure 1. Location of 78 Survey Farms by Type of Drying Installation in Indiana, 1953.

For descriptive purposes, survey farms were compared with the units operated by cooperators in the Indiana Farm Accounting Project. Items used for comparison were total acres in farm, tillable acres, corn acreage, and wheat acreage. In these items, survey farms were substantially larger than were the farm accounting units. As accounting cooperators typically operate larger units than the average of all farms, the farms with drying units apparently are those with well above average acreages of corn and wheat (Table 2).

Type A Dryers Found on Largest Farms

Type of installation changed from Type A through Type D as average acres on survey farms decreased.

The use of picker-shellers or field shellers requires that the grain be artificially dried in most seasons. Of the 30 farms using Type A dryers, 10 used picker-shellers, 8 used field shellers, 8 used portable or stationary shellers either in the field or next to drying equipment, and 4 had custom shelling done.

Only six of the 78 survey farms were operated by tenants. One farmer was a co-owner and 62 owned all of the acres they operated. The remaining 16 farmers rented some land.

Wheat was grown on 53 of the survey farms. Forty of these farmers sold 100 percent of their wheat crop. Corn was raised on all 78 farms and 16 sold their entire corn crop.

[4] Areas designated in *Farm Business Summaries,* Agricultural Economics Department, Agricultural Extension Service, Purdue University, 1953.

Table 2. Comparison of Average Acreages Per Farm on Survey and Farm Accounting Units by Geographic Area.[a]

Acres per farm	Geographic Area					
	Northern		Central		Southern	
	Accounting	Survey	Accounting	Survey	Accounting	Survey
Total acres	219	395	266	329	229	457
Tillable acres	183	351	224	286	161	403
Corn acreage	59	159	81	112	48	169
Wheat acreage	17	56	23	26	24	69

[a] Farm accounting unit figures taken from Farm Record Summaries, Agricultural Economics Department, Agricultural Extension Service, Purdue University, 1953.

Table 4. Summary of Costs and Related Data on 78 Farms Drying Grain in Indiana 1953.

Item	Type A	Type B	Type C	Type D
Number of farms studied	30	9	30	9
Average capital investment (depreciated value in 1953)	$ 2,781	$1,536	$ 662	$ 586
Average cwt. of water removed by drying per farm	447	1,129	502	34
Range of cwt. of water removed	11-1174	152-6072	99-1580	7-84
Average fixed costs per farm	$ 547	$ 247	$ 117	$ 104
Range in fixed costs per farm	$98-1260	$59-801	$19-309	$55-176
Average variable costs per farm	$ 116	$ 234	$ 30	$ 7
Range in variable costs per farm	$ 5-860	$52-801	$ 2-169	$ 3-16
Average total costs per farm	$ 663	$ 481	$ 147	$ 111
Range in total costs per farm	$162-1633	$131-1155	$21-341	$61-179
Fixed costs as percent of total	83	51	80	93

Farmers Pleased With Their Units

Each farm has an individual drying problem. Advantages or disadvantages of drying accruing to one farmer may not hold on another farm. Therefore it cannot be said that drying was profitable or unprofitable on these 78 farms without budgeting each situation individually. However, each farmer interviewed indicated his intentions to keep on drying. This suggests that he thought it was profitable to continue drying on his farm but it does not prove that the initial investment was a wise one in all cases. To help individuals determine the wisdom of such an investment on their farms, the following standards for and method of budgeting were developed.

Standards for Budgeting Drying Costs, Returns

The primary objective of this investigation was to provide data and methods which would assist individual farmers to determine the economic feasibility of drying grain on their farms. To do this, budgets were prepared.

Survey data provided a guide for the preparation of budgets which follow. However, much of the material developed is based on physical and engineering data on the performance of drying equipment and systems. Published and unpublished results of research in grain drying by Purdue and USDA engineers were used in estimating air flow requirements, drying time and other factors pertinent to both investment and operating costs.

Capital and Fixed Costs For Type A Installations—(Drying Shelled Corn and/or Wheat with Heated Air)

Necessary investment cost items for Type A installation include a dryer, commercial batch drying bin, electrical wiring, moisture tester (if desired), and a fuel tank. Containers other than commercial batch bins which are sometimes used include circular steel bins, an adapted wagon box, or adapted existing storage bin. Two sizes of dryers and three sizes of batch bins were considered (Table 5).

