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ELECTRIC LOAD SHIFTING IN IRRIGATION DISTRICTS – CALIFORNIA'S PROGRAM

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ABSTRACT

During the 2000-2001 winter, California experienced a severe imbalance in electricity supply and demand that resulted in blackouts and brownouts. The state legislature initiated a number of emergency programs, one of which (Senate Bill 5x) was targeted for irrigation districts. The primary goal of SB 5x is to reduce peak period electricity demand. The California Energy Commission (CEC), acting under authority of Section 5(b) of the legislation, developed the "Agricultural Peak Load Reduction Program". The program was announced on June 1, 2001, and Cal Poly ITRC administers the irrigation district portion of the program for CEC. During the first 9 months of implementation, the irrigation districts voluntarily participated in load shifting, utilizing approximately $6.2 million in cost-sharing grant money. In addition, approximately 550 pumps were tested and pump repairs were made, resulting in an estimated savings of 16 million kWh.

PROGRAM OVERVIEW

Legislation and Peak Load Reduction

California Senate Bill 5x ("SB 5x") was enacted in April 2001 as urgency legislation in response to an imbalance in electricity supply and demand in the State. The goal of SB 5x is to reduce peak period electricity demand. The California Energy Commission (CEC), acting under authority of Section 5(b) of the legislation, has developed an Agricultural Peak Load Reduction Program.

One part of the Agricultural Peak Load Demand Program provides incentive grant payments to agricultural irrigation districts to install energy efficient hardware or make other conservation efforts to reduce peak period electricity demand. "Peak Period" is defined as weekdays, excluding holidays, from 12:00 p.m. to 6:00 p.m. during the months of June through September. Cal Poly ITRC administers the irrigation district component of the SB 5x program. The Center for Irrigation

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Technology (CIT) at Fresno State University administers the on-farm component. This paper focuses on the irrigation district program.

Three categories of projects have received grants under this program. The categories are:

1. Category 1. High efficiency electrical equipment and other overall electricity conservation efforts. Projects in this category must reduce peak load. An example project in this category is the construction of a regulating reservoir, into which water is pumped during off-peak hours and from which water flows by gravity during peak hours.
2. Category 2. Pump efficiency testing and retrofit/repair
3. Category 3. Advanced Metering and Telemetry. The majority of these projects were very simple, and paid for equipment that would allow pumps to be shut off as requested by California's Independent System Operator (ISO) Demand Relief Program. Districts participating in the ISO program agreed to shut off pumps if requested, and in return they received electricity at a reduced rate. The CEC program paid for special meters that confirmed the participation in the program, as well as telemetry for remote on/off operation of pumps.

A fourth category – retrofit of natural gas-powered equipment to alternative fuels – has not been utilized by the irrigation districts.

Program Schedule and Cost Sharing

The legislation was passed in April, with the desire to reduce peak electric loads immediately – to avoid summer power brownouts and outages. Contracts between CEC and ITRC were not completed until mid-May. Guidelines needed to be developed, application processes written, quality control measures implemented, verification procedures defined, etc. Obviously, civil works under Category 1 and pump testing/repair under Category 2 could not be implemented within a few weeks of the announcement of the program.

ITRC and CEC had discussed this project since December 2000, because the legislature needed to have some idea of how much money was needed for irrigation districts. ITRC had canvassed the major California irrigation districts for information, and had informed them that this program was in the works. Therefore, many of the districts were ready to act almost immediately – even if the application process had not yet been refined.

The program was originally intended to last until March 2004. However, in March 2002 the funding was reduced to from $10 million to $6.5 million, and December 2002 was declared the last date for applications to be approved. The compression of the program is due to the financial crisis of the state of California – largely due to expensive power purchases by the State.

For projects in Categories 1 and 3, the grant can pay up to 65% of the project cost. The maximum reimbursement per kilowatt load reduction depends upon the date of project implementation – as a means of encouraging quick implementation of the projects. The reimbursement could be up to $350 per kilowatt for projects completed by July 31, 2001, $300 by September 30, 2001, and $250 by May 31, 2002. In reality, the maximum reimbursement has been almost always limited by the 65% cost sharing rule rather than by the dollars per kilowatt.

