
Buckeye Power Residential Load Control Profile #58

| | |
|---|-----------|
| Executive Summary | 2 |
| Utility Overview | 3 |
| <i>1992 Buckeye Power Statistics</i> | |
| Utility DSM Overview | 4 |
| <i>Buckeye Power 1993 DSM Programs Table; DSM Overview Table; Annual DSM Expenditure (chart); Annual Energy Savings (chart); Cumulative Demand Savings (chart)</i> | |
| Program Overview | 6 |
| Implementation | 7 |
| <i>Marketing and Delivery; Measures Installed; Staffing Requirements; Load Management Communication System Types</i> | |
| Monitoring and Evaluation | 11 |
| Program Savings | 12 |
| <i>Participation Rates; Water Heater Switch Installations Table; Water Heater Load Management Table; Space Heating Switch Installations Table; Space Heater Load Management Table; Free Ridership; Total Deferrable Load (chart); Number of Load Control Sessions (chart); Measure Lifetime</i> | |
| Cost of the Program | 15 |
| <i>Cost per Participant; North Western Electric Cooperative 1992 Residential Load Control Program Costs Table; Cost Components</i> | |
| Lessons Learned / Transferability | 16 |
| References | 17 |

Executive Summary

Buckeye Power's Residential Load Control program is offered to the member consumers of each of its 27 member cooperatives. Through the program, 81,000 residential electric water heaters throughout the Buckeye service area may be controlled during peak demand periods. Additionally, approximately 2,800 residential electric space heating systems are controlled through the program.

The primary goal of the Residential Load Control program is to prevent exceedance of the historical record peak demand. Each member cooperative pays a monthly demand charge, which is based on the cooperative's percentage contribution to the total system demand at the time of the peak of record. Thus, each time a new peak of record occurs, each cooperative's monthly demand charge is recalculated. The monthly demand charge may increase or decrease, depending on how much demand the cooperative was responsible for at the time of the new peak. As of May 1993, the system peak of record of 967 MW occurred in the evening on December 21, 1989. Through voluntary control and participation in the Residential Load Control program, member cooperatives have successfully limited the frequency with which new system peaks are reached. Prior to the December 1989 peak, Buckeye's system peak was 912 MW on December 24, 1983.

Each water heater controlled is estimated to save 1 kW. With 81,000 water heaters controlled in the winter of 1992-93, Buckeye had control over 81 MW. In addition, approximately 2,800 switches are installed on electric space heating equipment with average savings of 5 kW per switch, for a deferrable load of 14 MW in 1992-93.

Over the entire period that the program has been implemented, the duration of each water heater deferral has averaged 1.6 hours. The longest deferrals occurred during the winter of 1989-90, when some water heaters were turned off for 6.1 hours.

Space heating deferrals have been occurring since the winter of 1989-90. A total of 13 deferrals have been necessary, for an average of 4.0 hours per deferral.

The program has operated with little need for change in its implementation strategy. Perhaps the biggest changes for the program have been the installation of a new satellite communications system and PC-based central computer control facility. Buckeye evaluates the load control system's performance with 15 load monitoring points located throughout the service territory. Information from these points is transmitted via the satellite communication system back to Buckeye's central load control computer. With the success of the Residential Load Control program, Buckeye has shown that with careful planning and foresight, a program can update its equipment to a state-of-the-art system that enhances the program capability, creates opportunities to improve communication within the service territory, and has a favorable payback period.

Residential Load Control

Utility: Buckeye Power

Sector: Residential

Measures: Load control primarily on water heaters and backup space heaters

Mechanism: Switches are installed on customers' appliances; the load control system uses a satellite communication system

History: Started in winter of 1974 - 1975.

1992 - 1993 Program Data

Number of water heater switches: 81,000

Deferrable water heater load: 81 MW

Number of space heating switches: 2,800

Deferrable space heating load: 14 MW

Number of deferrals for season: 36

Average duration of each deferral: 1.9 hours

Conventions

For the entire 1993 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

Buckeye Power, Inc. is a consumer owned generation and transmission cooperative, headquartered in Columbus, Ohio. Buckeye, founded on September 1, 1949, supplies electric power to 27 electric distribution cooperatives in Ohio. These cooperatives serve more than 280,000 farms, homes, businesses, and industries. The service area of these cooperatives runs through 77 of Ohio's 88 counties, covering 40% of the land area in Ohio. Much of this land is used for agriculture, which remains the dominant component of the Ohio economy. Buckeye's member-cooperatives own 40,438 miles of distribution line. [R#1,11]

Buckeye's electric sales totaled 4,904 GWh in fiscal year 1992, accounting for revenues of \$172 million. The average rate paid by Buckeye's member-cooperatives was 3.42 ¢/kWh. The average rate paid by member-consumers was 6.66 ¢/kWh for residential customers, 6.62 ¢/kWh for small commercial and industrial customers, and 3.78 ¢/kWh for large commercial and industrial customers.

Buckeye's member-cooperatives sold 4,713.2 GWh in calendar year 1992. By far the largest of Buckeye's member-cooperatives is the South Central Power Company. In 1992, this coop delivered 1,223.6 GWh to its 74,583 member-consumers, representing 26% of the 4,713.2 GWh in 1992 energy sales. Of the 27 member-cooperatives, 25 had between 3,241 and 16,297 member-consumers with 1992 energy sales ranging from 46.7 GWh to 365 GWh. The smallest member cooperative is South East Michigan Electric Cooperative, which sold 11 GWh to 832 member-consumers in 1992. [R#1,11]

In 1992, Buckeye's 260,133 farm and non-farm residential member-consumers purchased 68% (3,207.6 GWh) of the total energy sold by the cooperatives. About 30% (1,435.1 GWh) of the cooperatives' 1992 energy sales were to 19,582 commercial and industrial accounts. The remaining 2% (70.5 GWh) of 1992 energy sales went to other electric service accounts and to others for resale. The breakdown between residential, commercial, industrial, and farm accounts varies for each cooperative.

