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Facility Costs of Centralized Grain Storage Systems Utilizing Computer Design

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Facility Costs of Centralized Grain Storage Systems Utilizing Computer Design

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THE item considered most often when estimating the cost of a grain storage facility is capacity. Of equal or greater importance is daily harvest rate. Other important considerations include drying method, materials handling equipment, energy cost, facility arrangement, labor requirements, grain quality and management ability. Only through a comparison of facilities which offer similar capacity, capability and convenience can the purchaser obtain his best system.

OBJECTIVES

The objective of this study was to determine the purchase and annual costs of centralized grain storage facilities as influenced by the:

1 Number of storage bins
2 Daily harvest rate
3 Degree of mechanization

for the three drying techniques, layer, batch-in-bin and portable. No differences in grain quality or labor requirements among the different drying techniques were considered.

COMPUTER DESIGN CONCEPTS

The computer design simulation BNDZN (Loewer et al. 1974) was used to determine the cost of various types of facilities. The input design parameters were as follows:

1 Design storage capacity: 5000, 10000, 15000, 20000, 30000, 50000, and 80000 bu
2 Number of bins: 1, 2, 3, and 4

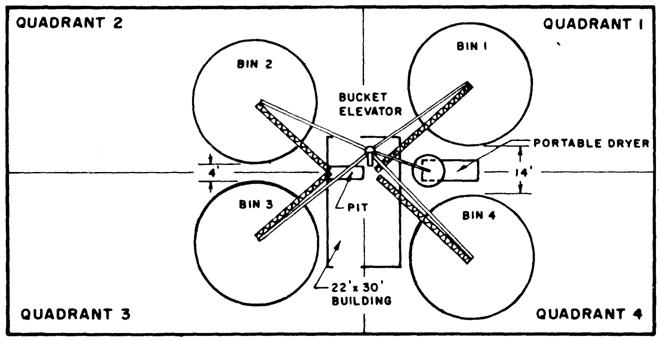

FIG. 1 Arrangement of bins used in BNDZN.

3 Number of harvest days: 5, 10, 15, 20, 25, and 30
4 Drying method: layer, batch-in-bin, portable (includes both portable batch and continuous flow dryers)
5 Degree of mechanization: portable auger, bucket elevator, pit and center building with accessories.

Not all combinations of these parameters were used in that bin diameters were restricted to 48 ft or less, and

TABLE 1. BIN ECONOMIC INFORMATION

No.	Item description	Expected life, years	Repair, percent of list	Interest, percent	Taxes, insurance, percent of list
1	Bin structure	20	0.05	10.00	1.00
2	Perforated floor	20	0.05	10.00	1.00
3	Unloading auger	7	2.00	10.00	1.00
4	Electric motor	10	1.00	10.00	1.00
5	Sweep auger	7	2.00	10.00	1.00
6	Electric motor	10	1.00	10.00	1.00
7	Aeration fan	10	1.00	10.00	1.00
8	Foundation ring	20	0.05	10.00	1.00
9	Concrete foundation	20	0.02	10.00	1.00
10	Aeration sub-floor	20	0.05	10.00	1.00
11	Grain spreaders	10	1.00	10.00	1.00
12	Humidistat	5	4.00	10.00	1.00
13	Thermostat	5	4.00	10.00	1.00
14	Miscellaneous	10	5.00	10.00	1.00

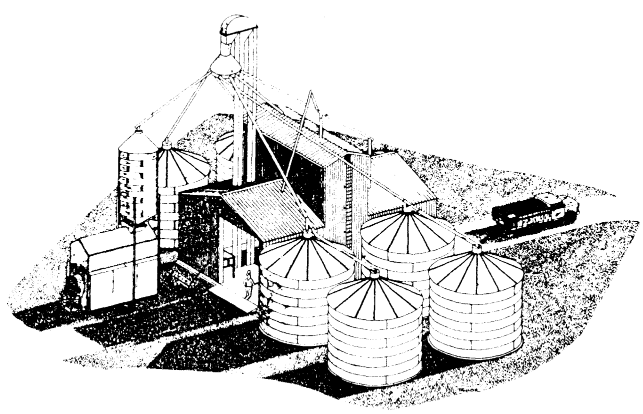

FIG. 2 Schematic of facility arrangement similar to that used in BNDZN [Kentucky Plan Service, KY 11.732-17].

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the maximum allowable bin eave height was 16 ft (6 rings). BNDZN selected the minimum diameter bin(s) that would contain the design capacity.

