ECONOMICS OF CONVERTING TO CENTER PIVOTS FOR SOUTHEAST COLORADO IRRIGATED ALFALFA

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INTRODUCTION

This paper provides an economic analysis of the profitability of converting from surface irrigation to center pivot systems along the Arkansas River in Southeast Colorado. The use of surface water from the Arkansas River in this region makes this analysis unique in the Great Plains region, where most irrigation systems rely on subsurface water supplies.

The focus of this analysis is on the economics of producing alfalfa, first with existing surface irrigation systems, and then under a newly installed center pivot irrigation system with water drawn from a holding or filtering pit. Net present value (NPV) analysis is used to project the profitability of a center pivot system investment under these conditions. Key factors examined in this study are a) expected alfalfa yields for center pivot systems relative to those under existing surface irrigation, and b) irrigation water application amounts for the two alternative systems. A key assumption is that the acreages irrigated with surface and center pivot systems are the same.

The findings of this analysis are preliminary in nature. The author's intent is to present the assumptions, method, and first-draft findings to farm and agribusiness audiences at the 2002 Central Plains Irrigation Shortcourse on February 5-6 in Lamar, Colorado. Further updated analyses will be produced if warranted by constructive critique received at the Lamar meeting.

Given the assumptions used in this study, preliminary results indicate that it is economically profitable to invest in center pivot irrigation systems if an alfalfa yield increase of 0.5 ton per acre or more occurs in conjunction with the irrigation system investment, and water application savings of 4 to 5 acre inches are achieved. While the efficiencies gained in irrigation water use with center pivot systems as opposed to surface irrigation systems are economically important,

they do not have as great an economic impact as do differences in alfalfa yield between the two systems.

METHOD OF ANALYSIS

The crop production and irrigation system investment information used in this analysis was obtained from several sources. Colorado State University Extension provided irrigated alfalfa hay cost and returns estimates for Southeast Colorado – Arkansas Valley for year 2000. Center pivot irrigation system investment costs were obtained through telephone interviews with agribusiness and extension contacts in the Lamar, Colorado area. Center pivot operation and maintenance costs were obtained from K-State Farm Management Guide crop budgets.

Irrigated Alfalfa Costs-Returns

Surface irrigated alfalfa cost and return estimates used in this study are summarized in Table 1. All alfalfa production costs and income projections are assumed to be the same for surface and center pivot irrigation systems except for the cost of irrigation water and irrigation labor. Alfalfa establishment costs are included in this budget and are allocated on an annual share basis over the projected life of the alfalfa stand (i.e., 4 years).

Pumping costs for center pivots are calculated using K-State crop budget estimates for Western Kansas. It is assumed that natural gas is used as the primary energy source at a cost of $3.72 per mcf. It is also assumed that the surface water holding pit-to-center pivot irrigation system has 20 feet of lift (friction loss), 20 psi discharge pressure, and that the natural gas engine operates at 75% of Nebraska Pumping Plant Performance Criteria. Total pumping cost under these assumptions is calculated to be $0.61 per acre inch. Additional maintenance costs for the power unit and center pivot system are assumed to be $0.33 per acre inch of water applied.

Irrigation labor is assumed to be half as much for center pivot systems (i.e., 2 hours per acre) as it is for surface irrigation systems (i.e., 4 hours per acre). Higher custom swath, baling, and hauling-stacking costs are accounted for when examining the costs associated with potentially higher alfalfa yields under center pivot irrigation systems.

Irrigation System Conversion Costs

The estimated cost of converting from a surface flood to a center pivot irrigation system is presented in Table 2. Cost estimates were obtained through telephone interviews with agribusiness representatives in the Lamar – Southeast Colorado area and with Colorado State University Extension staff.