Buckeye Power has a generating capacity of 1,230 MW, which is supplied in full by the coal-fired Cardinal Station, located near Brilliant, Ohio. The Cardinal Station was one of the first partnerships between electric cooperatives and an investor owned utility involving the joint ownership of an electric generating station. This project was also unusual because the cooperatives financed the project with private funds. The Cardinal Station is owned

1992 BUCKEYE POWER STATISTICS

| | |
|-------------------------------------|-----------------|
| Number of Customers | 283,097 |
| Energy Sales to Cooperatives | 4,904 GWh |
| Total Operating Revenues | \$172.0 million |
| Winter Peak Demand | 956 MW |
| Summer Peak Demand | 890 MW |
| Generating Capacity | 1,230 MW |
| Reserve Margin | 29 % |
| Avg. Rate for Cooperatives | 3.42 ¢/kWh |
| Electric Rates for Consumers | |
| Residential | 6.66 ¢/kWh |
| Small Commercial/Industrial | 6.62 ¢/kWh |
| Large Commercial/Industrial | 3.78 ¢/kWh |

by Buckeye and Ohio Power Company. Buckeye owns two of the three generating units. Buckeye forecasts that current Cardinal Station capacity can meet the cooperative's load well into the next century.

Buckeye is a winter peaking generation and transmission utility, with 1992 winter peak demand of 956 MW and summer peak demand of 890 MW, including system losses. During 1992 Buckeye had 5,192 heating degree days and 1,054 cooling degree days. The system's peak of record occurred on December 21, 1989, when demand was 967 MW, including system losses. There were 5,399 heating degree days in the winter of 1989-90. Average annual electricity use by residential customers in 1992 was 12,279 kWh per customer.

The Rural Electrification Administration (REA) currently has a zero-interest loan program to improve economic development in rural areas. The program allows cooperatives to make loans of up to \$100,000 to local firms requiring financial assistance to develop or expand their operations. Consequently, Buckeye has a professional development staff to assist customer prospects in selecting sites, qualifying for state development assistance and in packaging deals. This group also helps member-cooperatives with their development activities. In addition, the Buckeye staff provides members with special-application engineering services. ■

Utility DSM Overview

Buckeye has been involved in DSM since 1974, when it implemented one of the first large-scale load management programs in the country, the subject of this profile. The load control system uses a satellite communication network and radio base stations to transmit signals, which temporarily disconnect the power supply to the 81,000 electric water heaters and 2,800 electric resistance heaters on geothermal heat pumps. Through a related program started in 1990, Buckeye provides rebates to cover the cost of new energy-efficient electric water heaters that replace non-electric water heaters or irreparable electric water heaters. Rebates are only provided after a radio control switch has been installed on the water heater.

Since 1982 Buckeye has promoted energy-efficiency through a number of programs. A rebate program promotes installation of geothermal heat pumps. Over 900 of these systems are load controlled. In 1991, Buckeye arranged Ohio's first utility and HVAC dealer seminar on geothermal systems.[R#1]

| DSM Overview Table | <i>Annual DSM Expenditure (x1000)</i> | <i>Annual Energy Savings (GWh)</i> | <i>Cumulative Demand Savings (MW)</i> |
|---------------------------|---------------------------------------|------------------------------------|---------------------------------------|
| 1983 | \$1,615 | 0.91 | 53.00 |
| 1984 | \$1,557 | 1.92 | 53.00 |
| 1985 | \$1,503 | 2.92 | 53.00 |
| 1986 | \$1,673 | 4.37 | 54.50 |
| 1987 | \$2,252 | 6.31 | 61.50 |
| 1988 | \$2,183 | 9.48 | 66.00 |
| 1989 | \$2,211 | 12.60 | 70.44 |
| 1990 | \$2,149 | 15.37 | 74.09 |
| 1991 | \$3,066 | 20.75 | 81.60 |
| 1992 | \$3,318 | 26.17 | 89.97 |
| Total | \$21,526 | 100.78 | |

BUCKEYE POWER 1993 DSM PROGRAMS

Residential Load Management

Water Heaters

GLHP Back-up Resistance

GLHP with Fossil Fuel Back-Up

Electric Thermal Storage

Dual Fuel Program

(add-on electric air-to-air heat pump)

