Final Report

Evaluation of the Energy Efficiency Services for Electricity Consumption and Demand Reduction in Oil Production Program

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Executive Summary

This report presents an evaluation of Global Energy Partners' (Global's) Electricity Consumption and Demand Reduction in Oil Production Program (the Program) for the State of California. The evaluation was conducted in accordance with the requirements of the California Public Utilities Commission (CPUC).

The Program is a non-utility incentive program serving small to medium oil producers in the Southern California Edison (SCE) service area. Global's goal was to design a total service package including technical assistance and a financial incentive to help overcome the barriers to customer participation.

The primary goal of the evaluation Quantec conducted was to provide an assessment of the level of performance and success of the Program. This was achieved through two activity areas: implementation efficiency and cost efficiency.

This report presents the findings from the evaluations in these two areas and overall Program findings and recommendations.

Implementation Efficiency Findings

Our implementation efficiency findings were based on a review of relevant Program materials and a series of interviews conducted with participating and non-participating oil producers, the Program primary implementer, and vendors

Global leveraged the efforts of a prior program to identify potential Program participants and was able to be selective about its marketing and outreach activities. This appeared to have been an effective strategy.

Our findings indicate that multiple channels and media are needed to reach these businesses. Industry associations, vendors, and direct marketing were effective channels with different producers. The Program Web site received mixed reviews, but Program workshops generally received good ratings.

Despite the generally positive reviews of Global's outreach, there were a few shortcomings in the communications between Global and the oil producers. Over time, as Program details were better communicated and Global gained the confidence of this industry, these problems were mitigated.

The incentives were the main reason producers decided to participate in the Program and make upgrades. Most viewed the incentive application process as very easy and were satisfied with the incentive level. Vendors believed the incentives were very important and that they were sufficient to push most producers ahead with projects.

Participants usually felt that energy savings estimated by Program audits were credible and useful.

Vendors played an important role in the success of the Program. Global perceived the vendors as effective allies for promoting the Program and adding credibility to Global's efforts. However, Global found it difficult to involve vendors who maintained a consistent role in the Program.

Our initial non-participant interviews and Global's own experiences identified several participation barriers fairly early in the Program:

- Lack of time
- Uncertainty about the performance of energy-efficiency upgrades
- A conflict between the Program schedule and producers' capital budgeting cycles

Global responded to this early feedback by taking steps to alleviate some of these barriers.

Energy-efficiency awareness and knowledge increased overall, albeit a modest amount, for both participating and non-participating producers as a result of the Program. The interest of some non-participants and participants in future efficiency upgrades increased, thus suggesting that future behavioral changes are a likely result of the Program.

One area that did not receive very much attention during the Program, but could be a useful area to explore in future programs, is non-energy benefits of efficiency upgrades.

Overall, participating producers and vendors indicated high levels of satisfaction with the Program. Both groups gave Global good marks for effective implementation and noted that Global had demonstrated a strong ability to learn about the industry rapidly and establish credibility.

Cost Efficiency Findings

Because of the variety of efficiency measures implemented and the types of data available for each well and project, Global used several different methodologies to calculate energy and demand savings. The basic method we used to estimate the achieved energy and demand savings for each project was based on the data and approach that Global used. For each project, we reviewed the assumptions and methodology details applied by Global. Where we determined that the approach or inputs should be modified, as described in this report, we recalculated the energy and demand savings.

A total of ten producers participated in the Program, and they implemented efficiency measures on 137 individual wells or sites. We analyzed each of the individual cases and aggregated results by participant and designated each as a "project."

The results for the Program overall are shown in Table ES.1. The realization rate (achieved savings divided by incented savings) was calculated for each project and for the Program as a whole. The incented gross energy and demand savings, realization rates, and our estimated achieved gross savings are presented.

Table ES.1: Estimated Gross Savings and Realization Rates

Incented Savings		Realization Rate		Achieved Savings	
kWh/yr	kW	kWh/yr	kW	kWh/yr	kW
15,701,808	2,160	91%	76%	14,283,232	1,624

Net Program impacts are determined as the product of the gross impacts and an assumed net-to-gross ratio of 0.8. The net savings are shown in Table ES.2. Based on our study and Program implementation experiences, however, we believe a value closer to 1.0 would be more realistic since it appeared to be very unlikely that these projects would have occurred without this Program.

Table ES.2: Net Savings Impacts

Achieved Savings	
kWh/yr	kW
11,426,586	1,299

Table ES.3 shows the quantitative targets that Global established for this Program and the achievements in each area.

Table ES.3: Program Performance Targets and Achievements

	Customers Contacted	Qualifica-tion Surveys	Energy Audits	Work-shops	Wells/Sites Certified	Net Energy Savings (kWh/year)	Net Demand Savings (kW)
Target	400	300	220	2	200	12,334,080	1,760
Achieved	5,465	385	147	2	137	11,426,586	1,299
% of Target	1,366%	128%	67%	100%	69%	93%	74%

Cost Effectiveness Results

Program cost effectiveness was determined using the Total Resource Cost (TRC) and Participant Cost tests. Results are shown in Table ES.4. They demonstrate that the Program was cost effective under both tests.

Table ES.4: Cost Effectiveness Test Results

TRC Test Value	Participant Cost Test Value
1.79	3.2

Recommendations

This report provides several recommendations for ways this or future similar programs could be improved. It also suggests that there is a continuing need for such programs since there is a significant energy savings potential in this market, and these producers have a strong interest in improving their energy efficiency.

I. Introduction

This report presents Quantec's evaluation of Global Energy Partners' (Global) Electricity Consumption and Demand Reduction in Oil Production Program (the Program) for the State of California. The evaluation was conducted in accordance with the requirements of the California Public Utilities Commission (CPUC).

Program Description

The Program is a non-utility incentive program serving the non-residential process overhaul market segment in the Southern California Edison (SCE) service area, specifically Los Angeles, Long Beach, and Ventura. The specific target market is the small and medium sized on-shore oil producers that are in need of information and incentives to reduce their energy costs. The initial term of the project was 19 months, through December 2003, with a final report due in March 2004; Global requested and received a three-month schedule extension from the CPUC.

Global's goal was to design a total service package including technical assistance and a financial incentive to help overcome the barriers to customer participation including implementation costs, information gaps, lack of design expertise, and lack of time to arrange the transaction. Global's package included energy audits, education and training, design assistance, installation assistance, and an incentive equal to $0.08 per first-year kilowatt hours (kWh) saved, but not to exceed 50% of the installed cost of efficiency measures. The following is an initial list of eligible measures that were anticipated to be included in the Program:

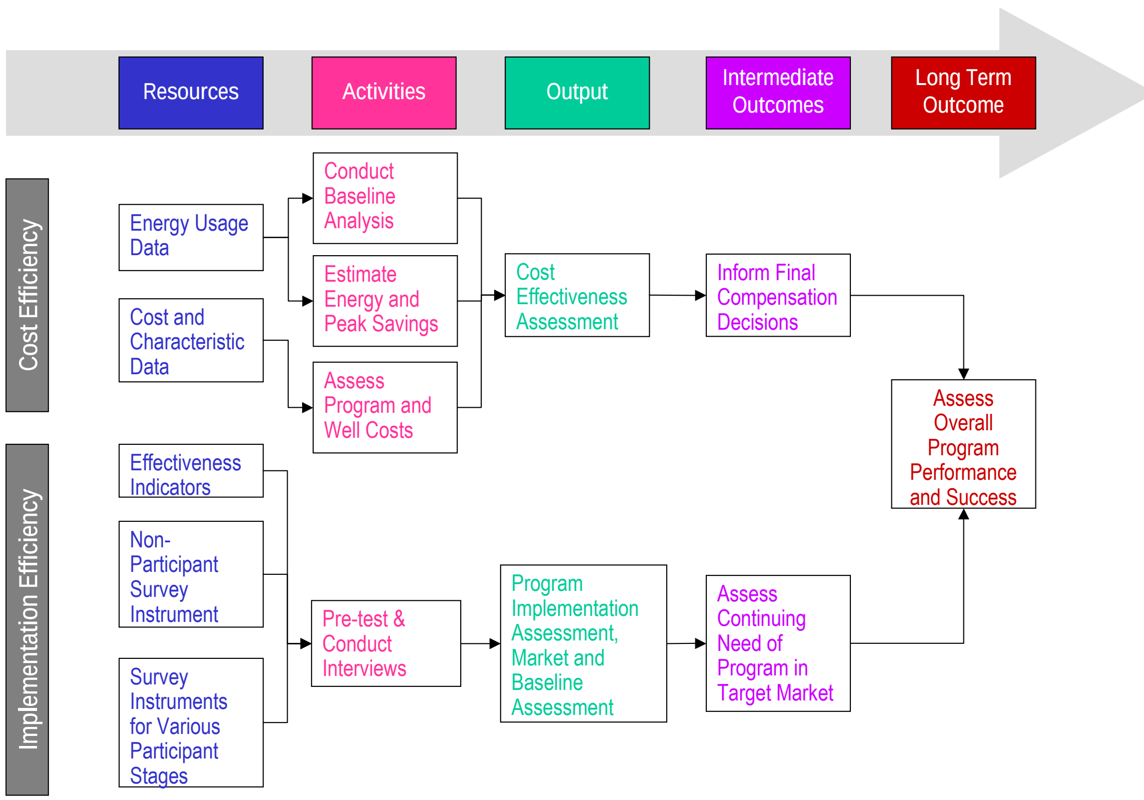
- Well pumping optimization through pump-off controllers and variable frequency drives
- Load balancing on rod pumps
- Proper sizing of water injection pumps
- Variable frequency prime movers
- Optimization of fluid cooling systems
- Specification of premium efficiency motors

During the course of the Program, some of these measures were not implemented and others were added.

Evaluation Overview

The primary goal of this evaluation was to provide an assessment of the level of performance and success of the Program. This was achieved through two activity areas: cost efficiency and implementation efficiency. Our methodology is outlined in the logic model below (Figure I.1). A logic model is a diagram that describes the logical relationships among program evaluation elements and shows how the various pieces – resources, activities, output, intermediate outcomes, and long-term outcomes – fit together. This figure includes the requirements outlined in Section 6 of the CPUC's Energy Efficiency Policy Manual.

Figure I.1: Logic Model



This report discusses our evaluation approach, findings, conclusions, and recommendations.

II. Evaluation Approach

Evaluation activities were focused in two areas: implementation efficiency and cost efficiency. The assessment of implementation efficiency addressed the process elements of the Program and qualitative issues such as awareness and satisfaction levels of participants. The assessment of cost efficiency targeted the cost effectiveness of the Program; consequently, it addressed Program costs, efficiency measure costs, energy savings, and other benefits.

Our approach to investigate implementation efficiency is discussed first. This is followed by a discussion of the approach used to assess cost efficiency.

Implementation Efficiency

Purposes of the implementation efficiency evaluation included the following:

- Provide baseline market information relevant to this Program
- Provide early feedback on the effectiveness of the Program and information on changes that might improve effectiveness
- Assess continuing need for the Program

Data Collection

Data for this task came primarily from three sources: Global's Program tracking information, market information from Global and other sources, and surveys we conducted with participating and non-participating oil producers, the Program primary implementer, and vendors.

