

## RESIDENTIAL LOAD MANAGEMENT

## PROGRAM AND PILOT

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## ABSTRACT

In 1986 LCRA embarked on residential load management to control peak summer loads. At that time, LCRA was considered a summer peaking utility, and residential air conditioning and water heating systems were selected for control. The program was suspended in 1989 because of defects with the cycling switch printed circuit boards. While these problems were corrected in 1989 and 1990, it was decided to leave the program on hold and conduct engineering tests to determine program impacts. In addition, in 1991 the scope of the pilot studies were expanded to investigate the possibility of redesigning the program so that both summer and winter peak load reductions could be realized. This paper presents the major events of the pilot test program and also quantifies some of the results. The pilot work is continuing and additional information will be available in the future.

## INTRODUCTION

The Lower Colorado River Authority (LCRA) generates and wholesales electricity to 11 Rural Electric Cooperatives and 33 municipal utilities in central Texas. The service

area covers 41 Texas counties and 31,000 square miles. LCRA serves primarily rural areas of Texas with approximately 55% of generation capacity used by residential customers and 45% by others including commercial, industrial and municipal end-users. LCRA's total generation capacity is 2,244 MW: 1,050 MW from gas, 955 MW from coal and 239 MW from hydro generation along the Colorado River. System peak loads normally approach 1,700 MW in the summer but have approached 2,000 MW during late December, 1989. LCRA is now considered a summer and winter peaker with winter peaks projected to grow faster than summer loads.

Let's start by investigating the original program impact estimates. The original program savings estimates were based on a typical home A/C unit running continuously during hot summer weather and drawing approximately 4 kW. Using a 25% control strategy, it was estimated that 1 kW would be saved per A/C unit. For water heaters a stand-by loss was calculated using a 40 gallon water heater and "reasonable"

water heater insulation. This calculation gave a water heater load control value of approximately .5 kW per unit.

To determine if A/C units were being controlled and the approximate savings, notch tests were performed during the summer of 1989 and 1990. Notch tests consist of signaling all A/C control switches simultaneously and measuring the total effect on the system. These tests were performed on switches installed in Georgetown, which was selected because it had approximately 1100 switches representing about 20% of the eligible homes and was close to our offices in Austin. Additional tests were later run in Smithville. Load changes were recorded for each feeder in the substations. A representative notch test is shown in Figure 1.

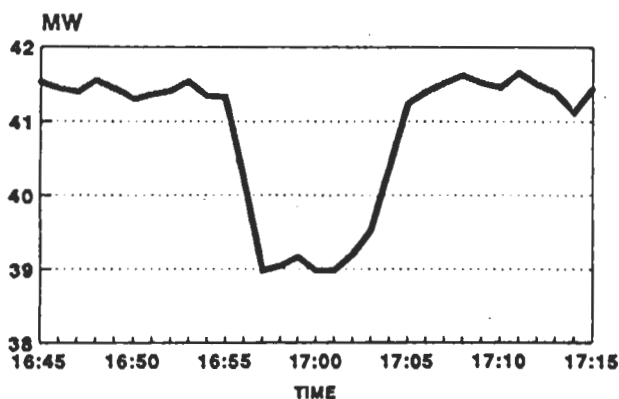


Figure 1 Notch Test Data

A sample of the A/C units was also surveyed to determine the average demand of each unit based on nameplate data. Using the nameplate data and the actual notch test kW load reductions, the average run time per hour for a typical unit was calculated. This information was then used to

determine what cycling strategy -- 25%, 35% or 55% would be needed to get a specific load reduction - kW/unit.

1. Notch Impact kW = kW load before test - kW load after test
2. kW per switch = Notch Impact kW / # switches
3. kW connected AC load = ( BTUH OUTPUT / 1000 ) / SEER
4. Duty cycle = kW per switch / kW connected AC load
5. AC run time per hour = 60 minutes \* duty cycle
6. AC off time per hour = 60 minutes - AC run time per hour
7. Strategy = % of hour AC is Cycled off
8. Strategy time = 60 minutes \* strategy
9. Strategy Impact time = Strategy time \* AC off time per hour
10. % Savings per hour = Strategy Impact time / 60 minutes
11. kW Savings per AC = kW connected AC load \* % savings per hr

Figure 2 Sample Calculation

Notch tests are easy to design but actually performing them can be tricky. The feeder metering system displayed 30 second interval data but only recorded 15 minute data. This required us to station personnel at the substation to monitor and record data. LCRA and City of Georgetown staff "volunteered" to record data in several un-air conditioned metal substation buildings when the ambient temperature exceeded 100 degrees!

