Bonneville Power Administration
WaterWise Program
Profile #85

Executive Summary

Bonneville Power Administration's WaterWise program is an agricultural initiative that has evolved into a comprehensive effort that results in the triple benefits of energy and water savings and often increased crop yields thanks to the precision application of water. WaterWise dates back to 1979 when BPA first addressed irrigated agriculture's energy use by developing a pilot program that focused on pump testing and evaluating farmers' irrigation systems. A few years later BPA instituted the program on a regional basis and added incentives to the program for equipment retrofits. Then in 1991 these early programs were dramatically ramped up to create WaterWise, a program that addresses the needs of farms of varying sizes. In its current form, WaterWise is implemented by 39 retail utilities within BPA's service territory.

A focus on saving water may sound ironic to those unfamiliar with BPA's service territory since the Northwest is well known for its high levels of precipitation. East of the Cascade Mountains that bisect the states of Washington and Oregon, however, the climate is dramatically different and quite arid. There farmers depend on irrigation. Large irrigators and irrigation districts draw water directly from the Snake and Columbia Rivers using extensive pumping and piping systems to ultimately feed massive sprinklers. Huge water lines, as big as 72 inches in diameter, provide sustenance to crops such as peas, wheat, corn, alfalfa, onions, and potatoes. Small farms tend to pump groundwater. In each case, WaterWise provides technical, financial, and informational services.

The WaterWise Program consists of three main features: System Testing and Design Work for new and expanding systems, a wide array of Hardware Retrofits, and a new concentration on Irrigation Management. This last feature reflects the sophistication of the program. Through its retail utilities and consultants, BPA stays in close communication with participating farms through a number of channels. The program provides announcements through local media. Staff at retail utilities also maintain direct contact with farmers, and directly-linked computer connections are used to link program consultants with large farms to provide farmers with detailed information on weather patterns and evapotranspiration rates so that the farmers can optimize crop watering.

In the program's decade-long history BPA has invested nearly $25 million in improving the efficiency of irrigated agricultural systems in its service territory and has saved 11 aMW to date. Currently WaterWise is operating with an annual budget of $2 million resulting in annual energy savings of 2 aMW.

BONNEVILLE POWER ADMINISTRATION
WaterWise Program

Sector:	*Agricultural*
Measures:	*Low pressure, mainline, and pump modification equipment*
Mechanism:	*BPA funded irrigation system testing, design assistance, and hardware incentives, coupled with focus on irrigation management techniques*
History:	*Pilot in 1979, Irrigated Agriculture Retrofit in 1982, revised to WaterWise program in 1991*

1993 PROGRAM DATA

Energy savings:	*14.9 GWh*
Lifecycle energy savings:	*223 GWh*
Annual capacity savings:	*1.6 aMW*
Cost:	*$2.2 million*

CUMULATIVE DATA (1983-1993)

Energy savings:	*506.3 GWh*
Lifecycle energy savings:	*1,419 GWh*
Capacity Savings:	*11.0 aMW*
Cost:	*$24.5 million*

CONVENTIONS

For the entire 1994 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 U.S. Federal Reserve's foreign exchange rates.

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.

The Bonneville Power Administration (BPA) is a U.S. Government-owned agency which provides wholesale power to electric utilities. It was created by Congress in 1937 as the marketing agent for power generated at the Bonneville Dam. Today it markets power from 30 federal dams and one non-federal nuclear plant in the Pacific Northwest region and has built one of the largest and most reliable transmission systems in the United States, consisting of more than 14,800 miles of high-voltage transmission lines and 389 BPA-owned substations. This network, known as the Federal Columbia River Power System (FCRPS), has become the backbone of the transmission system for the Pacific Northwest.[R#2]

BPA serves the states of Washington, Oregon, Idaho, and Montana west of the Continental Divide, plus small adjacent portions of California, Nevada, Utah, and Wyoming. BPA sells wholesale power to public and private utilities as well as to some large industries. It also sells or exchanges power with utilities in Canada. The service area, with a population of 9.7 million people, covers approximately 300,000 square miles. BPA's wholesale roster includes 181 customers made up of: 124 municipalities, cooperatives, and public systems; 7 investor-owned utilities; 16 industrial firms; 7 federal agencies; and 27 customers outside the Northwest region.[R#2]

In 1980, under the Pacific Northwest Electric Power Planning and Conservation Act, BPA was assigned the additional responsibility of meeting the future growth in demand for electricity in the region through the acquisition of new generating resources and conservation measures. Through its Office of Energy Resources, BPA develops programs that purchase resources from generators, utilities, and end-users of electricity. The resources themselves are obtained through the investment in and use of measures and practices that increase the efficiency with which electricity is generated, transmitted, or used, and measures that employ renewable resources to displace consumption of electricity at the point of end use.[R#1]

BPA FY 1993 STATISTICS

Number of Wholesale Customers	*181*	
Energy Sales	*79,234*	*GWh*
Electric Revenues	*$1.94*	*billion*
Peak Demand	*16,876*	*MW*
Generating Capacity	*21,629*	*MW*
Average MW Delivered	*8,950*	*aMW*
Reserve Margin	*28*	*%*
Average Electric Rates		
Northwest Residential	*4.7*	*¢/kWh*

Nearly half of all the power used in the Northwest comes from BPA and about 85 percent of the power it sells is hydroelectric while 8% is nuclear and 7% is from firm contracts. Because BPA's electricity is mostly hydro, the average megawatt (aMW) capacity stated in the accompanying table is a more representative number than peak capacity. BPA's full system generating capacity of 21,629 MW could be delivered for only a short time but could not be sustained. Based on rainfall data from the last 50 years BPA estimates that during a worst case rainfall year it would be able to deliver 8,464 aMW. In 1993 it delivered 8,950 aMW to its customers while its 3.7% annual growth in peak demand resulted in a 60-minute system load peak of 16,876 MW. BPA's total sales for 1993 increased 2.5% over 1992 to 79,233 GWh.[R#2] ■

In order to fulfill the added responsibilities mandated by the Pacific Northwest Electric Power Planning and Conservation Act, it became necessary for BPA to become involved in demand-side management (DSM) programs. In 1982, under the title Energy Resources Program/Project, BPA initiated full-scale DSM programs in the residential, commercial, industrial, and agricultural sectors. From 1982 through 1993 BPA spent $1.282 billion on a wide range of DSM programs. In addition, BPA initiated its Aluminum Smelter Conservation and Modernization (Con/Mod) program in 1988, whose $61.6 million cost was spread out over a six-year period but whose savings were realized almost immediately. This explains why in 1988 a significant increase in savings was not accompanied by a similar increase in expenditures.[R#3]