Table 1. Surface Irrigated Alfalfa Returns and Direct Costs for Year 2000

	Units	Price or Cost/Unit	Quantity	Value or Cost/Acre
Alfalfa Income	Tons	$85.00	4.75	$403.54
Direct Operating Costs				
Preharvest Operating Costs				
Phosphate	Lbs.	$0.44	40.00	$17.60
Insecticide	Lbs.	$14.37	0.25	$3.59
Application	Acre	$5.00	1.00	$5.00
Seed	Acre	$8.00	1.00	$8.00
Irrigation Water	Acre	$1.00	22.00	$22.00
Irrigation Labor	Hour	$10.00	4.00	$40.00
Machinery Fuel & Lube	Acre			$19.42
Machinery Repairs	Acre			$7.97
Interest on Operating Capital	Dollars	9.00%	$72.66	$6.54
Total Preharvest Operating Cost	Dollars			$130.11
Harvest Operating Costs				
Custom Swath	Acre	$9.00	4.00	$36.00
Custom Bale (Small Square)	Ton	$10.00	4.75	$47.50
Custom Haul/Stack	Ton	$6.25	4.75	$29.69
Interest on Operating Capital	Dollars	9.00%	$51.90	$4.67
Total Harvest Operating Cost	Dollars			$117.86
Property and Ownership Costs				
Machinery Replacement	Dollars			$17.05
Machinery Taxes and Insurance	Dollars			$3.46
General Farm Overhead	Dollars			$15.00
Real Estate Taxes	Dollars			$6.00
Total Property + Ownership Costs	Dollars			$41.50
Total Direct Operating Costs	Dollars			$289.48

Table 2. Surface to Center Pivot Irrigation System Conversion Costs

	Total Cost
Center Pivot Irrigation System 5 foot drop spacings Constructed to withstand water quality/salinity problems	$49,000
Underground Pipe, Connectors, Wiring, etc.	$11,200
Power Unit "Floater" engine on holding pond	$6,500
Cost of Holding Pit Construction, Other Miscellaneous Using own tractors, scrapers, etc.	$3,500
Total Irrigation System Conversion Costs	$70,200

The center pivot irrigation system represented here is designed to withstand water quality problems associated with handling Arkansas River water in this region. System longevity in light of water quality problems is a primary concern in this analysis. The system cost for this analysis is estimated at $49,000. However, such systems may be available for several thousand dollars less cost from other suppliers than the one interviewed. The cost of underground pipe from a holding pit to the center pivot, with associated connectors, electrical wiring, etc., amounts to $11,200. The power unit was estimated to cost approximately $6,500. This cost represents a "floater" unit in which the power unit is placed on a floating platform in the water holding pit. The cost of pit construction in addition to other miscellaneous costs is estimated at $3,500. This figure is much less than the cost of having a commercial excavating firm construct such a pit. One excavating firm quoted such costs at approximately $10,000. Rather, it represents the cost of farmers constructing this type of pit themselves using a dirt scraper. To the degree that such costs are less than $3,500, they can be allocated to miscellaneous expenses associated with this overall irrigation system conversion. The life of all these irrigation system investments is assumed to be 15 years. Sensitivity analyses are conducted to show the impact of a $10,000 decrease in the cost of irrigation system conversion (i.e., from $70,200 to $60,200), and of variations in the life of the center pivot irrigation system from the original 15 years.

The IRRIGATE program was used to carry out these analyses. IRRIGATE is an irrigation oriented spreadsheet developed by Kansas State University Research and Extension to help farmers evaluate irrigation investment decisions.

Key Assumptions

While this analysis focuses on irrigated alfalfa production in Southeast Colorado, irrigated corn and to some degree wheat are also important crops in the region. However, alfalfa is the primary cash crop in the region and is therefore the focus of this analysis.

The acreage of surface irrigation and center pivot irrigation enterprises are assumed to be the same in this analysis (i.e., 126 acres). In other irrigated regions of the Great Plains that rely on limited subsurface water supplies (such as in much of Western Kansas) it may be more appropriate to compare center pivot irrigated systems of approximately 126 acres to flood irrigated acreages of 60-80 acres. However in this surface water irrigated area it appears to be common practice to combine neighboring small surface irrigated fields together to come up with a full center pivot circle. Therefore, the acreages for surface and center pivot systems are assumed to be equal.