Layer drying fan horsepower calculations were based on eave height filling, while batch-in-bin drying horsepower determinations were calculated from the height of grain in the bin resulting from the daily harvest rate. For each drying technique the grain was dried from 25 to an average of 15 percent moisture content. The layer drying system was operated 18 hr to complete drying so that the last grain placed in the bin one day would be dry before additional grain was added the next day. The batch-in-bin system dried the daily harvest in 16 hr, and the portable dryer operated 12 hr. Three-phase electrical power was used.

The design storage capacity was divided by the number of harvest days to determine the daily harvest rate. For layer drying, the daily harvest rate was divided evenly among the bins. The batch-in-bin system dried the daily harvest in one bin. The portable dryer processed the daily harvest in a 12 hr period.

Each bin in a given system had the same diameter. Each layer drying bin had a perforated floor while only the drying bin in the batch-in-bin system was so equipped. An aeration sub-floor was placed in the remaining bins of the batch-in-bin drying system and in all the bins of the portable drying facility.

The bin arrangement used by BNDZN is shown in Fig. 1 (Loewer et al. 1974). A schematic of a similar system is shown in Fig. 2 (Kentucky Farm Building Plan Service 1974). Bin placement was in the order of quadrant numbers 1, 2, 3, and 4.

COMPUTER ECONOMIC CONCEPTS

Fixed and annual costs were based on categories of items with associated expense. These categories with their components were storage bins (Table 1), auger type pit (Table 2), bucket elevator (Table 3), drying equipment (Table 4), miscellaneous equipment (Table 5), construction expense (Table 6), electricity and LP gas.

Purchase costs were established through equations and cost arrays, using the manufacturer's suggested list prices of representative companies (Table 7). These prices were in force at the same time even though the effective dates of issue varied.

Annual costs were determined using straight line depreciation with no salvage value, an estimated life and rate of repair, and constant interest, tax, and insurance rates (Tables 1-6). The expenditures for electricity and LP-gas were added to the annual cost but not included in the purchase cost.

Of the items listed under "Miscellaneous Equipment" (Table 5), the costs for the center building, scale, truck hoist, and miscellaneous expense were constant for all facilities as was the pit size and bucket elevator capacity. Again, the portable dryer category included both continuous

TABLE 2. PIT ECONOMIC INFORMATION

No.	Item description	Expected life, years	Repair, percent of list	Interest, percent	Taxes, insurance, percent of list
15	Pit structure	20	0.05	10.00	1.00
16	Pit unloading auger	10	1.00	10.00	1.00
17	Electric motor	10	1.00	10.00	1.00
19	Pit miscellaneous	10	5.00	10.00	1.00

TABLE 3. BUCKET ELEVATOR ECONOMIC INFORMATION

No.	Item description	Expected life, years	Repair, percent of list	Interest, percent	Taxes, insurance, percent of list
19	Head and boot only	20	0.05	10.00	1.00
20	Leg assembly	20	0.02	10.00	1.00
21	Electric motor	10	1.00	10.00	1.00
22	Distributor	20	0.10	10.00	1.00
23	Cleaner attachment	20	0.50	10.00	1.00
24	Downspouting	20	0.02	10.00	1.00
25	Auger to bins 5, 6	10	1.00	10.00	1.00
26	Electric motor	10	1.00	10.00	1.00
27	Overhead auger, bin 5	7	2.00	10.00	1.00
28	Electric motor	10	1.00	10.00	1.00
29	Overhead auger, Bin 6	7	2.00	10.00	1.00
30	Electric motor	10	1.00	10.00	1.00
31	Miscellaneous	10	5.00	10.00	1.00

TABLE 4. DRYING TECHNIQUE ECONOMIC INFORMATION

No.	Item description	Expected life, years	Repair, percent of list	Interest, percent	Taxes, insurance, percent of list
32	Layer drying Fan 1	10	1.00	10.00	1.00
33	Layer drying Fan 2	10	1.00	10.00	1.00
34	Layer drying Fan 3	10	1.00	10.00	1.00
35	Layer drying Fan 4	10	1.00	10.00	1.00
36	Layer drying Fan 5	10	1.00	10.00	1.00
37	Layer drying Fan 6	10	1.00	10.00	1.00
38	Batch-in-bin dryer	10	1.00	10.00	1.00
39	Portable dryer	10	0.50	10.00	1.00