Fixed costs per year average about 13 percent of the purchase price. Annual depreciation costs, in percent of new value, by items were: dryer unit 10 percent; batch bin 6 2/3; wiring 6 2/3; fuel tank 3 1/3; moisture tester 6 2/3; adaptations 3 1/3, and perforated floor 5 percent.

Other fixed costs in percent of new cost per year include: interest 2.5 percent, taxes 1.0, insurance 0.2 and housing and maintenance 0.5 percent (where applicable). These charges for fixed costs other than depreciation hold for other types of dryers as well.

Capital and Fixed Costs For Type B Installations—(Drying Ear Corn With Heated Air)

New cost items for typical Type B installations would include a heated air dryer ($1,400), wiring ($150), fuel tank ($60), and either a vertical duct for a high round

Table 5. Estimated New Costs of Equipment Items for Type A Installation in 1954.

Item	Dryer size[a]					
	Small			Large		
	Wagon box[b]	Steel bin[c]	Existing bin[d]	130 bu. batch bin	260 bu. batch bin	470 bu. batch bin
	Capital Investment					
Dryer unit	$1,400	$1,400	$1,400	$1,400	$2,000	$2,000
Batch bin	.....	.....	.....	1,000	1,400	2,000
Adaptation	.....	.....	200	.....	.....	.....
Wagon box floor	50	.....	.....	.....	.....	.....
Perforated floor	.....	110	.....	.....	.....	.....
Wiring	150	150	150	150	150	150
Fuel tank	60	60	60	60	60	60
Moisture tester	e	e	e	e	200	200
Total	$1,660	$1,720	$1,810	$2,610	$3,810	$4,410

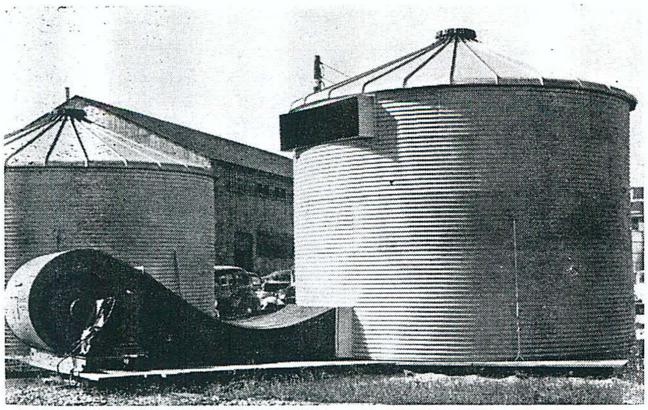
[a] Small size delivers about 500,000 BTU'S per hour. Large size delivers about 1,000,000 BTU'S per hour.

[b] Used as drying container in place of commercial batch bin.

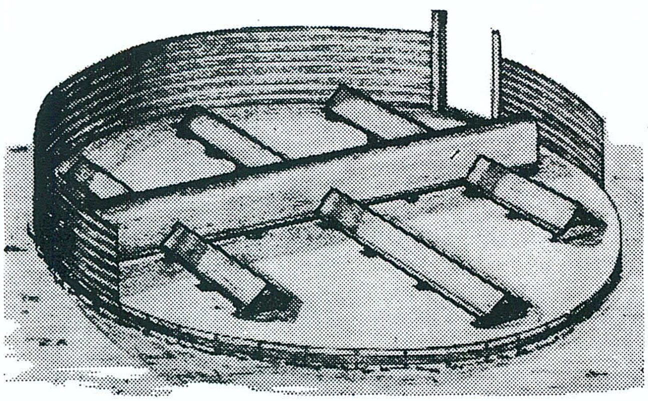
[c] Circular, 1,000 bushel capacity used in place of commercial batch bin.

[d] Adapted for drying.