With irrigated acreages for the two irrigation systems being approximately equal, and with the sizable financial investment required for transforming from a surface

to a center pivot irrigation system, it makes sense that more net income has to be generated from the new irrigated crop production system for the new investments to be profitable. Net income per acre can be increased either by a) generating more revenue per acre for approximately the same amount of expenses, b) reducing the costs required to produce the same amount of income, or c) producing more revenue with less cost. In this analysis it is assumed that net income will be increased for the new center pivot irrigation system by either a) higher alfalfa production, or b) lower water application amounts. The impact of changes in these two key factors upon the profitability of converting from surface to center pivot irrigation systems will be presented below. Lower labor requirements are also a cost factor favoring center pivot over surface irrigation systems.

RESULTS

Annual Cash Flow Example

Table 3 illustrates an annual cash flow analysis for the assumed 15 year life of the center pivot irrigation system investment. Direct comparisons are made between the income and expenses of the current surface irrigation system and the proposed center pivot irrigation system. In this example, it is assumed that alfalfa yields under the new center pivot system are 0.5 tons per acre greater than for the existing surface irrigation system (i.e., 5.25 tons per acre versus 4.75 tons for surface irrigation. It is also assumed that the amount of water applied under the center pivot irrigation system as approximately 5 inches less than for surface flood systems (i.e., 16.9 acre inches versus 22 inches).

This cash flow example was chosen to illustrate the minimum combination of a) alfalfa yield increases, and b) water application decreases needed to make it profitable to invest in a center pivot system given the assumptions used in this analysis. A net present value of +$2,021 is shown, indicating that it is profitable to install the center pivot system under these conditions. The net present value (NPV) results provided at the bottom of the Table 3 are explained more fully in the following section.

Net Present Value Findings

Net present value (NPV) results for a number of center pivot system alfalfa yields and irrigation application amounts are given in Table 4 and in Figure 1. Net present value analysis is used to represent the current value of income received over a number of years in the future. In other words, it illustrates the time value of money – how much is a stream of income received a number of years in the future worth today? The annual discount rate used in this analysis was 8%, which happens to be equal to the interest rate on money borrower to finance the irrigation investment. In other words, $1.00 received today would be worth $0.92 ($1.00 x 92%) next year, and $0.846 ($0.92 x 92%) the year after that. The total

NPV of a 15 year investment equals the sum of 15 discounted future annual net income results. When comparing two investment alternatives, the alternative with the greatest NPV result over time is determined to be the most profitable.

If there is a positive NPV in this analysis, it is an indication that the value of the center pivot investment over time is greater than the existing surface irrigation system. In other words, if a positive NPV exists, it is profitable to invest in the center pivot irrigation system. Conversely, if the NPV is negative, the value of the existing surface irrigation system is greater than the center pivot system, and it would not be profitable to invest in the new system.

Given the assumptions used here, it is generally unprofitable to convert an existing surface irrigation system into a center pivot irrigation system unless yield increases of 0.5 ton or more occur with the center pivot system, and at least some water savings are obtained with the new center pivot irrigation system. Each increase of 0.25 tons per acre of alfalfa produced resulting from the use of a center pivot system leads to an increase of $18,364 in the net present value of the center pivot system investment over that of the existing surface flood irrigation system. Alternatively, a 0.1 ton per acre of increased alfalfa production causes the net present value of the center pivot investment to increase by $7,345.

Decreases in water application requirements with center pivot systems are also economically important, but do not have as large an economic impact on this investment decision as do changes in alfalfa yield. Each 1 acre inch decrease in water applied resulting from the use of a center pivot system leads to an increase of $1,037 in the net present value of the center pivot system investment relative to that of an existing surface flood irrigation system.

Other Factors Affecting NPV Results

The key assumptions of this study need to be carefully reexamined by anyone seriously considering such an irrigation investment. The following sensitivity analyses show how the net present value results change if variation occurs in certain key factors.

A. Center Pivot Irrigation System Investment Cost

If it only costs $60,200 to convert from a surface to a center pivot irrigation system instead of $70,200 (i.e., $10,000 less), then the net present value of the center pivot system scenario increases by the same amount. Instead of having a +$2,021 NPV conversion benefit for the +0.5 tons per acre and 16.9 acre inches of water scenario, the NPV benefit is +$12,021. This NPV increase does not appreciably change the results in that at least a 0.5 ton per acre increase in alfalfa yields is still required to make the center pivot system economically profitable.