For Category 2 (pump testing and repair/retrofit) projects, the program reimburses up to 80% of the total pump tests, up to $200 for a "standard" test, and up to $250 for a special test that required two transects of data for flow measurement. For pump repair, up to 65% of the total cost has been reimbursed.

All projects are limited to installations that have existing connected electric load with a history of electricity consumption. Projects are approved on a first come-first served basis. In reality, the demand for the grant money has been less than the dollars available, so the issue of priority hasn't arisen. In addition, ITRC prepared and delivered a new pump test training program and new pump test standards. Pump test companies are required to meet the standards in order to be paid for their services.

Applications and Paperwork

The urgency of resolving the power crisis in California required quick implementation. That, in turn, required a well-defined yet simple application and verification process. Each of the categories of the program was unique, and within each category there were a variety of possibilities that would require different verification procedures.

Category 1: The program was designed as follows for Category 1:

1. Application forms were developed and placed on the ITRC web pages. This work was coordinated with CIT in Fresno, which has a similar program for on-farm and agricultural processing customers.
2. Computational spreadsheets were developed, and example computations for the value of the reimbursement were developed.
3. Districts submitted the application forms directly to ITRC for technical review and determination of eligibility and administrative completeness. This review process has gone quite smoothly, with a minimum number of questions. The districts have done an excellent job of submitting high quality applications. Several consulting engineering firms actively worked with their clients to fill out the applications.
4. ITRC reviewed the applications and defined the steps and data that would be needed for verification.

5. The program administrator for CEC was asked his approval; this approval was given within a few days. The district was given an e-mail approval to proceed – with financial reimbursement pending approval of the final contract.
6. The irrigation district was sent a contract document from ITRC. Technically, the contract was between the district and the Cal Poly Foundation. This is a key aspect to the program – by contracting directly between Cal Poly and the irrigation districts, the typical state paperwork and processing lag times were eliminated.
7. The contract document was signed by the district and returned to ITRC. The project received final approval.
8. Payment of 50% of the estimated incentive grant payment is made after completion of construction and full operations. Copies of all invoices, service contracts, personnel time records, and other relevant information to prove the final installation of the project are required.
9. The final grant payment is made after verification of the project's actual peak period demand reduction. This generally requires one full peak period of operation (June through September) after construction and operation.

In general, the Category 1 application process required a shortened but typical engineering application that provided historical information on peak electricity consumption, a plan for reduction of the peak load, a cost analysis, and agreement for verification. Very few problems were encountered in the program administration.

There were some challenges in determining the proper verification techniques, and in deciding exactly how to compute the eligible kilowatts. For example, if a pump is only operated 5 hours per year during the peak period it cannot receive the same rebate as one operating several hundred hours. Many pumps were not equipped with time-of-use meters to establish a historical basis of peak load usage. Also, 2001 was a dry year, meaning that irrigation districts would pump more during 2001 than they had during previous wetter years. Therefore, if one only looks at historical records one can lose opportunities for savings during a dry year.

Category 2: This category has 2 components:

1. Pump efficiency testing – Financially, this is a simple rebate program. Pump testers are required to follow specified pump efficiency testing requirements, and then submit properly completed paperwork for a rebate. No prior approval by the Grant Administrator to the Pump Owner/Operator is needed. Pump testing has been conducted by irrigation district employees, consulting engineers, and individuals and companies that specialize in pump testing. The paperwork requires completion of a form, as well as photo verification of the actual point of flow rate measurement. This should have been a very simple program, but many of the pump testers were unaccustomed to following rigid pump efficiency testing requirements and were also not used to presenting

their results in a specified manner. Therefore, this category was the most problematic in the entire program. It is discussed in more detail later.

2. Pump repair/retrofit – Prior approval is required for these rebates. Approval requires documentation of certain items, including computations showing the potential rebate, results of pump tests, and/or verification of historical electric power usage. Three options are available for computing the rebate – all of which are limited to a payment of 65% of the repair cost. A very simple EXCEL spreadsheet is available on the ITRC web page, which automatically computes the best rebate option. Table 1 below shows that Options A and C do not require pump tests. Option C assumes that there will be a 25% reduction in kWh due to the pump repair. About 70% of the rebates have fallen under Option C. None of the rebates used Option A. 24% of the rebates were limited by the 65% cost share limit.

