ELECTRICITY PRICES AND IRRIGATION DEVELOPMENT FEASIBILITY

by

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Ag. Econ. Research Paper #230

Paper presented at the American Agricultural Economics Association Annual Meetings, Champaign, Illinois, July 27-30, 1980.

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ABSTRACT

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A methodology was developed to measure impacts of rising electricity prices on high lift irrigation development. Effects of farm size, crop prices, yields, lift heights, and distance from water source were also incorporated. Results indicate that rising electricity prices will make development infeasible in high elevation areas of southern Idaho.

Electricity Prices and Irrigation Development Feasibility

Electricity price increases are causing concern not only among existing irrigators, but also among prospective operators who wish to irrigate more desert land. Irrigation is technically feasible on large blocks of land adjacent to the Snake River in southwest Idaho. The U.S. Bureau of Land Management is currently weighing the advisability of allowing development of some BLM lands in this area.

The course of irrigation development will depend on the private feasibility of such development. This paper presents the results of a simulation procedure to measure the impact of rising electricity prices on irrigation feasibility. The shifts in the relationship caused by farm size, crop prices and yields, lift heights, and project distance from the river are also examined.

Procedures Used to Simulate Feasibility

A parametric budgeting procedure was used to simulate the impact of these variables on the private feasibility of high lift irrigation development. A rotation budget was prepared with the aid of the Oklahoma State Budget Generator (Walker and Kletke). The rotation selected as typical of the Southwest Idaho study area consisted of half wheat and half potatoes for the first five years, changing to equal parts of potatoes, wheat, and beans after five years. Crop prices were an average of 1974-77 prices and costs represented 1978 levels. Yields were chosen as typical of class I and II soils in the study area. Because the crop mix changes after 5 years, the uneven time stream of returns was converted to a uniform stream of annualized equivalent returns using a 25 year planning horizon and an 8 percent discount rate. Table 1 shows the net returns per acre for this rotation as net returns to land, electric power, and irrigation facilities.

Costs for electric power and for ownership, operation, and maintenance of irrigation facilities were based on a side roll application system since that is and probably will remain the dominant application system in the study area. Specifying these costs, in a fashion that would allow parametric variation of power rates, lift height, and project distance, required a concept of "typical facilities" rather than site specific facilities. A hypothetical project located on benchland 550 feet above and 5 miles distant from the river was chosen as a base point. Pumping and application facilities typical of the study area were then specified using information in a number of project feasibility reports on file with the Idaho Department of Water Resources, Boise. Typical costs for such a system were the starting point for the simulation procedure. As the parametric variables were changed from this base, the required changes in facilities and hence changes in costs were computed.

A computer program was developed to compute electricity use, electricity costs, and installed pumping horsepower requirements based on crop water needs, irrigation efficiency, pump and motor efficiencies, lift height and distance, sprinkler operating pressure, electric rate schedules, and pump scheduling assumptions. The program starts with monthly consumptive irrigation requirements (Sutter and Corey) which, when divided by irrigation efficiency give the monthly water delivery requirements. These were computed for a typical weather year and a very dry year. The former were used to compute typical electricity use and the latter allowed computation of required pumping plant size. Total dynamic head is the vertical lift from the river to the point of application, plus the required sprinkler operating pressure, plus 0.8 percent of the length of the closed delivery pipe to account for typical friction loss. Horsepower was computed according to the formula:

$$HP = \frac{\text{Total Dynamic Head x Acre Feet Used in Month}}{\text{Efficiency of Pump and Motor}} \times .00188$$

Inserting water delivery requirements for the worst month in a dry year allowed computation of the required installed horsepower. The horsepower needed for the primary lift from the river and for the booster pumps atop the benchland was identified. Electricity use is computed using the expression:

$$KWH = \frac{\text{Total Dynamic Head x Acre Feet Used}}{\text{Efficiency of Pump and Motor}} \times 1.025$$

Electricity costs were based on 1978 Idaho Power Company rate schedules, taking into account assumptions about pump motor size and operating schedules. The primary lift was assumed to use 1500 horsepower motors which are engineered to be run at full capacity or else turned off when not needed. Smaller booster pumps are used on the benchlands for water distribution and sprinkler pressurization. For the hypothesized base conditions, electric power would cost $56.92 per irrigated acre.

