Western Area Power Administration
Pump Testing and Irrigation Efficiency
Profile #40, 1992

Executive Summary

The Western Area Power Administration (Western) Pump Testing and Irrigation Efficiency program promotes state-of-the-art methods for improving irrigation pump efficiency by providing pump tests and recommending efficiency improvements. The educational component of the program is perhaps its strongest, as WAPA provides irrigation efficiency analyses and recommends appropriate techniques for reducing the amount of water that must be pumped, and thus the demands upon the irrigation pumps, while still providing crops with sufficient water.

In 1986, funding for a formal pump testing and irrigation efficiency program run by the Colorado State Soil Conservation Board (CSSCB) was provided by WAPA and the Colorado Office of Energy Conservation. The Energy Conservation for Colorado Agriculture (ECCA) office was opened in 1987 to facilitate the interaction of diverse groups funding and participating in the program and to operate the program, with Mr. Carrol Hamon serving as its coordinator. The objective of the office was to promote agricultural energy conservation through an irrigation efficiency program, pump testing, field demonstrations, workshops, seminars, newsletters, and articles.

The program is actually implemented by three pump-testing teams who travel to farms to perform the irrigation pump tests. Pump tests determine well water levels during pumping, pumping rates, discharge pressure, pump and engine speed, and energy use. Any abnormal well conditions are also noted. The results of the pump test inform the farmer whether the pump needs to be adjusted, rebuilt, or replaced. If a pivot sprinkler system is in use, a pivot evaluation, including both a visual evaluation and an evaluation using a series of calibrated bottles spaced equidistant to the pivot, is performed after the pump test. Then the pump test team recommends whether the farmer should consider changing to medium or low pressure irrigation systems. Farmers are introduced to irrigation scheduling techniques and the team often installs gypsum blocks in the field and shows the farmers how to get weekly readings for soil moisture.

In addition to energy savings, the program's total water savings to date are 56,344 acre feet. A total of 1,749 wells have been tested during the course of the pump testing program, over 300 farms have used gypsum blocks to help with irrigation scheduling as a result of the program, and approximately 250 Low Energy Precision Application systems have been installed.

One of the most interesting lessons learned is that a program involving many diverse groups can indeed be successful. Federal, state, and local government agencies as well as utilities, commercial irrigation companies, farmers, and a university have all been involved. Furthermore, the program includes technologies which range from measurements of the actual need for water, to its most efficient delivery. Finally, this program has shown that farmers are willing to invest money in energy-efficient technologies once they are convinced of the potential for significant savings.

Pump Testing and Irrigation Efficiency Program

Utility:	Western Area Power Administration
Sector:	Agricultural
Measures:	Efficiency recommendations
Mechanism:	Pump and irrigation efficiency analysis
History:	Funded in 1986, continuing to present.

1991 Program Data

Energy savings:	8.9 GWh
Lifecycle energy savings:	35.6 GWh
FY 1992 Cost:	$115,400

Cumulative Data (1988-1991)

Energy savings:	43.8 GWh
LIfecycle energy savings:	82.8 GWh
FY 1987-1992 Cost:	$730,500
Participation rate:	~10%

Conventions

For the entire 1992 profile series all dollar values have been adjusted to 1990 U.S. dollar levels unless otherwise specified. Inflation and exchange rates were derived from the U.S. Department of Labor's Consumer Price Index and the International Monetary Fund's International Financial Statistics Yearbook: 1991.

The Results Center uses three conventions for presenting program savings. **Annual savings** refer to the annualized value of increments of energy and capacity installed in a given year, or what might be best described as the first full-year effect of the measures installed in a given year. **Cumulative savings** represent the savings in a given year for all measures installed to date. **Lifecycle savings** are calculated by multiplying the annual savings by the assumed average measure lifetime. **Caution:** cumulative and lifecycle savings are theoretical values that usually represent only the technical measure lifetimes and are not adjusted for attrition unless specifically stated.

Utility Overview

Western Area Power Administration (referred to throughout this profile as Western) is a federal power marketing agency created in 1977 with the passage of the Department of Energy Organization Act. Western markets energy to 615 wholesale power customers. These wholesale customers provide retail energy service to millions of customers in the central and western states. Western's "service area" covers approximately 1.3 million square miles and includes the states of Arizona, California, Colorado, Iowa, Kansas, Minnesota, Montana, Nebraska, Nevada, New Mexico, North Dakota, South Dakota, Texas, Utah, and Wyoming. WAPA markets power from 51 power plants run by the U.S. Army Corps of Engineers, the Bureau of Reclamation, and the International Boundary and Water Commission.

WESTERN 1991 STATISTICS

Number of Customers	615	
Energy Sales	33,858	GWh
Energy Sales Revenue	$614.030	million
Peak Demand	6,872	MW
Generating Capacity	10,407	MW
Reserve Margin	51	%
Western Composite Wholesale Rates		
Billings Area	1.05-1.14	¢/kWh
Loveland Area	1.80-1.89	¢/kWh
Phoenix Area	0.84-0.96	¢/kWh
Sacramento Area	3.06	¢/kWh
Salt Lake City Area	1.56	¢/kWh

[R#1,3]

Western markets 15% of the nation's hydroelectric generation and 75% of the regional hydroelectric generation. In 1991, Western marketed 33,858 GWh of power which accounted for more than $614 million in gross revenues. Peak demand for the year was 6,872 MW while Western's generating capacity was 10,407 MW. Western operates more than 16,550 miles of transmission lines. Western energy sales for 1991 were as follows: municipalities 10,248 GWh, cooperatives 7,518 GWh, state agencies 4,519 GWh, public utility districts 3,642 GWh, irrigation districts 2,487 GWh, investor owned utilities 2,245 GWh, federal agencies 2,072 GWh, the Bureau of Reclamation 636 GWh, and interdepartmental transfers 487 GWh. Western's electricity rates are very low. Composite wholesale rates for Western's five area offices range from a high of 3.06 cents per kWh for the Sacramento area office to a low of between 0.84 and 0.96 cents per kWh for the Phoenix area office.

