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Loan Management Controls: Economic Friend or Foe of the Irrigator?

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LOAD MANAGEMENT CONTROLS:
ECONOMIC FRIEND OR FOE OF THE IRRIGATOR?

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Abstract: Irrigator incomes are highly sensitive to yield losses from load management irrigation system power interruptions. Should irrigators, therefore, avoid load management control programs? Under the conditions examined in this case study, the answer is probably "yes" if irrigators are unable to opt out of the load control program during the irrigation season. If discretion to opt out is permitted, however, the answer is clearly the opposite "no."

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LOAD MANAGEMENT CONTROLS: ECONOMIC FRIEND OR FOE OF THE IRRIGATOR?

The price paid by U.S. farmers for electricity has continued escalating throughout the 1980s, while the prices of competing fuel sources have declined [USDA, 1986, p. 19]. The primary reason for escalating electricity prices is the high cost of recently built (coal-based) electric power generation facilities.

The major thrust in the U.S. electric power utility industry today to forestall future electricity price increases is "load management." Load management controls provide mechanisms for reducing peak kilowatt (kW) demands on an electric system--through shifting power demands from on-peak to off-peak times and/or curbing total power demands during on-peak periods. As the peak kW demands are shifted and/or curbed, the need for expanding power generation and transmission facilities to meet peak demand requirements is alleviated. To the extent that additional expenditures for such facilities can be avoided, upward pressures on wholesale power costs--and hence, also, on retail prices that must be paid by the end-users of electric power--can be forestalled.

Irrigators subject to load management controls experience electric power interruptions during periods of peak power demand. The resulting interruptions in irrigation pumping may result in moisture stress induced yield reductions for irrigated crops. If so, the economic incentives provided for following load management may be more than counterbalanced by the resulting yield losses.

While the literature on load management controls has burgeoned in recent years, analytic attention to possible yield reductions from irrigation system power interruptions has been almost totally lacking. This paper provides only the second publicly reported economic analysis of potential yield losses from load management. Unlike in the other study (Bosch _et al_.), a current real-world load management control program, multiple farm irrigation technologies, and remotely-controlled rather than time-clock controlled electric power interruptions are treated in this paper.

LITERATURE REVIEW

An extensive literature has emerged over the past 10 years on the technical dimensions of load management controls. The two major thrusts in the natural science and engineering literature are (1) determining and predicting the within-year pattern of electric power demands represented by irrigation and other rural electric energy uses [e.g., Stark and Stetson (1985, 1986a, 1986b); Stetson and Stark; Stetson, Farrell, and Shull] and (2) examining the linkage between irrigation scheduling and load management controls [Barnes et al.; Buchleiter et al.; Duke et al.; Elliott et al.; Heerman, Buchlieter, and Duke; Heerman, Duke, and Buchleiter; Kroutil and Fischback; Stetson, Watts, Corey, and Nelson]. Hagen and Roberts also examine interrelationships between load management and irrigation energy and water requirements.

Literature on the economic dimensions of load management controls is much more sparse. Buller and Nordin examine the prospective savings to a Kansas REC from providing load management and time-of-use electricity pricing options to irrigators. Gardner and Young examine the impacts on crop enterprise profitability, farm income, and energy use in northeastern Colorado of various energy price discounts for off-peak April, May, and September irrigation pumping. In neither of these two studies, nor in any of the prior-mentioned technical studies, is analytic attention given to possible reductions in crop yields from following load management.

Bosch et al. determine the electricity cost reductions that would have to be offered to keep irrigated corn producers in southwestern Minnesota from being made worse off economically by power interruptions arising from three different types of time-clock controlled load management controls. In all the cases examined through their simulation analysis, load management controls were shown to result in reduced crop yields. Irrigators with lower pumping capacities [600 versus 800 gallons per minute (gpm)] and lighter soils are more vulnerable to yield reductions. The authors determined that waiving an assumed $6.25 per kW monthly demand charge as incentive for irrigators to follow load management would make load controls economically attractive to irrigators with pumping capacities of 800 gpm, but not of 600 gpm.

The general objective of the analysis reported in this paper is similar to that in the Bosch et al. study. In this paper, however, attention is focused on (1) the actual load management control options offered by two case study RECs in South Dakota, (2) multiple irrigated crop and irrigation technology alternatives, and (3) remote-controlled rather than time-clock controlled load management mechanisms. Remotely-controlled load interruptions--triggered only on those days and at those hours when RECs actually experience a peaking in their power demands--are generally considered more suitable to meeting the mutual needs of RECs and irrigators than "everyday automatic" time-clock controlled electric power interruptions.