Table 1. Data Requirements for Various Pump Repair Rebate Options.

Data Needed	Data Requirements for Each Rebate Option		
	A	B	C
Hours of Peak operation during the summer	*	*	
Pre-repair kW	*	*	*
Post-repair kW	*	*	
Pre-repair pump efficiency		*	
Post-repair pump efficiency		*	
Annual hours of operation			*

Grants are made for pump repairs, pump bowl/impeller lining, motor or pump replacement and other actions to improve pump efficiency (not to include motor rewinding, unless it is necessary for proper operation of a variable frequency drive [VFD] control). Also, well cleaning that reduces draw down and removal/replacement of valves and fittings with high-pressure losses will be considered. To qualify for the incentive for motor replacement the new motor has to be rated "High Efficiency Premium".

Category 3 - Advanced Metering and Telemetry. This program has been extremely simple to implement and verify. It does not require documentation of actual load shifting. It merely requires verification of a contract between the irrigation district and the ISO, and the installation of the equipment.

Overall. All the programs have a built-in "reasonableness" economic safeguard – the cost sharing. The irrigation districts must pay at least 35% of the cost for all Category 1 and pump repair expenses.

PROGRAM RESULTS

The results as of April 2002 are found in Table 2, reflecting encumbered grant funding and peak energy reductions, rather than actual savings to date.

Table 2. SB 5x Results for Irrigation District as of April 2002.

Category	Encumbered $, million	Encumbered kW **Peak** Energy Reduction	$/ peak kW Reduction	**Annual** kWh Reduction
1 – High Efficiency Electrical Equipment/Other Overall Conservation Efforts	1.9	11,000	173	
2 – Pump Efficiency Testing and Pump Retrofit/Repair	2.3			16,000,000
3 – Advanced Metering and Telemetry	1.0	43,700	23	
Totals	5.2	54,700		16,000,000

It is clear that the most cost-effective category is the advanced metering and telemetry. This is the most simple for districts to implement, assuming that they have sufficient pumping capacity and control systems.

While the pump efficiency testing and retrofit/repair category may not result in any peak energy savings, the annual energy savings are large. Blaine Hanson of Univ. of California extension (personal comm.) has documented that typical agricultural pump repairs often do not save power. This is because farmers are often able to pump more water with rebuilt pumps, but they do not reduce the hours of pumping after a pump is rebuilt – they just pump more volume per year. But irrigation district pumps are not operated the same as on-farm pumps. With irrigation districts, there is generally a specified volume of water that must be pumped per year. Therefore, improving pumping plant efficiency truly saves energy in irrigation districts.

PUMP TESTING

Quality Control for Pump Testing

The Category 2 – Pump Testing program component has required the most interaction with participants from an administrative point of view. In particular, several companies and individuals with many years of experience felt that inexperienced testers would not be able to competently test pumps. ITRC was concerned about the quality of pump testing, regardless of who did the testing. This program offered the opportunity to "raise the bar" of pump testing, which was approached in two ways:

1. Pump test training. ITRC developed a 2-day class that has been offered twice. Another is scheduled for the end of summer 2002. The class includes classroom and laboratory activities that focus on safety, obtaining the input kW and power factor, and measuring the flow rates. A complete training manual accompanies the class. While this class is not mandatory, it has been attended by almost all of the pump testers. The class ends with an exam. ITRC and CEC only acknowledge if a person has passed the exam or not; we do not "certify the pump tester". Both inexperienced and experienced pump testers passed the exam; likewise, both inexperienced and experienced pump testers failed the exam.
2. Development of strong requirements for pump testing and reporting. Working with experienced pump testers, criteria were developed for the testing of flow rates in pipelines. Specifically, we developed criteria for various upstream conditions (check valve, elbow, etc.) and stated that within a certain distance downstream no test would be acceptable; within another distance range, 2 transects would be needed with a Collins tube or Hall tube or acoustical device; beyond that range, 1 velocity transect would be sufficient. Applications for rebates must be accompanied by photos of the test section, and by the field data.