TABLE 5. MISCELLANEOUS ECONOMIC INFORMATION

No.	Item description	Expected life, years	Repair, percent of list	Interest, percent	Taxes, insurance, percent of list
43	Center building	20	1.00	10.00	1.00
44	Scale	20	1.00	10.00	1.00
45	Portable auger	7	4.00	10.00	1.00
46	Truck hoist	20	2.00	10.00	1.00
47	Miscellaneous	10	5.00	10.00	1.00

TABLE 6. CONSTRUCTION ECONOMIC INFORMATION

No.	Item description	Expected life, years	Repair, percent of list	Interest, percent	Taxes, insurance, percent of list
48	Storage bins	20	0.0	10.00	1.00
49	Bucket elevator	20	0.0	10.00	1.00
50	Downspouting	20	0.0	10.00	1.00
51	Miscellaneous	20	0.0	10.00	1.00

flow and portable batch dryers.

RESULTS

Number of Bins

Reasons for having several bins in a single facility include limited storage capacity or having more than one crop or variety. It has been found that building additional bins is usually less costly for farm installations than construction of bins that have eave heights greater than 24 ft (nine rings) (Bridges 1974). For this study, the number of bins was increased from one to four in increments of one limiting the eave height to 16 ft. This was done to make the drying methods as comparable as possible and to enable portable handling equipment to be easily used. For each drying technique, the design storage capacity was to be dried in a 20-day harvest period. Results are shown in Table 8.

For layer drying, the purchase and annual cost per bushel consistently increased with the number of bins and decreased with capacity. Basically, the portable drying system behaved the same way; however, costs for the batch-in-bin system were inconsistent. A one-bin batch-in-bin system could only be used for selling immediately after drying and is really not a feasible storage alternative. However, the two-bin batch-in-bin system was generally less expensive than one-, three-, or four-bin systems.

For layer drying the number of bins was a more significant factor with relatively low capacities. This was also the case with the other drying techniques, although the cost difference was less pronounced.

TABLE 7. PRICE REFERENCES USED IN BNDZN

	Item	Company	Effective date†
1.	Bin structure	Circle Steel Corp.	August 31, 1974
2.	Perforated floor -20 ga channel lock—includes steel substructure	Circle Steel Corp.	August 31, 1974
3.	Unloading auger, 6 in. tube under bin hopper, slide gate control, motor pulley motor belt	Cardinal	November 1, 1974
4.	Electric motors, single and one 3-phase TEFC	MFS	January 1, 1975
5.	Aeration fans	MFS	February 15, 1975
6.	Foundation ring	Circle Steel Corp.	August 31, 1974
7.	Aeration subfloor—covers only plus transition	Circle Steel Corp.	August 31, 1974
8.	Grain spreader	Circle Steel Corp.	August 31, 1974
9.	Humidistat	Circle Steel Corp.	August 31, 1974
10.	Thermostat	Circle Steel Corp.	August 31, 1974
11.	Pit auger and U-trough—includes 20 bu storage	Sweet Manufacturing Co.	January 31, 1974
12.	Bucket elevator (a) head and boot includes cables, backstop, platforms, etc. (b) distributors (c) downspouting	Sweet Manufacturing Co.	January 31, 1975
13.	Cleaner—in leg type	Clay Equip. Co.	December 15, 1974
14.	Fans with heaters—includes transitions, controls, weather cover, 1 and 3 phase	Farm Fans, Inc.	January 1, 1974
15.	Portable batch dryers	DRIALL	February, 1975*
16.	Continuous flow dryers	Butler	June 1975
17.	Construction cost	Southern States	November, 1974

*Estimated

†All prices were obtained at the February 1975 Farm Machinery Show in Louisville, Kentucky.

TABLE 8. FIXED AND ANNUAL COST FOR DRYING AND STORAGE FACILITIES INCLUDING BUCKET ELEVATOR, PIT, CENTER BUILDING, SCALE, CONSTRUCTION AND FOR ANNUAL COST ONLY, THE COST OF ENERGY

