# Economic Incentives and the Timing of Investments in Energy Conservation: The Case of California Agriculture

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**ABSTRACT**

The public sector's effectiveness in promoting energy conservation ultimately depends on its ability to match its messages and programs to the profit maximization objectives of firms. However, if firms are not aware of public programs, they cannot act to maximize profits by participating in them. In order to explore how important awareness is in the participation in these programs, we analyze participation in an agricultural energy peak-load reduction program implemented in California during 2001 and 2002. By dividing the firms into different sectors, we consider the influence of program awareness on the firms' decisions, while controlling for other factors. The results suggest that program awareness is an important factor in participation.

## Introduction

A cold winter, low Sierra snowpack, energy production offline for maintenance and low electricity production in surrounding states contributed to an energy crisis in the winter of 1999-2000 in California. Energy shortages that resulted in brownouts and rolling blackouts throughout California prompted the California Senate and Assembly to pass emergency legislation Senate Bill 5x (California State Senate 2001) and Assembly Bill 29x (California State Assemble 2001) designed to reduce the likelihood of similar shortages occurring during the summer, when high temperatures and agricultural production contribute to higher demands for electricity. The Bills were passed in April 2001, and the programs began in June, 2001. This short implementation time reflects the "emergency" nature of the legislation, reflected in the "x" numbering of the Bills.

The Bills provided incentives for firms to undertake pump testing, natural gas retrofits, telemetry installation and energy conservation investments. The program accepted applications from 350 firms between June 1, 2001 and May 30, 2002. Those firms removed 4,652 kW from the peak load by installing new telemetry devices and making other investments in energy conservation.

The economic incentives included in the Peak Load Reduction Program and the data describing participation provide a unique opportunity to examine firm-level responsiveness to an incentive-based energy conservation program. Firms that chose to reduce energy demand earliest in the program received \$350 per kilowatt, while firms participating later received either \$300 or \$250 per kilowatt. Most firms participated late in the program and spent almost \$100 more per kilowatt than firms who participated early. One explanation for the late participation is that firms did not know about the program. This is plausible because the program was legislatively restricted from allocating funds to education activities. That task was assigned to a different organization. A second explanation is that the agricultural firms targeted by the program were not willing to incur the transaction costs of program application or the opportunity costs involved in shutting down a production facility in order to install new technology or to modify a device according to the retrofitting requirements of the program.

The objectives of this paper are to explore the impact of incentive size on firm investment timing and to illustrate the potential impact of program awareness and the agricultural production cycle on participation in energy conservation programs. We provide a conceptual background regarding energy policy and firm conservation investments before describing the rules and goals of the Agricultural Peak Load Reduction Program. We summarize the data describing program participation and we propose several hypotheses that might explain the observations regarding participation.

## Conceptual Framework

Public officials faced with an imbalance between supply and demand for electricity can implement policies that either increase supply or reduce demand. One method for reducing demand is to implement rolling blackouts and brownouts. That policy can be very costly, given the potential impacts on public safety, commerce, and personal inconvenience. Shifting load to other times of the day by encouraging firms and consumers to modify their energy use patterns also can reduce peak load demand. Load shifting is one goal of California's Agricultural Peak Load Reduction Program. The imbalance between electricity supply and demand also can be addressed by increasing energy supply, perhaps by constructing "peaker plants" that are small-scale generating facilities that are used only during peak demand periods. The average cost of constructing a peaker plant is $350/kW (Wiens 2003). That cost provides a benchmark for comparing alternative energy programs that address either supply or demand management. For example, it would be less costly for California to implement energy conservation measures that make electricity available for less than $350/kW.

Firms make investment and production decisions in order to maximize profits (Varian 1992). Profit maximization is consistent with minimizing input costs for a given level of production. One important input is energy. The cost of energy, particularly in California, is an increasingly important factor in production decisions. Investments in energy conservation enable firms to offset the burden of higher electricity prices. Profit-maximizing firms will invest in energy conservation when the expected present value of savings in electricity costs, over time, and any rebates received for implementing a conservation strategy, are greater than the cost of the investment, while considering also any adjustment and transaction costs.

We examine firm-level investment decisions by comparing the expected present value of annual savings and the conservation rebate with all pertinent costs, as described by the following equation, where *t* represents a year and *r* is the appropriate discount rate:

$$\sum_{t=0}^{T}\left(\frac{annual\_savings}{(1+r)^t}\right)+rebate \geq \text{Investment Cost + Adjustment and Transaction Costs}$$

The rebate equals the state-sponsored energy conservation incentives, while the value of energy savings reflects the decrease in future energy spending as a result of the investment.