Water Heater Replacement Program

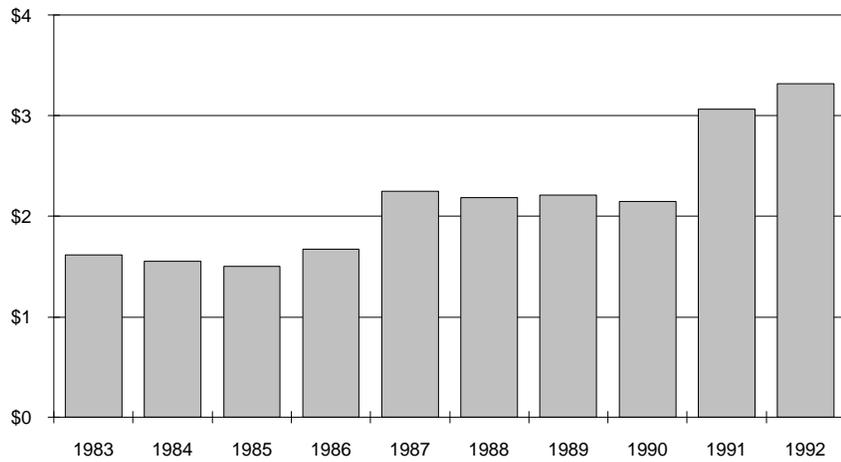
Electric Grills

Energy Efficient Lighting

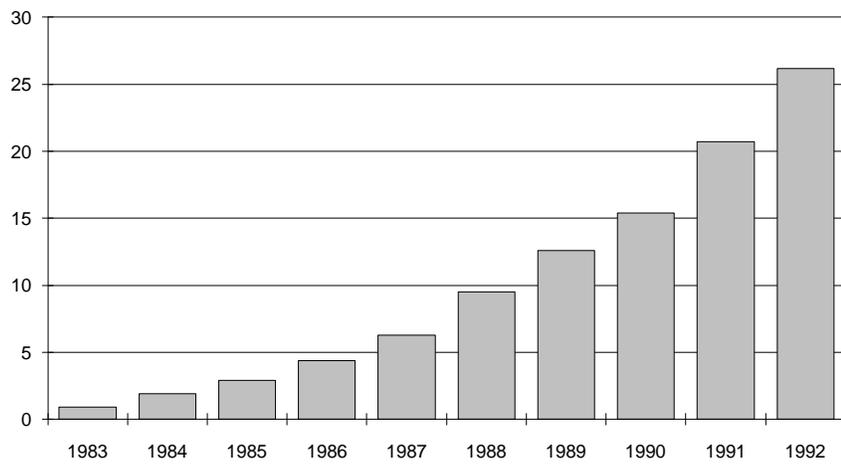
The Dual Fuel (add-on heat pump) program promotes the addition of a heat pump to a gas or oil furnace. Since 1982, 5,300 units have been installed through this program.[R#1]

Between 1983 and 1992, Buckeye has spent a total of \$21.5 million on DSM, and achieved total annual savings of 100.78 GWh. Total demand savings in 1992 were 89.97 MW; demand savings are cumulative, as there is not a clear distinction between new demand savings added each year and total demand savings realized in one year. Virtually all of Buckeye's demand savings are realized through its load management program. In 1992, Buckeye spent \$3.3 million on DSM, or 1.9% of its operating revenues, and achieved annual savings of 26.17 GWh. ■

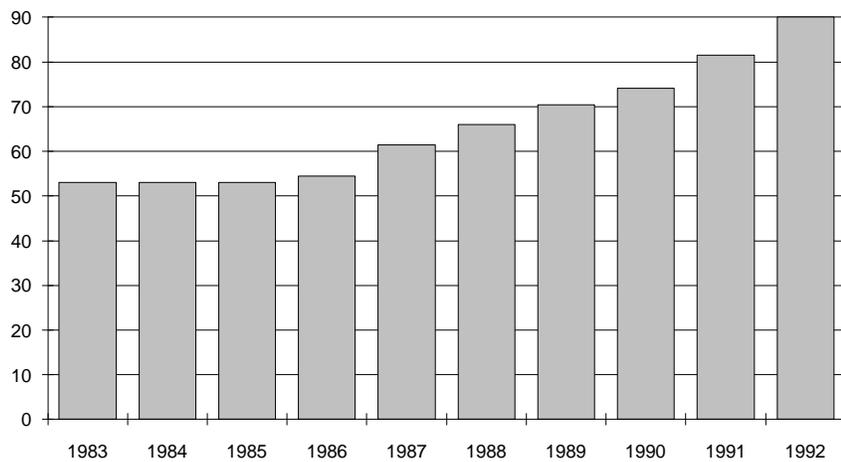
**ANNUAL DSM
EXPENDITURE
(\$1,000,000)**



**ANNUAL ENERGY
SAVINGS (GWH)**



**CUMULATIVE
DEMAND SAVINGS
(MW)**



Program Overview

Buckeye Power's Residential Load Control program is offered to the member-consumers of each of its 27 member-cooperatives. Through the program, 81,000 residential electric water heaters throughout the Buckeye service area may be controlled during peak demand periods. Additionally, approximately 2,800 residential electric space heating systems are controlled through the program. [R#8,9]

The program began during the winter of 1974-75, in an effort to control peak demand. Originally, the program utilized telephone lines to establish communication between the central load management computer and the field locations including radio base stations and load monitoring points. The load management computer estimates the Buckeye load from the real-time information obtained from the load monitoring points. As Buckeye approaches a peaking situation the computer instructs the radio base stations to control certain loads by broadcasting signals that control radio switches on water heaters and space heating equipment throughout the service area. Due to the expense of leasing telephone lines, Buckeye began looking at alternative methods for communicating between the radio stations and the central computer. Finally, in 1989, Buckeye signed a contract with Nova-Net Communications, Inc. to provide a state-of-the-art satellite data communications system for the Residential Load Control program. [R#4]

The satellite system was fully operational for the 1990-91 operating season. The system is comprised of a central computer, 32 radio base stations, 15 load monitoring points, and 42 satellite terminals, in addition to the satellite and network-based components. Changeover to the satellite system is estimated to have a payback period of just five years. Buckeye estimated in 1991 that monthly operating costs were reduced by 74% with the new system. [R#4,11]

The primary goal of the Residential Load Control program is to prevent exceedance of the historical record peak demand. Each member-cooperative pays a monthly demand charge, which is based on the cooperative's per-

centage contribution to the total system demand at the time of the peak of record. Thus, each time a new peak of record occurs, each cooperative's monthly demand charge is recalculated. The monthly demand charge may increase or decrease, depending on how much demand the cooperative was responsible for at the time of the new peak. As of May 1993, the system peak of record of 967 MW occurred in the evening on December 21, 1989. Through voluntary control and participation in the Residential Load Control program, member-cooperatives have successfully limited the frequency with which new system peaks are reached. Prior to the December 1989 peak, Buckeye's system peak was 912 MW on December 24, 1983. [R#4,8]

Participation in the program is two-pronged. First, the member-cooperative reaches an agreement with Buckeye Power to participate in the program. Presently, Buckeye provides an incentive to the member-cooperatives of an \$81 reduction in annual demand-related charges per peak kW deferred. Additionally, Buckeye reimburses the cooperatives \$25 for each newly installed radio switch, and \$25 for service calls to replace defective switches. [R#4,11]