Harvest days	Design capacity	1 bin			2 bins			3 bins			4 bins		
		C*bu	P*$/bu	A*$/bu	C*bu	P*$/bu	A*$/bu	C*bu	P*$/bu	A*$/bu	C*bu	P*$/bu	A*$/bu
DRYING METHOD: LAYER													
	5,000	5,320	7.30	1.07	5,442	7.86	1.16	5,103	9.06	1.35	5,296	9.54	1.42
	10,000	10.058	4.39	0.66	10,640	4.52	0.69	10,002	5.23	0.79	10,341	5.40	0.83
	15,000	16,292	3.16	0.49	15,117	3.50	0.54	15,960	3.60	0.56	16,292	3.79	0.60
20	20,000	21,280	2.72	0.43	20,116	2.88	0.46	20,199	2.94	0.49	21,280	3.12	0.50
	30,000				32,585	2.20	0.36	30,175	2.39	0.39	30,234	2.50	0.41
	50,000							51,834	1.92	0.33	50,052	1.90	0.32
	80,000										85,121	1.60	0.28
DRYING METHOD: BATCH-IN-BIN													
	5,000	5,320	7.23	1.06	5,164	7.66	1.13	5,471	7.61	1.14	5,848	7.63	1.14
	10,000	10,058	4.30	0.65	11,110	3.98	0.62	10,723	4.34	0.67	10,592	4.60	0.71
	15,000	16,292	3.09	0.48	15,852	3.05	0.48	16,901	2.98	0.48	17,373	3.09	0.50
20	20,000	21,280	2.56	0.41	21,006	2.48	0.40	21,390	2.53	0.41	22,691	2.51	0.41
	30,000				34,026	1.86	0.31	31,954	1.91	0.33	30,932	2.04	0.35
	50,000							51,760	1.48	0.26	51,056	1.51	0.27
	80,000										90,767	1.14	0.22
DRYING METHOD: PORTABLE													
	5,000	5,790	6.98	1.05	5,428	7.90	1.19	5,654	8.01	1.21	6,031	8.03	1.22
	10,000	10,947	4.03	0.65	11,581	4.06	0.66	11,083	4.51	0.72	10,857	4.83	0.77
	15,000	17,733	2.81	0.48	15,079	3.32	0.55	17,371	3.09	0.52	17,733	3.23	0.55
20	20,000	23,162	2.32	0.41	21,895	2.49	0.44	21,986	2.63	0.46	23,162	2.62	0.46
	30,000				35,467	1.84	0.35	32,843	1.97	0.37	30,159	2.21	0.40
	50,000							53,201	1.53	0.31	52,115	1.57	0.31
	80,000										92,649	1.19	0.26

*C = Actual capacity, P = Purchase cost, $ per actual bu, A = Annual cost, $ per actual bu.

Harvest Rate

Harvest rate is probably the single most important factor in terms of grain storage facility design. An inadequate drying or handling capacity usually results in a delayed harvest accompanied by increased harvest losses and inefficient utilization of labor and harvesting related machinery.

For this study, the daily harvest rate was equated to the design capacity of the structure divided by the number of harvest days. The fewest number of bins that would hold the design capacity were used in determining cost. However, a minimum of two bins were used with batch-in-bin drying. Results are shown in Table 9. As would be expected, the cost of the facility increased with the harvest rate.

In the case of layer drying, as the number of harvest days became small, the interactions among drying capacity, storage capacity, and the number of bins resulted in a more expensive facility although using fewer bins. Batch-in-bin drying exhibited similar characteristics for the 5-day harvest time. Part of this may be attributed to the selection of minimum diameter bins of similar size. As the number of harvest days increased, the harvest rate and, subsequently, the facility cost decreased. However, this effect diminished in significance