Western dealt with many environmental concerns in 1991. The environmental issue having the greatest direct effect on Western was the continued drought that has plagued the west for the past six years. Western was forced to buy over 10,000 GWh of power in large part because of generating restrictions caused by the drought. Hydro generation for Fiscal Year 91 was 23,000 GWh compared with an average generation of 30,100 GWh for the years 1986 to 1990.

Additional environmental issues led to reductions in power marketed by Western. Central Valley power plants were temporarily bypassed to ensure the correct temperature for spawning winter run salmon in California rivers. Similar water flow adjustments were made to protect endangered species in the Missouri River and Upper Colorado River basins.[R#1,3]

Western's involvement with DSM programs began in 1981 with the creation of the Conservation and Renewable Energy Program (C&RE Program). The C&RE Program was designed with the intent of encouraging energy conservation, improving electric power efficiency, and making C&RE technologies competitive with traditional power resources for future power needs. The Hoover Power Plant Act of 1984 required all long term Western customers to develop their own C&RE programs in order to purchase power from Western. In addition, the Guidelines and Acceptance Criteria outline customer program components. The 1992 Energy Policy Act has replaced the Hoover Act. Western customers are now required to perform integrated resource planning. Western's 1991 DSM expenditures were equal to 0.6% of gross energy revenues.

Western estimates that over 3,000 customer C&RE activities are currently under way as a result of Western's contract requirement. These program activities focus on areas such as conservation, energy management, cogeneration, wind power, solar power, biomass technology, hydropower, and geothermal power. Western assists in customer C&RE programs by providing peer matches, workshops, informational services, technology transfer and equipment loans. Western also helps customers with their C&RE projects by providing direct technical assistance and sharing project costs. By effectively sharing C&RE program costs with its customers, Western leverages the implementation of C&RE activities.

DSM Overview Table	DSM Expenditure ($1000)
1981	$719
1982	$880
1983	$997
1984	$1,390
1985	$2,845
1986	$3,003
1987	$3,462
1988	$3,415
1989	$3,117
1990	$2,704
1991	$3,493
1992	$3,846
Total	$29,870

[R#3]

EXEMPLARY C&RE PROGRAMS

• Navopache Electric received Western's highest C&RE award in 1989 for programs aimed at reducing demand and increasing load factor. Some interesting aspects of Navopache's programs included geothermal development of the hot dry rock technology, use of ground loop heat pumps, and developing off peak rates in order to shift load.

• Western customers have saved tens of thousands of dollars by borrowing infrared cameras from Western to scan electrical systems, distribution lines, transformers, substations, service drops, and buildings. The cameras reveal energy losses in buildings' hot spots that could cause future outages. The correction of problems revealed by camera use makes energy delivery more reliable and efficient.

• The Sacramento Municipal Utility District (SMUD), a Western customer, is noted by Western for its efforts to integrate conservation into its resource mix. In 1992 SMUD audited, rebated, and documented 7.6 MW of demand savings and 32.7 GWH of energy savings in the commercial/industrial sector. See Profile #13 for a description of one of SMUD's pilot programs.[R#3]

Program Overview

Western's Pump Testing and Irrigation Efficiency program promotes state-of-the-art methods for improving irrigation pump efficiency and reducing demands upon irrigation pumps. Western provides pump tests and recommends ways that pump efficiencies can be improved. Additionally, Western provides irrigation efficiency analyses and recommends appropriate techniques for reducing the amount of water that must be pumped, and thus the demands upon the irrigation pumps, while still providing crops with sufficient water. While pump tests under the program were initially provided free of charge, the program now charges $100 per test, which alleviates some funding needs for the program and furthers it toward a goal of economic self-sufficiency.

The program's educational element is perhaps its strongest, introducing farmers to new technologies such as low and medium pressure irrigation systems, surge irrigation systems, and irrigation scheduling techniques, that can reduce energy usage, and save both money and water. (Water rights are not lost in the underground or pump-irrigated areas. In fact, a farmer can apply to the state engineer's office for expanded acre usage if the farmer has adjoining land.)

Western's involvement with pump testing and irrigation efficiency in the state of Colorado began in 1982 shortly after the start of the C&RE program. Western was interested in the electricity conservation aspect of irrigation. In an attempt to address this issue approximately 14 pump testing kits were purchased. These kits were loaned to the USDA Soil Conservation Service, but they were hardly used due to personnel constraints at the time.[R#1]

In 1986, funding for a formal pump testing and irrigation efficiency program run by the Colorado State Soil Conservation Board (CSSCB) was provided by Western, which contributed $102,900, and the Colorado Office of Energy Conservation (OEC), which contributed $37,000. Throughout the course of the program, the USDA Soil Conservation Service (SCS) has provided transportation, telephone, office space, and equipment. SCS contributed an estimated $13,800 in the first year of the program.[R#1]

The OEC funding became available in 1986, when Project ARC (Agriculture Resources in Colorado) led a movement among all major agencies in the agricultural arena, including the Colorado State Soil Conservation Board, to create a proposal for the use of some of the Petroleum Overcharge Restitution Funds in an attempt to conserve energy in Colorado agriculture. (These "oil overcharge" funds existed as a result of a federal court settlement penalizing several oil companies for overcharging at the gas pump. The settlement required the return of more than $25 million to the state of Colorado, designated to be spent on energy conservation. Money from the settlement was given to OEC.)

The Project ARC proposal was titled the Agricultural Energy Project, and requested money for use on six major projects, one of which was pump testing and irrigation efficiency. In December of 1986, the OEC provided funds for the six projects from April 1987 through April 1990. The Colorado State Soil Conservation Board and Colorado State University (CSU) were given responsibility for monitoring the funds and supervising the program.[R#1,7]

The program contract required the establishment of an Energy Conservation for Colorado Agriculture (ECCA) office. This office was to consist of a full-time coordinator, half-time information specialist, and half-time secretary. This office was set up in May 1987, with Mr. Carrol Hamon serving as its coordinator. The objective of the office was to promote agricultural energy conservation through field demonstrations, direct technical assistance, workshops, seminars, newsletters, and articles in newspapers and magazines.