B. Center Pivot Irrigation System Investment Life Span

If the lifetime of the original $70,200 investment in the center pivot system is calculated at 20 years instead of the original 15 years, then the net present value of the center pivot system scenario increases by $9,000. Instead of having a +$2,021 NPV conversion benefit for the +0.5 tons per acre and 16.9 acre inches of water scenario, the NPV benefit is +$13,021. Conversely, if the lifetime of the original $70,200 investment in the center pivot system is calculated to be 10 years instead of the original 15 years, then the net present value of the center pivot system scenario decreases by $15,604. Instead of having a +$2,021 NPV conversion benefit for the +0.5 tons per acre and 16.9 acre inches of water scenario, the NPV benefit is –$13,583. Taken together, these findings indicate that the number of years over which the center pivot investment will be paid off has a very large impact upon the profitability of the center pivot system. Over longer investment horizons the center pivot system becomes more profitable, and less so for shorter investment horizons.

C. Alfalfa Price Variation

If the price of alfalfa is $95 per ton rather than $85 (i.e., $10 per ton higher), then the net present value of the center pivot system scenario increases by $5,393. Instead of having a +$2,021 NPV conversion benefit for the +0.5 tons per acre and 16.9 acre inches of water scenario, the NPV benefit is +$7,414. Conversely, if the price of alfalfa is $75 per ton rather than $85 (i.e., $10 per ton lower), then the net present value of the center pivot system scenario decreases by $5,393. Instead of having a +$2,021 NPV conversion benefit for the +0.5 tons per acre and 16.9 acre inches of water scenario, the NPV benefit is –$3,371. Taken together these findings indicate that higher prices (likely reflecting higher quality alfalfa or better alfalfa market prospects) have a positive effect upon the profitability of a center pivot system investment. The opposite holds true regarding the impact of lower alfalfa prices.

D. Diesel Fuel Instead of Natural Gas

If diesel fuel at $0.90 per gallon is used as the energy source instead of natural gas at $3.72 per mcf, then the net present value of the center pivot system scenario decreases by $224. Instead of having a +$2,021 NPV conversion benefit for the +0.5 tons per acre and 16.9 acre inches of water scenario, the NPV benefit is +$1,797. This NPV decrease does not appreciably change the findings of this analysis.

E. Decreasing the NPV Discount Rate and/or Interest Rate

If a 7% discount and/or interest rate is used in the net present value analysis instead of an 8% rate used in the original analysis (a 1% decrease), then the net

present value of the center pivot system scenario increases by $6,514. Instead of having a +$2,021 NPV conversion benefit for the +0.5 tons per acre and 16.9 acre inches of water scenario, the NPV benefit is +$8,535. This NPV increase does not appreciably change the findings of the analysis. A decrease in the NPV discount rate equates to a decline in the time value of money. When the discount rate is decreased, decision makers are indicating that they are now more willing to accept lower current net returns in order to gain future profits.

CONCLUSION

The findings of this analysis are consistent with the economic intuition of farmers. In order for the conversion from surface to center pivot irrigation systems to be profitable, net returns have to be increased by enough to pay for the added investment in the new irrigation system. Net income gains occur either through increased production, higher prices, lower costs, or some combination of these factors. These results indicate that moderate increases in production (of at least 0.5 tons per acre) and moderate decreases in water use (of at least 4 to 5 inches per acre) are needed to economically justify conversion, given the situation found in the Arkansas River region of Southeast Colorado.

How reasonable is it to assume that alfalfa yields can increase and water application amounts can decrease with the use on center pivot irrigation systems as opposed to surface flood systems? If the center pivot system allows alfalfa producers to both apply and withdraw irrigation water in a more timely manner which more nearly equates with the water demands of the crop, then production increases are possible. Also, if center pivot systems can reduce the amount of evaporation that commonly occurs in surface irrigation, then water application efficiency gains are possible - especially if water is applied in alfalfa production during periods of little vegetative cover. The ability to fine-tune the timing of water applications prior to alfalfa harvest may also lead to more timely cuttings and higher quality alfalfa, a factor that would be reflected in higher alfalfa prices.