We obtained Global's quarterly reports and other intermediate products to assess progress toward meeting the Program goals.

The market information sources we reviewed included the following:

- "Case Studies of Rod Pump Optimization using CPUC Oil Rebate Program," presentation by Russ Goold and Mark Reedy, Global Energy Partners
- "Cost Benefit Analysis of Rod Pump Optimization," presentation by Bettina Foster, Mark Reedy, and Russ Goold, Global Energy Partners
- "Oilfield Electric Consumption Survey," presentation by Carl Miller, EPRI PEAC and Iraj Ershaghi, University of Southern California, July 19, 2001

- "Showcase Demonstrations – The Challenge: Improving the Performance of Oil Well Pumping Units," U.S. Department of Energy, http://oit.doe.gov/best practices/motors/mc-cs09.html
- "Electrical Power Cost Reduction Methods in Oil and Gas Fields," Petroleum Technology Transfer Council, http://www.pttc.org/solutions/24.htm
- "A Comparison of the Energy Efficiency of Various Types of Artificial Lift Systems," Oil and Gas Automation Solutions Issue *#2*, http://www.unicous.com/oilgas/solutions002.html, August 8, 2003
- "Petroleum Industry Profile," California Energy Commission, http://www.energy.ca.gov/pier/indust/petro-industry.html

We interviewed both participating and non-participating oil producers in the Program area to characterize them and obtain their feedback on the Program. The original plan was to conduct a first round of interviews with 15 producers in the second quarter of 2003, split approximately equally between participants and non-participants. Global informed us, however, that no producers had proceeded very far into the Program at that point in time, so we revised our plan and interviewed just non-participants during the first interview phase.

Between April and October 2003, we completed interviews with seven non-participants selected randomly from a list of more than 200 that Global had contacted about the Program. At the time of the interviews, these producers had not participated, but since there was the possibility that some might choose to participate later, the interviews included questions about the participation decision. The topic areas covered included

- Awareness of the Program
- Assessment of Program Web site and other materials
- Perceptions about advantages/disadvantages of the Program
- Status of decision to participate in the Program and factors affecting decision
- Energy-efficiency improvements
- Recommendations for improving the Program

Once a sufficient number of producers had participated in the Program, we prepared an interview instrument and conducted telephone interviews in April and May 2004 with six producers with 94 wells enrolled in the Program. Topics covered in these interviews included those discussed with non-participants plus

- Assessment of the information provided by vendors who installed the efficiency measures

- Satisfaction with the financial incentive
- Effect of Program participation on future efficiency improvements

In May 2004, we interviewed two vendors who participated in the Program. The interviews were designed to help characterize this market, gain insights into the role played by vendors, assess the extent of market transformation caused by the Program, and the need for continuing the Program.

We also interviewed the main Program implementer from Global to gain his insights into the strengths and weaknesses of the Program and how it has been and could be improved.

Information Review and Data Analysis

Based on the Program report information provided by Global and our implementation and cost efficiency analyses, we assessed progress toward meeting the Program goals. Global's Program Performance Goals were identified in their Program Implementation Plan (PIP), including specific numbers of contacts, audits, surveys, and workshops to be completed as well as energy savings to be achieved.

We reviewed the market documents and presentation materials listed above to extract information about the oil producer market in California, especially the smaller producers targeted by this Program. This information was summarized to provide specific market characteristics information.

The telephone interview data were entered into an Excel spreadsheet. Analysis consisted primarily of tabulations of the responses, assessment of consistency across respondents, and extraction of key observations.

The number of participating producers we interviewed was relatively large compared to the participant population so the findings for this group are statistically valid for the entire group. On the other hand, the number of non-participating producers we interviewed was relatively small. As a result, we present a count of responses to the different interview questions, rather than the percent of responses. Also, with the small sample size, the findings for non-participants must be qualified as indicative of the non-participant group, rather than statistically valid findings for all non-participants.

These information sources were synthesized to provide findings on Program implementation and the market baseline. We also analyzed this information to determine whether it can be expected that the oil well efficiency upgrades will continue due to the training, marketing, and workshops associated with the Program after the rebate funds have been expended, including any spillover for non-participants.

Cost Efficiency

Purposes of the cost-efficiency evaluation included the following:

- Assess Global's energy savings estimation methodology
- Calculate the energy and peak demand savings for the Program, according to Option B of the International Performance Measurement and Verification Protocol (IPMVP) Manual using pre and post measure installation information provided by Global
- Analyze the Program's cost effectiveness using the methodology specified by the CPUC
- Inform decisions regarding compensation and final payments based on comparison of verified energy savings to Program Performance Goals

Data Collection

Several types of data were required to conduct the cost-efficiency analysis. These included:

- Energy usage data
  - Pre-implementation operating conditions
  - Energy and demand usage
  - Post-implementation operating conditions, energy and demand usage
- Well characteristics data
  - Verification, description, and location of installed energy-saving equipment
  - Any impact on production capabilities
- Cost data
  - Costs associated with measures
  - Program administration costs
  - Any costs paid by the well owner
- Avoided cost data
  - Costs required to assess the value of saved energy and demand in the cost effectiveness analysis

Although load shapes can affect cost effectiveness, oil well pumping is typically a continuous operation, so the load shape is relatively flat. Consequently, this factor will not be addressed further.

The energy, well characteristics, and cost data were all provided by Global. The specific project data provided varied by the types of measures installed and site characteristics. We reviewed the data and discussed any questions or issues with Global. The avoided costs were provided in the methodology from the CPUC.

Data Analysis

Energy and Demand Savings. The first analytic step was an early review of the methodologies used by Global to calculate energy and peak savings. Because the types of measures implemented varied by project and the data collected were tailored to each project, it was necessary to review multiple approaches. We examined the calculation spreadsheets for the first two projects. Although these did not cover all possible analysis approaches, they covered a broad range of methods. We had several discussions with Global staff and their technical consultant about the methodologies. A memo presenting our initial findings (see Appendix A) was presented to Global for comments.

One unique and critically important issue about these projects is the potential interaction between the energy savings measures and the production rate of the wells. This is discussed more in the findings discussion in Section IV.

Although we applied the IPMVP Option B methodology to as many projects as possible, the specifics of the method actually employed varied depending on the nature of each project and data that Global was able to collect. Option B stipulates use of engineering calculations and short-term or continuous measurements of the retrofit system. It was not always possible for Global to directly monitor energy data in the field for affected systems. In some cases, utility meter data were used instead. In general, there was no need to stipulate parameters (as permitted under Option A). However, because of the relationship between production rates and some of the measures, it was necessary in some cases to specify certain parameters to try to normalize the pre and post energy consumption estimates.

The relationships among well characteristics, such as top depth, bottom depth, pumping depth, pumping rate, and well life, are very complex and not always well understood. These complications make it difficult to explain and predict how an energy-efficiency improvement will affect them. For some of the projects, one or more of the basic characteristics changed significantly between the pre- and post-implementation periods, but it was not clear if or how the efficiency improvement affected the characteristics. It was even more difficult to predict how the changes would affect the long-term productivity of an oil field and the overall energy required to extract the maximum amount of oil. Global incorporated many of these characteristics in their energy savings calculation methods and, in some cases, we modified the methods for purposes of conducting this evaluation. Our modifications are described later.

In general, the analysis methodologies can be described as follows:

1. Use pre- and post-implementation short-term energy measurements with adjustments for well conditions
2. Use pre- and post-implementation short-term energy measurements with no adjustments for well conditions
3. Use pre- and post-implementation utility meter data for multiple wells

The first method was used for pump motor change-outs to install smaller motors that which increased efficiency. These calculations were the most complete and complex and required the most detailed well data. When oil production data were available, we used the following equation to calculate annual energy savings:

$$\text{Annual energy savings (kWh/yr)} = ((\text{kWh/bbl})_{oil,\ pre} - (\text{kWh/bbl})_{oil,\ post}) \times (\text{bbl}_{oil,\ pre} + \text{bbl}_{oil,\ post})/2 \times 365 \text{ days/yr} \times \text{Availability}$$

Where:

- $\text{kWh/bbl}_{oil,\ pre}$ = pre-implementation kWh required to pump one barrel of oil
- $\text{kWh/bbl}_{oil,\ post}$ = post-implementation kWh required to pump one barrel of oil
- bbl_{oil} = barrels of oil pumped per day
- Availability = percent of time well is not down for maintenance[1]

Our method differed from Global's in three respects as discussed in Appendix A. First, Global incorporated a pumping efficiency metric of kWh per barrel of fluid pumped per 1,000 feet of pumping depth. As a result of our discussions with Global and their technical expert, we feel that it is reasonable to exclude pumping depth, as defined in Global's methodology, and the changes in depth from the energy savings calculation.[2] Second, our calculation is based on the barrels of oil pumped rather than total fluid (water plus oil) pumped. In some wells, the fluid can be more than 90% water. The economic value of the fluid is, of course, determined by oil content, and pumping is not cost-effective if the oil content is too low. Primarily because we believe that oil quantity is the critical economic driver, we feel that it is reasonable to use the amount of oil pumped, instead of total fluid, in the calculations. Third,

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1 This factor was added after our preliminary review of the analyses methodologies to account for typical maintenance downtime. We used an availability of 98% based on "Oilfield Electric Consumption Survey: Objective, Methodology, and Results," presented 7/19/01 by Carl Miller of EPRI and Iraj Ershaghi of USC.

2 We do agree, however, that Global's metric is a good measure of pumping efficiency that can be used to identify candidates for efficiency improvements.

Global's calculation used the total fluid pumped per day *after* project implementation as the basis for calculating energy savings. We believe that the pumping rate could affect the well life because the quantity of oil (or total fluid) in the reservoir would not change with an efficiency improvement, although the pumping rate might. As a result, we use the average of the pre- and post-production rates in our calculation. As noted above, we use the oil, rather than total fluid, production rate.

The second method uses pre and post spot measurements of the pump current draw and voltage. Typically, a maximum and minimum current are recorded and the average value is used with the voltage to calculate the power. If the power factor is not measured, a value has to be assumed to estimate the real power consumption. The annual hours of operation are multiplied by the average real power consumption to estimate energy and energy savings. This method was applied to projects in which the Circuit Rider,[3] pump off controllers (POCs), and variable speed or frequency drives were implemented.

In the third method, pre- and post-implementation utility meter data for multiple wells were used to estimate energy and demand savings. Global obtained these data for their savings estimates. This approach was used in one case where a central, inefficient pump was replaced by individual, higher efficiency pumps.

Where appropriate, we adjusted our savings estimates using an estimate of 98% availability.

Cost Effectiveness Analysis. We used the evaluated energy savings and cost data to assess Program cost effectiveness. The cost data included Program administration, measure, and incentive costs and avoided costs. Cost effectiveness was determined using the Total Resource (TRC) and Participant Cost tests as specified by the CPUC. Future costs and benefits were discounted in these cost effectiveness tests using 8.15% as specified by the CPUC.