Additional funding from the Petroleum Overcharge Restitution funds provided for a two-year contract extension for the ECCA office from April 1990 through April 1992. The ECCA office still reported to the Colorado State Soil Conservation Board, but CSU was no longer involved. During this two year period (July, 1990 to June, 1992), OEC funded an extension of the ECCA Program; $30,000 of the OEC funds were used annually for the pump testing program with Western's contribution remaining at $75,000 and the USDA Soil Conservation Service contribution of $18,000.

Beyond June, 1992, program funding is being provided by Western contributions ($35,000), CSSCB ($20,000), the OEC ($35,000), and the SCS ($18,000). Additional program revenues are generated from the actual pump test fee of $100. The goal for the program has always been economic self-sufficiency. While this goal has not yet been achieved, the pump test is no longer a giveaway service, and the $100 fee has been readily accepted.

Glossary of Irrigation Terms

Irrigation System Improvements: The Pump Testing and Irrigation Efficiency program introduces farmers to new technologies and practices available to improve their irrigation efficiency. Most often, the pump test team recommends replacement of a high pressure sprinkler system with a medium or low pressure system. Additionally, the team may recommend retrofitting or replacing a gravity flow system with a surge flow system.

High Pressure Sprinkler Systems: Initially when the pump irrigated area of eastern Colorado was developed, all the pivot systems used high pressure (45 to 80 psi), high impact sprinkler nozzles to irrigate their crops. Theses nozzles were placed on top of the pivot span pipe. Major crops irrigated under these systems consisted of corn, wheat, and beans, with minor acreages of potatoes, onions and sunflowers. A pivot sprinkler consists of a main line mounted on towers that walk around a fixed pivot point. High pressure, high impact sprinkler nozzles throw the water high into the air as the line rotates in a 360 degree circle. Where summer temperatures average 90 to 100 degrees Fahrenheit, and wind speed average 15 to 20 miles per hour, a large portion of the water is lost to evaporation in the air, or after the water lands on the crop canopy. The result is poor application efficiency, of about 65% (i.e. 35% of the water pumped through the system is lost to evaporation). This method of irrigation was state-of-the-art until the early 1980's.

Medium Pressure Sprinkler Systems: In medium pressure pivot irrigation systems, the sprinkler heads are located just under the truss rods but above the crop, decreasing the distance between the sprinkler nozzles and the ground. With medium pressure systems, (25 to 40 psi), application efficiency can be increased to about 75%.[R#1,6,8]

Low Energy Precision Application Systems: In Low Energy Precision Application (LEPA) irrigation systems, the sprinkler nozzles are located at the end of drop tubes that hang from the pivot span pipe down to almost the soil surface. Water is distributed under low pressure (6 to 10 psi), directly to the soil. This method avoids evaporation losses from high temperatures and wind experienced with medium and high pressure sprinklers. Application efficiencies for LEPA systems range from 95% to 98%. A new LEPA conversion from a high or medium pressure system costs about $3,000 for the materials, and the farmer can do the installation. Should the farmer hire a commercial firm to do the conversion, it can cost from $10,000 to $15,000. This change to LEPA, however, will pay for itself in one to three years. Typically pump motor energy consumption is reduced by 30%.[R#1,6,8]

Surge Irrigation: Surge irrigation is an efficient adaptation typically used on furrowed fields where gravity flow irrigation techniques are employed. With many gravity flow systems, water is released so quickly that it runs off to the edge of the field before it has a chance to enter the crop root zone. This situation is avoided with surge flow systems; water is released in small surges through the gates in an irrigation pipe, flowing partially through each furrow with each water release. In between surges, water has time to seep into the soil, saturating the sections closest to the pipe; with subsequent surges, water travels over the saturated sections, supplying water to the areas further from the gated pipe. The surge irrigation demonstrations performed in the earlier years of the Pump Testing and Irrigation Efficiency program have been discontinued because of the time and personnel demands required to train irrigators in the use of the valves. Surge irrigation can reduce water and energy consumption by one-third.[R#6]

Irrigation Scheduling: Irrigation scheduling is used to reduce overwatering. Even with efficient irrigation systems, crop overwatering can create situations in which energy is used to pump water that may not be needed by the crop. The Pump Testing and Irrigation Efficiency program promotes two techniques for improving irrigation scheduling – soil moisture monitoring through gypsum blocks, and irrigation scheduling through the use of evapotranspiration data. Additionally, the program is a strong promoter of conservation tillage techniques, which improve soil moisture retention, allowing for less frequent irrigation schedules.

Gypsum Blocks: Gypsum blocks are a popular tool used to monitor soil water moisture and to determine when crops require more water. The blocks resemble soil in texture and look like marshmallows on strings. These blocks are planted at one foot intervals through the root zone of the soil profile. The blocks are cast around two concentric stainless steel electrodes, and the wetter the soil, the better the blocks conduct electricity. By connecting the blocks' wires to a meter, the available soil moisture is displayed. A set of gypsum blocks cost only $15, and the soil moisture tester costs between $150 and $200. By using gypsum blocks most farmers can delay their first irrigation of the season by up to thirty days.[R#1,6,7,8]

Tracking Evapotranspiration Rates: Evapotranspiration data gathered by local weather stations, combined with the water needs of various crops is another method that can be used to determine when the irrigation system should be turned on and off. Evapotranspiration is a measure of the water consumed by a crop or lost to evaporation in the air or from the crop canopy.