Through direct conservation acquisition programs in the residential, commercial, industrial, and agricultural sectors, BPA acquired 281.1 aMW of savings from FY 1982 to 1993. Over half of these savings have been realized in the residential sector. Through the Con/Mod program BPA has acquired about another 100 aMW of savings. In addition to the direct acquisition of conservation, BPA has promoted the adoption of more energy-efficient residential and commercial building codes in Washington and Or-

BPA FUNDED DSM PROGRAMS

Residential

Residential Weatherization (Weatherwise)
Manufactured Housing Acquisition (MAP)
Appliance Efficiency
Oregon & Washington State Energy Codes
SGC Manufactured Homes Consumer Rebate
Long-term Super Good Cents
Super Good Cents

Commercial

Energy Smart Design
Energy Edge Project
Lighting Design Lab
Commercial Retrofit & End-Use Study (CREUS)

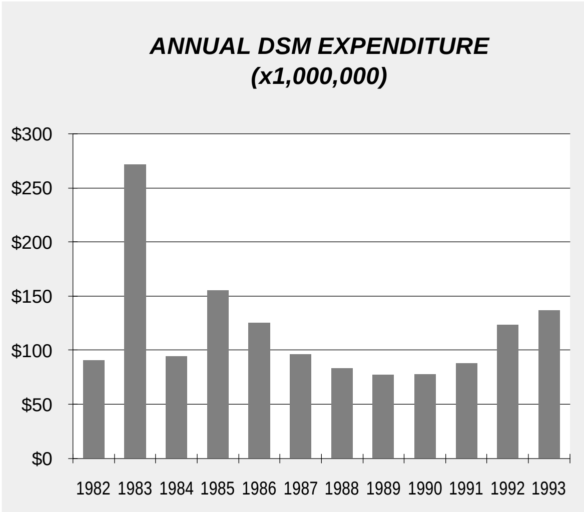
Industrial

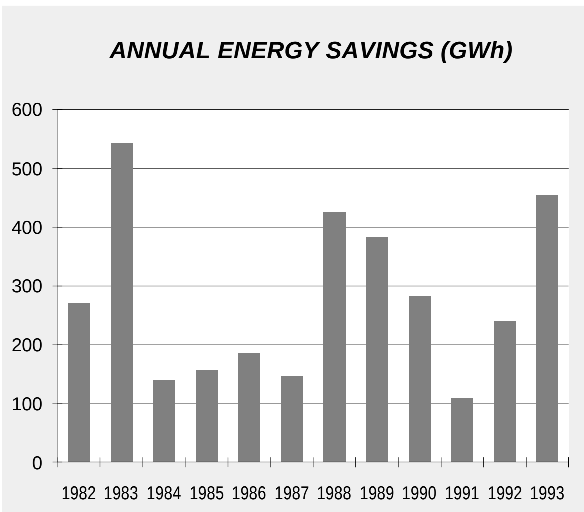
Sponsor Designed Plan
Aluminum Smelter Conservation/Modernization
Energy $avings Plan

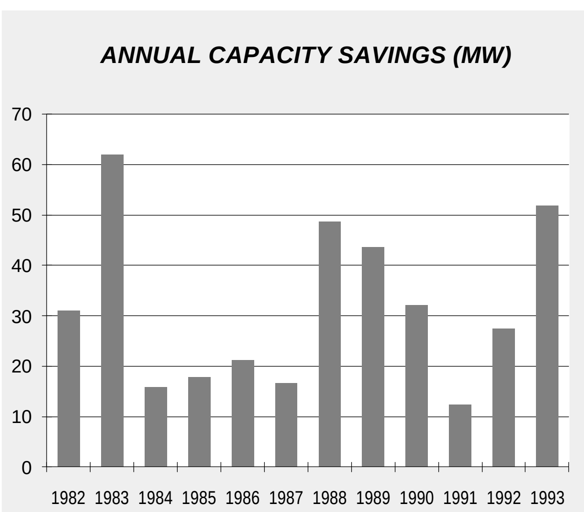
Agricultural

Irrigated Agriculture (WaterWise)

DSM OVERVIEW	DSM EXPENDITURE (x1,000,000)	ANNUAL ENERGY SAVINGS (GWh)	SUMMER CAPACITY SAVINGS (aMW)
1982	$90.6	272	31.0
1983	$271.6	543	62.0
1984	$94.5	139	15.9
1985	$155.2	156	17.8
1986	$125.2	186	21.2
1987	$95.9	146	16.7
1988	$82.8	426	48.6
1989	$77.2	382	43.6
1990	$78.0	282	32.2
1991	$87.7	109	12.4
1992	$123.2	240	27.4
1993	$136.9	454	51.8
Total	$1,281.9	2,880	328.8







egon and supported the adoption of residential Model Conservation Standards (MCS). Through FY 1993 these codes and standards resulted in energy savings of 58.2 aMW in BPA's service area. This makes the total energy savings attributable to BPA's wide range of DSM investments 435.2 aMW. In FY 1993 BPA's expenditure for DSM was $137 million, or 6.8% of its gross revenues. [R#3]

The Residential Conservation Agreement (RCA) is an umbrella contract whereby BPA's retail utilities are financed by BPA to operate energy savings programs under one contract instrument. BPA's WeatherWise program, for example, has installed cost-effective weatherization measures for 15,238 residences throughout the region via varying retail utilities in FY 1993. Over 280,000 residences have been retrofitted since the program's inception in 1990. This is quite an accomplishment considering the inherent difficulty of promoting energy efficiency in a region characterized by the lowest electrical rates in the nation.

Initially, BPA offered incentives and rebates to customers in the agricultural sector via their Irrigated Agricultural Hardware Programs. As of April 1991, these were rewritten and consolidated into the Irrigation Conservation Acquisition Agreement (WaterWise Program), the focus of this profile.

Some of BPA's other premier DSM programs include Super Good Cents Program (see The Results Center Profile #7), the Hood River Conservation Project (see Profile #12), Energy $avings Plan (see Profile #18), Manufactured Housing Acquisition Program (see Profile #30), and Energy Smart Design (see Profile #37). ■

BPA began its involvement in agricultural conservation programs under the heading Irrigated Agriculture Hardware Program in 1979. This initial effort consisted of a pilot program that evolved in 1982 into a regional pump testing and system evaluation program, administered and operated by participating utilities, but financed by BPA. These irrigated agricultural programs provided incentives and rebates to encourage irrigators to adopt cost-effective energy conservation measures. The programs were expanded to include contracts with certified analysts to test and evaluate irrigation systems. In April 1991, these programs expired, were rewritten, and then consolidated to form the Irrigation Conservation Acquisition Agreement, what is commonly called the WaterWise Program and which is scheduled to continue through June of 2001.