Table 1: Residual Returns to Land Per Irrigated Acre for the Base Run.

	320 acres	640 acres	960 acres
Returns to land, electric power, and irrigation facilities			
first 5 years	319.45	333.72	344.74
subsequent years	251.38	274.83	283.18
level annualized return	276.85	296.86	306.21
Cost of power and irrigation facilities	217.09	217.09	217.09
Residual returns to land	59.76	79.77	89.12

For costing the on-farm application facilities the side roll sprinklers were assumed to come in replicates of a 160 acre unit with 154 acres irrigated. An initial cost of $46,500 with a 10 percent salvage value and a 20 year life, result in annual on-farm system costs of $54.45 per irrigated acre which are detailed in Table 2.

For a hypothetical project comprising 7,238 irrigated acres and located 550 feet above and 5 miles back from the river, 18,000 installed horsepower would be required for the primary lift and 6,270 horsepower would be needed at booster pump stations to distribute water and pressurize sprinklers. Costs for each of the component parts of the system (pumps, pipes, valves, electric controls, etc.) and for each of the steps in construction (excavation, welding, construction overhead, etc.) were estimated based on information from a wide range of sources. The project feasibility reports from the Idaho Department of Water Resources were the most useful source of cost data. These costs were updated using cost indices obtained from the Boise Office of the U.S. Bureau of Reclamation to reflect a 1978 cost base. These project pumping and delivery system costs, summarized in Table 2, total just under $7.5 million. Spread over the 7,238 irrigated acres and amortized at 8 percent and 25 years this comes to $96.62 per acre.

The remaining cost item is $9.10 per irrigated acre for operation and maintenance of the pumping and water distribution facilities. Included here are items such as the salary of a project manager, a mechanic, and a part time secretary, office expenses, insurance, workmens compensation, F.I.C.A., and repair shop expenses. Total irrigation costs under the base conditions are summarized in Table 2 and total $217.09 per irrigated

Table 2: Cost of Power and Irrigation Facilities

On-Farm Irrigation System	Total Cost to Project	Annual Cost Per Irrigated Acre
interest on average investment		$ 16.61
taxes on average investment		1.16
straight line depreciation		13.59
insurance on average investment		1.00
repairs		7.51
labor		14.58
total cost		$ 54.45
Project Pumping and Delivery System		
river pumping plant	$1,783,720	
regulating reservoir	188,473	
penstock and outlet structures	1,493,484	
booster pumping plants	583,562	
pipelines and farm turnouts	2,003,058	
farm maintenance roads	427,556	
surface drainage and land preparation	139,590	
operation and maintenance equipment	150,913	
electric power delivery facilities	495,000	
management and other pre-project costs	200,000	
total cost	$7,465,356	
cost per irrigated acre	$1,031.41	$ 96.62
Electric Power		56.92
Project Operation and Maintenance		9.10
Total Cost		$217.09

acre per year. These costs can be subtracted from the net returns in Table 1 to give residual returns to land.

If the land being developed is assumed to be public land obtained under provisions of the Desert Land Entry Act or the Carey Act at nominal prices, any project which shows a positive residual return to land after covering all other costs is judged to be feasible. Under the base conditions all three sizes of farm pass the test of private feasibility.

III. Sensitivity of Returns to Changes in Critical Parameters

The impacts of the various critical variables is examined by parametrically varying them and showing the resultant changes in residual returns to land.

Computationally the easiest parameters to vary are crop prices and yields. The assumed crop rotation produces gross returns of $716.10 per acre in the first 5 years and $598.57 per acre in subsequent years. This converts to a level annual gross returns stream of $642.55 using an 8 percent discount rate and a 25 year planning horizon. A 10 percent increase in either yield or price would cause the gross returns stream to increase by $64.25. Since the cost items would be essentially unchanged, residual returns to land would increase by the same amount. While crop prices are notoriously difficult to predict, the 1974-77 average prices and 1978 costs used in the base run are probably a fair estimate of the expected long run relative levels of costs and prices. The yields used in the base run may be optimistic. Yields were estimated using information from five feasibility studies for projects in the study area and Soil Conservation Service estimates of yield capability.