TABLE 9. INFLUENCE OF HARVEST RATE ON THE COST OF GRAIN STORAGE AND DRYING FACILITIES

Design capacity	Layer drying				Batch-in-bin drying				Continuous flow drying			
	N*	C*,bu	P*, $/bu	A*, $/bu	N	C,bu	P, $/bu	A,$/bu	N	C,bu	P,$/bu	A,$/bu
HARVEST DAYS: 5												
5,000	1	5,320	11.67	1.88	2	5,164	7.77	1.16	1	5,790	7.36	1.12
10,000	1	10,058	9.46	1.60	2	11,110	4.27	0.67	1	10,947	4.44	0.72
15,000	1	16,292	7.48	1.29	2	15,852	3.29	0.53	1	17.733	3.19	0.54
20,000	1	21,280	7.11	1.24	2	21,006	2.78	0.46	1	23,162	2.71	0.48
30,000	2	32,585	6.51	1.16	2	34,026	2.13	0.36	2	35,467	2.24	0.41
50,000	3	51,834	7.33	1.33	3	51,760	2.55	0.46	3	53,201	1.97	0.38
80,000	4	85,121	5.99	1.09	4	90,767	2.74	0.52	4	92,649	1.59	0.32
HARVEST DAYS: 10												
5,000	1	5,320	7.86	1.18	2	5,164	7.66	1.14	1	5,790	7.11	1.07
10,000	1	10.058	5.26	0.83	2	11,110	4.00	0.62	1	10,947	4.17	0.67
15,000	1	16,292	3.85	0.62	2	15,852	3.06	0.49	1	17,733	2.94	0.50
20,000	1	21,280	3.28	0.54	2	21,006	2.49	0.41	1	23,162	2.45	0.43
30,000	2	32,585	2.89	0.50	2	34,026	1.88	0.32	2	35,467	1.96	0.37
50,000	3	51,834	2.66	0.47	3	51,760	1.55	0.28	3	53,201	1.68	0.33
80,000	4	85,121	2.16	0.35	4	90,767	1.26	0.19	4	92,649	1.33	0.21
HARVEST DAYS: 15												
5,000	1	5,320	7.38	1.09	2	5,164	7.66	1.13	1	5,790	7.02	1.06
10,000	1	10,058	4.64	0.71	2	11,110	3.98	0.62	1	10,947	4.08	0.66
15,000	1	16,292	3.33	0.52	2	15,852	3.06	0.48	1	17,733	2.86	0.49
20,000	1	21,280	2.84	0.46	2	21,006	2.48	0.40	1	23,162	2.37	0.42
30,000	2	32,585	2.37	0.39	2	34.026	1.87	0.32	2	35,467	1.88	0.35
50,000	3	51,834	2.08	0.36	3	51,760	1.49	0.27	3	53,201	1.57	0.31
80,000	4	85,121	1.72	0.30	4	90,767	1.17	0.22	4	92,649	1.24	0.27
HARVEST DAYS: 20												
5,000	1	5,320	7.30	1.07	2	5,164	7.66	1.13	1	5,790	6.98	1.05
10,000	1	10,058	4.39	0.66	2	11,110	3.98	0.62	1	10,947	4.03	0.65
15,000	1	16,292	3.16	0.49	2	15,852	3.05	0.48	1	17,733	2.81	0.48
20,000	1	21,280	2.72	0.43	2	21,006	2.48	0.40	1	23,162	2.32	0.41
30,000	2	32,585	2.20	0.36	2	34,026	1.86	0.31	2	35,467	1.84	0.35
50,000	3	51,834	1.92	0.33	3	51,760	1.48	0.26	3	53,201	1.53	0.31
80,000	4	85,121	1.60	0.28	4	90,767	1.14	0.22	4	92,649	1.19	0.26
HARVEST DAYS: 25												
5,000	1	5,320	7.27	1.06	2	5,164	7.66	1.13	1	5,790	6.95	1.05
10,000	1	10,058	4.35	0.65	2	11,110	3.98	0.62	1	10,947	4.00	0.65
15,000	1	16,292	3.12	0.48	2	15,852	3.05	0.48	1	17,733	2.79	0.48
20,000	1	21,280	2.60	0.41	2	21,006	2.48	0.40	1	23.162	2.30	0.41
30,000	2	32,585	2.16	0.39	2	34,026	1.86	0.31	2	35.467	1.81	0.34
50,000	3	51,834	1.77	0.30	3	51,760	1.48	0.26	3	53.201	1.50	0.30
80,000	4	85,121	1.48	0.25	4	90,767	1.13	0.22	4	92,649	1.16	0.25
HARVEST DAYS: 30												
5,000	1	5,320	7.24	1.06	2	5,164	7.66	1.13	1	5,790	6.94	1.05
10,000	1	10,058	4.33	0.65	2	11,110	3.98	0.62	1	10,947	3.99	0.64
15,000	1	16,292	3.11	0.48	2	15,852	3.05	0.48	1	17.733	2.77	0.47
20,000	1	21,280	2.59	0.40	2	21,006	2.48	0.40	1	23.162	2.28	0.41
30.000	2	32,585	2.15	0.35	2	34,026	1.86	0.31	2	35,467	1.80	0.34
50,000	3	51,834	1.75	0.29	3	51,760	1.48	0.26	3	53,201	1.48	0.30
80,000	4	85,121	1.47	0.25	4	90,767	1.13	0.21	4	92,649	1.15	0.25

*N = Number of bins; C = Actual capacity; P = Purchase cost per actual bushel; A = Annual cost per actual bushel.

with the increase in harvest days.