Soil Moisture Retention Improvement: Crop residue management and conservation tillage are methods of improving the retention of water during the winter months and the irrigation season. When crop residue is left in the fields after harvest, snow which would otherwise blow to other areas, is trapped by the crop residue and thus becomes available to the soil profile during spring meltoff. Additionally, evaporation during melting is reduced by the presence of the crop residue. Thus, more moisture enters the ground, where it can be used by the crops in the early part of the growing season. Conservation tillage, in which soil is worked less vigorously before and after the growing season, improves soil moisture retention. Crop residue management can add two to three inches of moisture to the soil profile before the growing season starts, while conservation tillage can significantly improve the ability of soil to hold excess rain and irrigation water until crops require it.[R#6]

The Pump Testing and Irrigation Efficiency program is implemented by three pump-testing teams based in the towns of Burlington, Wray, and Huxton, Colorado. Each team consists of one full-time and one part-time employee. Team members travel to individual farms to perform the irrigation pump tests. The team members are made up of State Civil Service employees who were hired by the State Soil Conservation Board, which is an agency of the State Department of Natural Resources.

During the first four years (1986 - 1990), with funding from Western, OEC, and SCS, pump tests were available only to farmers pumping water from the Ogallala Aquifer in a five county area in eastern and southeastern Colorado. In 1991 and 1992 pump tests were also available to farmers in the San Luis Valley of Colorado but as of April 1992 pump tests are no longer available there. All other agricultural services offered by ECCA are available state-wide.[R#1]

MARKETING

During the first year of the program (1986), contact with farmers was made through the federal Soil Conservation Service and utility referral. Because the SCS provided office space, telephone service, and transportation to the program, communication between the SCS and program staff was simple. In addition to this cooperation with SCS, key marketing tools for the program have been word-of-mouth, newsletters, fact sheets, field days, and workshops. Initially, there was a fair amount of resistance among the farming community toward the new technologies offered by the Pump Testing and Irrigation Efficiency program. Many farmers thought that the techniques and technologies that had been passed down through the generations were just fine. Few were willing to be guinea pigs and to try innovative techniques. However, program acceptance grew as farmers participated in the program and were pleased with the resulting savings.

The marketing abilities of the pump test teams have been essential to the success of this program. The teams consider the administration of the pump test as merely getting their foot in the door. This contact with the farmer provides the opportunity to recommend other energy efficiency measures such as improved irrigation pattern efficiencies, low energy precision application (LEPA) irrigation, soil moisture monitoring, and conservation tillage.

Marketing of the LEPA irrigation systems was helped greatly by taking farmers on bus tours to Big Springs, Texas to observe LEPA systems already installed. These tours occurred in the 1988 - 1989 winter and spring season. As a result of these trips, five Colorado farmers purchased LEPA systems. The following year thirteen LEPA systems were purchased. To date, over 250 LEPA systems have been bought by farmers in the program service area.

"In nearly three years, we don't know of a system that's been taken out. It's sort of like indoor plumbing... once you try it, you don't ever want to go back." *Vern Bauer, Burlington, Colorado Pump Testing/Irrigation Water Management Team*

Additional marketing measures include seminars and workshops held throughout the state, usually run by Carrol

Hamon, the local utility, and Western's Peggy Plate with assistance from the pump-testing teams. Irrigation efficiency experts are brought in to speak to farmers at these meetings. Local utilities also have meetings with farmers (usually when a rate increase is proposed) discussing ways that farmers can save money through energy efficiency measures. Members of the pump test teams are present at these meetings to explain pump testing and irrigation efficiency to the farmers.[R#1]

DELIVERY

Irrigationpump tests are scheduled upon request of the individual farmer. Pump tests often occur during irrigation season when demands upon the irrigation system are typical. However, as long as groundwater levels are not subject to seasonal fluctuation, meaningful pump test results can usually be generated year round. However, pump tests cannot be done in freezing weather or when they might interfere with harvesting or crop cultural practices. In 1992, the charge for pump tests was $100 though some utilities assist farmers by paying all or part of the pump test cost. In the early years of the program, pump tests were conducted free of charge. The pump test fee was initiated in 1990 as a result of reduced program funds. (As with most of Western's C&RE programs, funds are furnished to demonstrate the energy savings of a particular program, but once these savings are demonstrated, the practice should be self-sustaining. In time, Western will probably phase out their contribution altogether.)[R#1]

Pump tests include determination of the following: Well water levels during pumping, pumping rate, discharge pressure, pump and engine speed, and energy use. Any abnormal well conditions are also noted. The results of the pump test inform the farmer whether the pump needs to be adjusted, rebuilt, or replaced. Generally, pump efficiency can be improved with service to one of three major pump components, the pump, drive, or power unit.[R#1,8]

If a pivot sprinkler system is in use, a pivot evaluation is usually performed after the pump test. First, the pivot pattern is checked visually. Then, bottles are placed at 30 foot intervals along the pivot. The pivot is run past the bottles in a normal irrigation mode and the water in the bottles is measured. The data from the bottles is analyzed by computer which reports the pivot's efficiency nozzle by nozzle.[R#1,8]

After the pivot evaluation, the pump test team recommends whether the farmer should consider changing to medium or low pressure irrigation systems. Low pressure or LEPA systems are most frequently recommended. Conversion of an existing pivot system to a LEPA system or installation of a new LEPA pivot system can be performed by either the individual farmer or the irrigation company. The pump test teams are not involved with any irrigation conversions or installations.

Additionally, farmers are introduced to irrigation scheduling techniques. The team may install gypsum blocks in the field and read the blocks weekly, advising the farmer when to irrigate and in what quantities. The farmer is taught how to use the gypsum blocks properly, which includes interpreting the soil moisture meter reading and applying that information to determine when irrigation is required. The pump testing team may also show the farmer how to access and use evapotranspiration data, which is available in the newspapers, on the radio, through CSU, through a daily hotline, or where posted on bulletin boards at banks and restaurants. Finally, the team suggests that the farmer stop irrigating once sufficient moisture is available to take the crop to maturity. [R#1,6]

MEASURES INSTALLED

Installed measures include irrigation pump components and entirely new pumps. Similarly, existing irrigation pivots can be converted to a LEPA system or a new pivot system can be purchased. Surge valves are no longer a component of the program. Gypsum blocks are an inexpensive yet important measure used in the Pump Testing and Irrigation Efficiency program. A team can test one to four pumps in a day depending on the complexity of the problems found. It takes approximately two hours to plant the gypsum blocks in a typical field.