The WaterWise program includes system testing and design work, hardware retrofits, and irrigation management features and involves four groups: BPA, public utilities, technical consultants, and irrigators. BPA provides funds for irrigation system evaluations and design work for new and expanding systems as well as financial incentives for electrical efficiency improvements to upgrade existing irrigation systems. Public utilities implement the program using technical consultants who in turn work with irrigators on an as-needed basis.[R#6]

The objective of the WaterWise program is to acquire conservation in irrigated agriculture in order to reduce BPA's electric power load. By promoting irrigation system improvements and efficient irrigation management techniques the program conserves electricity and water. The program has many benefits appealing to consumers, utilities, BPA and the region. The program promotes acquisition and implementation of conservation, achieves more efficient use of water and energy, promotes customer service and good public relations for utilities and BPA, and it directly benefits irrigators' operations. A more energy-efficient system not only saves the customer money but can improve crop yield by more efficient and precision applications of water.[R#8]

The WaterWise Program reflects ten years of utility and BPA experience in irrigation-related conservation programs. Since these programs began, over $24 million has been spent on efficiency improvements and over 11 aMW have been acquired. The program matured because of the contributions of many utilities, analysts, state and Federal agencies, and other interested parties.[R#6]

The WaterWise Program targets the irrigated agriculture sector. To be eligible for WaterWise, an irrigator must irrigate a minimum of 15 acres and consume at least 20,000 kilowatt-hours of electricity annually from a utility that purchases firm power from BPA. From here the program divides irrigators into four levels: 1) Those irrigating 15 to 34 acres, 2) 35 to 69 acres, 3) 70 to 479 acres, and 4) 480 acres and over, to designate prescriptive eligibility for incentives and retrofit applications.[R#8]

INTRODUCTION TO IRRIGATED AGRICULTURE OF THE NORTHWEST

BPA serves over 130 utilities in the Northwest and its service territory is divided into four areas: the Lower Columbia, Upper Columbia, Puget Sound, and Snake River Area, each with several districts. The Snake River and the Upper Columbia areas are the two utilizing the WaterWise program. BPA's WaterWise program addresses 15% of the total load of all irrigation systems in the Northwest region.

The geography of the Northwest produces interesting effects upon BPA's irrigated agriculture power requirements. The Cascade Mountains create an effect whereby moist air charged by the Pacific Ocean results in heavy precipitation to the west of the Cascades which bisect the states of Oregon and Washington. On the other hand, to the east of the Cascades there is a stark contrast and very little precipitation. This results in very few pumped irrigation projects for WaterWise west of the Cascades because farmers and ranchers there have ample natural rainfall and use little energy for pumping to augment this rainfall, and certainly not enough pumping to make pump retrofits a cost effective pursuit for BPA.

On the east side of the mountains however, extensive amounts of irrigation and pumping is necessary due to lesser amounts and availability of water for farming. Some large irrigators pump directly from the Snake and Columbia Rivers, while other more moderately-sized irrigators belong to irrigation districts that pump water from these rivers many miles through extensive distribution systems. Some smaller irrigators get their water from on-site groundwater wells.[R#10] ■

Currently 39 retail utilities, all east of the Cascade Mountains, implement WaterWise in their service territories. The role of the retail utility personnel is to perform analyses or to select and engage a qualified consultant to do so, while continuing to act as the financial conduit to BPA for the participant. Based on their analyses, or their consultants' recommendations, meetings with irrigators are arranged, two-stage analyses begin, results of the analyses indicate proper measures to be selected, irrigators implement the changes to their irrigation systems to improve energy use efficiency, and incentives are disbursed.

MARKETING

Bonneville Power Administration, while headquartered in Portland, Oregon, has a wide variety of climatic patterns within its service territory. With the preponderance of irrigated agriculture to the east of the Cascade Mountains, it makes sense for BPA to administer the WaterWise program out of its Walla Walla, Washington area office. As a result of this concentration and orientation, marketing the program is done at the regional level rather than across the BPA service territory as a whole.

WaterWise has had moderate amounts of marketing since its inception. The program has been marketed using customer bill inserts, basic promotional materials, and by having staff attend booths at local fairs to promote awareness of the program. Presentations to local farmers through utility meetings have also been used. A presentation was given at the Bonneville Engineering Symposium to share WaterWise successes with other engineers. Fact sheets have been provided for high school and college students to develop an awareness about water and energy savings on the farm. Consultants working in the program also serve as a principle outreach mechanism because they generally spend several hours with irrigators performing pump tests and system analyses. Third-party word-of-mouth is also an important marketing mechanism. For instance, one farmer receives a pump test, he talks to his neighbor, and then often the neighbor asks to receive a pump test as well.[R#8]

DELIVERY: THE STEP BY STEP PROCESS

STAGE 1

Initial contact with the farmer is made by the local utility and Stage 1 begins. BPA-funded evaluations of potential energy savings and recommendations for implementation of cost-effective measures on existing irrigation systems are performed by a participating local utility or its qualified consultant. Once accomplished, an estimate of the amount of BPA-funded incentives for which the irrigator may be eligible is made. Essentially, this is a free audit that informs the farmer if he is eligible for an incentive.[R#10]

This analysis consists of various levels of sophistication which depend upon the size and complexity of the irrigation system. It includes taking measurements such as total dynamic head, flow rate, input power, system leaks, nozzle sizes, operation pressures, mainline velocity, friction losses and hours of operation at various flow rates. These calculations are used to determine the eligibility of measures for a given system.

Level 1 irrigation systems may qualify for low pressure and pump modification measures. Level 2,3, and 4 irrigation systems may qualify for low pressure, mainline, and pump modification measures although only measures recommended by the consultant may be implemented. [R#8]

STAGE 2

Stage 2 begins with the installation of the energy saving measures recommended in Stage 1 and then proceeds to an analysis of the system with the installed measures. For smaller systems, a visual inspection is made after successful installation of recommended retrofit measures. For larger systems the analysis consists of a visual inspection of installed improvements, plus a verification pump test, and a system evaluation to determine pumping plant electrical energy savings and thus the incentive payment. While the program provides incentives for retrofit activity, there are no payments made for recommended work on new or expanding systems beyond reimbursement for the study. The final result of Stage 2 is the determination of actual incentive payments.[R#7,8] ☞

IRRIGATION MANAGEMENT

The purpose of Irrigation Management in the WaterWise program is to facilitate the efficient use of energy and water resources. This is accomplished by optimizing the operation of the irrigation system through the application of irrigation management techniques, e.g. applying the precise amount of water at the right time which in turn reduces energy consumption. If the correct information about irrigation is available to the irrigator at the right time, efficient use of energy may occur and potentially result in energy and water savings.

This program component consists of several options which offer different approaches to irrigation management. The farmer and the utility decide which option a farmer gets.