Pump Test Results

As of March 2002, 554 pumps had been tested in 22 irrigation districts. The average overall pumping plant efficiency (including motor and impeller, but neglecting any column losses [which are typically small for irrigation district pumps]) was 59%. When weighted by horsepower, the average weighted efficiency was 67% – quite high.

Figure 1 shows the range of reported overall pumping plant efficiencies (OPPE). Some of the first tests results were unrealistically high – certainly indicating the need for the improved pumping standards and training that were incorporated by the end of the summer 2001.

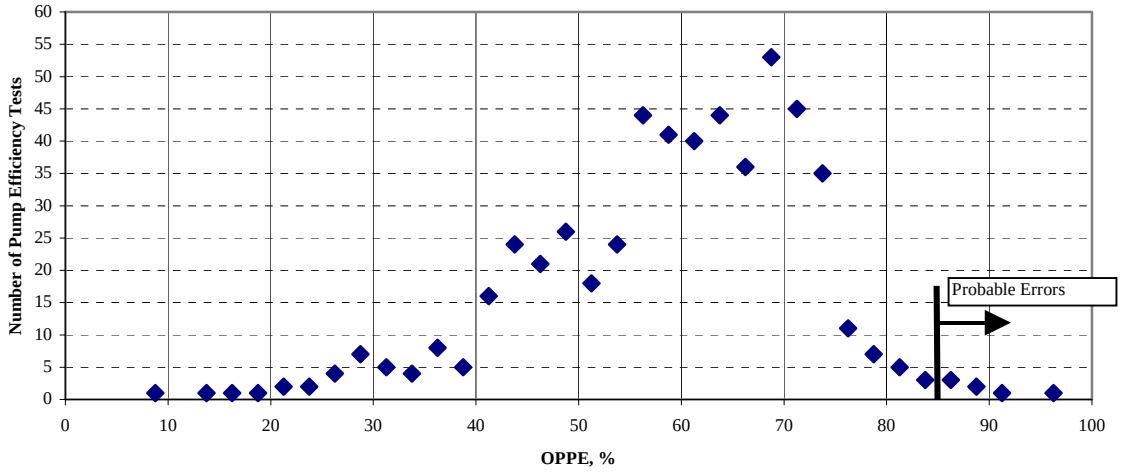

Fig. 1. Frequency of Distribution of Tests by Overall Pumping Plant Efficiency (OPPE).

Figure 2 displays the range of pump sizes that were tested. While the average kW was 125, it can be seen that some of the districts have very large pumps, and there is also an abundance of small pumps.

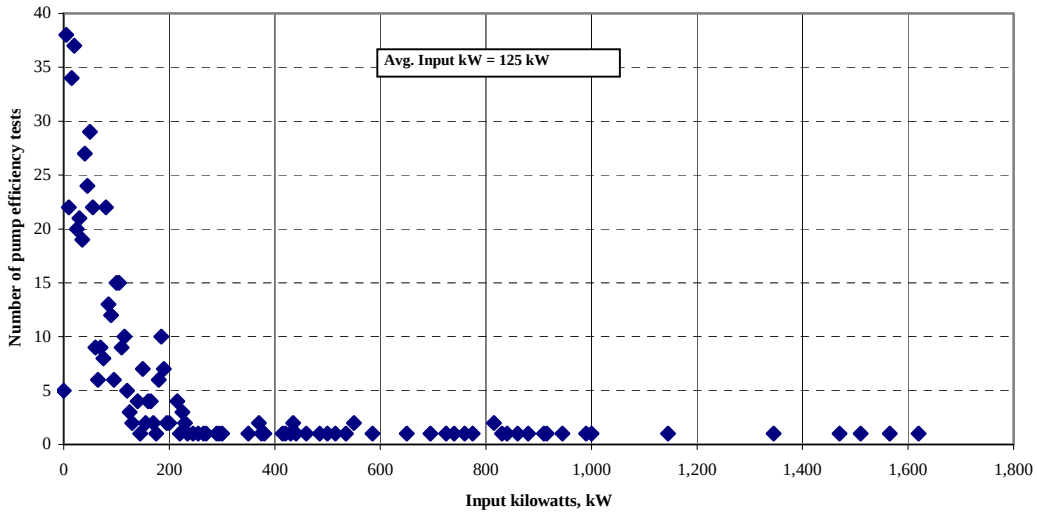

Fig. 2. Number of Pump Efficiency Tests Per Range of Input Kilowatts.