The yield estimates in the feasibility reports tended toward the high range of the SCS estimates. The environmental statement for the same area, recently released by the Bureau of Land Management used yield estimates which averaged about 9 percent below those used in the base run. Hence the results using the base yields should be viewed as defining the outer limits of feasibility.

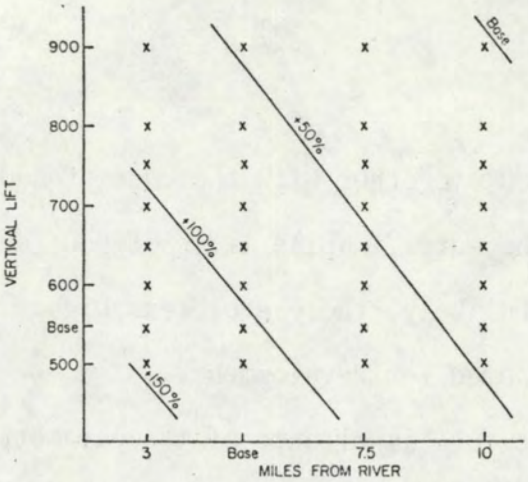
The parametric variation of electric rates follows a similar logic. In the base situation electricity costs were $56.92. A 50 percent increase in the rate schedule would cost an added $28.46 and would reduce the residual returns to land by that amount. The 1978 electric power rates used in the computer program seem low for long range planning. As load growth causes the Pacific Northwest to shift from near total reliance on hydroelectric generating capacity to heavy dependence on more expensive thermal generation, irrigation power rates are certain to rise (Hamilton and Whittlesey). The Idaho Power Company suggested during hearings for the proposed Orchard thermal powerplant that rate increases of 150 percent over the next decade would be necessary to finance their construction requirements.

When lift height is parametrically varied, the calculations become more complex. The computer program can easily show the added electricity cost. However, if added 1500 horsepower pumps and their associated facilities are needed to overcome the added head and friction loss, the marginal cost of these must be computed and subtracted from residual returns. Parametric changes in project distance from the river are treated in a similar manner. The computer program shows the marginal change in electricity cost. Changes in pumping plant to meet the altered pumping head must be determined, together with the cost of additional closed pipe used to convey the water. While lifts of 900 feet and distances of 10 miles may seem unlikely, there are areas higher and more distant than that being considered for development.

To appreciate the full importance of the parametric variables, it is useful to study their interaction as they are jointly varied. Using the methods outlined, lift, distance, and rates are varied together, while yield and price are kept at base levels. The results are shown in Figures 1-3; one for each farm size. Each cell in the figures corresponds to a given combination of lift height, project distance, and farm size. Feasible cells are located below and to the left of boundary curves which correspond to parametric electric rate levels. For example on a 640 acre farm, a 100 percent rate increase would make farms 3 miles from the river feasible if the lift is 900 feet or less. Farms 5 miles away could lift water to 750 feet and those 7.5 miles distant have a feasible lift of only 550 feet.

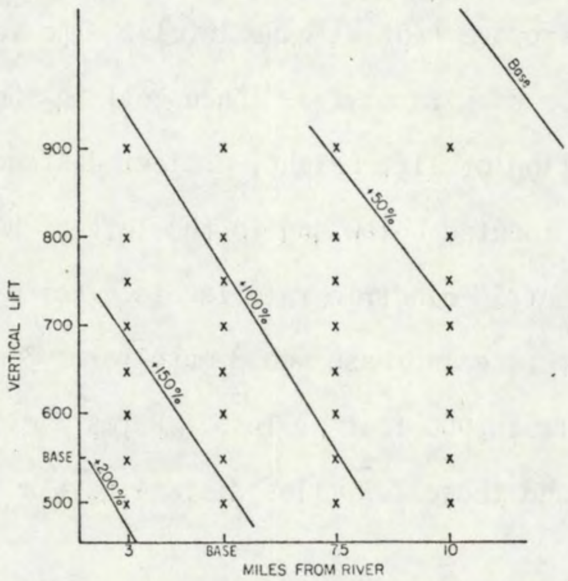
To demonstrate the applicability of this model relating irrigation feasibility to lift and distance, the model was used to evaluate the feasibility of irrigating the lands identified in the BLM Environmental Statement. The analysis was conducted using the lifts and distances for lands in the study area as reported by the BLM (BLM, page A-61). Of the 111,015 acres in the study area, 108,381 acres have lift heights and distances making them feasible as 960 acre farms under base conditions. If 640 acre farms were used, 107,453 acres would be developable, and 99,126 acres could be developed using 320 acre farms. As electricity rates increase above the 1978 base levels, irrigation of the more distant and