This analysis is preliminary in nature. That is particularly evident when examining the critical economic assumptions that were made in constructing and carrying out this analysis. Equal acreages for surface and center pivot systems, the level of alfalfa prices, the cost of converting to center pivot systems, and labor savings from center pivot as opposed to surface systems are key factors in making such conversion decision. Other key factors include alfalfa yields, irrigation water application efficiencies, the cost of water application, and the life span of the two alternative systems are also important factors to consider. If any of these key assumptions inaccurately represent the irrigation investment decisions of Southeast Colorado irrigators along the Arkansas River, additional analyses may need to be performed to correct for the inaccuracies. For more information about either the IRRIGATE program or other irrigation- oriented economic analysis, please contact the Extension Services of Colorado State University and/or Kansas State University.

Table 3. Annual Net Returns of Existing Flood Versus New Center Pivot Irrigated Alfalfa in Southeast Colorado[1]

	Year 1	Year 2	Year 3	Year 4	Year 5	Years 6 to 15	Sum of All Years
A. Alfalfa Production Income							
1. Center Pivot (new)	$56,228	$56,228	$56,228	$56,228	$56,228	$56,228	$843,413
2. Flood (existing)	50,873	50,873	50,873	50,873	50,873	50,873	763,088
3. Difference (1 – 2)	+$5,355	+$5,355	+$5,355	+$5,355	+$5,355	+$5,355	+$80,325
B. Alfalfa Production Expenses							
1. Center Pivot (new)	$30,140	$30,140	$30,140	$30,140	$30,140	$30,140	$452,099
2. Flood (existing)	33,223	33,223	33,223	33,223	33,223	33,223	498,338
3. Difference (1 – 2)	–$3,083	–$3,083	–$3,083	–$3,083	–$3,083	–$3,083	–$46,239
C. Irrigation Equipment Payments (Center Pivot, etc.)							
Principal & Interest	$8,201	$8,201	$8,201	$8,201	$8,201	$8,201	$123,022
D. Total Returns to Management, Land, & Crop Machinery							
1. Center Pivot (new)	$17,886	$17,886	$17,886	$17,886	$17,886	$17,886	$268,292
2. Flood (existing)	17,650	17,650	17,650	17,650	17,650	17,650	264,749
3. Difference (1 – 2)	+$236	+$236	+$236	+$236	+$236	+$236	+$3,542
E. Per Acre Returns to Management, Land, & Crop Machinery							
1. Center Pivot (new)	$141.95	$141.95	$141.95	$141.95	$141.95	$141.95	$2,129
2. Flood (existing)	140.08	140.08	140.08	140.08	140.08	140.08	2,101
3. Difference (1 – 2)	+$1.87	+$1.87	+$1.87	+$1.87	+$1.87	+$1.87	+$28
G. Financial Measures							
Net Present Value	+$2,021						

1. Key Assumptions: For flood and center pivot systems, alfalfa yields of 4.75 and 5.25 tons per acre, respectively. Water applications of 22 and 16.9 acre inches for flood and center pivot systems, respectively.

Table 4. Net Present Value of Converting from Furrow Flood to Center Pivot System Irrigation for Alfalfa Production in Southeast Colorado

	Center Pivot Irrigated Alfalfa Yields (tons per acre)				
Center Pivot Water Application (acre inches)	4.75 tons (+0.00 ton > Flood Irrig.)	5.00 tons (+0.25 tons > Flood Irrig.)	5.25 tons (+0.50 tons > Flood Irrig.)	5.50 tons (+0.75 tons > Flood Irrig.)	5.75 tons (+1.00 tons > Flood Irrig.)
22.0“	–$40,046	–$21,334	–$3,335	+$15,035	+$33,399
20.7”	–$38,698	–$19,986	–$1,986	+$16,383	+$34,747
19.5”	–$37,387	–$18,675	–$675	+$17,695	+$36,059
18.2”	–$36,038	–$17,326	+$673	+$19,034	+$37,407
16.9”	–$34,690	–$15,978	+$2,021	+$20,391	+$38,755
15.7”	–$33,379	–$14,667	+$3,333	+$21,703	+$40,067
14.4”	–$32,030	–$13,319	+$4,681	+$23,051	+$41,415

Figure 1. Profitability of Flood to Pivot Conversion