The cooperatives in turn market the program to their member-consumers, provide incentives to encourage participation, and perform switch installations, inspections, and service as necessary. Each cooperative's strategy for encouraging participation is slightly different from the others. Buckeye's free water heater program is offered by most of the cooperatives. Through this program member-consumers may qualify for a rebate covering the cost of a new, energy-efficient water heater as long as the member-consumer agrees to allow installation of a radio control switch. Through this program which has been offered since 1990, approximately 5,600 water heaters and 3,000 new switches are installed each year. Some cooperatives also offer a rate discount to member-consumers who participate in the Residential Load Control program. However, most rely on the feeling of ownership that the member-consumers have in the cooperative, and the desire to keep the cooperative's costs down is sufficient to inspire participation in the Residential Load Control program. ■

MARKETING AND DELIVERY

Because of the rate structure for Buckeye Power's member cooperatives, little encouragement is needed to persuade the member cooperatives to participate in the Residential Load Control program. Each member cooperative in turn must convince its member-consumers to participate in the program, and this is typically done through advertisements and articles in the monthly publication of the Ohio Rural Electric Cooperatives, "Country Living." The magazine is sent to each member-consumer, with a four page center section devoted specifically to the individual cooperative to which the consumer belongs.

Each cooperative may utilize the center "local" section to inform its member-consumers of noteworthy events occurring within the cooperative. The local section may include energy-saving tips, editorial comments, and descriptions of cooperative projects and programs of interest, including the Residential Load Control program. In addition, the body of the magazine includes advertisements and articles pertaining to all member-consumers. Buckeye Power utilizes this medium to advertise the Residential Load Control program and to inform the member-consumers of program details through occasional feature articles.

Though some incentives are offered directly to the member-consumers, the primary incentive to participate is the reduction in demand charges that the cooperative must pay to Buckeye Power. As members of the coop, member-consumers benefit directly from the incentives that Buckeye provides to each cooperative.

DELIVERY

There are essentially two sides to the program delivery. First, the cooperatives recruit participants and install radio switches on water heaters and electric space heating equipment. Second, Buckeye Power determines when

load control is necessary and utilizes its sophisticated satellite system to communicate with the radio control stations, which in turn send signals to switch off the controlled appliances.

MEMBER COOPERATIVES DELIVER THE PROGRAM TO CONSUMERS

Although each cooperative delivers the program to its member consumers slightly differently, the basic delivery mechanism is similar. After the consumer expresses interest in the program, an appointment is made for installation of the radio switch on the consumer's appliance. After the switch is installed, coop staff typically provide varying levels of service if there is a problem with the water heater. Switches are repaired or replaced at no charge to the member-consumer. Buckeye reimburses the member cooperatives \$25 for each switch installation and \$25 for service calls that require replacement of a defective switch.

Since 1990, Buckeye Power has been implementing a free electric water heater program in conjunction with the Residential Load Control program. Through this program, customers may purchase a 52 or 82 gallon energy-efficient electric water heater as a replacement for an electric water heater that cannot be repaired, or to replace a gas or oil-fired water heater. If the customer agrees to have a radio switch installed on their new water heater, then Buckeye and the cooperative will reimburse the customer for up to \$420 to cover the cost of the water heater. (Buckeye and the cooperative split the reimbursement cost 50%-50%.)

Additionally, some cooperatives offer a rate discount to their member-consumers who participate in the Residential Load Control program. North Western Electric Cooperative offers a \$2 discount on the monthly service charge, and a 0.9 ¢/kWh discount on energy use above 1,000 kWh per month. 

Implementation(continued)

The member cooperatives perform routine inspections of switch installations to insure that the switches are working properly. Additionally, some cooperatives take the opportunity to check switches during regular meter-reading visits to customers' homes.

BUCKEYE POWER CONTROLS THE LOADS

When Buckeye first began the Residential Load Control program in 1974, appliance control was accomplished via a central processor which ran a real-time based multi-tasking operating system. Three load monitoring points provided the data needed to determine when load control was necessary. The computer was connected to the load sampling points and the 10 radio base stations via leased telephone lines. Upon receipt of a message to control loads at the radio base station, the base stations would broadcast tones that, when received by the radio switches installed on the consumers' appliances, would activate the switches and turn off the appliances.[R#2]

Over the years, Buckeye has upgraded various components of the Load Control system in an effort to streamline the program and make control most efficient. First, the central computer was upgraded to a network of personal computers providing greater flexibility, improved reliability and increased processing power. The number of radio base stations was increased to 32 stations, and the stations were converted to digital-based equipment. The stations are capable of transmitting messages by both tone and digital messages, thus precluding the need to retrofit individual radio switches.[R#2]

After the radio stations were converted, Buckeye began using digital radio switches for all installations. The

new switches, manufactured by Scientific Atlanta, have several features that have made switch installation and monitoring much simpler. The digital switches have self-diagnostic tests that enable the installer or inspector to determine whether the switch is working properly. The switches also have check features which help determine radio frequency field strength to indicate whether or not the strength of the radio reception is adequate for proper operation.[R#2,11]

Perhaps one of the most significant changes that Buckeye has implemented over the years has been the change to a satellite communications system. The satellite system has replaced the leased telephone lines as the connection between Buckeye's load management computer and the radio base stations and load monitoring points.

Using the satellite system, information from the 15 load monitoring points is transmitted to Buckeye's central computer, which calculates projected loads and determines an appropriate load control schedule. When load control is called for, Buckeye's central processing computer communicates with the satellite via a series of specialized components. Information is then transmitted from the satellite to each of the 32 radio base stations. The radio base stations, upon receipt of a message to control loads, transmit a digitally encoded message as well as tone bursts, which are received by the 84,000 radio switches installed on water heaters and electric space heating equipment. (Approximately 40,000 of the switches in the system are tone units.)