Figure 1



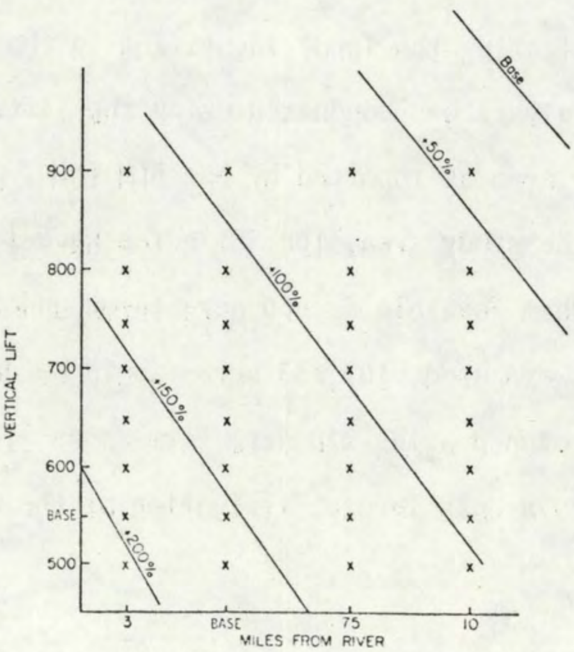
The Effect of Lift, Distance and Electricity Rates on Project Feasibility for 320 Acre Farms.

Figure 2



The Effect of Lift, Distance and Electricity Rates on Project Feasibility for 640 Acre Farms.

Figure 3



The Effect of Lift, Distance and Electricity Rates on Project Feasibility for 960 Acre Farms.

higher lift lands is precluded, and the total developable acreage falls sharply as shown in Figure 3. If, as suggested, electric rates should increase by 150 percent, the developable acreage would fall to 43,101 acres composed of 960 acre farms, 35,050 acres of 640 acre farms or 27,523 acres of 320 acre farms. Even these estimates are based on assumptions of good yields and recent crop prices.

IV. Limitations of the Analysis

One must be careful in interpreting what is essentially a partial equilibrium feasibility analysis. Figure 4 suggests that the acreage which can feasibly be developed for pump irrigation declines sharply with power rate increases of 100 to 200 percent. In a general equilibrium setting if higher power rates caused agricultural production to lag behind demand growth, crop prices would rise, improving the feasibility of development. Such a general equilibrium model is beyond the scope of this paper.

As with most simulation procedures, there are areas where refinement would probably improve the model's performance. Most important would be improved detail in specifying the way in which physical irrigation facilities depend on such parameters as lift and distance. A second refinement would be to explicitly incorporate some financial accounting variables such as tax treatment of income and capital gains, investment tax credit, and the impact of expected appreciation in land values. The challenge will be to incorporate these refinements while maintaining model generality. The model will be less useful as it becomes site specific and situation specific.