The notch tests demonstrated that to achieve 1 kW/unit during the hottest weather of the summer would require cycling strategies of 45 to 55%. Remember that the original program was designed around a cycling strategy of only 25%!

Our next objective was to determine if we could cycle air conditioners at 45 to 65% and still have customers participate. Most of the participants in the cycling program volunteer and do not

receive any direct compensation. In addition to cycling at high strategies, we decided to monitor air conditioner loads at 50 residences in the test area to validate the notch test results.

The end-use metering data has been very useful in determining that the radio communications system was working properly. We had several instances where problems were diagnosed in the radio control system or computer control program by analyzing the end-use data.

We also controlled another 250 unmetered residences with the same control strategy. This group was our "squawk" test group. We monitored the number of complaints and also performed a survey of this group after the summer cycling was complete. To our amazement, we found that we could indeed cycle at 45 to 65% without causing undue problems for the customers. Only one customer dropped out of the program and less than 3% felt inconvenienced by high cycling strategies. Also, the end-use data confirmed that we could achieve the desired 1 kW reduction in load for each A/C unit. At this point it looked promising that a cycling program could produce the desired load reduction and not cause customer problems.

In 1991 the LCRA integrated resource planning process recognized that we had become both a summer and winter peaking utility and, in the swing months (spring and fall), maintenance on

generating facilities could cause us to need some load management during peak load periods as well. The question was asked - could residential load management produce reasonable load reductions throughout the entire year? To redesign the program for year-round load reductions LCRA turned to Florida Power Corp (FPC). FPC has a very large residential load management program that controls A/C, water heaters, electric heating systems and some pool pumps. They also use only one switch per residence where practical. We have redesigned our program using many of the ideas FPC has developed.

In the winter of 1992 we asked our wholesale customers to approve a pilot demonstration project on one feeder in the City of Lockhart. The purpose of the pilot was to demonstrate an advanced residential load management program in central Texas using one switch to control A/C, water heater and strip heat. This program was also to demonstrate program load reduction monitoring and load control during each season of the year.

Approximately 250 homes are participating in the pilot. Load reductions are monitored at the feeder substation using 2 minute interval metering. Approximately 20 homes are equipped with multi-channel end-use metering systems to collect data on the whole house, A/C, water heater and strip heat. Process Systems S-2000 recorders are used and data is collected at 5 minute

intervals.

The switches were installed in the spring and summer of 1993. During the switch installation and inspection period we activated the transmitter to turn on and off a test light on the switches. We still continue to require this signal be sent when switches are being installed. This tests the communication system including the transmitter and load management computer plus confirms the switch is addressed properly, receives the signal and is working.

Load control was initiated in July 1993, but data indicated lower than expected load reductions. A review of the end-use data showed not all the switches were responding to the transmitter signal. Further investigation proved that the transmitter signal was too weak to activate many of the switches. A simple field monitoring board was built and confirmed that signal strength was too low. Approximately 6 weeks of hot summer test data was lost while we obtained an emergency license and installed a transmitter closer to the test site.

We were surprised by this development! Even though we tested the strength of the transmitted signal in the proposed pilot area prior to selecting Lockhart, and made sure each switch worked with the transmitter, we still had signal strength problems when the testing started. The only explanation for this has been that the weather change to hot conditions probably reduced

the signal propagation.

We expected about a 20 mile radius for signal propagation in the coastal plains area. In reality, 15 miles appears more reasonable. This can increase the transmitter requirements significantly for rural utilities. We had hoped to use approximately 20 to 25 transmitters to cover our service territory. Now we estimate that 30 to 40 will be required.

We used local installers when possible. Our earlier experience in the late 1980's had proven that if the local A/C contractors weren't involved in installing the switches, they were likely to disconnect them when servicing the A/C units.

Local installers should be recruited, trained and used when possible to get their buy-in to the program. If not, they will remove or by-pass switches when working on the units. The original cycling program allowed switches to be installed at the A/C unit. A/C repairmen removed or by-passed many of the switches within 2 years. An advantage of the new installation procedure is that it requires most switches be installed at the water heater. Because the A/C repairman never sees the switch, he is less likely to remove or by-pass it.

Initially we had trouble getting local installers to participate in the program. Only two of five A/C contractors in the pilot city agreed to participate in the

switch installation training. When we started installing switches, one company withdrew because one of its two employees broke his leg. The other participating company has had labor and other problems and now has withdrawn. We have recruited additional installers which has required us to provide additional training. To complete the switch installations, we resorted to using LCRA employees for some of the installations.