Pertinent costs include both explicit and implicit firm costs. Explicit costs represent the expenditure for the conservation investment, while implicit costs include adjustment and transaction costs such as program application time, facility downtime, and business interruption for equipment installation. A "rational" firm will not invest in conservation if the expected present value of energy savings and rebate is smaller than the sum of all pertinent costs. The literature regarding firm-level investments in conservation suggests that awareness, capital availability and the business cycle are important factors in those decisions (Shogren 1995; Nadel 2000; Bouman 2000; Burnes and Hays 2003).

The public sector contributes to firm willingness to invest in conservation by providing education and capital (Shogren 1995). Awareness includes technological information, needs assessment, and the promotion of conservation programs and opportunities. The public sector's effectiveness in promoting conservation ultimately depends on its ability to match its messages and programs to firms' profit maximization objectives.

## The Program

Senate Bill 5x provided $654.6 million for education, program administration, metering, and energy conservation to reduce electricity demand in California. The Agricultural Peak Load Reduction Program received $70 million to offer firms incentives to participate in a range of energy programs. The California Energy Commission managed the Program, which offered grants to agricultural growers, packers and processors for removing demand (load) from the system during the peak period: 12-6 pm, Monday through Friday, June through September.

The program offered grant money for investment in high-efficiency electrical equipment and other electricity conservation equipment (Category One), pump efficiency testing, retrofitting and repair (Category Two), advanced metering and telemetry (Category Three) and retrofitting of natural gas powered equipment to alternative fuels (Category Four). Firms eligible for the program included: confined animal feeding operations, greenhouses/nurseries, food processors, cold storage and refrigerated warehouses for agricultural commodities, agricultural and commodity non-profit organizations serving agricultural customers (e.g. marketing cooperatives and trusts). Ineligible firms or projects include California investor owned utilities, projects that have previously received grants funded by the public goods charge (an alternate state program that funds equipment retrofit, repair, upgrade and efficiency testing), projects that impact management rather than the physical plant, maintenance programs, electricity generation or co-generation from fossil fuels, new construction and fuel switching, except as noted under category one or four.

### Rules and Rebates

Grant eligibility was retroactive to January 1, 2001. To encourage peak load reduction prior to the summer demand, grant rebates were adjusted to motivate early investment. The grant schedule for categories one and three (conservation and telemetry) was:

- Projects completed by July 31, 2001 received $350/peak load kilowatt reduced.
- Projects completed after July 31, 2001, and before September 30, 2001 received $300/peak load kilowatt reduced.
- Projects completed after September 30, 2001 receive $250/peak load kilowatt reduced.

Program participants were given 50% of the grant money at the time that projects became operational, with the additional money allocated after verifying the reduction in peak load demand. Firms are eligible to receive up to 65% of the cost of their investment.

The application process consists of five steps, followed by construction, verification, and grant payments. Application forms submitted to the grant administrator are evaluated for eligibility, and technical and administrative completeness. Requests for more information are made if necessary to calculate expected kilowatt reductions and to determine investment costs. The grant administrator makes a final determination based on prioritization criteria, and contracts are mailed to successful applicants. At any point during the application and acceptance process, the grant may be rejected or withdrawn.

## Data and Methods

We collected data from 350 accepted grant applications for the California Agricultural Peak Load Reduction program. We evaluate participation in Category One of the program: energy conservation. These projects cover the installation of high-efficiency electrical equipment and other energy conservation efforts. The data used in this study are broadly grouped by participation category, application time, and agricultural sector.

Table 1 provides summary statistics of total program applications by category, time and sector. With respect to time, early investors completed the project by July 31, 2001, middle investors completed the project between August 1, 2001 and September 30, 2001 and late investors completed the project after September 30, 2001.

The industry sectors that we identified for this study are broadly represented as producers, processors and dairies. The producers include row crops, vineyards, orchards, nurseries and livestock. The processors represent firms including wineries, cotton gins, canners and dryers. We separate dairies from other producers because of significant differences in timing and energy conservation opportunities.