Five hundred nineteen (519) of the 554 pumps tested had less than 75% OPPE – a number we estimate is a reasonable goal for OPPE. If all of these 519 pumps were repaired and brought up to 75% OPPE, a net savings of 9,030 kW would be achieved – assuming no change in flow rate or in total dynamic head (TDH). The distribution of potential energy savings for these 519 pumps is shown in Figure 3. Figure 3 does not show 1 pump each of 81, 102, 141, 144, 150, 177, 186, 230, 353, and 296 kW.

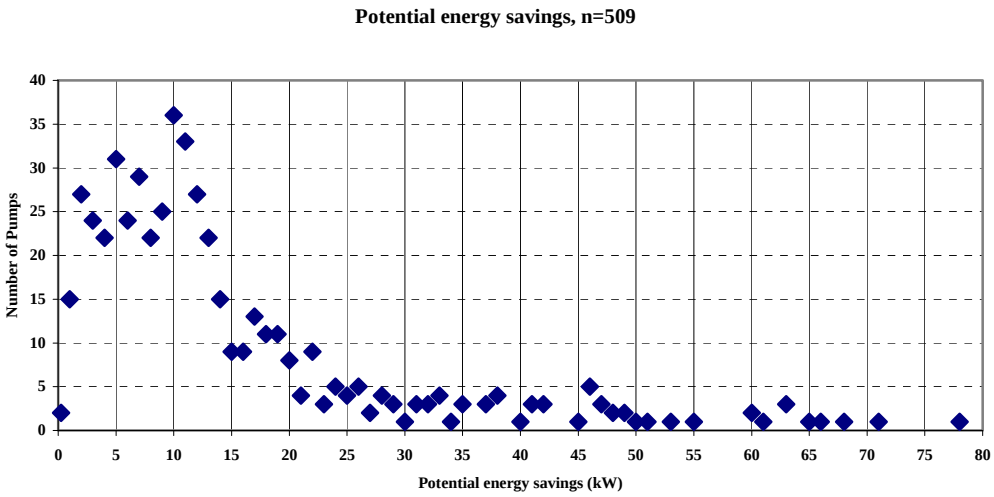

Fig. 3. Potential Energy Savings Resulting from Pump Repairs on the Smallest 509 of the 519 Pumps of Less Than 80 kW.

FINAL NOTES

The program was launched quickly and has resulted in major reductions in peak electrical load consumption by irrigation districts. The actual load reduction exceeded the expectations. However, there was less dollar demand (less participation) than expected. The lower-than-anticipated participation is probably due to these factors:

1. The short lead time for the program was unrealistic for many districts. Some districts have projects with considerable potential for load shifting, but the projects would require construction permits, decisions by the district Boards of Directors, design, etc.
2. The 65% cost sharing is substantial, but so is the remaining 35% cost sharing. The 35% is more than some districts can afford, even if the projects have a 3- or 5-year payback. Prices for many agricultural commodities are at record or near-record lows. Farmers and districts often only invest in projects with immediate or one-year paybacks.
3. The Category 1 projects required innovative solutions, and for some districts the innovations could not be conceptualized or appreciated.
4. Some irrigation districts that could have participated receive extremely inexpensive power from the Western Area Power Administration (WAPA), so there was little apparent incentive to participate.

Districts that participated in Category 1 projects were quite enthusiastic. The electricity bills for these districts were typically substantial. This program provided a relatively inexpensive path to achieving long-term savings through reduced power rates (because they will no longer use electricity during peak hours).

We had anticipated that districts would be able to organize farmers along pipeline or canal laterals to shut off their pumps during peak hours. This would result in removing both irrigation district and farmer pumps from the peak demand. It has high potential in areas with pumped pipeline laterals serving drip systems. This was just too difficult for districts to organize by the beginning of the 2001 summer irrigation season.

For Category 2, the new pump testing requirements have helped to improve the quality of future pump testing programs. Prior to this program, pump testers had little or no external quality control constraints.

Detailed information on this program can be obtained by accessing ITRC's web page (www.itrc.org) and then selecting the "CEC Agricultural Peak Load Reduction Program".