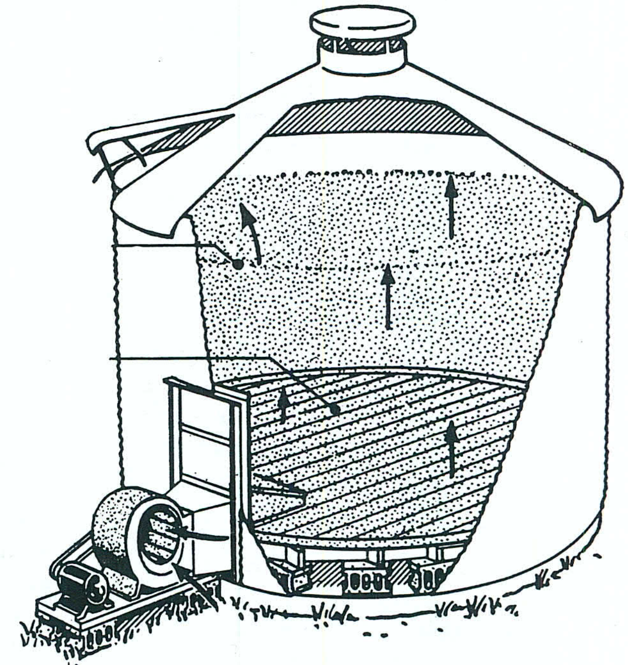
[e] Moisture tester would probably not be used with these smaller size operations.



◀ *Type D Installation—circular metal bin. For shelled corn, wheat, and other small grains.*



Duct System



Perforated Floor

Cross sections of above circular metal bin showing two systems for distributing air.

crib ($75) or adaptation of existing storage ($200). Totals would be $1,810 for the high round crib and $1,685 for the adaptation.

Fixed costs per year average about 14 percent of new cost.

Capital and Fixed Costs For Type C Installations (Drying Ear Corn With Unheated Air)

Equipment needed in Type C installations includes a fan, electric motor to power the fan, electrical wiring, and a duct system to distribute the forced air. Three different fan-motor combinations were considered (Table 6).

Fixed cost per year amounts to about nine percent of the new cost. Annual depreciation charges by items in percent of new value used were: electric motors 5, fans 5, ducts 4, and wiring 6 2/3.

Table 6. Estimated New Costs of Equipment Items for **Type C** *Installations in 1954.*

Item	Equipment		
	3 h.p. motor 32″ fan[a]	5 h.p. motor 36″ fan[b]	7½ h.p. motor 42″ fan[c]
	Capital investment		
Electric motor	$280	$420	$605
Fan	220	246	310
Duct	75	100	125
Wiring	150	150	150
Total	$725	$916	$1,190

[a] Arbitrarily used for volumes up to 3,000 bushels.
[b] Arbitrarily used for volumes of 4,000 and 5,000 bushels.
[c] Arbitrarily used for volumes above 5,000 bushels.

Total Cost of Drying Calculated on Per Bushel Basis.

Total drying costs per bushel were computed for various initial moisture levels with various volumes of grain assuming certain fixed capital investments (Tables 9-13).

Using Type A installations for drying shelled corn and wheat, calculated total cost per bushel increases about 1 cent for each 2 percent increase in initial moisture level (Tables 9 and 10).

Type B—For ear corn, cost per bushel increases about 1¼ cents per bushel for each 2 percent increase in initial moisture level (Table 11).

Type C—For ear corn, cost of drying per bushel increases about one-half cent per bushel for each initial moisture level increase of 2 percent (Table 12).

Type D—When drying wheat and shelled corn with unheated air, the depth of grain dried in one batch as well as the initial moisture level are important factors in determining the power required. Since the power requirement rises rapidly as the depth increases, it is important not to exceed the maximum recommended depth for the initial moisture level of the grain (Appendix Table 15). The time required to dry a batch of grain with unheated air may not vary much for initial moisture levels up to 20 percent. This is especially true where much fan operating time may be necessary to remove the last 1 or 2 percent of moisture required for safe storage. However, the increased air flow rate required to dry the higher moisture grain fast enough to prevent deterioration is reflected in higher costs per bushel through the larger equipment required (Table 13). When the recommended depths are exceeded with grain at the higher moisture levels, the power costs to provide the recommended unit air flow rate may be prohibitive.

Table 9. Calculated Total Cost Per Bushel For Drying Shelled Corn with Heated Air Using Various Combinations of Volumes, Capital Investments, and Initial Moisture Levels—Final Moisture Level of 15.5 Percent.