The basic analyses were conducted at the project level and for the Program as a whole. We also examined how the results varied by producer size in terms of oil production rates.

Decisions Regarding Compensation and Final Payments. The verified energy savings from our analyses were compared to Global's calculated values and the Program Performance Goals.

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[3] This technology is described later.

The results from these comparisons are provided for consideration in the compensations and final payments decisions.

III. Implementation Efficiency Findings

This section provides our implementation efficiency findings. It includes baseline and market characteristics information and findings from our interviews.

Baseline and Market Characteristics Information

The first commercial oil production in California occurred in 1876. Since then, oil production has been an integral part of the State's economy. California's production currently ranks fourth among the oil producing states and the state ranks third in petroleum products production. The value of petroleum product shipments for California is about $26 billion per year, or 11% of the U.S. total.

According to production statistics, California produced 257.4 million barrels of oil in 2002 (excluding production in Federal waters).[4] In 2002, 15 counties produced crude oil from 210 active fields and approximately 47,000 wells.

Production comes mainly from 42,000 small producing wells in southern California.[5] Ninety-nine percent (99%) of the producers have assets of less than $1 million, and 80% operate only one or two wells. Electricity is used to pump the oil, transfer it, and inject excess water back in the well. Electricity costs typically range from $2 to $3 per barrel of crude oil.[6]

This Program targets smaller "hard to reach" producers with production rates of 6,000 barrels of oil/day (bopd) or less. The intent was to have 60% of the participants in this category. Producers with rates up to 20,000 bopd are eligible to participate.

Production by the eligible producers statewide is summarized in Table III.1. Producers in the small eligible group represent about 10% of total production and all eligible producers produce about 18.5% of the total.

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4 California Division of Oil, Gas, and Geothermal Resources. 2003. *2002 Annual Report*. Sacramento, California.

5 California Energy Commission. 2003. *Petroleum Industry Profile*. http://www.energy.ca.gov pier/indust/petro_industry.html. Sacramento, California.

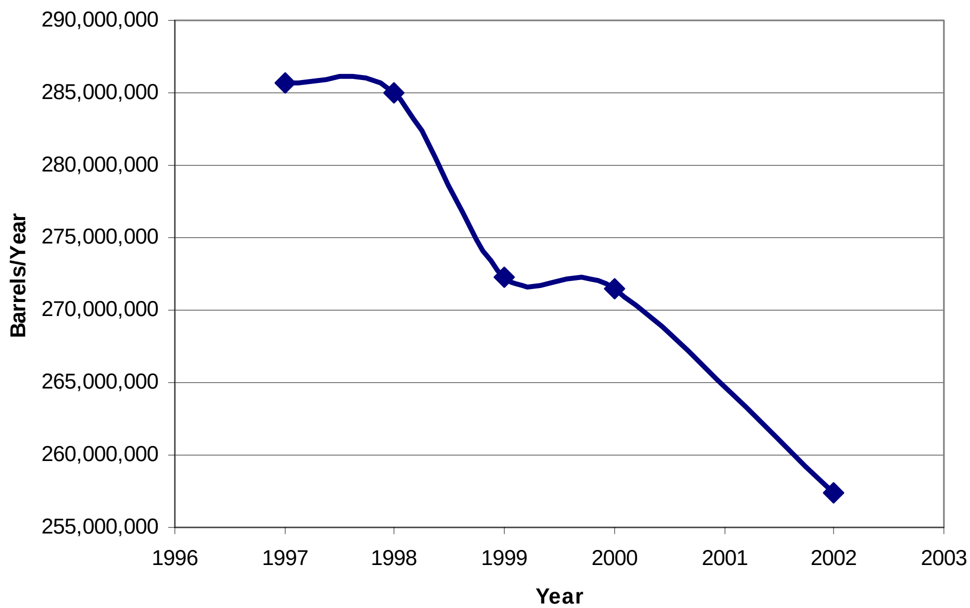
6 Ibid

Table III.1: California Oil Production Summary Statistics, 2002

Producers	Annual Production (Million Barrels)	State Production Share
≤ 6,000 bopd	26.5	10.3%
≤ 20,000 bopd	47.6	18.5%
All	257.4	100%

Two other factors are important in describing the baseline characteristics of this industry. First, most of the energy required to extract oil in California goes to pumping water. As of 1999, the ratio of water to oil was 7.58:1, or oil constituted only 11.7% of the extracted fluid.[7] Second, oil production in California has been declining for several years, as shown in Figure III.1. The production decline suggests that it is more difficult to extract oil and that energy consumed per barrel of oil extracted is likely to increase.

Figure III.1: California Oil Production Trend



Global has estimated that the producers in California consumed about 3,700 GWh in 1999 for oil well pumping, or about 1.5% of total state electricity use.[8] Based on production that year, the average consumption per barrel was about 13.5 kWh. In previous research, Global determined that wells

7 Miller, C. and I Ershaghi. 2001. "Oilfield Electric Consumption Survey," presentation available from Global Energy Partners, Lafayette, California.

8 Global Energy Partners, LLC. June 2002. *Revised Program Implementation Plan for the Energy Efficiency Services for Consumption and Demand Reduction in Oil Production in the State of California –248B-02.* Lafayette, California.

requiring more than 0.5 kWh/(barrel of fluid)/(1,000’ of pumping depth) were viable candidates for pumping efficiency improvements. They estimated that, statewide, improving the efficiency of these wells could reduce energy consumption by 1,700 GWh per year and aggregate demand by 221 MW.

Assuming that comparable savings could be achieved with producers in the categories eligible for the Program gives an energy savings potential of 175 and 315 GWh per year for producers under 6,000 bopd and 20,000 bopd, respectively. The comparable demand savings would be 22.8 and 40.9 MW, respectively. Because it is likely that smaller producers would have more opportunities for efficiency improvements, these potentials are probably underestimates.

Non-Participant Interviews

Between April and October 2003, we completed interviews with seven non-participants selected randomly from a list of more than 200 that Global had contacted about the Program. At the time of the interviews, these producers had not participated, but since there was the possibility that some might choose to participate later, the interviews included questions about the participation decision. As noted earlier, the topic areas covered included

- Awareness of the Program
- Assessment of Program Web site and other materials
- Perceptions about advantages/disadvantages of the Program
- Status of decision to participate in the Program and factors affecting decision
- Energy-efficiency improvements
- Recommendations for improving the Program

Overview

The initial interviews were conducted in late April and early May 2003. We resumed and completed them in early October 2003. Of the 36 people contacted, seven completed the interview. Representatives from the 29 other companies did not complete the interview for the following reasons:

- We were unable to reach the correct contact person or left voice messages that were not returned.
- They were too busy to participate.
- They had not heard of the Program.
- They were not interested in being interviewed.

The findings from these interviews must be interpreted cautiously for two reasons:

1. The sample size was limited by the scope of the study to only seven producers.
2. The producers we were able to interview are probably not representative in some ways of the complete group of targeted producers.

Based on information gathered during the phone calls (with and without completed interviews), we believe that the producers we did not interview were likely to be among the smallest ones. The smallest producers typically do not have an administrative assistant, engineer, or other support staff, and they are often in the field; therefore, they were difficult to reach by phone during the day. This observation is supported by the interviews we did complete, and it has implications for Global's efforts to reach the small producer segment.

Findings

Findings from the seven responding operators are summarized below by topic.

Awareness of Program and Interest in Energy Efficiency. Five of the seven producers first became aware of the Program in Spring 2003 through conferences or vendor/contractor referrals. The other two had just learned about it in September from a presentation at a Petroleum Technology Transfer Council (PTTC) meeting.

Before learning about the Program, all were interested in energy-efficiency improvements for their operations; six of the seven said they had been very interested and one said he had been fairly interested. This suggested that Global was targeting producers who were, in fact, receptive to making efficiency improvements. However, as noted above, those who completed the interview may not have represented the full spectrum of producers in the targeted group.

Two of the seven producers said that their interest in energy efficiency had increased since learning about the Program, indicating that the Program had had an effect on some non-participants, even those who were already interested in energy efficiency. The remaining five producers indicated their interest level had not changed.

Assessment of Program Components. We asked the non-participants for feedback on three of the Program components – workshops, Website, and Program materials. Overall, these components received favorable ratings.

Only two of the seven producers said they had participated in one of the Program workshops. Both gave the workshop high marks in terms of usefulness; one gave the presenters a “good” rating and the other rated them as “satisfactory.”

Three of the seven producers said they had visited the Program Web site. Two said that it was “very useful” and the other rated it “somewhat useful.”

Five of the producers recalled receiving materials about the Program, and the other two were unsure. Two rated the materials as “very useful,” two thought they were “somewhat useful,” and the fifth was unable to rate them.

Program Positive/Negative Features. We asked interviewees what they saw as the positive features of the Program. Most mentioned the possibility of reducing their operating costs. Several noted that this was especially useful to small producers who needed as much help as possible. One respondent said that the Web-based application form was a positive feature.

There was no dominant negative feature mentioned by the respondents. However, several negative comments related to the participation process including complicated rules, the amount of paperwork, and the time spent on the phone. One non-participant felt that the Program required too much money up front. Another producer specifically noted that the engineering costs were too much and probably wouldn’t meet their three- to four-year payback requirement.

When we asked about the incentive amount, the responses of these non-participant producers varied widely: one was “very satisfied,” two were “satisfied,” and two were “not satisfied at all.” Two responded that they did not know whether the incentive level was satisfactory. One respondent also thought the incentives were not as generous as those available under a similar utility program.

Participation Decision. Only two of the seven non-participants said they had definitely decided not to participate in the Program; one producer said that he had decided to participate but hadn’t formally signed up yet. Four had not yet made a decision.

The one producer who decided to participate said he would do so for the monetary savings. Of the four undecided producers, two were uncertain if they were eligible,[9] and the others were unsure of their ability to take the time to commit to applying and carrying out the Program. These undecided producers said they were more likely to participate under the following conditions:

- It became easier to determine their eligibility

9 One producer thought there was a production limit that determined eligibility, but was unsure what the limit was.

- They could receive assistance preparing the savings estimates needed for the application
- They could receive broader assistance with overall energy issues and clearer information about the potential energy and dollar savings

Of the two producers who said they would not participate, one said that it was because his wells that were in need of efficiency upgrades were not in the area covered by the Program. This producer said that, if the Program were extended statewide, he would be likely to participate. The other had the impression that his company would have to share the monetary savings and, since they already knew what to do, there was no need to involve anyone else or share the financial benefits.

Efficiency Improvements. Another factor that probably contributed to these producers' decisions to not participate was that five of the seven had already taken steps to reduce their operating costs in the following ways:

- Installing pump motor-off controllers
- Adding timers to compressors
- Downsizing water pumps
- Installing a new pumping unit
- Upgrading an injection pump motor
- Changing their utility tariff to the agriculture rate for water production

The Program did not appear to convince these producers to take additional steps to improve their energy efficiency, at least in the near term. None said they implemented additional efficiency improvements on their own after hearing about the Program.