LOAD MANAGEMENT IN SOUTH DAKOTA

Of South Dakota's 33 RECs, 23 are served by the East River Electric Power Cooperative located in Madison. East River provides electric power to about 1,500 irrigators with a combined irrigation pumping horsepower of over 115,000. About 55% of East River's overall power cost is tied to demand charges.

East River's load management system--with an installation cost of $9.1 million--became operational in December 1984. During the first two years of load management operation, $6.5 million of saved purchased power costs were realized [Feragen].

East River is a traditional winter-peaking system. The winter and summer peaks during 1985-86 involved roughly 290 and 240 megawatts, respectively. Consideration is now being given to pricing electricity in relation to both summer and winter power peaks. Since irrigation and air conditioning are the dominant causes for summer peaking, possible means of controlling irrigation-induced electric power demand peaks are being actively explored. A $50 per kW saving for each kW of demand avoided during times of peak power demand is envisioned by the East River Electric Power Cooperative.

The Clay-Union and Union RECs in southeastern South Dakota--served by East River and selected for case study examination in this paper--are the State's two oldest RECs. Their electric rate structures for irrigation provide for an **annual minimum** facilities charge, a **monthly demand** charge of $9.00 per peak kW used during each monthly billing period when an irrigation system is operated, a **two-step energy** charge, and a **load management** option.

The load management control option provides for the waiving of monthly demand charges during those billing months in which irrigators agree to 5 pm to 9 pm electric power interruptions to their irrigation systems. During 1985, power interruptions were made every day. During 1986, power interruptions were made only on those days when the RECs actually experienced a peaking in their power demand. Irrigators not electing to follow the load management option in 1985 and 1986 were entitled to a 1.1 cent per kilowatt hour (kWh) credit on all irrigation pumping energy used. This credit arose from a discount by one of East River's two wholesale power suppliers (namely, the Basin Electric Power Cooperative) on the electric power used for irrigation.

CASE STUDY REC CROP PRODUCTION ENVIRONMENT

Well irrigation, with typical lifts of about 25 feet, dominates the Clay-Union and Union REC service areas. Center pivot sprinklers are common. Water distribution pressures of 65 to 85 pounds per square inch (psi) are most frequent, although some "low" pressure systems (25 to 35 psi) have also been introduced. Some gated pipe, surface-irrigation units are also found along the Big Sioux River flood plain in the Union REC service area. May to September seasonal precipitation is most commonly 11 to 17 inches.

A Corn Belt-type of agriculture is found in the study areas, with corn the dominate irrigated crop and smaller acreages of irrigated soybeans and irrigated alfalfa (only Clay-Union). Soils in the Union REC study area are rather heavy (Forney-Lutton and Modale-Blyburg-Benclare soil associations) and the topography is level to nearly level. Soils in the Clay-Union study area are rather light (Haynie and Sarpy soil associations), with nearly level topography.

The irrigation water application rates for the various irrigated crops and irrigation technologies in the two REC study areas were determined taking into account specific demand-for- and supply-of-moisture factors. The demand-for-moisture factors are daily evapotranspiration (Jensen-Haise methodology) and the pattern of crop canopy development during the growing season. The supply-of-moisture factors are the amount of effective precipitation (an assumed 80% "exceedence level"), the pre-season carryover of soil moisture, and the assumed levels of soil moisture depletion during and at the end of the irrigation season.

The net irrigation requirements--representing the surplus of daily evapotranspiration requirements over and above daily effective precipitation and carryover moisture--were then adjusted up by appropriate net-to-gross irrigation efficiency factors, to obtain the gross irrigation application rates shown in

Table 1. The center pivot seasonal irrigation rates range from 7.7 inches for soybeans in the Union REC study area to 18.9 inches for alfalfa in the Clay-Union study area. (More extensive descriptive information and procedural details are provided in the first of a series of five research reports concerning this paper's umbrella electric rate structure-irrigation study which is available from the author.)

ECONOMIC ANALYSIS OF LOAD MANAGEMENT CONTROLS

The Clay-Union and Union REC load management control option in 1986 is the subject of economic analysis in this paper. The specific objective of the analysis is to determine the extent of yield reduction that irrigators could afford to sustain from following load management. Break-even yield losses are determined--via standard budgeting analysis--in relation to the net electric power related benefit to irrigators from load management participation.

The 1986 load management control option is examined within two contexts. The first involves an overview, aggregate-type analysis in which irrigators are assumed to opt to follow load management either throughout the entire irrigation season or not at all during the irrigation season. The second context involves a more in-depth analysis in which load management followers are assumed to be able to opt out of load management controls at any time during any billing month that they should choose to do so.

No account is given in analysis to the time and inconvenience associated with irrigators having to reactivate their irrigation systems after power interruptions. This simplified analytic procedure was adopted because of wide variations among irrigators in the amounts of time required to reactivate their systems and the values placed on such added time and inconvenience. The break-even yield losses determined in this analysis should, in principle, be adjusted down to take into account the time and inconvenience required by load management followers to reactivate their irrigation systems in the wake of power interruptions to the systems.