CASE STUDY: A LARGE IRRIGATOR

A farm located in eastern Oregon irrigates 10,500 acres with center pivot sprinklers. The farm receives its water from the Columbia River to irrigate wheat, corn, alfalfa, onions, and potatoes. Five major pump stations with 36 pumps requiring 23,350 horsepower are needed to supply ample water for the farm. This water is pumped over 50 miles through various sized piping ranging from 8 to 72 inches in diameter. All of this results in an annual energy use of over 32,000 MWh of electricity for pumping.

Over 80,000 feet of cement mortar lining work was completed on pipelines ranging from 14 to 72 inches in diameter. New pressure regulating valves were installed at pivot cluster points. New PVC laterals were installed to replace steel laterals from clusters to pivots. All the center pivot sprinklers were retrofitted with new sprinkler nozzles and pressure regulators, and since this increases the water application efficiency of a pivot, it will result in water savings as well as energy savings. Assorted pump work and pump operation changes were also completed.

The entire project has projected annual energy savings of 7,000 MWh of electricity. BPA's incentive to the farmer was $1.25 million, while the farmer's out-of-pocket cost was $650,000, resulting in a total project cost of $1.9 million.

(Option 1) Media Approach: This option involves the dissemination of crop evapotranspiration information from a weather station through the local news media. This can be an effective technique for water management especially for the farmer who irrigates a small acreage. This media, often a publication, may actually be all the additional information needed by an irrigator.

(Option 2) On-Site Approach: This option involves the dissemination of irrigation management information to the irrigator through an on-farm visit by a qualified specialist. This option includes personal contact with the irrigator to explain and evaluate in detail irrigation management specific to the irrigator's circumstances. While this visit is in the first year, often a visit in the second year is warranted in order to answer questions and reinforce efficiency and conservation practices.

(Option 3) Computer Based Approach: This option utilizes a computer linkup between the consultant and irrigator to transfer irrigation scheduling information at the convenience of the irrigator. An on-site visit is performed to help orient and show the irrigator how to access the computer and utilize its valuable information.[R#8]

(Option 4) Contractor Designed Approach: This option permits the contractor to offer an irrigation management approach other than what has been presented in Options 1 through 3. This enables the contractor to meet specific, unique requirements relative to the irrigators in its service territory.

Historically, system testing and retrofit activities were limited to small and medium systems. Fiscal year 1992 (Oct 91-Sept 92) saw the addition of procedures to analyze large irrigation systems (over 480 acres). Some large irrigation systems' project costs exceed $1 million. The program budget was nearly doubled for FY 1992 to cover these systems.[R#8]

INCENTIVES AND REIMBURSEMENTS

Administrative reimbursements to the utility: After Stage 1 and Stage 2 analyses have been completed, a determination of administrative reimbursements to the retail utility begins. Funds are available for all or a portion of the cost of the analyses. BPA disburses four-tiered administrative reimbursements to the utility proportional to the system Level to cover the cost of Stage 1 and Stage 2 evaluations.

Stage 1 administrative reimbursements range from $100 to $600 for Levels 1, 2, and 3 respectively, to a maximum of $2,100 for design work for systems exceeding 70 acres. For Level 4 irrigators the minimum Stage 1 analysis administrative reimbursement is $2,000, not to exceed .05¢/kWh times the average annual kWh consumption plus $0.75 per irrigated acre. These reimbursements are disbursed to the local utility. There are no incentive payments to customers offered for Stage 1 activities.

For Stage 2, administrative reimbursements range from $50 to $8,300 depending on system complexity. Irrigation Management administrative reimbursements are as follows: For Option 1, $250 per weather station; for Option 2, $225 per farm for first the year visit and $125 per farm for an optional second year visit; Option 3, $100 per initial on-farm orientation plus 25¢ per irrigated acre scheduled. (Note that if a soil moisture measurement is needed, an additional $175 per field monitored plus $2.50 per acre scheduled, with a 1500 acre cap, is disbursed.)

Startup funds up to $1,500 per year for Options 2 and 3 listed in this section are available to utilities. These funds are available only for the first and second year from the start of the program.

Customer incentives: After Stage 2 incentive payments to the irrigator have been determined, BPA will reimburse the utility. Stage 2 incentive payments are reimbursed on a two-tiered basis: Level 1 irrigators receive $10 per nameplate pumping plant horsepower for installed pumping plant equipment and $2 per low pressure sprinkler head for installed sprinkler equipment. Level 2 through 4 irrigators receive the lesser of the following: measured first-year energy savings (kWh) times $0.22, or a minimum guarantee of $15 per affected nameplate pumping plant horsepower evaluated, or the cost of the retrofit, not to exceed 50% of all recommended equipment, except recommended mainline equipment which is not to exceed 75%. Level 1 requires site inspection while Levels 2-4 require site inspection and a verification pump test. These analyses determine the actual energy savings and the amount of financial incentive payment BPA will make.[R#5]

Many Level 1-3 farms take two and three months to send in bills. These incentive payments are often belated due to the reluctance of farmers to expeditiously send their bills and invoices for the retrofit to the local utility. The post-metering is done by the consultant via a post-pump test. They determine the savings and inform the farmer that all he has to do is send all the bills from implementing the measures to the utility. Within 30 days BPA will send the incentive to the local utility which in turn will send it to the farmer. Level 4 retrofits can take over a year for verification due to the complexity of the system.[R#10]

MEASURES INSTALLED

There are three main categories of measures that a qualified participant may install: low pressure, mainline, and pump modification equipment. These measures involve the following equipment: sprinkler, pumping plant, fittings, and mainline equipment. Level 1 irrigators do not qualify for mainline equipment retrofits. A unique equipment list is associated with each category and only the listed equipment is eligible for funding by BPA.[R#8]

Recommended conservation measures include improving pumping plant efficiencies through irrigation pump rebuilding, replacement, or impeller trimming; reducing operating pressure through pipeline upgrades and fitting replacements; and replacing standard nozzles with low-pressure components. Design assistance can be provided for new and expanding systems.[R#5]

Sprinkler equipment includes low pressure spray heads, nozzles and big guns, pressure regulators; center pivot drop tubes, goosenecks, elbows, nipples and bushings; swing pipes, flex pipes, and levelers for offsetting. Mainline equipment includes thrust blocks, saddles, cones, couplers, and seals; pressure relief, check, drain, gate, vacuum air, and butterfly valves; PVC pipes; coated steel pipes, and installation. Pumping plant equipment includes turbine pumps, centrifugal pumps, and high efficiency motors. Fittings equipment includes vanes, bells, sealers, couplers, elbows, gaskets, and tees.[R#5].