Producers' Program Recommendations and Comments

The non-participants provided several suggestions for ways to improve the Program. A few addressed the financial incentives, including

- Provide larger incentives not necessarily tied to the amount of energy savings (e.g., give financial incentives based on the amount of investment required)
- Apply incentives to new wells, not just existing ones

Several recommendations involved the Program design and services provided, such as

- Increase Program scope to cover all of California

- Stress to producers that higher efficiency can lead to increased production and reduced O&M costs in addition to lower energy costs
- Provide focused engineering audits to direct producers' efforts in the right way
- Provide information on what can be done to avoid flaring natural gas produced with the oil

Additional recommendations dealt with Program outreach and delivery, including:

- Put more effort into getting the word out and work with the California Independent Petroleum Association
- Stress and clarify in the Program materials what the participation rules are, including eligibility
- Streamline the rebate process by reducing administrative burden and the verification process

Finally, we asked the non-participating producers for any additional comments they wanted to offer on the Program. A few comments addressed the specific situation faced by small producers. One noted that it is very difficult to reach small producers with a program that requires investments in new equipment; consequently, ways should be explored for getting used and reconditioned equipment in the hands of smaller producers. He noted that there is a large inventory of such equipment because many wells are now shut in.

One producer stated that vendors supporting the Program had done a good job of providing data on how production could be increased through efficiency improvements. Another suggested that Global needed to get the word out that there was still Program money remaining, but that time was running out.

Most of the closing comments were positive ones on the performance of Global in the Program. These comments included the following:

- "Global did a good job presenting the overall Program."
- "Global has done a very good job learning about the industry's needs and modifying the Program quickly."
- "Working with Global has been great; they have been very courteous and helpful. They were able to bring us up to speed quickly."

Conclusions

As noted earlier, it is difficult to draw definitive conclusions from this small sample of non-participating producers. However, we believe that several useful observations and insights can be provided based on the process of trying to reach the non-participating producers and the completed interviews. The following conclusions were drawn from these interviews and provided to Global in October 2003 for their consideration in making Program modifications. Subsequently, we asked Global for their feedback on these observations and how they had responded to them.

First, a significant proportion of the targeted *producers targeted have serious capital, staff, time, and expertise constraints*. The Program was designed to help overcome these barriers, yet some producers believed that they couldn't even dedicate the resources needed to apply to the Program. To improve Program participation, it would be useful to develop a mechanism that can further reduce the capital cost burden on the small producers targeted.

Global noted that the timing of the Program exacerbated the problem of access to capital. Their discussions with several producers revealed that producers typically establish their capital budgets some months prior to the beginning of the calendar year and that, by the time the Program was implemented, they had missed the window of time when they could influence capital budgeting. Several producers informed Global that they would like to include projects in their next capital budget, but given the Program's schedule Global could not offer this option. Global also stated that they became aware of the difficulty producers had setting time aside to become educated about the Program and that many of the targeted producers did not have staff with relevant expertise. To address these problems, Global revised their promotional efforts to expand the amount of in-person time spent with producers and encouraged vendors to do the same.

Second, some of the *non-participants did not understand the full benefits that energy-efficiency improvements could deliver* such as increased productivity and reduced O&M costs, in addition to energy cost reductions.

Global was also aware of this problem and took steps to enhance their Web site to provide information about non-energy benefits. They had discussed the possibility of including a calculator that producers could use to identify the best energy-efficiency options for their operations, but this was not implemented during the Program. Near the end of the Program (May 2004), Global held a workshop that presented producers with testimonial case studies from participants. They made the workshop available via a Webcast. Global also believed that equipment vendors could be an effective channel for informing producers about the non-energy benefits, but the vendors apparently did not take significant steps to include this information in their promotional efforts.

Third, *areas of miscommunication or incomplete communication about the Program were evident* when we conducted our interviews. For example, some producers were uncertain about their eligibility, and one producer seemed to interpret the Program as a shared-savings approach.

Global acknowledged that incomplete communications were a problem and they had modified and simplified their materials to make them easier to use and understand. Nevertheless, Global was not satisfied that a large number of the targeted producers were able to extract the essential information from these materials. This problem appeared to be part of the major constraint that producers had in allocating the time necessary to become educated about the Program and enroll in it.

Fourth, even among these non-participants, *the majority had not closed out the option of participating*. Generally, they recognized that there were benefits to be gained, but there were some remaining obstacles that prevented their participation. We believe, based on feedback from the non-participants interviewed, that the majority of these obstacles could be overcome through resolution of the communication issues and streamlining the application, implementation, and verification process.

Finally, *most of these producers volunteered their observations that Global had done a good job* implementing the Program and had established credibility with the industry.

Taken as a whole, Global felt that these conclusions were consistent with their findings and experience. Their primary perception was that many of the problems were attributable to the nature of the targeted group in this industry. In general, these producers are small businesses, with many operating a very small number of wells. Their focus is on meeting day-to-day demands on their time to ensure that production continues. They do not fully understand the importance of energy costs in their operations and lack credible information on how energy costs can be reduced. Finally, they are truly "hard to reach;" Global made an intensive effort to contact targeted producers, but found that they are often not available by telephone, many have occupations in addition to their oil production, and a large segment does not participate in any of the relevant industry associations.

Participant Interviews

We were able to complete interview with six of ten participants in Global's Program to obtain their views regarding the implementation efficiency of the Program.[10] The energy-efficiency measures for these participants represented the full range of Program offerings including installation of pump off controllers, Circuit Riders, variable frequency drives, more efficient and properly sized motors, and individual well rod pumps to replace a central pumping system. The interviewees represented producers with production

10 We made multiple attempts to contact the remaining participants via telephone. We also left voice messages and sent emails to those who had email addresses.

rates ranging from 20 bopd to more than 200,000 bopd with project annual energy savings ranging from 74,000 kWh to over 5 million kWh.

Program Awareness

There was no dominant source through which participants became aware of the Program, thus showing that it takes a variety of methods to get the word out to these businesses. Word-of-mouth, notices from professional organizations, and direct contact from Global were cited by participants who recalled how they first learned about the Program.

Two participants had gone to a workshop, and one found it “somewhat” useful and the other said it was “extremely” useful. Four visited the Program Web site; all gave different ratings of its usefulness ranging from “very useful” to “not at all useful.” Only two had seen marketing materials and their reviews were mixed.

Project Implementation

Those participants who did not already have an efficiency project in mind typically found the initial audit to be helpful in pointing out measures for savings energy. A few participants already had a project in mind when they decided to participate in the Program, and the audit was less useful to them.

Of the three participants who received an audit and commented on its usefulness, two were “confident” in the energy savings estimates and one was “very confident” in the savings. After the project was implemented, one participant said he was “very confident” in the savings, whereas he had stated he was “confident” prior to implementation. The other two did not change their stated confidence levels.

When asked about any concerns they had about the Program, two participants said they would have liked to have had a better understanding of how the incentive would be calculated before they proceeded with the project so they would have known how large a rebate to expect. Another concern expressed by a few was an initial perception that the Program implementers lacked an adequate understanding of the industry. However, these participants were quick to note that they were also impressed by the fast and significant progress made by the implementers in gaining a solid understanding of their business; their initial concerns dissipated throughout the Program.

Overall, preparation and submittal of the incentive application were considered to be very easy and the participants appreciated the simplicity of this process. Most said that the rebates were received promptly.

They were either “very” or “somewhat” satisfied with the incentive overall, and the incentive was the number one reason for their participation in the first place. The potential energy savings and opportunities to optimize production were the other main reasons mentioned for participation.

All participants rated the Program implementers as either “very” or “extremely” effective in their efforts, stating that they were helpful, responsive, had a great Program, and were good to work with.

Energy-Efficiency Awareness

All respondents said that, prior to participating in the Program, they were “very interested” in ways to improve energy efficiency. Before the Program, some had replaced worn pumps and practiced peak demand management strategies in an effort to lower their energy bills.

As a result of participating, all responded that their interest had either “slightly increased” or “remained the same.” Since little time had passed since the participants had completed their projects under the Program, none had been able to do additional energy saving projects, but they said they were interested in pursuing new projects if they passed the organization’s cost effectiveness tests.

Project Decision-Making Process

Each participant, regardless of firm size, said they have specific procedures they follow for capital improvement project authorization and funding. Most efficiency improvement ideas start with the onsite engineer who then builds a case for the project, determining its rate of return (ROR) or life cycle costs.

Depending on the size of the company and the expense involved, the decision to go ahead is either handled just one or two steps above the engineer or it goes all the way to the president of the company. For the smallest companies, there are only a couple levels and business decisions are made quickly. One participant mentioned that for such projects, they first decided what they wanted to do and then would seek out a program offering incentives to help tip the cost analysis in their favor.

Comments/Suggestions

General comments provided by the participants on the Program included the following:

- “Keep it going.”
- “Vendor involvement was the key to this Program and Global’s relationship with them is very important.”
- “Global needs to better explain how the rebate is calculated so they have a better understanding of how much value they get before going in.”

Only one participant offered a suggestion for improving the Program. He thought that communication could be improved and suggested using full-page ads in publications from professional associations.

Summary

The six surveys represented the full range of participant company size and energy-efficiency Program measures. In general, it was difficult to make contact with the participants due to their busy schedules. Those we interviewed were able to provide useful feedback on Program operations and insights on how the Program could be improved. The following are the main highlights and conclusions from these interviews:

- These businesses are hard to reach due to their busy schedules; consequently, communication efforts need to be wide ranging.
- Once aware, these oil producers were very open to energy-efficiency improvements and willing to go through the Program process to receive incentives.
- Although already interested in ways to lower operating costs and use rebates to finance capital projects, the Program did help to further raise awareness and provided good ideas and was well received.
- Vendors can play an important role in such programs, and Global should continue their communication efforts and relationships with vendors and professional societies.
- Participating in the Program had a positive impact on operations for these businesses.

Overall, participants were satisfied with the Program process and their relations with the implementers.

Vendor Interviews

Since the vendors played a significant role in the success of this Program, we decided to interview a sample to gain greater insight into the process implementation. We were able to complete interviews with two vendors of the four suggested by Global. Both produce electrical distribution technologies, one of which focuses on technologies to cut back on line losses.

Program and Energy-Efficiency Awareness

These vendors first heard of the Program through customers who wanted to participate with the goal of reducing their operating expenses. Both vendors agreed that energy-efficiency equipment installation in general is very important to their businesses. One vendor said a “Significant cost of bringing products to market is the energy costs, so reducing that cost is important for marketing." In this respect, both vendors said that the Program allowed them to highlight energy efficiency even more in their marketing. However, both vendors pointed out that, as one put it, "Producers are generally pretty skeptical because there are a lot of people out there selling snake oil." Although a project may be economical, there is still a level of doubt on the part of the customer that savings will really be achieved.