All season controls

A two-part budgeting procedure is followed in this section. In the first part, the net electric power related benefits and costs of load management are determined. In the second part, attention is given to possible yield losses from following load management.

The electric power related benefits from load management are represented by the potentially waived monthly demand charges. The magnitudes of these benefits for the various crops and irrigation technologies reflect the monthly demand charges for the different irrigation technologies [e.g., for the Union REC, $603 high pressure (75 psi) center pivot (HP-CP), $321 low pressure (30 psi) center pivot (LP-CP), $161 gated pipe] and the monthly durations of the irrigation season for the different crops (Table 2).

The costs of following load management are represented by the value of the foregone Basin credit to which load management non-followers are entitled. These costs reflect the cross-product of:

- The irrigation application rates (inches) for the respective crops and REC service areas;

- The acres per irrigation system, namely, 130 for center pivot and 160 for gated pipe systems;

- The kWh requirement per acre-inch of irrigation water pumped, namely, 28.69, 15.35, and 5.59 for HP-CP, LP-CP, and gated pipe water distribution, respectively; and

- The Basin credit of 1.1 cent per kWh.

If irrigated crops are experiencing moisture-related stress and the supply of irrigation water is interrupted because of load management controls, however, yield reductions can be experienced. To take this possibility into account, a second budgeting component to determine break-even yield losses that irrigators can afford to sustain from following all-season load management was undertaken.

The break-even yield losses were determined by dividing the net electric power related benefits per irrigation system by the acres per irrigation system and the assumed crop prices (corn $2.36/bu, soybeans $5.14/bu, alfalfa $45/ton). For HP-CP irrigators, the break-even per-acre yield losses are no greater than 3 bu for corn, 2 bu for soybeans, and 0.38 ton for alfalfa (Table 3). These maximum break-even losses are 2.0%, 4.3%, and 6.9% of the average expected respective crop yields with normal precipitation. HP-CP irrigators anticipating yield reductions from possible 5 to 9 pm interruptions in irrigation throughout the irrigation season equal to or greater than these amounts are ill-advised economically to follow the load management option. With lesser or no anticipated yield losses, irrigators can expect to benefit from following the load management option.

For LP-CP and gated pipe irrigators, the maximum tolerable yield losses from all-season load management are considerably less than those for HP-CP irrigators. The reduced margin for loss arises primarily because of the lesser electric power requirement per acre-inch of irrigation water pumped for these types of systems.

Selective month-by-month controls

In the preceding analysis, following load management was treated as a seasonal "all or none" proposition. The Clay-Union and Union REC load management option, however, allows for irrigators to opt out of load management at any time during any month that they should choose to do so.

In this section, the economics of a CP irrigated soybean producer in the Clay-Union REC study area following load management selectively month-by-month are examined. The same methodology is used as that in the prior section (Table 4).

The monthly break-even yield losses vary inversely with the amounts of monthly irrigation applications and are about 85% more with HP than LP water distribution. The maximum monthly break-even yield loss for soybeans (HP water distribution in September), however, is only 53 lb per acre or 1.8% of the yield with normal precipitation. [The next most likely "candidate" for a large break-even percentage yield loss is alfalfa in May in which the irrigation water application rate is 2.1 inches. The break-even yield loss for it, however, is only 1.6%.]

Being able to manage irrigation water so as to avoid a minimum level of moisture stress leading to anything less than a 1.8% yield loss during a particular month is an unrealistic management objective for any irrigator. The conclusion of this analysis, therefore, is clear. Clay-Union and Union REC irrigators following load management who anticipate that a possible 5 to 9 pm interruption in irrigation on any day would begin to place their irrigated crops under any yield reducing moisture stress should straightaway break their meter seal, and opt out of load management control for the remainder of the then current monthly billing period. By doing so, they become no worse off, regarding the payment of the monthly demand charge, than their load management non-follower counterparts in that month. In all billing months during the irrigation season when 20 hours per day of pumping on load controlled days is adequate, on the other hand, the load management followers gain economically as they avail themselves of the waived monthly demand charges.

CONCLUSION

This study shows irrigator incomes to be highly sensitive to yield losses from load management irrigation system power interruptions. Does this outcome imply that irrigators should avoid load management control programs? If the Clay-Union and Union REC load management option required all-season participation, the answer is probably "yes." Only irrigators with substantially over-sized pumping capacities and/or a willingness to incur substantial risk would be willing to participate in the load management program--knowing that the maximum yield reductions that they could afford to sustain from load control irrigation system interruptions throughout the full duration of the irrigation season would be 2% to 7% (HP-CP's) or less (LP-CP and gated pipe units).