STAFFING REQUIREMENTS

The Pump Testing and Irrigation Efficiency program is administered by a full-time coordinator (Carrol Hamon), a half-time information specialist, and a half-time secretary. The program is implemented by the pump-testing teams, headed up by three full-time team leaders and assisted by one part-time employee. Vern Bauer is in charge of the Burlington pump-testing team, Conrad Bauer runs the Wray pump-testing team, and Bill Sauder is in charge of the Haxtun team. These three men have been with the Pump Testing program since it began in 1986.

There are also several part-time employees on the pump-testing teams. Peggy Plate of Western manages all Loveland Area Office conservation program activities, including planning, and developing contracts and programs such as the irrigation efficiency program. She has been a constant advisor and supporter of the program, in both technical matters and in funding concerns, since the program's inception. Additionally, she was instrumental in the early design and implementation of the program. [R#1]

MONITORING

The program monitoring is performed by the pump test team leaders who gather information from participating farmers and report the data to program coordinator Carrol Hamon. Computer programs are used to record and compute individual pump test data locally with a summary sheet sent to the Coordinator quarterly. However, the most important information is gathered through quarterly narrative reporting activity such as individual farmer testimonials, news articles, field days, and workshops.

EVALUATION

Evaluation of the program is done by Carrol Hamon in the form of quarterly reports and annual reports. A summary report of the program from January 10, 1987 through April 30, 1990 was also prepared by Mr. Hamon. This report provided summaries of all the programs funded in large part by the Petroleum Overcharge Restitution Funds. A similar two-year summary report is scheduled to be finished by the end of 1992. From 1990 to 1992, all reports reflected the combined Western and OEC sponsored programs.

DATA QUALITY

The kWh energy savings for the program only reflect results from the pump tests, as measured from pump readings. Program dollar savings are based on projected pump test savings combined with all other irrigation efficiency measures including gypsum blocks and conservation tillage. These dollar savings are based on a rate of $0.06 per kWh, which is the average cost of electricity in the area. The numbers in the Savings Overview Table account only for the years 1988 through 1991. Program accomplishments and savings for the 1986 and 1987 years were reported to Western in the form of quarterly reports by the CSSCB, but no attempt was made to summarize them into a yearly report because that was not a requirement of the financial sponsors. The 27.7 GWh figure reported in the text of the Savings Overview Section is an estimate of all savings attributable to the program between 1986 and 1992.[R#1]

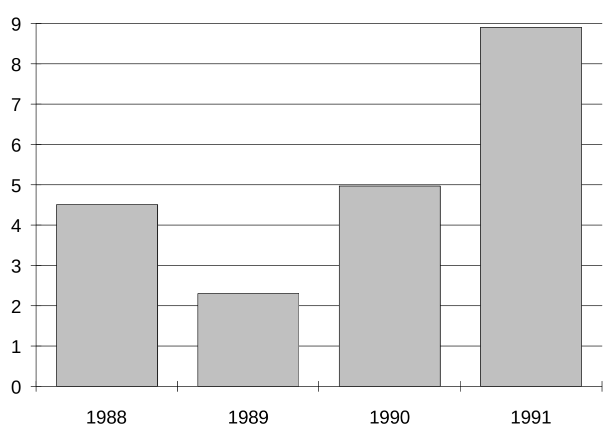
Cost breakdowns for each fiscal year of the program were provided by Mr. Carrol Hamon. The Results Center did not perform any cost per participant calculations, as the number of pumps tested in each year are reported by calendar year, while costs are reported by fiscal year. Thus, the costs and participation do not necessarily correlate in each year reported. The Results Center did, however, calculate cost of saved energy for the program, even though savings and costs are not reported for corresponding periods. The Cost of Saved Energy figures in the Cost of the Program section should therefore be used only for comparison purposes, and not as verifiable figures.

Program Savings

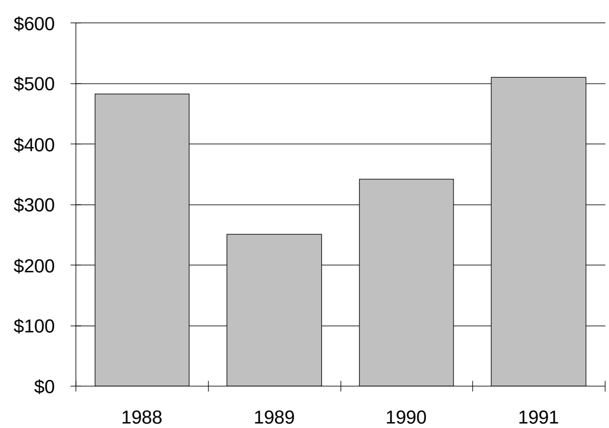
Savings Overview Table	Annual Energy Savings (MWh)	Cumulative Energy Savings (MWh)	Lifecycle Energy Savings (MWh)	Annual Energy Cost Savings Potential (x1000)	Water Savings from LEPA Installations (Acre-Feet)
1988	4,511	4,511	18,044	$483	25,000
1989	2,300	6,811	9,200	$251	520
1990	4,979	11,790	19,916	$342	18,300
1991	8,901	20,691	35,604	$511	12,524
Total	20,691	43,803	82,764	$1,587	56,344

[R#1]