Market Barriers

When asked what market barriers must be overcome for smaller oil producers to make investments in ways to increase energy efficiency, the responses differed. One vendor said it is easier for smaller companies to overcome barriers; they just need to be shown that there will be results. The other vendor said that smaller companies have set capital funds to work with and must be judicious and are, therefore, more skeptical of unproven technologies. However, when asked how the Program helped to overcome these barriers, both vendors agreed that the rebate gave producers a higher comfort level because they didn't have to pay as much for the technology. One vendor pointed out, "The rebate subsidized installation costs. It turns a 24 to 30 month payback into a 12 to 18 month payback, which is the difference between go and no go."

When asked what additional things Global could have done to overcome the barriers, one vendor said "Nothing, they have been doing a great job." The other said, "Focus on technologies that do save energy or make processes more efficient for small producers."

Benefits of Participation

Both vendors said one of the main benefits from participating in the Program was making new customer contacts. In addition, it gave them the ability to have people to try out their products and realize the potential savings, which gives them more legitimacy.

In addition, when asked what Global could have done to make it easier and more effective for the vendor to market energy efficiency, the only suggestion offered was allowing more time for the vendors to gear up. This vendor said that they met with Global originally in September and the Program started in December.

Market Assessment for Program Continuation

When asked what percent of small oil producers could benefit from energy efficiency improvements, one vendor said 70% and one said 100%. The vendor who said 100% went on to say, "Smaller producers are not able to buy power at the best level; therefore, the savings are very important. Plus other benefits like improved run times, and less maintenance also can really benefit the small producer."

When asked if they think smaller producers will be more interested in efficiency improvements in the future, both said they expected energy prices to increase substantially and energy savings would become more important. They felt the Program could play a role by giving an endorsement to efficient products. Producers have a lot more confidence in trying out their energy-efficiency products once they've been tested and demonstrated.

Both vendors agreed that all aspects of the Program (incentives, information, and education) had been very important in increasing small producers' interest in energy-efficiency investments. One vendor said, "The financial incentive is very important, it's what makes them go ahead with the Program, but the education and information are just as important in getting people interested."

When asked if they see a need to continue the Program, both vendors responded with an emphatic "yes." One said, "The Program is going to get small companies that are gun shy and watching every penny. They're not prone to try something new, but with the incentive they have more comfort, especially when the CFO, president, and guy out there drilling are the same person."

Suggestions and Comments

Neither vendor had suggestions on how to improve the Program. Both were very pleased with it. One vendor offered this additional comment: "I hope the Program continues for at least a period to get more people on board, to feel comfortable."

Summary

The two vendors we spoke with were very positive about the Program in general and believed that there was a need to continue it. They have benefited through making more contacts but felt they hadn't had enough time to work with customers because the Program was too short.

Program Implementer Interview

A detailed discussion with the Program Implementer provided significant value for the process evaluation of the Program. This section summarizes the Program implementation strategy as well as its strengths and weaknesses as seen from the perspective of the primary Program implementer.

Program Development and Marketing

This Program was designed to assist small oil producers in the SCE territory who are struggling to compete with large producers by reducing their energy cost and overcoming the market barriers of first-cost and lack of information on energy-efficiency equipment and benefits.

Since most of the target participants for this Program were involved in the previous and similar California Energy Commission (CEC) Phase I Program, marketing efforts were kept at a minimum with no emphasis put on brochures and advertisements. The focus of the marketing strategy was mainly process-oriented, with most efforts directed to the Web site management. The intent of the Web site was to provide a one-stop shop for in-depth Program information such that people could go to it often and feel encouraged to participate. Global also made several presentations at related industry workshops to try to get out and talk to people and show the benefits of the Program through case-study results. Both these efforts were thought to be effective at reaching the participants needed to meet the Program goals in an efficient manner.

Barriers to Participation

Throughout Program implementation, Global noticed three main barriers to customer participation and project completion:

- Lack of time
- Conflict with budget cycles
- Suspicion of performance issues

The first barrier turned out to be the greatest obstacle in achieving customer commitment and follow-through with projects. Even if the economics of the proposed efficiency improvements showed a one- to two-year payback period, other day-to-day issues at producers' facilities tended to take precedence over these capital projects. Global found that, even once a customer was signed up for the Program, she needed continuous attention to remain engaged in it through project completion. Even after a project was completed, Global had to spend considerable effort to encourage participants to send in the final form for the incentive payment, all due to lack of time on the part of the producers.

Recognizing this barrier as significant to the Program success, Global reduced the amount of paperwork involved in the Program for the participants and restructured their Program budget mid stream so that they could devote a project manager to the field. The project manager met participants at their offices and assisted them as much as necessary through the process. With this internal change, they saw significant improvements in turnaround time on projects, and Global credits their ability to meet their Program goals to this single adjustment.

Conflict with the producers' budget cycles was not fully anticipated as a barrier prior to starting the Program. Many of the facilities make capital improvement budgeting decisions for the coming year in October or November. Once the budget is set, it's difficult to add projects to the schedule unless other projects are removed. Global first started to promote their Program in the fall of 2002 and were often told that the Program looked great, but that it would have to wait until the next budgeting cycle since the producer had just closed the 2003 budget. To overcome this obstacle, Global had to make the case that the improvement from the efficiency project far outweighed the benefits of other projects or just had to wait until the budgeting cycle was at a more favorable point for new project consideration.

The last significant barrier Global encountered was producers' general doubts about the technology and suspicion that Global was really trying to sell something. Although much of the technology Global was suggesting was not anything new with unproven results in the industry, Global had to overcome a lack of trust in the savings estimates. One way they were able to break down this barrier was by presenting case studies of results where a producer could see that, if his neighbor could install this equipment and receive significant savings, he could do it too. The case studies added more credibility to the Program measures and helped boost participation rates.

Global identified these three issues as being potential barriers to participation prior to the Program but didn't fully understand the magnitude of the lack-of-time barrier. Instead, they initially focused their attention on education, thinking the workshop and Website material would prove to customers how economical the measures were and then the producers would start pouring in to receive their incentives.

Strengths and Weaknesses of the Program

The Program implementer saw one of the major strengths of the Program to be its use of trade allies who helped to get the word out and lend credibility to the Global name. At the beginning, Global enlisted four vendors and listed them on their Web site. Global found that the vendors could be effective partners, but the key was to actively recruit vendors, identify the right person, and work with him or her on an ongoing basis.

Global's ability to focus its implementation team entirely on the Program without distraction from running other programs, and the flexibility to redistribute efforts to provide customer coaching, were also keys to success.

The implementer felt weaknesses of the Program were mostly structural in that the term of the Program was too short to fit within the budgeting and large capital project timeframes of most customers who plan on a larger scale. In addition, the start of the Program was delayed four months beyond its planned start date.

Although mentioned as an overall strength of the Program, the vendors were also a weakness at times due to their insufficient training and inconsistent engagement throughout the Program.

Suggested Improvements and Continued Need

To make the Program more successful, Global would modify it by extending its term, encouraging more vendor participation with increased training, and possibly adding an optional project management service to the list of offerings to encourage participation and see the project through to completion.

After conducting the Program, Global sees a large energy savings technical potential, which is also mostly economically feasible. Global believes the Program is absolutely worth continuing since they feel that their efforts have really only scratched the surface of the savings potential.

Summary

This Program was successful overall from the Program implementer's standpoint since it reached its goals for participation and energy and demand savings. Although there were significant barriers to participation, Global feels they were able to modify the Program management enough to overcome the largest barrier. They see a continued need for the Program and have offered suggestions for ways to improve it even more by adding a project management option and setting back the deadline for incentives. In addition, they would provide additional training and encouragement for vendors and continue the effective education method of presenting case studies at workshops to help prove the value of the measures.

IV. Cost Efficiency Findings

This section provides our cost efficiency findings. Because of the uniqueness of the projects, the information is presented by project, grouped according to the energy analysis method applied. Baseline and energy and demand savings data are presented along with cost data. The cost effectiveness results are then presented for the Program (using the methodology provided by the CPUC).

Short-Term Energy Measurements with Adjustments for Well Conditions

In several cases, Global was able to collect data on well conditions as well as short-term energy measurements for retrofit efficiency equipment. In these cases, we used a savings estimate methodology that was modified from the one used by Global, as noted earlier. Our methodology required data on the short-term power demand and oil pumping rate (barrels of oil per day) before and after the efficiency modification. The daily consumption was calculated by multiplying 24 hours by the short-term power measurement, and the energy consumption per barrel was calculated as the ratio of the daily power consumption to the number of barrels pumped per day.

When oil production data were available, we used the following equation, shown earlier, to calculate annual energy savings:

$$\textit{Annual energy savings (kWh/yr)} = ((kWh/bbl)_{oil,\ pre} - (kWh/bbl)_{oil,\ post}) \times (bbl_{oil,\ pre} + bbl_{oil,\ post})/2 \times 365\ days/yr \times Availability$$

Where:

- KWh = kilowatt-hours to pump oil
- $kWh/bbl_{oil,\ pre}$ = pre-implementation kWh required to pump one barrel of oil
- $kWh/bbl_{oil,\ post}$ = post-implementation kWh required to pump one barrel of oil
- bbl_{oil} = barrels of oil pumped per day
- Availability = percent of time well is not down for maintenance

This method does not inherently provide higher or lower savings estimates than Global's. We have used it for the reasons presented in Appendix A and believe, since it is dependent directly on the quantity of oil produced, that it provides a valid estimate of energy savings normalized by production and accounts for the effects of changes in production rate.

Project 5

This producer proposed downsizing motors for 13 wells under the Program and all 13 were completed and received incentives.[11]

Very complete information was available on each of these wells and retrofits, and these retrofits were suitable for analysis using the more detailed methodology, taking into account changes in well characteristics. For each motor downsizing, we calculated the pre- and post-implementation energy consumption and demand savings.

Global estimated gross energy savings of 5,019,790 kWh/year and gross demand savings of 648 kW. Our analysis provided evaluated savings estimates of 4,170,173 kWh/year and 476 kW. These results are summarized in Table IV.1.

Project 3

This project also involved downsizing pump motors. Eleven well pumps were replaced, but each pump served more than one well, so the analysis was done at the well level and then aggregated to the pumps.

Our results agreed well with Global's for all sub-projects except one in which a single pump served three wells. In this case, a 100-hp motor replaced a 150-hp motor. In the post-retrofit situation, one of the wells no longer produced and the production in the other two increased slightly. Using Global's measure of pumping efficiency, the efficiency of the two producing wells declined after the downsizing. However, Global's analysis showed overall energy savings because the non-producing well no longer consumed any energy, and this reduction in energy consumption was treated as energy savings that offset the increased consumption for the other two wells. Global estimated energy savings of 156,188 kWh/year for the three wells combined.

In our analysis, we took a different approach. Quantec did the analysis at the pump level, using the total energy consumption for all three wells and total quantity of oil and fluid pumped in the pre- and post-retrofit situations. Using the aggregate values, the energy consumption per barrel of oil or total fluid pumped actually increased after the motor downsizing. Consequently, we estimated that these changes for this one pump resulted in a decrease in overall efficiency and an increase in energy use and average demand. Our estimate for this one pump was an increase in energy consumption of 156,035 kWh/year. Although there are many uncertainties about how these wells interact with each other and potentially other wells in the field, we believe that for this one pump alone this analysis provides a reasonably

[11] One sub-project involved replacing a motor with a high-efficiency one of the same size.

accurate measure of the effects of the changes made since the results are normalized by production rate.