Buckeye estimates that recurring monthly cost savings of up to 74% have been realized with the new satellite system. Leasing telephone lines cost up to \$19,000 per

month during the 1980's, before the system was switched over to the satellite. Current monthly costs are significantly less, at 26% of \$19,000, or \$5,100.

Another significant change to Buckeye's load management system has been to replace the mini-computer central processor with a network of 10 personal computers (PCs). The PCs are linked through a local area network (LAN) and perform separate jobs, yet are integrated through the common data storage area located on the LAN file server. This configuration is what is called distributed (concurrent) processing in a loosely coupled fashion. The system provides for a high degree of reliability through independent operation, while at the same time allowing for total integration. Flexibility has also been improved due to the modular system design.

MEASURES INSTALLED

Through the Residential Load Control program, radio switches are installed on electric water heaters, as well as some electric space heating equipment, and the appliances are then subject to control during peak periods as identified by Buckeye Power. Appliances may be switched off for periods up to five hours.

STAFFING REQUIREMENTS

The Residential Load Control program is operated and administered by personnel at Buckeye Power and each of the participating member cooperatives. Herbert Caldwell, Jr., is the Manager of the program at Buckeye Power. He is principally responsible for the operation and administration of the program, including program planning, system upgrading and maintenance. Under Mr.

Caldwell's direction at Buckeye, a staff of five technical personnel installs, maintains, and operates the load management system, including data telemetry, radio base stations, satellite communication equipment, and computer hardware. The Buckeye staff also performs software engineering and completes all statistical and monitoring functions.

Employees at each member cooperative are responsible for marketing the program to the consumers, installing, maintaining, and inspecting radio switches, and administering the program. Typically, one person at each coop is responsible for the program, and spends on average about 25% of their time on the program. However, each coop is different, and staffing needs are dependent upon program activity. Some split the work among several staff members, while others have one individual who works specifically on the program. ■

LOAD MANAGEMENT COMMUNICATION SYSTEM TYPES

There are a variety of ways to establish the communication between a central computer and radio base stations necessary for a load control program. Buckeye Power began its load control program by using leased telephone lines to transmit load control messages. The new satellite system is significantly more cost-effective and has proven to be virtually error-free in the four years that the system has been operating. These and other types of communications methods are discussed below.

Telephone lines were leased by Buckeye Power to bidirectionally connect Buckeye's load management computer with the radio base stations and the load monitoring points. In 1974, when the Residential Load Control program was beginning, telephone lines provided an inexpensive and efficient method for communication between the system components. But by the 1980's, costs were increasing significantly. Buckeye paid \$20,000 to install 37 leased lines, and \$19,000 in monthly charges on 2,500 miles of lines. These increasing costs caused Buckeye to look at its options for load control communications.

Multiple address radio systems were one option that Buckeye considered. These systems are similar to the one employed by United Power Association in its Residential Load Control program (see The Results Center Profile #56). The VHF radio load management control system is comprised of a master controller, transmitters, and receivers. The master controller is located in UPA's Energy Control Center and monitors UPA's system load through a SCADA (supervisory control and data acquisition) system. Depending on the load and time of day, the master controller will instruct the transmitters when to send the appropriate "off" commands. The master controller sends its signals to a network of 31, 300 watt transmitters. Each of these has a 20-mile transmitting radius. In 1992 this system of transmitters covered roughly 95% of UPA's service area. These pro-

vide one-way communications with the load management receivers. Each transmitter operates independently and broadcasts a specific group of discrete cooperative codes.

Buckeye also considered using a **private microwave system** similar to the one used by Florida Power Corporation in its Residential Load Control program (see The Results Center Profile #54). In that system, a tone generator is used to translate a power interruption instruction to an audio analog message, which is sent over company-owned microwave to 21 transmitters located throughout the service area. The transmitter antennas are located on towers shared with FPC's microwave and mobile radio communication systems.

The **satellite communications system** which Buckeye implemented in 1989 utilizes a satellite owned by GTE which orbits the earth at 23,300 miles, at approximately the same speed as the earth's rotation. Thus, the satellite does not appear to move relative to someone standing on the earth, giving the appearance of a geo-stationary position. The satellite system is comprised of four other components in addition to the satellite itself. The space segment on the satellite uses a transponder to allow communication with the satellite. The master earth station, or HUB, on earth is used to direct all messages to the satellite; any message sent to the satellite must first go through the HUB. A user network control center interfaces with the HUB to insure that the messages sent by users, such as Buckeye, are transmitted in a timely and error free fashion. The final component is the VSAT (very small aperture terminal), which is Buckeye's satellite earth station. The VSAT is comprised of a dish antenna, an outdoor radio unit, which communicates with the HUB, an interfacility link cable connecting the outdoor radio unit to the indoor equipment, and the indoor processing unit, which interfaces the Buckeye computer with the satellite communications system.

Monitoring and Evaluation

MONITORING

Several methods are used to monitor the status and efficiency of the load control system. First, each member-cooperative is responsible for performing routine inspections of the switch installations. Each year, most coops randomly select approximately 10% of the current switch installations for inspection by a coop employee. The inspection typically involves confirmation that the switch is installed properly, and a test to assure that the switch is working. Some coops take advantage of regular meter reading visits to inspect switch installations.

Buckeye's satellite communications provider, Nova-Net, is responsible for monitoring the performance of the satellite system. Nova-Net provides 24 hour network monitoring of each site on the system and immediately notifies Buckeye of any communications network difficulties. Buckeye receives weekly and monthly reports of the system's overall operation, including the performance of the system from the perspective of all users.

Buckeye estimates and projects its load with information collected at 15 load monitoring points, which monitor 15% of Buckeye's total load. Information from these points is transmitted via the satellite communication system back to Buckeye's central load control computer. Data from these locations includes wind, temperature, and current electricity demand, enabling accurate estimation of demand for the entire system.

EVALUATION

For the entire time that the Residential Load Control program has been operating, Buckeye has performed routine evaluations of the system and its performance. These evaluations and program projections resulted in Buckeye's decision to change the original communications system to the more sophisticated and versatile satellite system.