SPRINKLER SYSTEM EQUIPMENT

High Pressure: A pivot sprinkler consists of a main line mounted on towers that rotate around a fixed pivot point. High pressure, high impact sprinkler nozzles spray the water high into the air as the line rotates in a circle. With high summer temperatures and wind speeds, a significant portion of the water is lost to evaporation in the air or after the water lands on the crop canopy. The result is a poor application efficiency of about 65% (35% is lost). This method of irrigation was state-of-the-art until the early 1980's. ☞

Low Pressure: In a low pressure pivot irrigation system, 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 low pressure systems application efficiency can be increased to about 75%.

Low Energy Precision Application (LEPA): In low energy precision application systems the sprinkler nozzles are located at the end of drop tubes that hang from the pivot span pipe nearly to the soil surface. Water is distributed under low pressure directly to the soil. This method avoids evaporation losses from high temperatures and wind experienced with medium and high pressure sprinklers. Application efficiencies for these systems range from 95 to 98%.

Pumping Plant: Sometimes downsizing a motor is appropriate while other times retrofitting to a higher efficiency motor or trimming the impeller provides the most cost-effective savings.

Mainline and Fittings: Often, simply fixing leaks within the system with proper fittings, gaskets, and seals improves efficiency. Mainline equipment refers to upgrading the piping system, including fittings, but with best results coming from cement mortar lining which reduces friction losses.

STAFFING REQUIREMENTS

The WaterWise program is administered by BPA out of its regional Walla Walla, Washington office by Robert Holman, the Program Manager, who joined the team in 1992 and works full time on the program. Tom Osborn, Mechanical Engineer, devotes about one-quarter of his time to the program. Dick Stroh, an Agricultural Engineer, works out of Idaho Falls and devotes half of his time to the program along with one other engineer who put in a combined one-quarter time equivalent. The rest of the program staffing consists of support staff. In 1992 the program required 2.75 full-time equivalents (FTE). In 1993 the program was staffed by 3.3 FTE while in 1994 2.80 FTE's were used. Thus the program has required an average of 3 full-time equivalent staff. ■

CASE STUDY: HANSELL BROTHERS FARM

An exemplary case study of BPA's WaterWise Program involves the 1,300-acre Hansell Brothers farm in the Oregon desert. In the early 1980's, with the help of their local utility, Umatilla Electric Cooperative Association, and BPA, the farm became one of the first to convert from high pressure impact sprinklers to more efficient low pressure heads on drop tubes. This provides a better drop size, more efficient application of water, and less water loss due to evaporation and wind drift. (For a glossary of Irrigation terms, see The Results Center Profile #40, page 6.) Then, in 1991, the Hansell Brothers turned to one of several irrigation specialist consultants used by their local utility. They replaced old steel mainlines with smooth PVC pipe, thereby allowing two pumps to be reduced by nearly 50% in size. Analysis showed that if the deteriorated steel pipe was replaced with PVC pipe, smaller pumps, and less energy, would be required to deliver the same amount of water and pressure to the pivots.

Thanks to WaterWise, Hansell Brothers is now saving $4,800 per year in electricity costs on just four center-pivot fields. While the work cost $68,000, BPA's WaterWise payments covered $35,000 of it, leaving the farm with a simple retrofit payback of just over six years. Annual electricity savings were measured at 159,951 kWh. Today, Hansell Brothers is utilizing an assortment of conservation measures to reduce energy use including neutron probe soil moisture monitoring, satellite-fed computerized weather and crop irrigation data, improved pumping plant efficiency, and better irrigation system design. [R#7]

MONITORING

The WaterWise program requires verification to quantify the energy savings and cost effectiveness of the improvements to the system. All Levels of systems require a site inspection where a personal visit by the contractor to the irrigation system is performed to determine if all claimed measures are installed and operational. Additionally, a verification pump test is required for Levels 2, 3, and 4 to measure total head (pumping water level, discharge pressure, and miscellaneous friction losses), flow rate, and input power in order to determine pumping plant electrical energy savings and to determine the incentive after measures are installed.

For Level 2 systems, a “Simple System Analysis” is conducted first. This analysis includes a pump test supplemented with identification of irrigation methods, system leaks, nozzle sizes, sprinkler operating pressures, crop types and rotations, scheduling techniques, and field elevations for the irrigation system. For Levels 3 and 4, an additional “System Review” is conducted. This consists of a pump test supplemented with the same irrigation methods as the “Simple Analysis” along with additional measurements to quantify mainline velocity and friction losses.

For larger systems which typically have multiple pump stations with pumps in parallel and series the verification process involves metering of flows, pressures, and power input to determine the flow regime through the system. The metering is done for the entire irrigation season after installing the improvements. This data plus information on the cropping patterns and evapotranspiration requirements provides sufficient information for a detailed analysis of the energy savings attributable to the improvements. For the Level 4, large irrigator classification, the same type of metering is done for a season preceding any improvements to the system in order to develop a complete engineering analysis to determine which improvements to recommend.

At the completion of the project the irrigator retains ownership of the metering equipment to use for farm management applications such as monitoring and controlling adjustable speed drives and providing information for computer controlled software used to control the irrigation pumping plant and center pivots.[R#8]

EVALUATION

In February of 1990, a process evaluation of BPA’s Irrigation Hardware Retrofit program was conducted by Pacific Northwest Laboratory to review the development and implementation of the program from 1986 to 1989. To that date, 2,575 irrigation systems had Stage 1 audits. This represented a 10% penetration of all irrigation accounts in the territories of participating utilities. Of these, 421 went on to Stage 2 retrofit work.[R#13]

The program underwent significant changes over the years, resulting in a well-received, workable program. The management was shifted from BPA’s central office to the Snake River Area office. Key findings of the evaluation include: logistical problems with record keeping, participation decreases in Stage 2 analyses (where the savings are most notable), difficulty obtaining financing to pay for the up-front costs of retrofits, the perception of it being a hassle for the farmer to be responsible for all the retrofit work, and uncertainties over the amount of incentive. The major benefit of the program to the utilities was good customer relations and public image.