Global estimated energy savings of 3,194,047 kWh/year and demand savings of 425 kW for all the sub-projects in Project 3. Our evaluated savings were 2,398,734 kWh/year and 256 kW.

Summary Results

Table IV.1 compares our savings estimates for these two projects with Global's estimates. For the projects combined, we estimated annual energy savings of 6,569 MWh and demand savings of 732 kW. The resulting realization rates are 80% for energy savings and 68% for demand savings.

Table IV.1: Savings Comparison for Production Impacted Projects

Project	Measure Desc.	Avg. Gross Demand Savings (kW)		Annual Gross Energy Savings (kWh)		Realization Rate	
		Global	Evaluated	Global	Evaluated	Demand	Energy
5	Motor Downsizing	716	476	5,019,790	4,170,173	66%	83%
3	Motor Downsizing	425	256	3,194,047	2,398,734	60%	75%
Total	*All*	*1,141*	*732*	*8,213,837*	*6,568,907*	*64%*	*80%*

Table IV.2 presents the cost and incentive information for these two projects.

Table IV.2: Project Cost and Incentive Data

Project	Project Cost	Project Incentive
5	$701,294	$265,380
3	$405,738	$166,000

Short-Term Energy Measurements with No Adjustments for Well Conditions

This method was employed when the installed measures had no impact on the well conditions, such as production rate and fluid level, but impacted energy and demand only. Typically, energy use for the pump motor was measured before and after installation of the new equipment either with a recording meter or with amperage and voltage readings. This category included the following list of measures:

- Circuit rider equipment
- Pump off controllers

- Variable frequency drive motors
- Gas compressor

Circuit Rider Equipment

Project 4 installed Circuit Rider equipment on pump motors. A Circuit Rider improves the efficiency of the motor by providing surge suppression, capacitance, and line noise filtration. The Circuit Riders use capacitors to supply reactive power to the motor instead of pulling current through the line. The result is a reduction in line current and, therefore, line losses, and an increase in voltage and power factor for a reduction in demand and energy use.

The Circuit Rider equipment does not impact well production rate, just demand and energy use; therefore, no adjustments for well conditions were needed in the energy savings analysis. Pre- and post-implementation amperage measurements were taken at each of the 25 pumps in this project. Maximum and minimum amp readings were available for all but four of the 25 pumps. Although one benefit of installing Circuit Riders is an improved power factor, this analysis assumed no change in power factor. This conservative assumption was made due to lack of reliable data on how much of a power factor improvement can be assumed. The energy analysis from Global used an average of the minimum and maximum amp readings to calculate power use in kW based on the following equation:

$$\text{Average kW (pre or post)} = \text{Average amps (pre or post)} * 0.48 * p.f * 3^{1/2}$$

where p.f. is the power factor (assumed to be 80%) and 0.48 is the average metered voltage for these wells in kilovolts. Global then calculated the difference between pre and post demand and multiplied it by 8,760 hours to estimate the annual energy savings. For the four units where there were only maximum amperage readings, Global used these values to calculate the pre and post kW for the purpose of estimating the demand and energy savings. Global summed the results for the 25 pumps to estimate the energy savings for this project to be 1,736,250 kWh/year and demand savings to be198 kW.

Our approach differed in relatively minor ways. Global’s energy savings calculation for each pump assumes the difference in kW from pre to post is the amount of savings for every hour of the year. The assumption that all pumps will operate 8,760 hours per year at an average power use is probably overly optimistic. We have added an availability factor of 98% for each pump to reflect downtime for maintenance and other unforeseen operating problems throughout the year.[12] The other change we made was to estimate the pre and post average demand for the four pumps for which only maximum amperage readings were available. We used the pre and post average ratios between the maximum and minimum amp readings for the other pumps to estimate the minimum amp readings for the four other pumps.

With these two changes in our methodology, we estimated the energy savings to be 1,692,242 kWh/year and the demand savings to be 197 kW.

Pump Off Controllers

The second measure analyzed using short-term metering with no well characteristics adjustments was pump off controllers, or POCs. The amount of fluid that can be pumped during one pump cycle depends on how quickly fluid accumulates in the well. As wells age they become less active and the amount of time it takes for the well to produce a full load of fluid increases, but the pump cycle time remains unchanged. When this happens, the pump lifts less fluid than it is capable of pumping, resulting in inefficient operations. POCs are used to shut down the pump until enough fluid has accumulated in the well to produce a full barrel. As in the Circuit Rider analysis for Project 4, there is no change to well production with POC installation, only in the amount of operating time needed to produce the same number of barrels.

In Project 10, the producer installed POCs on ten wells. Low and high power readings for the pumping cycles were measured prior to installation, along with the strokes per minute and hours of operation per day. After installation, the power use was assumed to be unchanged, so only the hours of operation per day were noted by Global. Daily average energy consumption was estimated using the averages of the measured current and voltage, hours of operation per day, and an assumed power factor of 95%. For the energy savings, Global multiplied the difference in average daily energy consumption in the pre and post conditions times 365 days per year. To calculate demand savings, they divided energy savings by a load factor of 80% times 8,760 hours per year. Using this approach, Global estimated energy savings of 391,238 kWh/year and demand savings of 56 kW for this project.

We took a slightly different approach to calculate the energy savings. We used Global's estimated 80% load factor and applied it to the peak demand reading for each well pump to estimate the average demand. We used the resulting value to estimate the energy savings for each well, based on the difference in operating hours. We multiplied the resulting value by an availability factor of 98%. Our estimate of energy savings was 376,372 kWh/year.

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[12] Our source for typical availability values was "Oilfield Electric Consumption Survey: Objective, Methodology, and Results," presented 7/19/01 by Carl Miller of EPRI and Iraj Ershaghi of USC.

We also calculated demand savings in a modified way. To estimate the average demand savings for each well, we used the average demand, which was calculated with the load factor and peak demand measurement for each well. We then multiplied the average demand by the change in runtime between pre and post conditions, and averaged the demand savings over 24 hours. Our estimate of demand savings was 44 kW.

Project 1 installed POCs on 27 wells. Unlike Project 10 where average voltage and current measurements were used to calculate average demand, energy use before installation was measured to provide an energy use per day rate assuming 24-hour use. With the addition of the POC, the total daily hours of operation for the well decreased, reducing the energy use and average demand. Energy savings were calculated as the difference in pre and post daily energy consumption for each well over 365 days per year. Global then calculated demand by dividing annual energy savings by 80% of 8760 hours per year assuming a pre and post load factor of 80%.

Again, we followed a slightly different methodology for calculating demand savings by subtracting the average demand post installation to the average pre installation demand rate calculated as the daily energy use divided by hour per day run rate. Energy savings were evaluated as 806,457 kWhs with 94 kW of demand savings. We applied an availability factor of 98% to the energy savings calculation for unplanned unit downtime.

Project 6 was the final POC project in the program. Since it was the first project completed in the program, the amount of energy use and operations data was not as complete as the other projects. For this reason, we applied the average energy and demand savings realization rates (97% energy and 79% demand) from the two other POC sites and applied these percentages to the estimated savings for the Project.

Variable Speed Drives

Projects 7 and 9 installed variable speed drives (VSDs) on several pump motors. VSDs change the speed of the motor, better matching it to variable loads. Although having no impact on well production rate, the VSDs reduce energy use by providing the ability to reduce the energy input to a motor when it is not fully loaded so that it will better match the load of the pump throughout the pumping cycle.

Before the VSDs were installed in these projects, the pump motor energy use was monitored for about one to two weeks and recorded as total kWh. Once installation was complete, Global metered the motors again and recorded total energy use. The pre and post readings were divided by the number of days over which the data were recorded to calculate kWh/day usage for pre and post conditions. To calculate energy savings, Global then subtracted the daily post energy use from the daily pre energy use and multiplied by 365 days/year. Global estimated average demand savings by dividing estimated annual energy savings by 8,760 hours and an assumed load factor of 80%. For Project 7, Global estimated annual energy savings of 26,505 kWh and demand savings of 4 kW. For Project 9, they estimated annual energy savings of 189,387 kWh and demand savings of 27 kW.

Quantec believes that the energy savings analysis for these projects was reasonable and we used the same basic approach to estimate energy savings. We did make an adjustment for availability, however, because the metered data were gathered over such a short time that they were not likely to reflect downtime. We multiplied Global's estimated energy savings for both projects by an availability factor of 98%. Our estimated energy savings were 25,975 kWh/year and 185,599 kWh/year for Projects 7 and 9, respectively.

We used a different approach than Global to estimate demand savings. Global's methodology assumes that the addition of the VSD did not impact the load factor of the motor. In our review of the demand savings, however, we assumed that use of a VSD would change the load factor. This was addressed in our savings analysis by determining the average demand over a 24-hour period by dividing daily energy use by 24 hours. We then subtracted the average post demand from the average pre demand to estimate the demand savings. Our estimated demand savings were 3.0 kW and 22.0 kW for Projects 7 and 9, respectively.

VSD Application to Gas Compressor

Natural gas captured from the pumping operation can be of value to producers if they can sell the gas. To better meet their gas customer's needs, one Program participant (Project 8) had decided to add a gas compressor to their facility. After learning about the Program, they decided to participate and install a unit with a VSD, rather than a single-speed unit.

To estimate energy and demand savings, Global used measured energy consumption data for the compressor with the VSD and compared it to energy use without the compressor. These data were used to estimate the average power used by the compressor. This average was then compared to the manufacturer's full-speed power use for the compressor. These data allowed Global to estimate how much energy and demand savings were provided by the VSD, compared to what the compressor would have used without the VSD. Global estimated annual energy savings of 1,950,159 kWh and average demand savings of 223 kW.

We believe that Global's overall approach was reasonable for this project given the data available. The only difference in our method was an adjustment for the availability, applying again a value of 98%. When we applied this factor, our estimated energy savings were 1,911,156 kWh/year and demand savings were 218 kW.

Summary Results

Table IV.3 summarize the results for projects in this category. Overall, our estimate of gross energy savings was 105% of the original value and our evaluated gross demand savings were 92% of the original estimate. Cost and incentive data for these projects are presented in Table IV.4.