Degree of Mechanization

The cost figures previously presented reflect comparable materials handling capability for all levels of design capacity, which tends to amplify cost differences. The cost of facilities with portable handling equipment was relatively constant for design capacities in excess of 20,000 bu. The cost increased significantly with increases in mechanization. However, this is not to say that increased mechanization will result in lower net profits when considering the total harvesting, storage and drying system. The cost figures presented do not reflect an optimum design but rather a typical farm facility based on list prices of representative manufacturers and contractors. It should also be noted that cost figures were based on actual capacity rather than design capacity. Should design capacity have been used, the least cost facility would usually have been the one that most closely matched the design capacity.

Tables 10-12 indicate that layer drying facilities with portable handling equipment were competitive in purchase and annual cost to other drying techniques only for design capacities less than 10,000 bu. Batch-in-bin and portable drying facilities were competitive in purchase cost for all capacities with the batch-in-bin technique having a significant advantage in annual cost. Again, this is not to say that factors such as grain quality, hours of operation, hauling distance, etc. would not alter the relative cost positions for a given capacity. However, it does explain why many farmers who select layer drying when their initial storage capacity is small, are faced with unnecessary expense when they expand. For a graphical display of Tables 10-12, see Loewer et al. (1975).

The relative cost influence of the facility component categories is also shown in Tables 10-12.

The categories of "miscellaneous equipment" and "bucket elevator" comprised a significant portion of facility cost at lower capacities. As

TABLE 10. PROPORTIONAL COST OF COMPLETELY MECHANIZED CENTRALIZED GRAIN STORAGE FACILITY

Number of harvest days: 20 — Drying method: Layer

Facility components (Design capacity, bu)	5000				10000				15000				20000				30000				50000				80000			
Actual bu / No. of bins	5320		1		10058		1		16292		1		21280		1		32585		2		51834		3		85121		4	
	P*	PCP*	A*	PCA*	P	PCP	A	PCA	P	PCP	A	PCA	P	PCP	A	PCA	P	PCP	A	PCA	P	PCP	A	PCA	P	PCP	A	PCA
Storage bins	1.07	14.7	0.15	14.0	0.92	21.0	0.12	18.5	0.89	28.2	0.11	23.5	0.83	30.4	0.11	24.5	0.89	40.5	0.11	32.0	0.85	44.1	0.11	33.8	0.83	51.6	0.11	37.9
Auger type pit†	0.51	7.0	0.08	7.0	0.27	6.2	0.04	6.3	0.17	5.3	0.03	5.3	0.13	4.7	0.02	4.6	0.08	3.8	0.01	3.6	0.05	2.7	0.01	3.1	0.03	2.0	<0.01	1.8
Bucket elevator†	1.35	18.5	0.16	15.3	0.76	17.4	0.09	13.9	0.52	16.3	0.06	12.8	0.41	15.1	0.05	11.5	0.28	12.9	0.03	9.6	0.20	10.3	0.02	6.1	0.13	8.3	0.02	5.8
Drying equipment	0.39	5.4	0.07	6.3	0.25	5.7	0.04	6.5	0.17	5.5	0.03	6.1	0.24	8.8	0.04	9.5	0.17	7.9	0.03	8.4	0.24	15.2	0.05	15.6	0.24	14.8	0.04	14.8
Miscellaneous equipment‡	3.44	47.1	0.47	44.2	1.84	41.8	0.25	38.2	1.14	36.2	0.16	32.5	0.88	32.4	0.12	28.5	0.57	26.0	0.08	22.2	0.36	18.8	0.05	15.5	0.22	13.8	0.03	11.1
Construction expense	0.52	7.2	0.06	5.4	0.34	7.9	0.04	5.8	0.27	8.5	0.03	6.1	0.24	8.7	0.03	6.1	0.20	9.0	0.02	6.1	0.17	8.9	0.02	5.8	0.15	9.5	0.02	6.0
Electricity cost§			0.03	2.3			0.02	2.6			0.01	2.7			0.01	2.8			0.01	2.9			0.01	3.4			<0.01	3.1
L. P. gas cost§			0.05	5.1			0.05	8.2			0.05	11.1			0.05	12.6			0.05	15.2			0.05	16.6			0.05	19.5
TOTAL	7.30	100	1.07	100	4.39	100	0.66	100	3.16	100	0.49	100	2.72	100	0.43	100	2.20	100	0.36	100	1.92	100	0.33	100	1.60	100	0.28	100

* P = Purchase cost, \$ per actual bu; PCP = Percent of total purchase cost; A = Annual cost, \$ per actual bu; PCA = Percent of total annual cost.
† Pit Capacity = 72 bu; bucket elevator capacity = 2000 bu/h.
‡ This item includes a center building, scale, and truck hoist for a total purchase and annual cost of \$17,206 and \$2,242, respectively. Remaining items are a portable auger and miscellaneous expense.
§ Electricity @ \$0.025/kWh; L.P. gas @ \$0.40/gal.