Volume (dry bushels)	Initial moisture level						
	30	28	26	24	22	20	18
Capital investment $2,000[a]				Total cost per bushel dried[d]			
1,000	$.325	$.315	$.304	$.295	$.286	$.279	$.270
2,000	.195	.185	.175	.165	.156	.148	.140
3,000	.151	.141	.131	.122	.113	.105	.096
4,000	.130	.120	.110	.100	.091	.083	.075
5,000	.117	.107	.096	.087	.078	.071	.062
6,000	.108	.098	.088	.078	.069	.061	.053
7,000	.102	.092	.082	.072	.063	.055	.047
8,000	.097	.087	.077	.067	.058	.050	.042
Capital investment $3,000[b]							
5,000	.143	.133	.122	.113	.104	.097	.088
6,000	.130	.120	.110	.100	.091	.083	.075
7,000	.120	.110	.100	.091	.082	.073	.065
8,000	.113	.103	.093	.084	.075	.066	.058
9,000	.108	.098	.088	.078	.069	.061	.053
10,000	.104	.094	.083	.074	.065	.058	.049
11,000	.100	.090	.080	.070	.061	.053	.045
12,000	.097	.087	.077	.067	.059	.050	.042
13,000	.094	.084	.075	.065	.056	.048	.040
14,000	.092	.082	.072	.063	.054	.045	.038
15,000	.091	.081	.070	.061	.052	.044	.036
Capital investment $4,500[c]							
10,000	.123	.113	.103	.093	.084	.077	.068
11,000	.118	.108	.098	.088	.079	.071	.063
12,000	.113	.103	.093	.084	.075	.066	.058
13,000	.110	.100	.090	.080	.071	.063	.055
14,000	.106	.096	.086	.077	.068	.059	.052
15,000	.104	.094	.083	.074	.065	.058	.049
16,000	.101	.091	.081	.071	.063	.054	.046
17,000	.099	.089	.079	.069	.060	.052	.044
18,000	.097	.087	.077	.067	.058	.050	.042
19,000	.095	.085	.075	.066	.057	.048	.040
20,000	.094	.084	.074	.064	.055	.047	.039

[a] 130 bushel batch bin—Small dryer unit capable of delivering 50,000 BTU'S/hr.

[b] 260 bushel batch bin—Large dryer unit capable of delivering 1,000.000 BTU'S/hr.

[c] 470 bushel batch bin—Large dryer unit capable of delivering 1,000,000 BTU'S/hr.

[d] These costs based on use of indirect heat dryer; for direct heat dryer, the total reduction in cost would range from 0.1 to 1.0 cents per bushel as the initial grain moisture ranges from 18 to 30 percent.

Estimating Drying Costs On An Individual Farm

Fixed costs are incurred each year. They change little with the amount of grain dried. To estimate fixed costs per year, multiply the new investment cost for the total drying installation by the percentages already described: 13 percent for Type A, 14 percent for Type B, and 9 percent for Types C and D.

For illustration here, a capital investment of $3,810 (Type A) is assumed. This means a fixed cost of $492.88 per year.

Variable costs are tied directly to the amount of water removed from the grain. In the illustration just given, 45,900 pounds of water would be removed from the grain in drying 560,000 pounds of corn from 22 percent moisture down to 15.5 percent (Use Table 8);

(a) 61 — 56 = 5 pounds of water to be removed per bushel.

(b) 5 x 9,180 dry bushels = 45,900 pounds of water to be removed.

Pounds of water are used as a measure of work done. When the weight of water to be removed is known, this quantity can be multiplied by the variable costs per hundredweight developed in Table 7.

In the illustration cited here, variable costs are estimated to total $257.96 (45,900 pounds of water

Table 11. Calculated Total Cost Per Bushel For Drying Ear Corn with Heated Air Using Various Combinations of Volumes, and Initial Moisture Levels—Final Moisture Level of 15.5 Percent—Capital Investment of $2,000.[a]

Volume (dry bushels)	Initial moisture level 30	28	26	24	22	20	18
	Total cost per bushel dried[b]						
1,000	$.367	$.354	$.342	$.329	$.317	$.304	$.293
2,000	.227	.214	.202	.189	.177	.164	.153
3,000	.181	.168	.156	.143	.131	.118	.106
4,000	.157	.144	.132	.119	.107	.094	.083
5,000	.143	.130	.118	.105	.093	.081	.069
6,000	.134	.121	.109	.096	.084	.071	.059
7,000	.127	.114	.102	.089	.077	.064	.053
8,000	.122	.109	.097	.084	.072	.060	.048
9,000	.118	.106	.093	.080	.068	.056	.044
10,000	.115	.102	.090	.077	.065	.052	.041
11,000	.113	.100	.088	.075	.063	.050	.038
12,000	.111	.098	.086	.073	.061	.048	.036
13,000	.109	.096	.084	.071	.059	.046	.034
14,000	.107	.094	.082	.069	.057	.044	.033
15,000	.106	.093	.081	.068	.056	.043	.031
16,000	.105	.092	.080	.067	.055	.042	.030
17,000	.104	.091	.079	.066	.054	.041	.029
18,000	.103	.090	.078	.065	.053	.040	.028
19,000	.102	.089	.077	.064	.052	.039	.027
20,000	.101	.088	.076	.063	.051	.038	.027

[a] Includes small dryer unit capable of delivering 500,000 BTU'S per hour.