With provision for irrigators to opt out of load management at any time they should choose to do so--as with the current Clay-Union and Union REC load management program--the answer to possible load management participation is clearly the opposite. Irrigators are well-advised economically to enter and stay under the load management program as long as irrigation system power interruptions do not create yield reducing moisture stress for irrigated crops. For every billing month that irrigators do so, they can avail themselves of waived monthly demand charges. If such stress conditions do arise, however, irrigators should immediately opt out of the load management program, continue to pump irrigation water, and be no worse off economically during that billing month than their all-season load management non-follower counterparts.

Table 1. Gross irrigation water application rates (inches), selected crops and irrigation technologies, Clay-Union and Union REC study areas.

	Clay-Union REC			Union REC			
	Center pivot irrigation			Center pivot irrigation		Gated pipe irrigation	
Month	Corn	Soybeans	Alfalfa	Corn	Soybeans	Corn	Soybeans
May	n/a	n/a	2.1	n/a	n/a	n/a	n/a
June	n/a	n/a	3.5	n/a	n/a	n/a	n/a
July	5.5	5.5	5.6	3.6	3.5	6.5	6.3
August	5.5	5.1	5.1	4.4	4.2	7.8	7.6
September	n/a	0.2	2.6	n/a	n/a	n/a	n/a
Total	11.0	10.8	18.9	8.0	7.7	14.3	13.9

Table 2. Electric power related benefits and costs of all-season load management per irrigation system, by type of irrigated crop and irrigation technology, Clay-Union and Union REC study areas.

	Clay-Union REC		Union REC		
	Center pivot irrigation		Center pivot irrigation		Gated pipe irrigation
Crop	High pressure	Low pressure	High pressure	Low pressure	
Corn					
Benefit	$1,190	$ 642	$1,206	$642	$322
Cost	451	241	328	176	141
Net benefit	739	401	878	466	181
Soybeans					
Benefit	$1,785	$ 963	$1,206	$642	$322
Cost	443	237	316	169	137
Net benefit	$1,342	$ 726	$ 890	$473	$185
Alfalfa					
Benefit	$2,975	$1,605	n/a	n/a	n/a
Cost	775	415	n/a	n/a	n/a
Net benefit	$2,200	$1,190	n/a	n/a	n/a

Table 3. Break-even per-acre yield losses that can be sustained from all-season load management, by type of crop and irrigation technology, Clay-Union and Union REC study areas.

	Clay-Union REC		Union REC		
	Center pivot irrigation		Center pivot irrigation		Gated pipe irrigation
Crop	High pressure	Low pressure	High pressure	Low pressure	
Corn (bu)	2.4	1.3	2.9	1.5	0.5
Soybeans (bu)	2.0	1.1	1.3	0.7	0.2
Alfalfa (ton)	0.38	0.20	n/a	n/a	n/a

Table 4. Technical and economic data for assessing the advisability of an irrigator selectively following load management month-by-month, center pivot irrigated soybeans, Clay-Union REC study area.

Water distribution pressure and month during the irrigation season	Monthly electric power related benefits and costs per center pivot from load management				Break-even monthly yield losses that can be sustained from load management	
	Benefit: waived monthly demand charges ($)	Cost: foregone Basin credit — Gross irrigation application (inches)	Cost: foregone Basin credit — Amount of foregone Basin credit ($)[a]	Net monthly benefit ($)[b]	Pounds per acre[c]	Percent of normal yield[d]
(1)	(2)	(3)	(4)	(5)	(6)	(7)
High pressure (HP)						
July	595	5.5	226	369	33	1.2
August	595	5.1	209	386	35	1.2
September	595	0.2	8	587	53	1.8
Season total	1,785	10.8	443	1,342	120	4.2
Low pressure (LP)						
July	321	5.5	121	200	18	0.6
August	321	5.1	112	209	19	0.7
September	321	0.2	4	317	28	1.0
Season total	963	10.8	237	726	65	2.3

[a]The monthly foregone Basin credits are represented by the cross-product of (1) the respective monthly gross irrigation applications; (2) 130 acres per center pivot; (3) 28.69 and 15.35 kWh per acre-inch of irrigation water pumped for HP and LP water distribution, respectively; and (4) the Basin credit of $0.011 per kWh.

[b]The net monthly benefits represent the difference between the Col 2 and Col 4 values for the respective months.

[c]The monthly pounds per acre yield losses represent the respective net monthly electric power related benefits per center pivot divided by (1) 130 acres per center pivot and (2) the 1985 price of soybeans of $0.0857 per pound ($5.14 per bu).

[d]The irrigated soybean yield in the Clay-Union REC study area is 48 bu per acre.

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