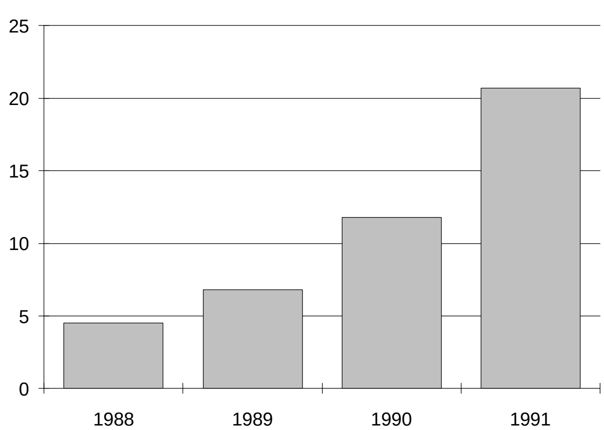
ANNUAL ENERGY SAVINGS (GWH)



ANNUAL ENERGY COST SAVINGS (x1000)

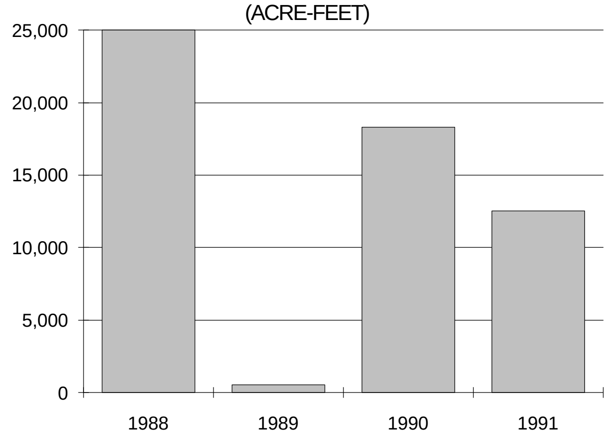


CUMULATIVE ENERGY SAVINGS (GWH)



WATER SAVINGS DUE TO LEPA INSTALLATION

(ACRE-FEET)



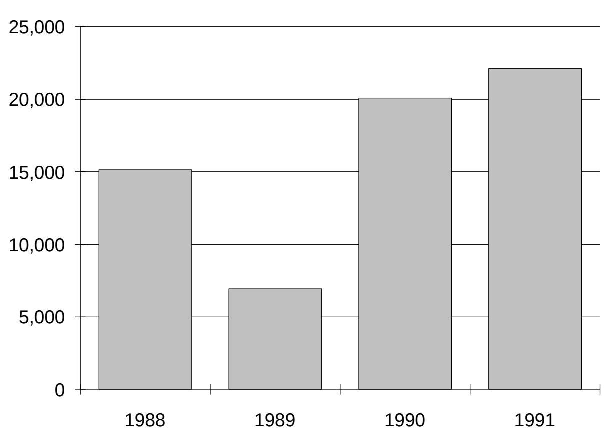
In 1991, 403 wells received pump tests which accounted for savings of 8.9 GWh. Total annual energy savings for the program between the program start in 1986, and 1992, have been 27.7 GWh. (As shown in the Savings Overview Table, total annual energy savings between 1988 and 1991 were 20.7 GWh.) Total dollar savings from the pump testing and irrigation efficiency program in 1991 were $511,000, and cumulative savings have exceeded $1.6 million since the program's inception. In addition, the program in 1991 accounted for savings of 12,524 acre feet of water. The program's total water savings to date are 56,344 acre feet.

PARTICIPATION RATES

A total of 1,278 wells have been tested during the course of the pump testing program. There are approximately 12,000 to 15,000 wells in the Colorado portion of the Ogallala Aquifer. However, not all of these wells are in active use. Probably at least 10% of the eligible wells have been tested.

Savings Per Participant Table	Number of Wells Tested	Annual Energy Savings per Participant (kWh)
1988	298	15,138
1989	332	6,928
1990	248	20,077
1991	403	22,087
Total	1,281	

SAVINGS PER PARTICIPANT (KWH)



The number of pumps tested each year is directly affected by the weather. That is, in some years, the weather is amenable to the performance of tests throughout all 12 months, but in others, perhaps only 8 months may have suitable weather.[R#1]

Over 300 farms have used gypsum blocks to help with irrigation scheduling as a result of the program, and approximately 250 LEPA systems have been installed.

MEASURE LIFETIME

A 20-year lifetime for a pumping system is typical although many pumps tested had been running for 40 years. Pumps rarely have to be replaced entirely at one time. Instead, various parts are replaced on an as needed basis. Once a LEPA system has been installed, the lifetimes of both the pump and the pivot are increased, due to less demands on the pump, and lower pressures.[R#1]

The team estimates that pump tests could be justified every two years, to accurately predict the wear and tear on the pump and motor, and to detect any depletion change in the aquifer and or recharge. In some areas there is a 20% drop in efficiency from spring to fall because the geologic formations release the water at different rates. However, in general practice, the pump test is a one time event. Only where some change has taken place are the pump and pivot re-tested. The Results Center conservatively used four years as the lifetime for calculating lifecycle savings in the Savings Overview Table and to calculate the values presented in the Cost of Saved Energy Table in the next section.

PROJECTED SAVINGS

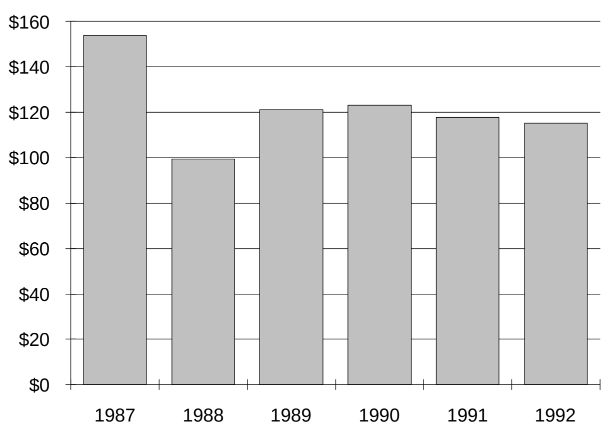
Western has estimated that energy-cost savings worth $11.6 million could be achieved if all of the measures recommended throughout the program life had been installed. Actual energy-cost savings were slightly more than one-tenth of the potential as not all of the improvements recommended have actually been installed or were not cost effective at that time.