[b] These costs based on use of indirect heat dryer; for direct heat dryer, the total reduction i ncost would range from 0.3 to 1.7 cents per bushel as the initial grain moisture ranges from 18 to 30 percent.

Table 12. Calculated Total Cost Per Bushel For Drying Ear Corn with Unheated Air Using Various Combinations of Volumes, Capital Investments, and Initial Moisture Levels—Final Moisture Level of 18 Percent.

Volume (dry bushels)	Initial moisture level 30	28	26	24	22	20
	Total cost per bushel dried					
Capital investment $800 (3 h.p. motor with 32" fan)						
1,000	$.100	$.095	$.090	$.086	$.081	$.076
2,000	.064	.059	.054	.050	.045	.040
3,000	*	.047	.042	.038	.033	.028
4,000	*	*	*	.036	.031	.027
Capital investment $1,000 (5 h.p. motor with 36" fan)						
1,000	.118	.113	.108	.104	.099	.094
2,000	.073	.068	.063	.059	.054	.049
3,000	.058	.053	.048	.044	.039	.034
4,000	*	.045	.041	.036	.031	.027
5,000	*	*	*	.032	.027	.022
6,000	*	*	*	.029	.024	.019
Capital investment $1,200 (7½ h.p. motor with 42" fan)						
1,000	.136	.131	.126	.122	.117	.112
2,000	.082	.077	.072	.068	.063	.058
3,000	.064	.059	.054	.050	.045	.040
4,000	.055	.050	.045	.041	.036	.031
5,000	.050	.045	.040	.035	.030	.026
6,000	*	.041	.036	.032	.027	.022
7,000	*	.038	.034	.029	.024	.020
8,000	*	*	*	.027	.022	.018

* Not practical.

Therefore, in addition to computing a dollar figure for value of dry versus wet grain minus cost of drying, individual estimates should be placed on the other indirect advantages or disadvantages which apply to a particular farm.

Break-Even Points Give Some Guides

As one further aid in deciding on the feasibility of drying, break-even points in volume of drying were calculated. These are the quantities at which market value of dry grain equals market value of wet grain plus costs of drying. Volume of drying is one of the two key factors influencing unit costs. The less moisture that is removed per bushel, the more bushels a farmer must dry to break even. Break-even points in volume for a range of specified conditions appear in Table 14. In general, break-even points occur at smaller volumes as one moves from Type A to Type D installations and from low to high moisture levels.

Break-even point analysis is useful only to farmers who do not own drying equipment. For those who already own drying equipment, it is usually profitable to dry as much as possible each year since variable costs (comprising only a small percentage of the total cost) are generally recovered.

Appendix

A. Method of Calculating Fuel Oil Cost

To estimate fuel requirements in gallons to remove a hundredweight of water, 100 was divided by the appropriate division factor (Appendix Table 1). The resulting figure in gallons times 15 cents per gallon gave the cost of fuel oil per 100 pounds of water removed.

Appendix Table 1. Division Factors in Estimating Fuel Requirements[a].

Type of dryer	Time of year	Factor
Indirect fired units	Summer	60
	Fall	50
	Winter	35
Direct fired units	Summer	85
	Fall	70
	Winter	50

[a] Taken from "Drying Shelled Corn and Small Grain with Heated Air," Leaflet Number 331, USDA, September, 1952.

B. Method of Calculating Electrical Energy Cost for Types "A" and "B"

To estimate the cost of electrical energy, the following procedure was used.