**Table 1. Summary of Data Describing the Agricultural Peak Load Reduction Program 2001-2002**

| A. Applications Reviewed by Category | | | |
|---|---|---|---|
| **Category** | **Description** | **Number of Applications** | |
| Category One | Energy Conservation | 116 | |
| Category Two | Pump Testing | 187 | |
| Category Three | Telemetry | 11 | |
| Category Four | Natural Gas Retrofit | 36 | |
| Total | | 350 | |
| | | | |
| B. Applications Reviewed by Time of Application | | | |
| **Time** | **Description** | **Number of Applications** | |
| Early | June1 - July 31, 2001 | 83 | |
| Middle | Aug. 1 - Sept. 30, 2001 | 30 | |
| Late | Oct. 1 - May 31, 2002 | 237 | |
| | | | |
| C. Applications Reviewed by Sector | | | |
| **Sector** | | **Number of Applications** | |
| Processors | | 240 | |
| Producers | | 86 | |
| Dairies | | 24 | |

## Program Participation

We consider only the 116 firms participating in Category One, investments in energy efficiency and conservation. Table 2 depicts the summary statistics for all 116 firms, arranged according to the time at which the conservation investments were made. Key variables include the number of kilowatts reduced, the dollars invested, the mean and median values of those variables.

**Table 2. Summary of Participation Statistics over Time**

| Time | Number of firms | kW Reduced | $ invested | $/kW (mean) | $/kW (median) | $/firm (mean) | $/firm (median) | kW/firm (mean) | kW/firm (median) |
|---|---|---|---|---|---|---|---|---|---|
| Early | 37 | 2,163 | 1,833,382 | 848 | 564 | 49,551 | 13,000 | 58 | 32 |
| Middle | 9 | 1,776 | 1,437,293 | 809 | 958 | 159,699 | 33,000 | 197 | 958 |
| Late | 70 | 3,589 | 3,854,281 | 1,074 | 919 | 55,061 | 15,958 | 51 | 16 |
| Total | 116 | 7,528 | 7,124,956 | 946 | | 61,422 | | 65 | |

Table 3 depicts the summary statistics for all 116 firms, arranged by the sector in which the firms operate (processors, producers, and dairies).

**Table 3. Summary Statistics by Sector**

| Sector | Number of firms | kW Reduced | $ invested | $/kW (mean) | $/kW (median) | $/firm (mean) | $/firm (median) | kW/firm (mean) | kW/firm (median) |
|---|---|---|---|---|---|---|---|---|---|
| Processors | 43 | 4,854 | 5,184,421 | 1,068 | 936 | 120,568 | 41,632 | 113 | 53 |
| Producers | 54 | 2,431 | 1,614,828 | 664 | 390 | 29,904 | 4,025 | 45 | 25 |
| Dairy | 19 | 243 | 325,707 | 1,340 | 1,304 | 17,142 | 15,941 | 13 | 10 |
| Total | 116 | 7,528 | 7,124,956 | 946 | | 61,422 | | 65 | |

We analyze the timing of investment decisions in each sector, using the summary statistics presented in tables 4, 5, and 6.

Table 4. Summary Statistics for the Processing Sector

| Processors | Number of firms | kW Reduced | $ invested | $/kW (mean) | $/kW (median) | $/firm (mean) | $/firm (median) | kW/firm (mean) | kW/firm (median) |
|---|---|---|---|---|---|---|---|---|---|
| Early | 20 | 1,251 | 1,493,634 | 1,194 | 564 | 74,682 | 80,000 | 63 | 82 |
| Middle | 3 | 1,165 | 1,060,362 | 910 | 928 | 353,454 | 41,632 | 388 | 101 |
| Late | 20 | 2,438 | 2,630,425 | 1,079 | 1,321 | 131,521 | 125,687 | 122 | 76 |
| Total | 43 | 4,854 | 5,184,421 | 1,068 | | 120,568 | | 113 | |

Table 5. Summary Statistics for the Producer Sector

| Producers | Number of firms | kW Reduced | $ invested | $/kW (mean) | $/kW (median) | $/firm (mean) | $/firm (median) | kW/firm (mean) | kW/firm (median) |
|---|---|---|---|---|---|---|---|---|---|
| Early | 16 | 905 | 318,675 | 352 | 148 | 19,917 | 2,525 | 57 | 46 |
| Middle | 3 | 559 | 298,865 | 535 | 157 | 99,622 | 52,000 | 186 | 122 |
| Late | 35 | 967 | 997,288 | 1,031 | 390 | 28,494 | 4,332 | 28 | 11 |
| Total | 54 | 2,431 | 1,614,828 | 664 | | 29,904 | | 45 | |

Table 6. Summary Statistics for the Dairy Sector

| Early | Number of firms | kW Reduced | $ invested | $/kW (mean) | $/kW (median) | $/firm (mean) | $/firm (median) | kW/firm (mean) | kW/firm (median) |
|---|---|---|---|---|---|---|---|---|---|
| Early | 1 | 7 | 21,073 | 2,907 | 2,907 | 21,073 | 21,073 | 7 | 7 |
| Middle | 3 | 52 | 78,066 | 1,573 | 1,737 | 26,022 | 28,968 | 17 | 19 |
| Late | 15 | 184 | 226,568 | 1,299 | 1,286 | 15,105 | 15,000 | 12 | 10 |
| Total | 19 | 243 | 325,707 | 1,340 | | 17,142 | | 13 | |

## Analysis

We show both the mean and median numbers for dollars per kilowatt, dollars per firm, and kilowatts per firm because we have a small number of observations in some sectors, and there is considerable heterogeneity among the participants. Some participants are from small, family-owned businesses while others are large corporations.