TABLE 11. PROPORTIONAL COST OF COMPLETELY MECHANIZED CENTRALIZED GRAIN STORAGE FACILITY

Number of harvest days: 20 — Drying method: batch-in-bin

Facility components (Design capacity, bu)	5000				10000				15000				20000				30000				50000				80000			
Actual bu / No. of bins	5164		2		11110		2		15852		2		21006		2		34026		2		51760		3		90767		4	
	P*	PCP*	A*	PCA*	P	PCP	A	PCA	P	PCP	A	PCA	P	PCP	A	PCA	P	PCP	A	PCA	P	PCP	A	PCA	P	PCP	A	PVA
Storage bins	1.44	18.8	0.22	19.1	0.96	24.0	0.14	22.2	0.86	28.0	0.12	24.5	0.78	31.6	0.11	26.4	0.74	39.7	0.10	30.8	0.69	46.3	0.09	34.3	0.61	53.3	0.08	36.6
Auger type pit†	0.53	6.9	0.08	7.2	0.25	6.2	0.04	6.1	0.17	5.6	0.03	5.5	0.13	5.2	0.02	4.9	0.08	4.3	0.01	3.9	0.05	3.6	0.01	3.1	0.03	2.6	<0.01	2.1
Bucket elevator†	1.38	18.0	0.17	14.7	0.68	17.2	0.08	13.4	0.50	16.5	0.06	12.6	0.39	15.6	0.05	11.6	0.26	14.1	0.03	10.1	0.18	12.4	0.02	8.4	0.12	10.9	0.01	6.9
Drying equipment	0.27	3.6	0.05	4.2	0.13	3.2	0.02	3.6	0.09	3.0	0.02	3.2	0.07	2.8	0.01	2.9	0.04	2.3	0.01	2.4	0.03	2.2	0.01	2.2	0.02	1.9	<0.01	1.8
Miscellaneous equipment‡	3.52	45.9	0.48	42.3	1.65	41.1	0.23	36.8	1.16	38.2	0.16	33.2	0.88	35.4	0.12	30.1	0.55	29.4	0.08	24.1	0.36	24.3	0.05	18.9	0.21	18.2	0.03	13.3
Construction expense	0.52	6.8	0.06	5.3	0.32	7.9	0.03	5.7	0.27	8.7	0.03	6.0	0.23	9.3	0.03	6.3	0.19	10.2	0.02	6.7	0.17	11.2	0.02	6.9	0.15	13.0	0.02	7.5
Electricity cost§			0.02	1.6			<0.01	1.5			<0.01	1.4			<0.01	1.3			<0.01	1.1			<0.01	1.1			<0.01	1.2
L.P. gas cost§			0.07	5.8			0.07	10.7			0.07	13.6			0.07	16.4			0.07	20.9			0.07	25.0			0.07	30.5
TOTAL	7.66	100	1.13	100	3.98	100	0.62	100	3.05	100	0.48	100	2.48	100	0.40	100	1.86	100	0.31	100	1.48	100	0.26	100	1.14	100	0.22	100

* P = Purchase cost, \$ per actual bu; PCP = Percent of total purchase cost; A = Annual cost \$ per actual bu; PCA = Percent of total annual cost.
† Pit Capacity = 72 bu; bucket elevator capacity = 2000 bu/h.
‡ This item includes a center building, scale, and truck hoist for a total purchase and annual cost of \$17,206 and \$2,242, respectively. Remaining items are a portable auger and miscellaneous expense.
§ Electricity @ \$0.025/kWh; L.P. gas @ \$0.40/gal.

capacity increased, the cost of "storage bins" became the dominant factor. Annual energy cost for electricity remained relatively small while LP gas increased significantly in proportional cost with increases in capacity.

SUMMARY

List prices were incorporated into the design computer simulation BNDZN to generate comparative purchase and annual costs for layer, batch-in-bin, and portable drying facilities. Design factors included capacity, number of bins, harvest rate, and degree of mechanization.