First, the required BTU's to remove a cwt. of water were calculated from Appendix Table 2 for various climatic and moisture level conditions. The required BTU's are divided by the BTU's supplied by the dryer unit to determine the time required to remove the cwt. of water. The time required plus cooling time[7] gives the total running time of the electric motor on the dryer. Energy was charged at the rate of 2 cents per kilowatt hour. If the smaller dryer delivering 500,000 BTU's per hour is used, the cost is 6 cents per hour (3 h.p. x 1 kwh/h.p./hr. = 3 kwh x $0.02 = 6 cents).[8]

The differences in electrical energy costs caused by climatic conditions and varying starting moisture levels were very small, hence the midpoints were used for the three batch sizes. Also midpoints were very close among various batch sizes which allowed the use of one cost figure for shelled corn ($0.0488) and one for wheat ($0.0648). (See Appendix Table 3).

[7] Cooling time per cwt. of water removed varied by size of batch dried. Times of 0.5, 0.75, and 1.0 hours per batch for batch sizes of 130, 260, and 470 bushels were used.

[8] The smaller dryer (500,000 BTU's per hour) was used when calculating the cost for 130 bushel batches. The larger dryer (1 million BTU's per hour) was used when calculating costs for the 260 and 470 bushel batches. The larger burner has a 5 h.p. electric motor.

Appendix Table 2. Sensible Heat Required in the Drying Air to Remove One Pound of Water from Ear Corn, Shelled Corn and Wheat Under Various Climatic and Moisture Level Conditions[a].

Grain	Initial moisture [b]	Ambient temperature (F) 50°, Temperature rise 50°	50°, Temperature rise 90°	70°, Temperature rise 50°	70°, Temperature rise 90°
		BTU'S required to remove one pound of water			
Ear corn—					
	22	2,870	2,700	2,450	2,350
	24 or higher	2,800	2,600	2,400	2,300
Shelled corn—					
	15	3,200	3,000	2,700	2,600
	20	2,950	2,800	2,500	2,400
	25	2,800	2,600	2,400	2,300
	30	2,800	2,600	2,400	2,300
Wheat—					
	14	3,250	3,050	2,720	2,650
	16	3,150	2,960	2,660	2,560
	18	3,050	2,880	2,580	2,480
	20	2,950	2,800	2,500	2,400

[a] These data are estimates based on results of cooperative research by Purdue and USDA agricultural engineers.

[b] All final moistures 13 percent.

Appendix Table 3. Estimated Electrical Energy Cost per 100 Pounds of Water Removed for 130,260, and 470 Bushel Batch Sizes for Shelled Corn and Wheat Under Various Climatic Conditions[a].

Initial moisture[b]	Ambient Temperature (F) 50°, Temperature rise 50°	50°, Temperature rise 90°	70°, Temperature Rise 50°	70°, Temperature Rise 90°
	BTU's per pound of water removed.[c]			
Shelled Corn—Cost per 100 pounds of water removed				
130 bushels				
15	$.0570	$.0546	$.0510	$.0498
20	.0540	.0522	.0486	.0474
25	.0522	.0498	.0474	.0462
30	.0522	.0498	.0474	.0462
260 bushels				
15	$.0550	$.0530	$.0500	$.0490
20	.0525	.0510	.0480	.0470
25	.0510	.0490	.0470	.0460
30	.0510	.0490	.0470	.0460
470 bushels				
15	$.0490	$.0470	$.0440	$.0430
20	.0465	.0450	.0420	.0410
25	.0450	.0430	.0410	.0400
30	.0450	.0410	.0410	.0400
Wheat—Cost per 100 pounds of water removed				
130 bushels				
14	$.0720	$.0696	$.0656	$.0648
16	.0708	.0685	.0649	.0637
18	.0696	.0676	.0640	.0628
20	.0684	.0666	.0630	.0618
260 bushels				
14	$.0735	$.0715	$.0682	$.0675
16	.0725	.0706	.0676	.0666
18	.0715	.0698	.0668	.0658
20	.0705	.0690	.0660	.0650
470 bushels				
14	$.0625	$.0605	$.0572	$.0565
16	.0615	.0596	.0566	.0556
18	.0605	.0588	.0558	.0548
20	.0595	.0580	.0550	.0540

[a] The smaller dryer (500,000 BTU's per hour) was used when calculating the cost for 130 bushel batches. The larger dryer (1 million BTU's per hour) was used when calculating the 260 and 470 bushel batches.

[b] Final moisture level 13 percent.

Type C

Appendix Table 8. Sensible Heat Required in the Drying Air to Remove One Pound of Water from Ear Corn with Unheated Air Under Various Climatic and Moisture Level Conditions[a].