Buckeye evaluates the load control system's performance with 15 load monitoring points located throughout its service territory. For each load control session, Buckeye determines and records the number of appliances controlled, the duration of the control period, the average weather conditions across the state, the estimated peak before load control was initiated, the actual peak during the control session, and the estimated impact of the control session.

Each member-cooperative also conducts their own evaluation of the program. For example, the North Western Electric Cooperative conducted a market survey in 1992 which sought to determine, among other things, consumer awareness of the load control program. The survey found that 73% of the 300 consumers surveyed were aware that the utility has a program to reduce peak demand. Of 246 consumers with electric water heaters, 56.9% said they already had a radio control switch on their water heater, and 17.9% said they would consider having one installed. Of the 88 consumers that heated primarily with electricity, 74% said that they would be willing to reduce the temperature in their homes by two to five degrees for three to five hours on the coldest days of the year. [R#10] ■

Program Savings

Since the winter of 1982-83 Buckeye has estimated that each water heater controlled saves 1 kW. (Program savings were calculated differently in the first eight years of the program.) With 81,000 water heaters controlled in the winter of 1992-93, Buckeye had control over 81 MW. In addition, approximately 2,800 switches are installed on electric space heating equipment with average savings of 5 kW per switch, for a deferrable load of 14 MW in 1992-93.

PARTICIPATION RATES

Of Buckeye's 283,000 member-consumers, approximately 92% are residential customers, most of whom have electric water heaters. With 81,000 switches installed by 1993, Buckeye estimates that it has achieved a participation rate of approximately 40% of qualifying member-consumers. The water heater rebate program in effect since 1990 has been responsible for the installation of 7,000 efficient new water heaters with load control switches. More than half of these switch installations were new participants in the program.[R#1]

There are few dropouts from the program. Participation figures take into account program dropouts and switch failures.

During the first three years of the program, a total of 32,000 switches were installed. In most of the subsequent years, up to 4,000 new switches were installed each year. (About 7,000 switches were added between 1986-87 and 1987-88.) Due to an emphasis on field maintenance, the total number of switches did not significantly change during the years of 1984 through 1986.

In the 19 years that the program has been operating, a total of 136 water heater deferrals have been required, for an average of 11 deferrals in each of the 12 years that load

| Water Heater Switch Installations | <i>Cumulative Number of Water Heater Switches Installed</i> | <i>Total Deferrable Water Heater Load (MW)</i> |
|--|---|--|
| 1974-75 | 10,000 | 14 |
| 1975-76 | 22,000 | 31 |
| 1976-77 | 32,000 | 44 |
| 1977-78 | 35,000 | 38 |
| 1978-79 | 40,000 | 44 |
| 1979-80 | 44,500 | 49 |
| 1980-81 | 48,000 | 43 |
| 1981-82 | 50,500 | 45 |
| 1982-83 | 51,500 | 52 |
| 1983-84 | 53,000 | 53 |
| 1984-85 | 53,000 | 53 |
| 1985-86 | 53,000 | 53 |
| 1986-87 | 54,500 | 55 |
| 1987-88 | 61,500 | 62 |
| 1988-89 | 66,000 | 66 |
| 1989-90 | 70,000 | 70 |
| 1990-91 | 72,500 | 73 |
| 1991-92 | 76,500 | 77 |
| 1992-93 | 81,000 | 81 |

| Water Heater Load Management | <i>Number of Deferrals</i> | <i>Average Duration of Each Deferral (hours)</i> |
|-------------------------------------|----------------------------|--|
| 1974-75 | 0 | |
| 1975-76 | 0 | |
| 1976-77 | 37 | 1.9 |
| 1977-78 | 12 | 1.3 |
| 1978-79 | 3 | 0.7 |
| 1979-80 | 0 | |
| 1980-81 | 0 | |
| 1981-82 | 7 | 2.0 |
| 1982-83 | 0 | |
| 1983-84 | 3 | 2.3 |
| 1984-85 | 1 | 2.2 |
| 1985-86 | 1 | 0.5 |
| 1986-87 | 0 | |
| 1987-88 | 4 | 1.6 |
| 1988-89 | 1 | 1.7 |
| 1989-90 | 26 | 2.1 |
| 1990-91 | 0 | |
| 1991-92 | 5 | 1.7 |
| 1992-93 | 36 | 1.9 |
| Total/Average | 136 | 1.6 |

| Space Heating Switch Installations | <i>Cumulative Number of Space Heating Switches Installed</i> | <i>Total Deferrable Space Heating Load (MW)</i> |
|---|--|---|
| 1989-90 | 1,000 | 5 |
| 1990-91 | 1,400 | 7 |
| 1991-92 | 2,200 | 11 |
| 1992-93 | 2,800 | 14 |

management operations were required. (No load management was necessary during seven winters, as shown in the Water Heater Load Management table.)

The average duration of each water heater deferral was 1.6 hours. The longest deferrals occurred during the winter of 1989-90, when some water heaters were turned off for 6.1 hours. ☞

| Space Heater Load Management | <i>Number of Deferrals</i> | <i>Average Duration of Each Deferral (hours)</i> |
|-------------------------------------|----------------------------|--|
| 1989-90 | 6 | 4.6 |
| 1990-91 | 0 | |
| 1991-92 | 1 | 3.9 |
| 1992-93 | 6 | 3.6 |
| Total/Average | 13 | 4.0 |

Program Savings (continued)

Space heating deferrals have been occurring since the winter of 1989-90. A total of 13 deferrals have been necessary, for an average of 4.0 hours per deferral.