Table IV.3: Savings Comparison for Non-Production Impacted Projects

Project	Measure Desc.	Avg. Gross Peak Demand Savings (kW)		Annual Gross Energy Savings (kWh)		Realization Rate	
		Global	Evaluated	Global	Evaluated	Demand	Energy
4	Circuit Rider	198	197	1,389,000	1,692,242	99%	122%
1	POC	117	94	822,915	806,457	80%	98%
6	POC	17	13	74,720	72,478	79%	97%
10	POC	56	44	391,238	376,372	79%	96%
7	VSDs	4	3	26,505	25,975	80%	98%
9	VSDs	27	22	189,387	185,599	80%	98%
8	Gas Comp	223	218	1,950,159	1,911,156	98%	98%
Total	*All*	*641*	*591*	*4,843,924*	*5,070,279*	*92%*	*105%*

Table IV.4: Project Cost and Incentive Data

Project	Project Cost	Project Incentive
4	$129,775	$64,888
1	$37,704	$18,852
6	$13,000	$6,500
10	$5,029	$2,120
7	$1,500,000	$156,013
9	$67,007	$15,151
8	$26,199	$13,100
Total	*$1,778,714*	*$276,623*

Utility Meter Data

This method of energy and demand savings calculation uses a direct comparison of metered energy and demand use before and after the installation of energy-efficient measures. The difference in energy use is the savings attributed to the equipment replacement or upgrade. This technique was most applicable to projects where only affected wells were included in the meter readings and there were no changes to production rates after the equipment installation. If pre-installation spot energy use measurements were not available, this method provided a simplified approach for estimating savings.

This method was applied to only one customer. In Project 2, Sites 5, 8, and 11, this producer replaced old central pumps (Kobe pumping systems) on more than 40 wells with individual rod pumps and hydraulic rod pumps (HRPs). The wells at these project sites operate on timers for only two to three minutes every 15 minutes. Due to this schedule, special equipment was required for installing metering at these wells. Reviewing billing data was seen as a more accurate approach to energy savings analysis than attempting to use actual metered date.

For the first field completed in the project, Site 8, pre-installation data were available for five months prior to installation and only one month after installation. Based on the daily billing data, the average energy use declined from 3,030 kWh to 1,316 kWh per day, for an annual energy savings of 625,819 kWh. The average monthly peak during the pre-installation period was 156 kW compared to a peak demand of 85 kW for December after installation. Global intended to base demand savings on the peak billed demand; however, when they did so they found that the CPUC Worksheet formula produced an unrealistic estimate of annual operating hours.[13] To eliminate this problem, Global calculated demand savings for this site by applying a constant 80% load factor before and after the retrofit to the energy savings to estimate a 225 kW demand savings. Global calculated the demand savings by dividing the annual energy savings by 80% of 8760 hours in a year for 89 kW.

We found the approach for estimating energy savings to be reasonable and estimated the same energy savings as Global for a realization rate of 100% for energy. For the demand savings analysis, however, we took a slightly different approach. After discussions with Global and CPUC staff, our understanding of the CPUC's intention was that demand should reflect average demand savings, rather than savings based on peak.[14] Consequently, we calculated demand savings for this field by dividing the pre- and post-installation daily energy consumption by 24 hours per day and taking the difference. This calculation gave us an average demand of 126.3 kW in the pre period and 54.8 kW in the post period, for demand savings of 71.5 kW. This gave a demand realization rate of 80%.

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13 The problem was that the spreadsheet calculates annual operating hours by dividing kWh savings by kW savings. Using the change in peak kW as the kW savings in this calculation, however, can produce operating hour estimates exceeding 8,760 because this calculation does not account for possible changes in the load factor. Using our approach for Site 5, as discussed below, nearly eliminates this outcome. Nevertheless, we believe that it is more appropriate to take into account possible changes in the load factor and determine the appropriate operating hours independently.

14 We had a telephone discussion with Mr. Eli Kollman on June 22, 2004, that led to this interpretation.

For the second field in the project, Site 5, there were three months of pre-installation energy and demand billing data and two months of post-installation readings. The average energy use per day declined from 7,607 kWh to 3,290 kWh for an annual energy savings of 1,575,811 kWh. In our analysis, we used the same approach we applied to Site 8. Our energy savings estimate agreed with Global's for an energy realization rate of 100%. However, based on the methods applied to demand savings calculations as described above, our demand savings had an 80% realization rate.

Global and Quantec analyzed energy and demand savings for Site 11 consistent with analyses for the other two sites.

Together, these three sites resulted in estimated annual savings of 2,644 MWh. Table IV.5 summarizes the gross energy and demand savings for this project. Project cost and incentive data for this project and sites are presented in Table IV.6.

Table IV.5: Comparison of Estimates for Project 2

Project	Measure D esc.	Avg. Gross Peak Demand Savings (kW)		Annual Gross Energy Savings (kWh)		Realization Rate	
		Global	Evaluated	Global	Evaluated	Demand	Energy
2, Site 5	HRP	225	180	1,575,811	1,575,811	80%	100%
2, Site 8	HRP	89	71	625,819	625,819	80%	100%
2, Site 11	HRP	63	51	442,417	442,417	80%	100%
Total	*All*	*377*	*302*	*2,644,046*	*2,644,046*	*80%*	*100%*

Table IV.6: Project Cost and Incentive Data

Project	Project Cost	Project Incentive
2, Site 5	$948,842	$126,065
2, Site 8	$427,020	$50,065
2, Site 11	$72,488	$36,244
Total	*$1,448,350*	*$212,374*

V. Findings and Recommendations

This section presents our evaluation findings about the performance and success of the Program, recommendations, and observations about the continuing need for the Program. The findings are based on a synthesis of the information gathered from our review of the Program materials, implementation effectiveness surveys, and the cost efficiency impact analysis.

Our recommendations address characteristics of the Program that could be modified to increase performance and the level of success. Recommendations are based on the findings, implementer and participant views on how the Program could be improved, and our assessment of Program effectiveness and efficiency and where Program changes could have significant benefits for the Program.

Findings

Findings are presented in the following categories:

- Customer and market characteristics and barriers to energy-efficiency investments
- Implementation effectiveness and efficiency
- Quantitative performance indicators
- Energy and demand savings
- Cost effectiveness

Customer and Market Characteristics

The evidence from the Program implementers, vendors, industry statistics, and oil producers themselves all suggests that the vast majority of oil producers in California are small producers, i.e., they produce less than 20,000 bopd. The findings are also very consistent that these producers have significant opportunities to improve their energy efficiency; the potential for energy savings in this sector is probably more than 300,000 MWh per year and more than 40 average MW.

The information also is consistent in demonstrating that these customers are literally hard to reach. They are likely to have a very small staff, little energy and engineering expertise, and little time to examine ways to improve their energy efficiency. In addition, they are likely to be “just getting by” and have little capital available for significant investments in improving their operations.

On the other hand, our participant, non-participant, and vendor interviews all suggested that these producers are good candidates for energy-efficiency upgrades. Several non-participants and all the participants said that they had been interested in energy efficiency, and several had already taken some steps to improve their efficiency. The small size of these producers also tends to make it easier for them to make decisions, once they have adequate and credible information, to move ahead with investments such as in more energy-efficient equipment.

Despite widespread need and interest, there are significant barriers to improving efficiency in this industry. Lack of credible information, lack of capital funding, and limited expertise and time to dedicate to obtaining requisite information appeared to be the significant barriers.

Program Implementation Effectiveness

Program Targeting, Outreach, and Communications. Global was able to effectively leverage the efforts of a prior program to identify potential Program participants. This allowed Global to be selective about its marketing and outreach activities. From our interviews with both participants and non-participants, and Global's success recruiting participants, this appears to have been an effective strategy.

Our findings indicate that multiple channels and media are needed to reach these businesses. Participants said they heard about the Program through a wide range of sources. Using industry associations appeared to be an effective way to reach some targeted producers, but not all of them belong to these organizations. Vendors were another effective outreach channel.

Some of the participants and non-participants had visited the Program Web, site and some had attended a workshop. The reviews of the Web site were mixed, and attendees generally gave the workshops good ratings. Producers were less likely to be aware of or be able to rate Program materials; this was consistent with the Program's focus on other outreach mechanisms.

Despite the generally positive reviews of Global's outreach, there were a few shortcomings in the communications between Global and the industry. Some participants and non-participants had incomplete understandings about things such as producer eligibility for the Program and how the incentives would be calculated. Some producers were unsure about Global's knowledge or understanding of the industry. It appeared, however, that over time, as Program details were better communicated and Global gained the confidence of this industry, these problems were mitigated.

Incentives. The incentives were the main reason producers decided to participate in the Program and make upgrades. Most participants viewed the incentive application process as very easy and most were satisfied with the incentive level. Some of the participants, on the other hand, felt that the incentives were not large enough. Vendors believed the incentives were very important and expressed the opinion that the incentives were sufficient to push most producers ahead with projects.

The only concern expressed about the incentive was some uncertainty about how much producers would receive.

Audits. Participants who commented on the audits usually felt that the audit savings estimates were credible. After making the upgrades, confidence in the savings estimates remained relatively high.

Vendors. Overall, vendors played an important role in the success of the Program. Global perceived the vendors as effective allies for promoting the Program and adding credibility to Global's efforts.

Vendors were natural allies because of the potential business benefits to them. They also saw value in the Program providing a mechanism for demonstrating the benefits of energy-efficiency measures to uninformed customers.

There was some limited risk, however, in relying too heavily on vendors. Global found it difficult to involve vendors who maintained a consistent role in the Program.

Process Issues. Overall, the process of enrolling in the Program and participating worked smoothly. However, as a result of our initial non-participant interviews and Global's own experiences, they identified several participation barriers fairly early in the Program. Two of the barriers were the same ones that limited these businesses' investments in energy efficiency – 1) lack of time and 2) uncertainty about the performance of energy-efficiency upgrades. Lack of time to learn about the Program and take the steps to participate turned out to be the biggest participation barrier.

The third barrier that Global encountered was a conflict between the Program schedule and producers' capital budgeting cycles.

Global responded to the early learning about process problems and participation barriers. Several of the barriers were addressed through Program adjustments, which helped increase participation during the latter stages of the Program.

Effects on Awareness, Knowledge, and Behavior. Interviews indicated that energy-efficiency awareness and knowledge increased overall for both participating and non-participating producers as a result of the Program. The increase appeared to be fairly limited, however. This is probably because the Program did not place a strong emphasis on producer education, but instead emphasized participation and implementation.

The interest of some non-participants and participants in future efficiency upgrades increased. This suggests that future behavioral changes are a likely result of the Program, particularly for those producers who implemented upgrades through the Program.

One area that did not receive very much attention during the Program, but could be a useful area to explore in future programs, is non-energy benefits of efficiency upgrades. Several diverse interviewees noted that some efficiency upgrades could result in higher productivity or reduced downtime and maintenance, but that the Program had not increased awareness about these benefits widely.

Satisfaction. Overall, participating producers and vendors indicated high levels of satisfaction with the Program. Both groups gave Global good marks for effective implementation.

In addition, both groups felt that Global had demonstrated a strong ability to learn about the industry rapidly and establish credibility.

Quantitative Performance Indicators

Table V.1 summarizes the targets set for the Program and the performance relative to those targets. In general, the planning and reporting requirements were met on schedule. The workshops and Web site creation occurred later than planned. Recruitment was conducted at a much larger scale than originally planned; more than 12 times the planned number of producers were contacted initially to inform them about the Program. Nearly one-third more qualifications/surveys were conducted than originally planned. Audits and commissioning/certification fell short of the Program targets because producer participation was less than expected. However, the Program exceeded its energy and demand savings goals.