Initial moisture[b]	Ambient temperature (F)	
	50°	70°
	BTU'S per pound of water removed[c]	
22	4,000	3,100
24 or higher	3,300	2,600

[a] See Appendix Table 2 for similar data on heated air drying. These data are from the same source as those in Appendix Table 2.

[b] All ending moistures 18 percent.

[c] Based on 70 percent ambient relative humidity and continuous fan operation.

The estimated cost to remove 100 pounds of water from ear corn with unheated air at an ambient temperature of 40 degrees using a 3 h.p. motor and 32-inch fan with a starting moisture level of 22 percent is $.1848 (Appendix Table 9).

Appendix Table 9. Budgeted Electrical Energy Costs for Removing 100 Pounds of Water from Ear Corn with Unheated Air (Type C) with Various Climatic Conditions, and Moisture Levels.

	Ambient temperature (F)			
	50°		70°	
	Initial moisture level in percent			
Type of equipment used	22	24 or higher	22	24 or higher
	Cost per 100 pounds of water removed			
3 h.p. motor, 32-inch fan	$.1848	$.1524	$.1428	$.1200
5 h.p. motor, 36-inch fan	.2060	.1700	.1600	.1340
7½ h.p. motor, 42-inch fan	.2190	.1800	.1695	.1425

Type D

Appendix Table 10. Sensible Heat Required in the Drying Air to Remove 1 Pound of Water from Shelled Corn and/or Wheat with Unheated Air Under Various Climatic and Moisture Level Conditions[a].

Initial moisture[b]	Ambient temperature (F)	
	50°	70°
Percent		
15-24	4,700	3,600
24 or higher	3,300	2,600

[a] All ending moistures 13 percent. Data source same as Appendix Table 2.

[b] Based on 70 percent ambient relative humidity and continuous fan operation.

Appendix Table 11. Budgeted Electrical Energy Costs for Removing 100 Pounds of Water from Shelled Corn and/or Wheat with Unheated Air (Type D) with Various Climatic and Moisture Level Conditions.

Grain	Initial moisture (percent)	Ambient temperature (F)	Cost per 100 pounds of water removed
Shelled corn	15-24	50°	$.313
	15-24	70°	.240
	Above 25	50°	.220
	Above 25	70°	.173
Wheat	14-20	50°	.313
	14-20	70°	.240

E. Multiple Regression Analysis—Type "A"

A multiple regression analysis was made on Types A and C installations. In each case, capital investment and volume in pounds of water removed were the two independent variables with total costs of drying as the dependent variable.[11] This type of analysis was used because of the small size of sample and the wide variability in the sample data. No groups or subgroups could be made from the small number of observations. Although multiple regression is an averaging process, it gives reasonably accurate results with limited amounts of data, whereas the averaging of groups and subgroups does not.

From the analysis, a predictive equation was formulated for Types A and C. After costs were predicted throughout typical ranges of capital investments and volumes (in each case holding the other independent variable constant at the mean), 99 percent confidence limits were computed around each predicted total cost curve (Appendix Tables 12 and

Appendix Table 12. Computed Confidence Limits Around Predicted Total Cost Curve for Type A Installations.

Equation: $F_{.01} = \log X_2 \pm (Sy)(t_{.01})$

$t_{.01} = 2.78$

Degrees of freedom: 28

		Range of confidence limits[a]	
X_2	Sy	Antilog (—)	Antilog (+)
$1,000	.03179	$249	$ 374
2,000	.01923	465	595
2,781 (mean)	.01857	606	768
4,000	.02285	784	1,000
5,000	.02742	908	1,290
Using log X_3 in the equation [b]			
X_3			
10,000	.01799	517	651
30,000	.01734	585	730
44,680	.01857	606	768
65,000	.02155	619	815
85,000	.02391	627	852

[a] X_3 held constant at mean of 44,680.

[b] X_2 held constant at mean of $2,781.

[11] For Type A installations, a fourth independent variable (X_4 — maximum thermal efficiency obtainable under each particular farm drying conditions) was used and then eliminated. The reason was that theory would indicate a negative relationship for X_4 and a positive one of .23 resulted, however, it was not significant. After elimination of X_4, $r_{13.24}$ moved from .48 to .53 ($r_{13.2}$), while R^2 was changed from .8648 to .8575.