FREE RIDERSHIP

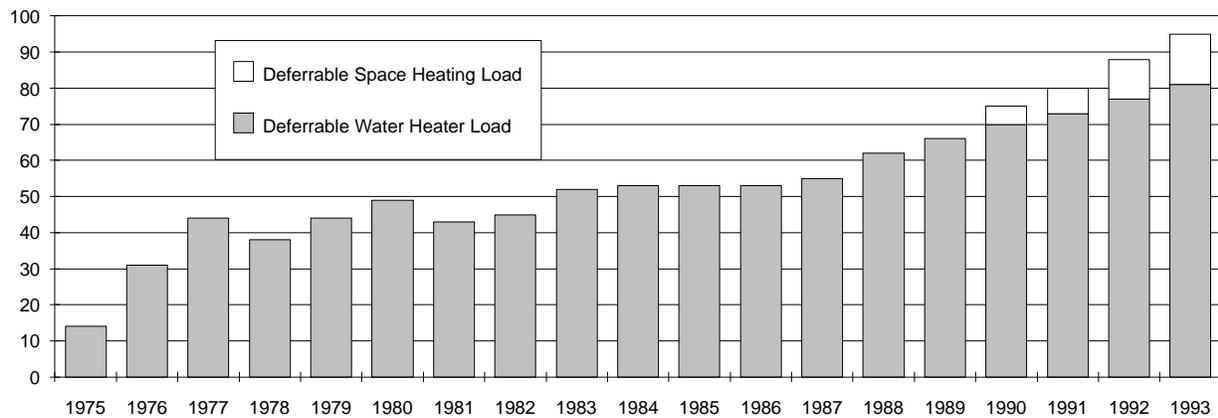
Free-ridership is not an issue for this program. Although some load deferral occurs through voluntary control when Buckeye announces a Peak Alert, Buckeye does not have the same control over the time and amount of demand reduced as it does through this program.

MEASURE LIFETIME

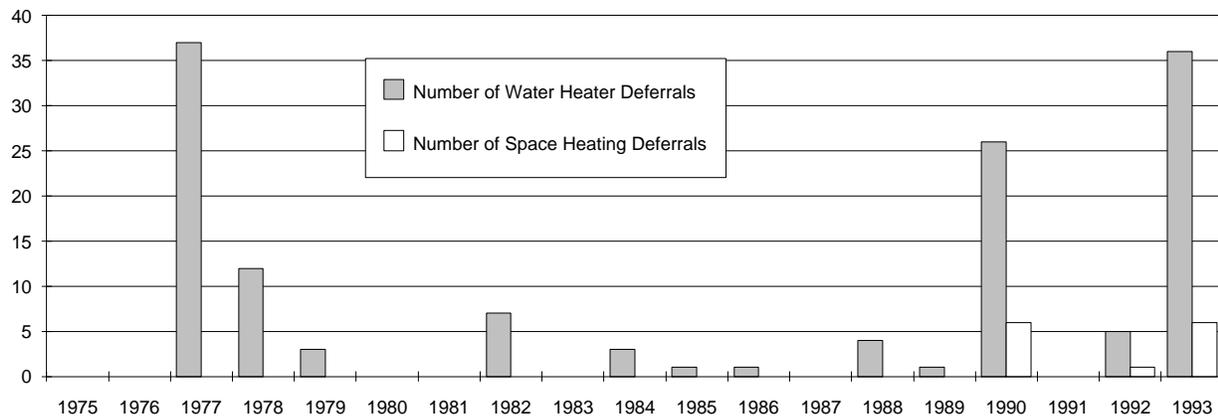
The switches installed through the Residential Load Control program typically last 20 years. Many of the switches installed during the first years of the program in 1974-75 are still operating properly, as confirmed through routine inspections.

One of the benefits of the satellite communications system is its versatility. As the needs of the program change, the satellite communications system can be easily reconfigured to most efficiently manage the loads connected to the system. This state-of-the-art system will be able to meet the needs of the Residential Load Control program for many years. ■

TOTAL DEFERRABLE LOAD (MW)



NUMBER OF LOAD CONTROL SESSIONS



Cost of the Program

In 1992, Buckeye spent approximately \$2 million to operate the Residential Load Control program and maintain the associated equipment. This cost includes interest payments on mortgage notes, depreciation, taxes, insurance, payroll, and employee benefits. Buckeye has invested a total of approximately \$10 million in the program since its inception. The installation of the satellite communications system required a significant capital outlay. However, the reduced monthly costs are expected to pay for the system in five years.

COST PER PARTICIPANT

From Buckeye's point of view, the program has cost a total of about \$10 million. With 81,000 water heater switches and 2,800 electric resistance backup switches installed, the cost is about \$120 per switch. Note that this cost per participant is a cumulative cost; the annual cost per participant would be lower.

From each cooperative's point of view, the program cost will differ depending on the size of the service area and the amount of program activity each year. North Western Electric Cooperative had gross 1992 costs of \$52,949. Rebates from Buckeye of \$25 per new switch and 50% of the cost of the water heaters totalled \$13,490, for a net cost to the cooperative of \$39,459. The total number of switches installed in North Western Electric's service area as of the end of 1992 was 2,783, thus the

cooperative's net 1992 costs were \$14 per switch.

COST COMPONENTS

While each cooperative's expenditures will differ, North Western Electric Cooperative's 1992 expenditures are one example of the way that an individual cooperative's costs are allocated. Nearly one half of North Western's 1992 expenditure went toward water heater switch inspections and maintenance. In 1992, North Western inspected 550 existing radio control switches. Their expenditure of almost \$26,000 includes all labor and transportation costs to inspect the switches. The figure also includes approximately \$2,500 for the design and implementation of a consumer data base used by the cooperative for the load management program. North Western's next biggest expense was its portion of the customer incentive for the free water heater program. The cooperative spent \$23,000 in rebates for 151 water heaters; half of the cost was reimbursed by Buckeye. North Western also spent \$2,000 for water heater parts (the cooperative provides free parts to all load management participants). Almost \$800 was spent on water heater service calls that were not related to the radio control switches (and thus not eligible for reimbursement from Buckeye). Installation of new radio control switches, before reimbursement from Buckeye, cost \$655 for water heater switches and \$413 for resistance backup heat switches. [R#10] ■