In 1987, Pacific Northwest Laboratory also conducted an impact evaluation of energy savings resulting form BPA’s Stage 2 part of the retrofit program. This evaluation sought to perform three tasks: 1) Estimate the energy savings resulting from the installation of conservation measures on irrigation systems through bill analysis; 2) Analyze the factors influencing irrigation system electricity consumption using statistical regression techniques; and 3) Evaluate the energy savings prediction methods of the Stage 2 part of the program and to estimate the costs per kWh saved for conservation measure installations.[R#14]

Another, even earlier process evaluation of BPA’s Irrigated Agriculture Conservation program was performed by Minimax Research Corporation in October of 1986. This evaluation provided insights into the program ranging from its strengths such as technical expertise, flexibility, and straightforward approach to energy and water savings, to its weaknesses which included poor quality site inspections and lengthy time for incentive payment disbursements.[R#15]

To date, no evaluations have been done on the WaterWise program since its revision and renaming in 1990 and no further evaluations are planned. ■

Program Savings

In 1991, the first year of the WaterWise program, 859 measures were installed which accounted for savings of 1.2 aMW of capacity and 10.5 GWh of generation. The following year, 407 measures were installed at over roughly 100 farms which accounted for 1.2 aMW of capacity savings and 7.9 GWh of electricity savings. In 1993, 1.6 aMW of capacity savings and 14.9 GWh of electricity savings were due to the WaterWise program. Total annual energy savings from 1991 to 1993 for the program since its revision and renaming in 1991 are 33.2 GWh and 4.0 aMW of capacity. Since the inception of the Irrigated Agricultural Hardware Program in 1982, WaterWise's predecessor, 11.0 aMW and 94.6 GWh of annual savings has accrued over the program's eleven-year history.[R#3,2]

PARTICIPATION RATES

For this profile, participation is defined in two ways: the number of hardware retrofits that have been implemented in the program, and the number of farms that have been audited for a typical year. These do not include irrigation management activities. For 1992, 313 farms were audited in the Stage 1 analysis. Of these, 233 were eligible for Stage 2 incentives while only 102 went on to implement recommended conservation measures and actually received BPA incentives. In 1993, participation increased with increased auditing: 393 farms were audited in the Stage 1 analysis and 293 of these were eligible for Stage 2 incentives, while 124 actually received incentives. In general, approximately 75% of the irrigation systems receiving a Stage 1 evaluation are eligible for incentives through Stage 2 of the WaterWise program. Approximately 40% of these systems that are eligible for Stage 2 go on to receive incentives for making recommended improvements to their irrigation systems.

PARTICIPATION	PARTICIPATION (HARDWARE)
1985	200
1986	285
1987	247
1988	93
1989	109
1990	384
1991	859
1992	407
1993	474
Total	3,058

FREE RIDERSHIP

Since no recent evaluation of the WaterWise program has been completed, no calculations or adjustments of savings for free ridership have been assessed to program savings. An evaluation of the former irrigated agriculture program, however, estimated that 40% of customers who underwent Stage 1 analysis qualified as free drivers. After learning of the deficiencies in their irrigation systems, they went ahead and upgraded their systems themselves without the incentives or assistance from the utilities. Attempting to avoid "bureaucratic hassles" was sighted as the reason they financed and implemented the retrofits themselves. BPA has not taken any credit for these energy savings though arguably they are part of the program's net effect and may outstrip free ridership.[R#10]

MEASURE LIFETIME

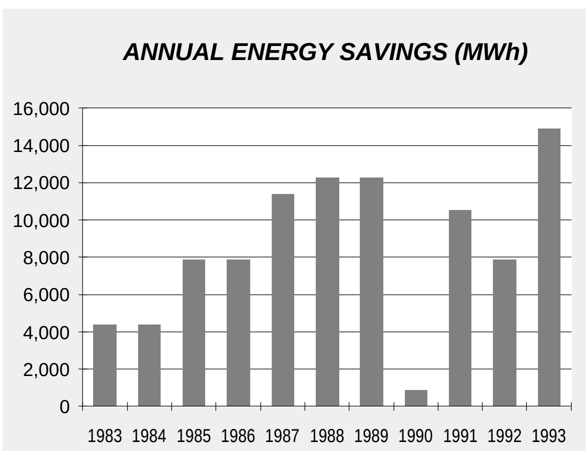
The WaterWise Program assigns a 15-year average measure life to determine the cost effectiveness of BPA's investment reflecting the weighted average of equipment lifetimes. For example, sprinklers have a five-year measure life, whereas pump work and installation of new low-loss pressure reducing valves have ten-year measure lives. New PVC pipelines and cement mortar lining have a 15-year measure life.[R#3]

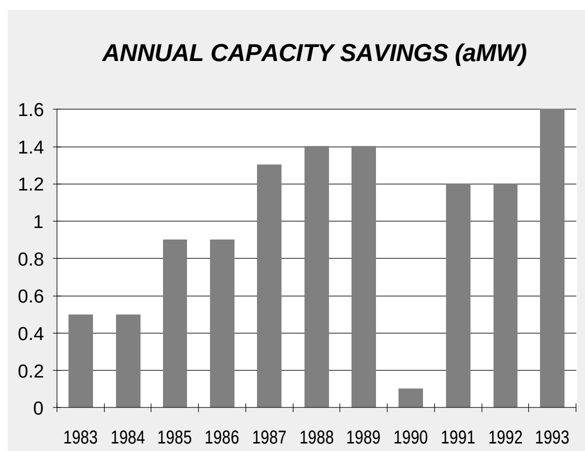
PROJECTED SAVINGS

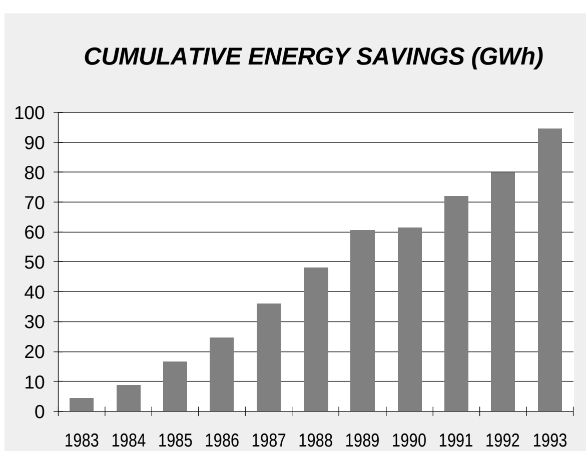
Since the inception of the WaterWise program over $7 million has been spent on efficiency improvements. Over 11 aMW have been acquired and the goal of the program is to acquire an additional 2 aMW per year through 2003. If the program achieves its targets, it will result in 20 aMW of savings, 3% of the 660 aMW of projected savings for all of BPA's DSM programs by 2003.