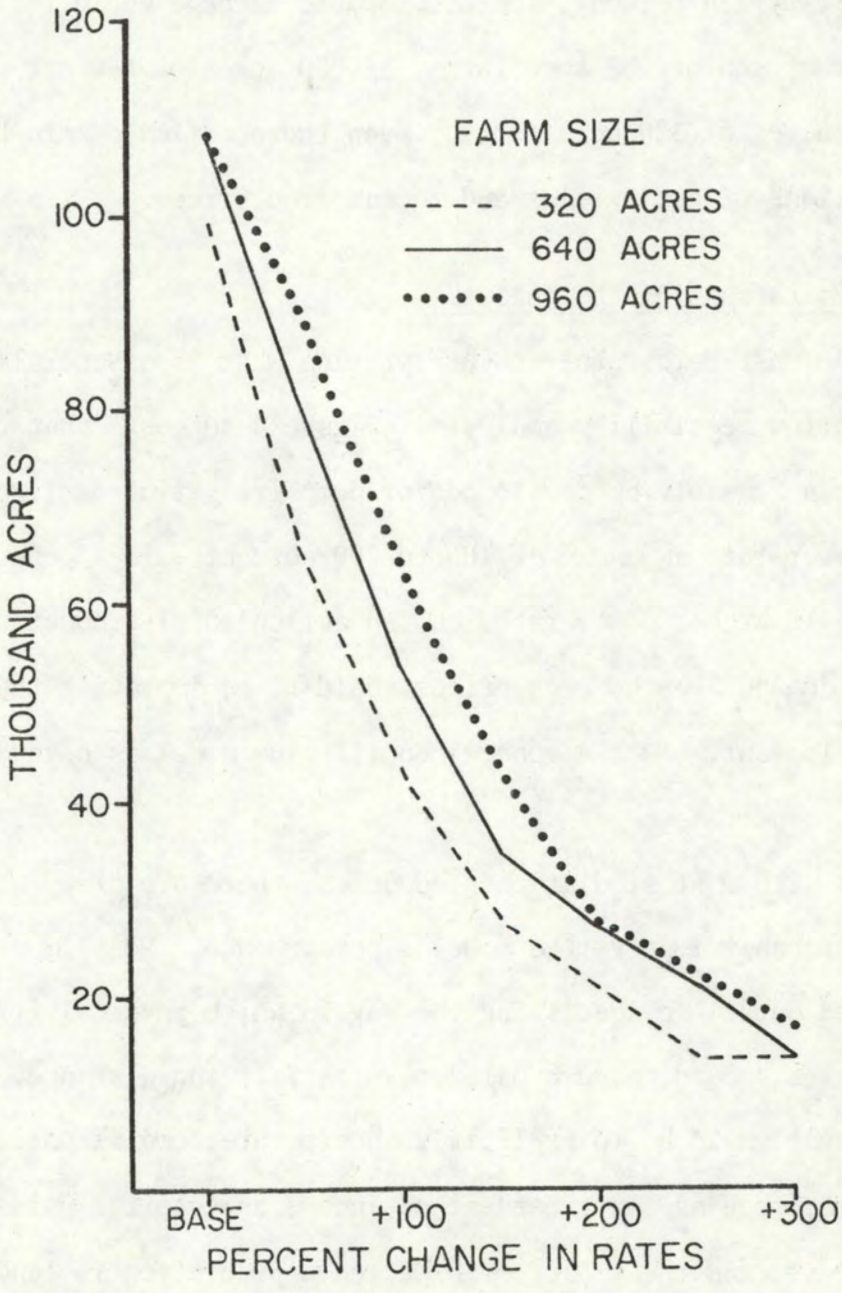


Figure 3. The Effect of Electric Rate Increases and Farm Size on Feasible Development Acreage in the BLM Study Area.

V. Conclusions

The model outlined in this paper gives a reasonable simulation (in a partial equilibrium setting) of the impact of critical parameters such as crop prices and yields, electricity rates, farm size, lift height, and distance from the river upon the feasibility of high lift irrigation development in Southwest Idaho. The results indicate that per acre returns on irrigated tracts increase slightly with farm size. Furthermore, under base conditions all farm sizes examined could sustain a 10% decline in crop price or yields. Given the base lift height, 550 feet, and the base water carry distance, 5 miles, all farm sizes considered could sustain a 100% increase in electric rates. With a 200% power rate increase, however, irrigation feasibility would be limited to the largest farms, 960 acres, with lift heights less than about 550 feet and water carry distances less than about 4 miles.

Of the lands in the BLM study area, all but the highest and most distant could be developed under base yields, prices, and power rates. However, likely increases in power rates could limit development to low lift land near the river, sharply reducing the total developable acreage.

While the model developed in this paper, and the conclusions derived from it are specific to conditions in the Pacific Northwest, the analytical approach has wider potential application. Moreover, the conclusions point to the kinds of responses that can be expected from energy intensive agriculture in other regions as energy prices rise.

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