Cost of the Program

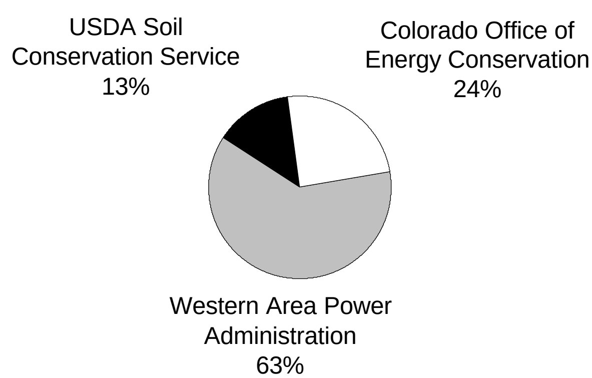
Costs Overview Table	Western Area Power Administration (x1,000)	Colorado Office of Energy Conservation (x1,000)	USDA Soil Conservation Service (x1,000)	Total Program Cost (x1000)
1987	$102.9	$37.0	$13.8	$153.7
1988	$55.2	$27.6	$16.6	$99.4
1989	$79.1	$26.4	$15.8	$121.2
1990	$75.0	$30.0	$18.0	$123.0
1991	$71.8	$28.7	$17.2	$117.8
1992	$70.3	$28.1	$16.9	$115.4
Total	$454.3	$177.9	$98.3	$730.5

[R#1] All costs are for fiscal years, ending in June of the year noted, except for 1987 costs, which cover the period from April 1986 to June 1987.

TOTAL PROGRAM COST (x1,000)



TOTAL PROGRAM COST CONTRIBUTORS



Cost of Saved Energy Table (¢/kWh)	Discount Rates						
	3%	4%	5%	6%	7%	8%	9%
1988	0.59	0.61	0.62	0.64	0.65	0.67	0.68
1989	1.42	1.45	1.49	1.52	1.56	1.59	1.63
1990	0.66	0.68	0.70	0.71	0.73	0.75	0.76
1991	0.36	0.36	0.37	0.38	0.39	0.40	0.41

In the fiscal year 1991 - 1992, the Pump Testing and Irrigation Efficiency program cost $115,400, with 61% of the budget being supplied by Western, 24% provided by the Colorado Office of Energy Conservation, and 15% provided by the USDA Soil Conservation Service, through the use of their office, phones, and vehicles. Western's annual contributions of $75,000 are levelized in the Cost Overview Table. Total program expenditures are $730,500. (See the chart at left for the total program's cost contributions.) It should be noted that not all of Western's budgeted funds are necessarily used in a given year. Actual nominal dollars spent between 1986 and the end of the fiscal year in 1992 have been $416,004, or 95% of the total $439,400 (nominal dollars) allocated in that period.[R#1]

COST EFFECTIVENESS

The Results Center calculated the cost of saved energy for this program based on the savings reported from the pump testing program alone. However, total costs were used, possibly skewing the results upward. The calculations are shown in the Cost of Saved Energy Table based on a 4-year lifetime of the measures. At a 5% discount rate, the cost of saved energy has ranged from a low in 1991 of 0.37 ¢/kWh to a high in 1989 of 1.49 ¢/kWh. These costs are very attractive, especially when compared to the average 6 ¢/kWh cost of electricity in the area served by the program.

FREE RIDERSHIP

Free ridership is not an issue for this program. While some farmers may have the pumps tested and serviced in the event of pump failure or malfunction, few would be likely to have their pumps tested on a regular preventative basis. Additionally, it would be difficult for most farmers to obtain the amount of information and on-site assistance regarding irrigation efficiency in the absence of this program. Institution of the $100 fee in the 1991 calendar year also serves to preclude any free-ridership in the program.

COST COMPONENTS

Salaries account for most of the expenditures, at 77%, with transportation making up for most of the remaining costs, at 12%. Additionally, the teams spend a total of about 11% for travel expenses, supplies, and overhead.[R#1]

Environmental Benefit Statement

Marginal Power Plant	Heat Rate BTU/kWh	% Sulfur in Fuel	CO2 (lbs)	SO2 (lbs)	NOx (lbs)	TSP* (lbs)
Coal	**Uncontrolled Emissions**					
A	9,400	2.50%	94,439,000	2,241,000	453,000	45,000
B	10,000	1.20%	100,703,000	867,000	292,000	217,000
	Controlled Emissions					
A	9,400	2.50%	94,439,000	224,000	453,000	4,000
B	10,000	1.20%	100,703,000	87,000	292,000	14,000
C	10,000		100,703,000	578,000	289,000	14,000
	Atmospheric Fluidized Bed Combustion					
A	10,000	1.10%	100,703,000	265,000	145,000	72,000
B	9,400	2.50%	94,439,000	224,000	181,000	14,000
	Integrated Gasification Combined Cycle					
A	10,000	0.45%	100,703,000	178,000	29,000	72,000
B	9,010		90,585,000	65,000	22,000	4,000
Gas	**Steam**					
A	10,400		54,929,000	0	125,000	0
B	9,224		47,701,000	0	299,000	14,000
	Combined Cycle					
1. Existing	9,000		47,701,000	0	183,000	0
2. NSPS*	9,000		47,701,000	0	87,000	0
3. BACT*	9,000		47,701,000	0	12,000	0
Oil	**Steam--#6 Oil**					
A	9,840	2.00%	79,502,000	1,205,000	142,000	135,000
B	10,400	2.20%	84,321,000	1,195,000	179,000	87,000
C	10,400	1.00%	84,321,000	171,000	144,000	45,000
D	10,400	0.50%	84,321,000	501,000	179,000	28,000
	Combustion Turbine					
#2 Diesel	13,600	0.30%	105,521,000	210,000	326,000	18,000
Refuse Derived Fuel						
Conventional	15,000	0.20%	125,277,000	323,000	425,000	94,000

Avoided Emissions Based on 43,803,000 kWh Saved (1988-1991)

In addition to the traditional costs and benefits there are several hidden environmental costs of electricity use that are incurred when one considers the whole system of electrical generation from the mine-mouth to the wall outlet. These costs, which to date have been considered externalities, are real and have profound long term effects and are borne by society as a whole. Some environmental costs are beginning to be factored into utility resource planning. Because energy efficiency programs present the opportunity for utilities to avoid environmental damages, environmental considerations can be considered a benefit in addition to the direct dollar savings to customers from reduced electricity use.