The original cycling program did not require inspections of installations. We found that some installations were paid for but the switch was never installed. We now require our staff to inspect enough installations to keep the installers' work first-class. We now include enough resources in the program to allow for 10 to 20% of the installations to be inspected by LCRA staff.

Another problem we have encountered has been noise on the feeder monitoring data. By "noise" we mean the load as recorded using a 2 minute interval varies appreciably between intervals.

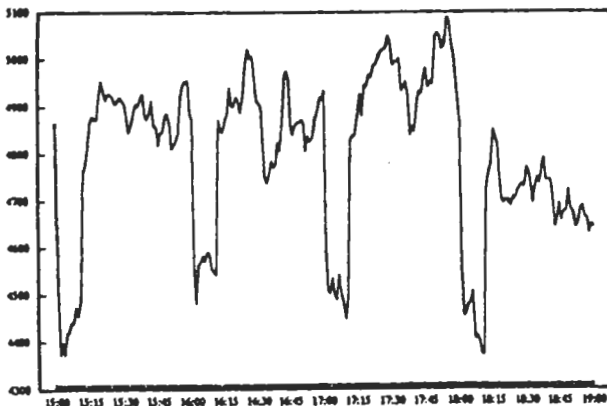


Figure 3 - Feeder Load

We had selected a feeder with minimal commercial customers; three public schools are on the feeder, but the majority of the load is residential. We monitored the load during the spring of 1993 and found the load variation between each 2-minute data interval to be reasonable when compared to the load reduction expected during tests. The noise has been found to increase as the load on the feeder increases. This has been measured both in the summer and winter.

We have investigated the problem to identify the cause but have not been successful. Thinking it was caused by unidentified commercial accounts, we performed a detailed survey to identify commercial facilities. This was not a solution. We went as far as isolating all the commercial area served by the feeder and monitoring just the residential area. The noise still persisted. Our last attempt was to check the voltage regulators operating on the feeder. We felt they could be changing taps during our tests and cause major load changes due to automatic voltage adjustments. Field observations of the voltage regulators have demonstrated that they are not the cause of the noise.

Currently we are having to perform more tests than originally planned so that we can average out the noise. This is a problem when we have very few days that the weather is near an extreme - above 100 degrees F in the summer and below 25 degrees F in the winter. Discussions with FPC indicates the noise is normal

and additional testing is the only solution.

#### Other lessons learned:

**Test Equipment:** Because our program is on hold and only pilot programs are now being implemented, we have not been able to replace our aging load control system. Currently we use two controllers. Both are outdated and one is not user friendly at all. We have set up a transmitter signal monitoring board in our office to monitor the control system. All load management programs, whether pilot or full scale, need to have direct, real time monitoring of signals sent to the switches.

Initially we could not program the controller to automatically perform notch tests. In the winter we test at 6:30, 7:30, 8:30 and 9:30 AM. After having staff come in at 6:15 AM for 2 weeks to perform tests manually, they were able to find a way to program the controller to perform the tests automatically. In fairness to our staff I must mention that our controllers are so outdated that the suppliers won't provide training and we have not been able to find anyone to work on one of the systems.

**Timing of tests:** We normally monitor at the residences using 5-minute intervals. Our load control switches have a preset 7.5 minute time-out period. One load control signal makes the switch stay off for 7.5 minutes. We have increased the switch control period to

10 minutes by refreshing the switch after 2.5 minutes to make sure we always have at least one 5-minute interval of good data during each test.

**Verification of Tests:** End-use metering data has proven very valuable to monitor control system operation. When we perform tests, we review the end-use data to confirm that the switches in the field responded properly. The overwhelming quantity of the data makes it difficult to handle and review all the data available. We selectively review data pertinent to our testing schedules.

#### Summary:

Summer A/C control strategies of 45 - 65% produce the desired load reduction and customers are not made uncomfortable. Water heater load control for up to four hours in the summer and three hours in the winter also is acceptable to customers. The LCRA Integrated Resource Plan evaluation based on data reviewed to date indicates the program is cost beneficial as redesigned.

Plan ahead and get your local contractor work performed in the spring and fall! Also, there are few days that the weather is perfect for testing. Start testing before the weather is good, review the data, get the bugs out and be completely ready when mother nature finally cooperates!

Additional testing of the pilot program will continue during the next twelve months.