Processors and producers removed more expensive kilowatts later in the program (Tables 4 and 5). On average, processors removed more kilowatts per firm later in the program than producers or dairies. The median kilowatts removed late in the program were 2.3 times as expensive as those removed earlier ($1,321/kW vs. $564/kW). The median expenditure per processor was 1.5 times higher in the late period as compared with the early period ($125,687/firm vs. $80,000/firm). Yet, the median kilowatt reduction per firm declined 7% (from 82 kW/firm to 76 kW/firm).

The median expenditure per kilowatt reduced by the late participants was 2.6 times more than the median expenditure by the early participants ($390/kW vs. $148/kW). Further, the median late firm removed one quarter as many kilowatts as early investors as a result of their participation. Yet, the median kilowatt reduction per firm declined 76% (from 46 kW/firm to 11 kW/firm).

The dairy information (Table 6) is less useful given the low number of observations. The median expenditure per kilowatt reduced by late participants in the dairy sector ($1,386/kW) is similar to that of late participants in the processing sector ($1,321/kW) and is 3.3 times the median expenditure by late participants in the producer sector ($390/kW). This may reflect the similarity of conservation investments between dairies share and other processors. These median values may also suggest a contrast between the investments made by producers with respect to dairies and processors.

Processors and producers show higher median expenditure per kilowatt removed in the late period as compared with the early and middle periods even though the rebates were $100/kW less in the late period. This may reflect the pace at which firms gained awareness of the program. It may also reflect the transaction and adjustments costs and capital constraints faced by firms.

## Conclusions

Bouman et al (2000) note that the business cycle plays an important role in firms' decisions to invest in facility retrofits. While those authors consider pollution abatement, their methods are applicable to this energy conservation setting. They suggest that in order to induce optimal investment timing, the government needs to announce programmatic changes with sufficient lead-time. Otherwise, firms are forced to suffer production shortfalls to make the necessary changes.

Shogren (1995) indicates that capital availability and information are two key components of successful energy conservation program participation. The Agricultural Peak Load Reduction Program, provided a portion of the capital required for energy conservation investments.

Dairies provide potentially useful insight regarding the issue of program awareness. We would expect dairies, *ceteris paribus* to remove a greater number of kilowatts sooner. While we note that one explanation for this could be greater expectations of future energy costs savings, other authors, suggest that profit maximization assumptions may not always be accurate (DeCanio 1998).

However, firms can only make optimal decisions when they have accurate and timely information. In the case of this program, the information that many firms faced was program awareness, which refers to firms' knowledge of both the program and the available conservation technologies. While we cannot speak to the latter, the former proved to be one of the greater challenges of the Agricultural Peak Load Reduction Program. First, there were only six weeks between program inception and implementation. Second, a separate program was responsible for program notification and statewide peak load reduction education.

Thus, while we find that firms did not minimize their energy conservation costs at first glance, other factors such as timing and information suggest that firms may have responded optimally given their investment environment. A more careful look reveals that program timing was a factor in the willingness to participate in this energy conservation program. Furthermore, the investment pattern in the processing and dairy sectors suggests that lack of information may have been an issue in the investment timing decision.

Although not evaluated in this report, load switching investment incentives, in addition to those for conservation investments, also were available to firms. Nevertheless, firms showed a preference for investing in energy conservation. This, and the fact that firms participated in the program, even with the lower rebate, suggests that agricultural producers are willing to invest in energy conservation. In fact, we notice that firms are willing to spend more on conservation investments than the available rebate. This suggests that the overall impact on energy expenditures may also be a decision criterion for the firm. Since the energy savings from installing energy efficient equipment accrue whenever the equipment is utilized, this savings may motivate the conservation investment. An area for future research is to evaluate the energy prices faced by the participating firms and estimate the total benefits of program participation not only due to subsidies, but also to energy cost savings.

As this study suggests, program timing and information may be needed to ensure the success of future programs. Additionally, informing the firms of the opportunities for conservation within their facilities also will be an important aspect of these programs.

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