The environmental benefits of energy efficiency programs can include avoided pollution of the air, the land, and the water. Because of immediate concerns about urban air quality, acid deposition, and global warming, the first step in calculating the environmental benefit of a particular DSM program focuses on avoided air pollution. Within this domain we have limited our presentation to the emission of carbon dioxide, sulfur dioxide, nitrous oxides, and particulates. (Dollar values for environmental benefits are not presented given the variety of values currently being used in various states.)

HOW TO USE THE TABLE

1. The purpose of the previous page is to allow any user of this profile to apply Western's level of avoided emissions saved through its Pump Testing and Irrigation Efficiency Program to a particular situation. Simply move down the left-hand column to your marginal power plant type, and then read across the page to determine the values for avoided emissions that you will accrue should you implement this DSM program. Note that several generic power plants (labelled A, B, C,...) are presented which reflect differences in heat rate and fuel sulfur content.

2. All of the values for avoided emissions presented in both tables includes a 10% credit for DSM savings to reflect the avoided transmission and distribution losses associated with supply-side resources.

3. Various forms of power generation create specific pollutants. Coal-fired generation, for example, creates bottom ash (a solid waste issue) and methane, while garbage-burning plants release toxic airborne emissions including dioxin and furans and solid wastes which contain an array of heavy metals. We recommend that when calculating the environmental benefit for a particular program that credit is taken for the air pollutants listed below, plus air pollutants unique to a form of marginal generation, plus key land and water pollutants for a particular form of marginal power generation.

4. All the values presented represent approximations and were drawn largely from "The Environmental Costs of Electricity" (Ottinger et al, Oceana Publications, 1990). The coefficients used in the formulas that determine the values in the tables presented are drawn from a variety of government and independent sources.

*** Acronyms used in the table**

TSP = Total Suspended Particulates
NSPS = New Source Performance Standards
BACT = Best Available Control Technology

LESSONS LEARNED

One of the most interesting lessons learned from the Pump Testing and Irrigation Efficiency program is that a program involving a number of diverse units can actually be successful. Throughout the course of this program, federal, state, and local government agencies have all been involved. Other participants have included utilities, commercial irrigation companies, farmers, and a university.

Program administrators discovered immediately that dealing with the agricultural community takes patience when trying to market new technologies. Farmers are cautious by necessity as their budgets are typically very tight. Many farms are handed down from generation to generation, along with farming techniques. As a result, many farmers tend to believe that their current farming practices do not need alteration or improvement. This tendency is changing somewhat due to the hard times that hit farmers in the 1980's, which forced farmers into new ways of doing business in order to survive.

It is also apparent that farmers need to see new technologies demonstrated and then see proven savings before they will make an investment. Many farmers initially viewed the pump test teams no differently than other equipment salesmen. Program administrators also feel that farmers are more accepting of technologies that are user friendly.

Several valuable marketing lessons have been learned from this program. Farmers do trust each other and will listen to other farmers when it comes to agricultural technologies that have been successful. As a result, word of mouth became the strongest program selling point. After a few farmers participated in the program and liked it, their testimonials really helped the program to take off. Similarly, as the expertise of the pump test team leaders grew, so did their credibility and acceptance within the farming community. Having the same three team leaders for the duration of the program has been a tremendous help in establishing credibility and program continuity.

It is also clear that having mobile pump-testing teams is essential because farmers are not likely to travel to learn about agricultural techniques. Dissemination of program details by the pump test teams has been much more effective than relying on local utilities to encourage farmers to reduce energy consumption. Some local utilities now publish articles in their newsletters on irrigation efficiency, including case studies.

This program has also shown that farmers are willing to invest money in energy-efficient technologies, once they are convinced of the potential for significant savings.

TRANSFERABILITY

This type of program is clearly transferable because several rural utilities have implemented similar programs. One succesful program is in Wyoming and operated by the SCS in Torrington, where it is supported and encouraged by the local utilities. Unfortunately, most of these programs have been dropped due to a lack of sufficient funding.

In areas where irrigation water is not supplied by deep wells, a pump testing program would not generate the amount of energy savings that WAPA's program has. Additionally, the energy savings generated through irrigation efficiency improvements would not be as great in areas where pumps are not set so deep. However, in areas where the water is scarce and expensive, the water saving aspect of the irrigation efficiency component would likely be an attractive selling point.

The program design of the Pump Testing and Irrigation Efficiency program is not hard to duplicate, but it is essential that such programs have plenty of funding and organizational support.

References

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4. Western Area Power Administration, “Annual Report-Statistical Appendix,” 1991.

5. Theresa Williams, Western Area Power Administration, personal communication, October-November 1992.

6. Energy Conservation For Colorado Agriculture, “Annual Report,” 1991.

7. Energy Conservation For Colorado Agriculture, “Final Report January 10, 1987 through April 30, 1990,” 1990.

8. Carrol Hamon & Kate Jones, “Energy Conservation through Irrigation Efficiency, A Handbook.”

9. Energy Conservation For Colorado Agriculture, “Conservation Tillage and Low-Pressure Irrigation: Saving Water and Energy,” Fact Sheets.

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