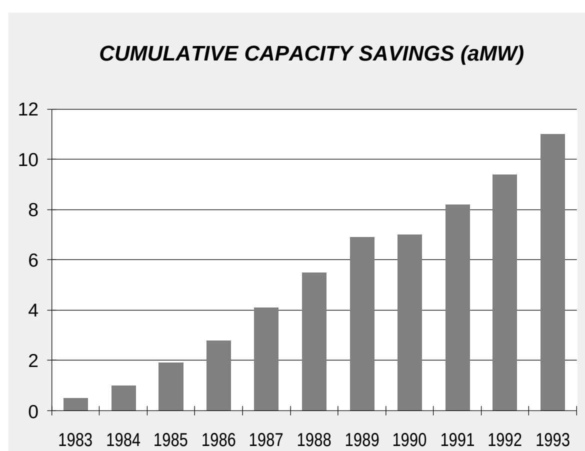
The Results Center calculates that the program's lifecycle energy savings for projects implemented in 1993 will be 223 GWh. The lifecycle savings from all measures installed to date will result in over 1,400 GWh of savings using the 15-year measure lifetime.[R#3,8] ■

SAVINGS OVERVIEW	ENERGY SAVINGS (MWh)	CUMULATIVE ENERGY SAVINGS (MWh)	LIFECYCLE ENERGY SAVINGS (MWh)	CAPACITY SAVINGS (aMW)	CUMULATIVE CAPACITY SAVINGS (aMW)
1983	4,380	4,380	65,700	0.5	0.5
1984	4,380	8,760	65,700	0.5	1.0
1985	7,884	16,644	118,260	0.9	1.9
1986	7,884	24,528	118,260	0.9	2.8
1987	11,388	35,916	170,820	1.3	4.1
1988	12,264	48,180	183,960	1.4	5.5
1989	12,264	60,444	183,960	1.4	6.9
1990	876	61,320	13,140	0.1	7.0
1991	10,512	71,832	157,680	1.2	8.2
1992	7,884	79,716	118,260	1.2	9.4
1993	14,892	94,608	223,380	1.6	11.0
Total	94,608	506,328	1,419,120	11.0	









Cost of the Program

BPA has spent a total of $24.5 million from the combined programs of WaterWise (1991-1993) and the Irrigated Hardware Program from (1982-1990). Expenditures have fluctuated each year, reflecting no significant changes in the program until 1991 when expenditures jumped to over $3.2 million due to the newly-written Irrigation Conservation Acquisition Agreement, otherwise known as the WaterWise Program. Expenditures for the following two years leveled off to $2.1 million and $2.2 million respectively.[R#3,5]

HISTORICAL COSTS	TOTAL PROGRAM COSTS (x1000)
1983	$1,174
1984	$1,647
1985	$2,548
1986	$4,229
1987	$2,207
1988	$2,393
1989	$1,505
1990	$1,428
1991	$3,120
1992	$2,060
1993	$2,227
Total	$24,539

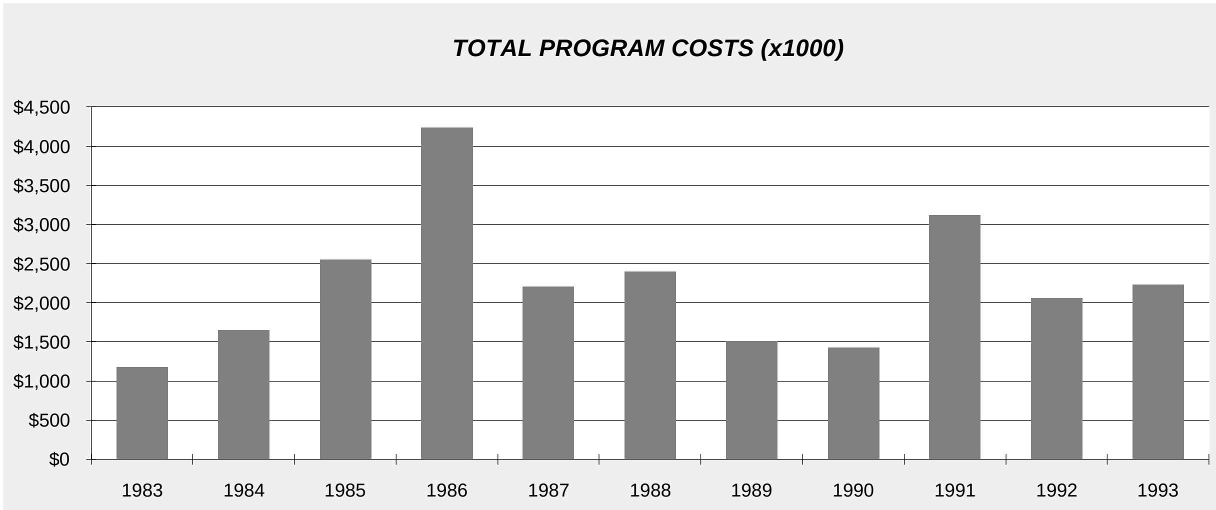
COST EFFECTIVENESS

In 1991, the first year of the dramatically-revised WaterWise program, it had a cost of saved energy that ranged from 2.49 ¢/kWh to 3.68 ¢/kWh at a 3% and 9% real discount rate respectively. At a 5% real discount rate, the cost of saved energy was 2.86 ¢/kWh in 1991. In 1992, at a 5% real discount rate the cost of saved energy was 2.94 ¢/kWh, a value which fell to a highly respectable 1.28 ¢/kWh in 1993. (Note that in 1990, the year of the program's transition, costs were high and savings low, resulting in an abnormally high cost of saved energy.)

COST COMPONENTS

From 1991 to 1993 the WaterWise program alone has accounted for $7.4 million in BPA expenditures. The largest part of BPA expenditures has been incentives. In FY 1993, BPA spent $1.59 million in agricultural retrofit incentives, a 25% increase over 1992. The next highest cost for BPA was remuneration for audits, accounting for $174,311, a 55% decrease from 1992. BPA's total expenditures in 1993 of $2.23 million include staffing, travel, shipping, and supplies. Expenditures from 1993 were slightly higher than for 1992, which totaled $2.06 million.[R#11] ■

COSTS OVERVIEW	CUST. INCENTIVE (x1000)	AUDITS (x1000)	BPA STAFFING (x1000)	CONTRACT STAFFING (x1000)	TRAVEL (x1000)	SUPPLIES (x1000)	CORP. OVERHEAD (x1000)	TOTAL COST (x1000)
1992	$1,189.4	$368.1	$158.5	$29.8	$16.4	$22.2	$276.3	$2,060
1993	$1,587.2	$174.3	$151.5	$37.2	$11.5	$9.9	$256.3	$2,227
Total	$2,776.6	$542.4	$310.0	$67.0	$27.9	$32.1	$532.6	$4,288



COST OF SAVED ENERGY AT VARIOUS DISCOUNT RATES (¢/kWh)	3%	4%	5%	6%	7%	8%	9%
1983	2.25	2.41	2.58	2.76	2.94	3.13	3.33
1984	3.15	3.38	3.62	3.87	4.13	4.39	4.66
1985	2.71	2.91	3.11	3.33	3.55	3.78	4.01
1986	4.49	4.82	5.17	5.52	5.89	6.27	6.65
1987	1.62	1.74	1.87	2.00	2.13	2.26	2.40
1988	1.63	1.75	1.88	2.01	2.14	2.28	2.42
1989	1.03	1.10	1.18	1.26	1.35	1.43	1.52
1990	13.66	14.66	15.71	16.78	17.90	19.04	20.22
1991	2.49	2.67	2.86	3.06	3.26	3.47	3.68
1992	2.56	2.75	2.94	3.15	3.35	3.57	3.79
1993	1.11	1.19	1.28	1.36	1.45	1.55	1.64