| North Western Electric Cooperative 1992 Residential Load Control Program Costs | <i>Cost</i> | <i>Percent of Total Costs</i> |
|---|-------------------|-----------------------------------|
| Water Heater Switch Installations | \$655.0 | 1.2% |
| Resistance Backup Switch Installations | \$413.4 | 0.8% |
| Water Heater Switch Maintenance | \$25,966.0 | 49.0% |
| Reimbursement for Free Water Heater Program | \$23,078.4 | 43.6% |
| Water Heater Parts | \$2,037.5 | 3.8% |
| Un-reimbursable Water Heater Calls | \$799.0 | 1.5% |
| Total Program Cost | \$52,949.4 | |
| Reimbursements from Buckeye | (\$13,490.3) | |
| Net Program Cost | \$39,459.1 | |
| Cost per Switch | \$14.18 | |

Lessons Learned / Transferability

LESSONS LEARNED

Buckeye's Residential Load Control program has been very successful in its nearly 20 years of operation. The program has enlisted the participation of over one fourth of its member-consumers, and has kept the historical peak of record from being exceeded on numerous occasions. Program Manager Herbert Caldwell, Jr. attributes the program's success not only to the diligent work of the current program staff, but also to the foresight and planning of the original program designers who, in 1974, saw the opportunity for enhanced system operation and efficiency that could be achieved through a load control program.

The Residential Load Control program is one component of Buckeye's comprehensive load management strategy. Buckeye's unique arrangement with the investor-owned utility, Ohio Power, allows Buckeye to benefit in many ways from successful load management. Excess capacity available from Buckeye's two generating units at the Cardinal Station is sold to Ohio Power and "banked" for future use by Buckeye. In this way, Buckeye in effect stores the capacity saved through its conservation and load management efforts and can buy back the banked capacity when it is needed in the future at the average price for which it was sold. The availability of this capacity has postponed the need for construction of new capacity. Buckeye had planned the need for new generation facilities around 1986, but with load management, conservation, and banked capacity affecting its load forecast, new baseload capacity was not needed at that time. Buckeye's plans now call for combustion turbine peaking units sometime after the year 2000.

The Residential Load Control program has effectively operated with little need for change in its implementation strategy, but with constant refinements to the program and load control system. Perhaps the biggest changes for the program have been the installation of the new satellite communications system and PC-based central computer control facility. Buckeye has shown that with careful planning and foresight, a program can update its equipment to a state-of-the-art system that enhances the program capability, creates opportunities to improve communication within the service territory, and has a favorable payback period.

Besides reducing operating costs, the system is more reliable than the telephone line based system that it replaced. In 1990, the system was fully operational and available 99.8% of the time, and the system is guaranteed to operate at 99.5%.

Another benefit of the system is its flexibility. The VSAT's, which allow communication through the satellite between the central computer, each of the load monitoring points and the radio base stations, can be easily moved if it becomes necessary to reconfigure the system. In this way, Buckeye can continually reexamine its load control system and change the system as it finds more efficient and effective modes of operation.

Buckeye is planning to take advantage of the system's other communications capabilities. Using the satellite system, Buckeye is planning to implement an electronic mail system and a computerized bulletin board that allows communication between the Buckeye headquarters and each of the 27 cooperatives.

TRANSFERABILITY

Buckeye's Residential Load Control program is highly transferable, not only to other generation and transmission cooperatives, but to investor-owned and municipal utilities as well. As a member-owned organization, Buckeye's member-consumers benefit directly through reduced demand related charges due to savings achieved by the program. These benefits may not be applicable to an investor-owned utility. Thus, the marketing strategy for an investor-owned utility's load control program must take on a different (and perhaps more aggressive) approach than what has been utilized by Buckeye. Such a strategy is in place to market Florida Power Corporation's Residential Load Management program. (See Profile #54.) United Power Association's Residential Load Control program (Profile #56) is more analogous to Buckeye's program in that it is delivered through its member-cooperatives, and the consumers have a stake in the savings achieved by the program.

Both FPC's and UPA's programs include several different types of equipment that may be controlled through the program, while Buckeye's program is primarily aimed at controlling electric water heaters, with a much smaller electric resistance backup component. Buckeye added an electric thermal storage component to the residential load management program in 1993. Additionally, the program anticipates that the geothermal heat pump component will expand, with 400 new switches expected each year. While control of several different types of appliances affords more opportunities for demand savings, the simplicity of a single-appliance program may be appealing to program managers and participants alike. ■

References

1. Buckeye Power, "Annual Report," 1992.
 2. Herbert E. Caldwell, "Load Management Reaches for the Stars," *Transmission & Distribution*, February 1991.
 3. John Lowrey, "SCADA by Satellite," *Rural Electrification Magazine*, May 1991.
 4. Herbert E. Caldwell, Jr., "Satellite Used for Load Management," March 26, 1991.
 5. Jeff Brehm, "Shedding the Load," *Country Living*, January 1992.
 6. Herbert E. Caldwell, Jr., "High Tech Communications for Utility Control and Data Applications," October 23, 1987.
 7. Buckeye Electric Utility Company, "Load Management Operations Summary Winter Period 1992-93," April 26, 1993.
 8. Buckeye Electric Utility Company, "History of Water Heater Load Management Operations," April 23, 1993.
 9. Buckeye Electric Utility Company, "History of Space Heating Load Management Operations," April 26, 1993.
 10. Wes McFarland, Director of Marketing and Communications, North Western Electric Cooperative, personal communication, May 1993.
 11. Herbert Caldwell, Jr., Manager, Residential Load Control Program, Buckeye Electric Utility Company, personal communication, May - June 1993.
- ☞ Special thanks to Herbert Caldwell for his guidance and support throughout the development of this profile.