Generally, on a per bushel basis within the range of the test parameters, it was found that:

1 purchase and annual cost decreased rapidly for capacities up to approximately 20,000 bu and then tended to decrease at a lesser but more uniform rate

2 layer drying had a slight purchase and annual cost advantage for capacities up to 10,000 bu

3 batch-in-bin and portable drying were competitive in purchase price at all capacities. However, batch-in-bin had a significantly less annual cost owing to increased fuel efficiency and less investment in the "dryer equipment" category

4 purchase and annual costs were significantly reduced as the number of harvest days increased up to approximately 20 harvest days. At very high harvest rates, special care must be taken to minimize layer and batch-in-bin facility cost because of the interaction between bin dimensions and drying fan horsepower requirements

5 purchase and annual cost usually increased with the number of bins, but this factor was not very significant at capacities exceeding 50,000 bu

6 the degree of mechanization was very important in terms of cost for capacities less than 20,000 bu. After 30,000 bu, the rate of cost decrease was relatively constant

7 the cost figures presented do not reflect a minimum cost facility nor the optimum design required for maximum net return

Each individual farm represents a unique situation in terms of design, and factors other than facility costs must be considered when evaluating the total harvesting, storage and drying system. The key factor in terms of cost is to compare truly comparable systems.

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TABLE 12. PROPORTIONAL COST OF COMPLETELY MECHANIZED CENTRALIZED GRAIN STORAGE FACILITY

Number of harvest days: 20 — Drying method: Portable

Facility components	Design capacity, bu																															
	5000				10000				15000				20000				30000				50000				80000							
Actual No. of bu / bins	5790		1		10947		1		17733		1		23162		1		35467		2		53201		3		92649		4					
	P*	PCP*	A*	PCA*	P	PCP	A	PCA	P	PCP	A	PCA	P	PCP	A	PCA	P	PCP	A	PCA	P	PCP	A	PCA	P	PCP	A	PCA				
Storage bins	0.82	11.7	0.12	11.4	0.64	15.9	0.09	13.7	0.59	21.0	0.08	16.5	0.54	23.1	0.07	17.2	0.59	32.0	0.08	22.6	0.58	38.5	0.08	25.7	0.54	45.1	0.07	27.3				
Auger type pit†	0.47	6.8	0.07	6.9	0.25	6.2	0.04	5.9	0.15	5.5	0.02	4.9	0.12	5.1	0.02	4.4	0.08	4.2	0.01	3.4	0.05	3.4	0.01	2.6	0.03	2.5	<0.01	1.8				
Bucket elevator†	1.39	20.0	0.17	15.9	0.74	18.3	0.09	13.7	0.49	17.3	0.06	12.2	0.39	16.7	0.05	11.4	0.26	14.1	0.03	9.0	0.18	12.0	0.02	7.3	0.12	10.0	0.01	5.5				
Drying equipment	0.58	8.3	0.08	7.8	0.38	9.3	0.05	8.5	0.27	9.7	0.04	8.5	0.24	10.4	0.04	8.9	0.20	10.9	0.03	9.0	0.19	12.4	0.03	9.9	0.16	13.2	0.03	9.9				
Miscellaneous equipment‡	3.17	45.4	0.43	41.3	1.69	41.8	0.23	35.8	1.05	37.3	0.15	30.4	0.81	34.8	0.11	27.3	0.53	28.6	0.07	21.0	0.35	22.9	0.05	15.9	0.20	17.0	0.03	10.9				
Construction expense	0.55	7.8	0.06	5.7	0.34	8.5	0.04	5.8	0.26	9.2	0.03	6.0	0.23	9.9	0.03	6.1	0.19	10.3	0.02	6.0	0.17	10.9	0.02	6.0	0.15	12.3	0.02	6.2				
Electricity cost§			0.02	1.8			0.01	1.5			0.01	1.4			0.01	1.3			0.01	1.0			<0.01	0.9			<0.01	0.7				
L. P. gas cost§			0.10	9.2			0.10	15.0			0.10	20.2			0.10	23.5			0.10	28.0			0.10	31.8			0.10	37.7				
TOTAL	6.98	100	1.05	100	4.03	100	0.65	100	2.81	100	0.48	100	2.32	100	0.41	100	1.84	100	0.35	100	1.53	100	0.31	100	1.19	100	0.26	100				

* P = Purchase cost, $ per actual bu; PCP = percent of total purchase cost; A = annual cost, $ per actual bu; PCA = percent of total annual cost.

† Pit cpapcity = 72 bu; bucket elevator capacity = 2000 bu/h.

‡ This item includes a center building, scale, and truck hoist for a total purchase and annual cost of $17,206 and $2,242, respectively. Remaining items are a portable auger and miscellaneous expense.

§ Electricity @ $0.025/kWh; L.P. gas @ $0.40/gal.