AVOIDED EMISSIONS BASED ON 506,328,000 kWh saved 1983 - 1993						
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%	1,091,643,000	25,899,000	5,235,000	524,000
B	10,000	1.20%	1,164,048,000	10,025,000	3,381,000	2,506,000
	Controlled Emissions					
A	9,400	2.50%	1,091,643,000	2,590,000	5,235,000	42,000
B	10,000	1.20%	1,164,048,000	1,003,000	3,381,000	167,000
C	10,000		1,164,048,000	6,684,000	3,342,000	167,000
	Atmospheric Fluidized Bed Combustion					
A	10,000	1.10%	1,164,048,000	3,063,000	1,671,000	835,000
B	9,400	2.50%	1,091,643,000	2,590,000	2,094,000	157,000
	Integrated Gasification Combined Cycle					
A	10,000	0.45%	1,164,048,000	2,061,000	334,000	835,000
B	9,010		1,047,086,000	746,000	251,000	50,000
Gas	**Steam**					
A	10,400		634,935,000	0	1,448,000	0
B	9,224		551,391,000	0	3,453,000	163,000
	Combined Cycle					
1. Existing	9,000		551,391,000	0	2,116,000	0
2. NSPS*	9,000		551,391,000	0	1,003,000	0
3. BACT*	9,000		551,391,000	0	139,000	0
Oil	**Steam--#6 Oil**					
A	9,840	2.00%	918,985,000	13,924,000	1,643,000	1,559,000
B	10,400	2.20%	974,681,000	13,813,000	2,066,000	1,003,000
C	10,400	1.00%	974,681,000	1,972,000	1,660,000	524,000
D	10,400	0.50%	974,681,000	5,792,000	2,066,000	319,000
	Combustion Turbine					
#2 Diesel	13,600	0.30%	1,219,744,000	2,428,000	3,771,000	206,000
Refuse Derived Fuel						
Conventional	15,000	0.20%	1,448,098,000	3,732,000	4,912,000	1,092,000

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 accomanying page is to allow any user of this profile to apply Bonneville Power Administration's level of avoided emissions saved through its WaterWise 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 include 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 interesting lesson learned from the WaterWise Program is that a program involving a number of diverse players can be successful. Throughout the course of this program BPA, its retail utilities, technical consultants, and irrigators have been integrally involved. Furthermore, within the irrigators group there are vast disparities in size and complexity, ranging from massive irrigation districts pumping water from the Columbia and Snake Rivers through extensive distribution systems over many miles to irrigate tens of thousands of acres, to individual small irrigators pumping groundwater from their backyards for use on 15 acres.

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 and which forced many farmers to consider new ways of doing business in order to survive.

BPA staff note that several valuable marketing lessons have been learned from this program. Farmers need to see new technologies demonstrated and then see proven savings before they will make an investment. Farmers tend to 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 is a strong selling point. Essentially, farmers are willing to invest money in energy-efficient technologies once they are convinced of the potential for significant savings.

Program Manager Robert Holman provides the following insights and lessons learned from his experiences with the program to date:

Incentives and rebates: Monetary incentives are successful in promoting participation. With over 300 farms being evaluated annually and only about 100 of those actually following through with the retrofits, a substantial financial impetus is a key driver to success. However, BPA believes that they could still pay less than the current 50% and 75% cost share. BPA also realizes that maybe restructuring rebates to place more emphasis on Stage 2 analysis would improve the number of farms making improvements, because currently the simple rebate program is not utilized to the extent expected.

Irrigation measures: Large amounts of energy savings lie within the Level 4, very large irrigators. More specifically, a push towards retrofitting mainline distribution systems with cement mortar lining for these irrigators can result in an increase in the overall savings of the program. These irrigators need to be targeted for retrofit.

New sprinkler technologies make energy savings improvements feasible for center pivot irrigation systems: ie. drop tubes, low pressure sprinklers, pressure regulators, along with a good acceptance of flow control technologies. This contrasts starkly with a poor acceptance of offset and low pressure technology for wheel line and hand line systems. Gravity conversion offers potential for energy savings and lining of irrigation canals offers a good potential for water savings, but neither is included in the program. While this deficiency is a liability to the program, the list of eligible components for the program is good for participating irrigators because it clearly defines what is included in the program.

Water savings: Water savings are also a reason for irrigators to make system improvements. Water savings often are coupled with energy savings. In these cases, the value of the water saved should be considered in analyzing the cost effectiveness of the program. The WaterWise program currently does not account for these savings in any costs analysis.

Improving system efficiency does not always result in decreasing the energy or water use of a system. An irrigator could be applying less than the required amount of water to a crop for several reasons: a worn pump, an inappropriately sized pump, or a declining water table that increases the pumping depth from the original design conditions for the pump. Repairing the pump or selecting a correctly-sized pump may improve the efficiency of the system, but it may also allow the irrigator to pump more water in order to meet the crop's water requirement. Delivering more water to the crop could ultimately increase the energy use even though the overall efficiency of the system is improved.

General: The technical aspects of the program and time involved require most utilities to use professional consultants for auditing and scheduling services, especially for complex irrigation systems. A computer program for conducting the analysis reduces the chances for error and makes the analysis easier to do than previous forms.

Besides the energy savings, utilities view the public relations/customer service aspect of the program also as a benefit. Often, farmers discuss energy (and thus monetary) savings, spreading the word about the program, thereby creating higher participation.

There is a large potential for energy savings through 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. WaterWise promotes irrigation scheduling through the effective use of evapotranspiration data.

Environmental concerns: Recently, with salmon runs through many of the rivers in the Northwest, mainly the Columbia and Snake, being continually decimated, water conservation from irrigated agriculture has become a critical issue. Due to pressure from environmentalists, dams are being required to release more water for spawning newborn salmon (smolts) to guide them back out to sea. The release of water that could be used for electricity, but spilled for salmon, could result in an increase in the price of electricity in the Northwest. Conserving water upstream can act as one solution to helping alleviate this environmental problem.

TRANSFERABILITY

One requirement of the program is that it be administered an agricultural area requiring extensive irrigation via pressurized systems. As in the case of the northwest region, only the east side of the Cascade Mountain range requires extensive irrigation, thus this program only works within that area. Parts of the midwest grain belt, Florida's citrus industry, and the California fruit and vegetable industry could likely adopt many aspects of the WaterWise Program to their irrigation districts.

The program design is not hard to duplicate, but it is essential that such programs have plenty of funding and organization support. In WaterWise's case, BPA fills this role due to its large size and available finances. While the WaterWise Program could readily work in virtually any pressurized irrigation district, in some areas of the Southwest, where gravity flood irrigation is used, the program would not be applicable. ■

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