Another intent of the Program was that no single facility, nor participant, should receive more than 20% of the total funds allocated from the Commission for this Program. The Program met this criterion; the largest incentive amount was 19% of the total; another producer received 18% and a third received 17%.

Table V.1: Quarterly Performance Targets for Total Program (Goal/*Actual*)

Task	2002			2003				2004		Total
	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	
1: Program Implementation Plan	100% complete	*PIP Approved 7/10/02*								
2: Customer Recruitment and Marketing (wells)		76/*0*	108/*2278*	108/*2992*	108/*195*	0/*0*	0/*0*	0/*0*		400/*5465*
3: Qualification and Survey Process (surveys/well)			75/*70*	75/*151*	75/*155*	75/*0*	0/*0*	0/*9*		300/*385*
4: Energy Audits (audits)			36/*0*	54/*18*	54/*0*	54/*17*	22/*87*	0/*25*		220/*147*
5: Training and Outreach		50% website	Workshop #1 Website 100%	*50% website Website 100%*	*Workshop #1 (4/17/03)*	Workshop #2			*Workshop #2 (5/27/04)*	
6: Commissioning and Certification (commissioning)				75/*0*	75/*0*	50/*6*	0/*16*	0/*90*	0/*25*	200/*137*
7: E M & V Coordination				20%/*20%*	20%/*10%*	20%/*20%*	40%/*20%*	0%/*20%*	0%/*10%*	100%/*100%*
8: Submission of Quarterly and Final Reports		Q2 report due *Q2 02 Done*	Q3 report due *Q3 02 Done*	Q4 report due *Q4 02 Done*	Q1 report due *Q1 03 Done*	Q2 report due *Q2 03 Done*	Q3 report due *Q3 03 Done*	Q4 report due and Final Report *Q4 03 Done*	*Final Report Done*	
Energy Goal (Net kWh)								12,334,080/ 11,426,586		12,334,080/ 11,426,586
Demand Goal (Net kW)								1,760/*1,299*		1,760/*1,299*

Another Program intent was for at least 60% of the participants to have production rates of less than 6,000 bopd. Global met this intent; eight of the ten participants produced an average of less than 6,000 bopd.

Energy and Demand Savings

Table V.2 presents our estimated gross energy and demand savings for the Program and compares them with Global's estimates.

Table V.2: Program Energy and Demand Savings Results

Annual Gross Avg. Demand Savings (kW)		Annual Gross Energy Savings (kWh)		Realization Rate	
Global	Evaluated	Global	Evaluated	Demand	Energy
2,160	1,624	15,707,808	14,283,232	91%	75%

Table V.3 presents the evaluated net energy and demand savings for this Program using a net-to-gross ratio of 0.8. This ratio was assumed in Global's original Program planning documents, but we believe a value closer to 1.0 would be more appropriate. It was beyond the scope of this evaluation to conduct a thorough analysis of free-ridership, but the evidence from our evaluation and the experiences of Global implementing this Program all suggested that it was very unlikely that these projects would have occurred without this Program.

Table V.3: Net Program Impacts

Achieved Savings	
Net kWh/yr	Net kW
11,426,586	1,299

Program cost and incentive data are presented in Table V.4.

Table V.4: Program Cost and Incentive Data

Project Costs	Program Incentives
$4,334,096	$920,379

Cost Effectiveness

Program cost effectiveness was determined for the Program as a whole using the CPUC worksheet methodology. The costs and benefits were compiled and analyzed using the Total Resource Cost (TRC) and Participant Cost Tests.

Results are shown in Table V.5 based on an assumed net-to-gross ratio of 0.8. As discussed above, this value is probably too low; thus, the Program cost effectiveness test values in the table are likely to be lower-bound estimates. These results show that the Program was cost effective from a total resource perspective as well as for participants. Table V.6 lists the costs and benefits for each test.

Table V.5: Cost Effectiveness Test Results

TRC Test Value	Participant Cost Test Value
1.79	3.20

Table V.6: Costs and Benefits by Test

CE Test	Costs	Benefits	Net Benefits
TRC	$4,461,224	$8,002,232	$3,541,008
PTC	$3,413,717	$10,923,168	$7,509,451

Recommendations and Need for Continuing Program

Based on our evaluation, we offer several recommendations for ways in which we believe the impacts and effectiveness of this Program could have been improved, or future, similar programs could be more effective.

Our recommendations are based on common themes that emerged from the interviews and our analysis. Some recommendations reflect the observations of just one or a few interviewees, but they appeared to be insightful and have the potential for significant benefits. Our key recommendations are presented below:

- ***Continue using multiple channels to inform producers about the Program***. The targeted producers are a heterogeneous group and they get their information in different ways. To be successful, a program targeting these customers must employ multiple information and promotion channels.
- ***Time the program to accommodate producers' capital budgeting cycles and extend the term if necessary***. Several producers stated that the Program schedule did not allow them to incorporate identified efficiency projects in their capital budgeting process. Given the information from this Program, future programs should take these schedules into account allow enough time to get projects through the decision process and into the budget.

- ***Provide more technical and administrative support to participants***. Global identified this need midway through the Program and stepped up their efforts to provide assistance to potential participants. These producers typically have very limited technical expertise and, even more important, limited time to fill out paperwork. Future programs will need to be able to offer both technical and administrative assistance as needed.

- ***Leverage the role that vendors and other trade allies can play***. Several interviewees identified vendors and trade allies as instrumental in the success of the Program. In the future, the role of vendors and trade allies should be expanded and be more clearly defined from the outset. Vendors can benefit from such programs by expanding their opportunities to sell and install energy-efficiency equipment, thus they should be natural allies. For their involvement to be successful, however, the Program should not appear to advocate a particular vendor and the vendors should be educated adequately about the Program.

- ***Simplify and streamline the process***. This Program was modified to make it easier to enroll after some producers voiced concerns about the complexity of the process. Future programs should continue to find ways to simplify the participation process.

- ***Provide more certainty and clarity about eligibility and the incentives***. Some producers indicated that there were uncertainties about what the eligibility requirements were.[15] Others indicated that they were unsure how the incentives would be calculated. In the future, both these program details should be more clearly defined at the beginning and communicated to potential participants.

- ***Make more use of case studies in promotion and recruitment***. This Program has provided enough information to develop case studies demonstrating successful projects in many different situations. Global was able to use such case studies in their final producer workshop. In the future, these case studies should be made available from the beginning as a means to inform potential participants about efficiency opportunities that might fit their needs. The case studies also should highlight non-energy benefits of such efficiency upgrades.

- ***Examine ways to increase producer access to used and reconditioned equipment***. One producer indicated that a large quantity of used and reconditioned equipment is available at reasonable prices. Future programs should investigate this market

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[15] This was understandable since the requirements did change after the implementation plan was finalized.

and determine whether this inventory includes equipment that is more efficient than what the targeted producers are using. If so, program implementers could work with the industry to make this equipment more accessible to producers who face significant cost hurdles and include qualifying equipment in the Program.

- ***Consider extending a program to new wells***. This Program was limited to existing wells. To the extent that new wells come on line, there could be opportunities to increase efficiency beyond standard practice for the smaller producers. Designers of future programs should investigate this market potential and determine whether it would be feasible and efficient to extend a program to new wells.
- ***Conduct further research on interactions between energy-efficiency measures and well characteristics***. Energy-efficiency changes, particularly those involving the performance of pump motors, can affect well characteristics. In turn, these changes can affect well or field productivity, and these changes need to be taken into account in determining the impacts of energy-efficiency improvements. Additional research should be conducted to establish the best possible basis for calculating energy and demand savings when productivity also changes.
- ***Collect more comprehensive data on each participating well***. The data available to analyze the projects varied considerably. It would be useful to document the well characteristics consistently for each project, both before and after the efficiency upgrade. This information would be useful for identifying and assessing any productivity changes and providing a more complete analysis of each project.

Finally, we believe that there is solid evidence that there is a continuing need for a program of this type. Our study shows that there is a significant energy savings potential in this market and that these producers have a strong interest in improving their energy efficiency. This Program was cost-effective and implementing the recommendations presented above could make future programs even more cost-effective. The challenge in future programs will continue to be reaching potential participants and working with them through the process; however, we believe that implementing several of our specific recommendations could help reduce these barriers significantly.

Appendix A. Memorandum on Savings Analysis

This appendix presents a memorandum prepared by Quantec addressing the analytic options for analyzing well projects where well characteristics changed when efficiency improvements occurred. The oil producer name has been deleted from the memo.

Date: **March 25, 2004**

To: **Mark Reedy**

From: **Allen Lee, Elaine Prause**

Re: **Review of Energy and Demand Savings Methodology**

Global Energy Partner's Electricity Consumption and Demand Reduction in Oil Production Program employs a systems approach to increasing the overall energy efficiency of participating oil producers' production to reduce their energy costs. Multiple energy savings measures may be implemented at each participating well depending on site characteristics.

The amount of energy savings due to installation of more efficient equipment will vary by participant and the pre conditions of the pumping equipment and well reservoir. Therefore, each participant's energy savings must be calculated individually while following a consistent methodology across participants. This memo reviews the approach that Global has used in its initial method to estimate energy savings for two projects, in which more efficient, lower horsepower motors were installed, and recommends potential changes.

Background

We investigated the magnitude of energy savings resulting from installing more efficient lower horsepower motors by reviewing the pre and post well and production conditions for two well projects. Data collected by Global before and after installation and used in this analysis included

- gross production (oil plus water)
- oil production
- fluid surface level
- amperage and voltage of motor with power factor
- pump depth
- top and bottom depth of the well perforation

Besides the obvious and expected difference in motor amperage and voltage, the gross production, oil production, and fluid surface depth of the wells changed from pre to post conditions due to changed well production dynamics with the new motors. The direction of the change in gross production, the ratio of oil to fluid production, and fluid surface depth varied from well to well, driven by many possible factors at each site including the new pressure differential created in the well, fluid viscosity and permeability of the surrounding rock.

To calculate energy savings for purposes of applying the standard energy-efficiency program cost-effectiveness tests, it is necessary to have an energy consumption baseline against which to compare the post energy consumption. For most end-uses, the output of a system is the same in the pre and post conditions, but the energy consumption declines. For example, a more efficient heating system provides the same comfort conditions as the less efficient system it replaced. In Global's Program, however, the projects we examined demonstrated that not only output can change, but other key factors that determine the efficiency of production are also variable. Just looking at changes in energy consumption for a particular well can give misleading results; for example, energy consumption can increase rather than decrease, but production can increase substantially.

Global's current method of estimating energy savings is based on a performance measure, kWh/bbl/1000', which is the electricity required to pump a barrel (bbl) of fluid 1000 feet. This is an appropriate performance measure (PM) to compare the efficiency of different wells. Global's approach calculates this measure once using the pre conditions, and again using the post conditions, to compare the pumping efficiency of the well before and after the project. In either case, the quantity of fluid pumped is the barrels of fluid (gross) and the depth is the surface level of the fluid being pumped.

Energy savings are then estimated by multiplying the change in this PM times the post gross production (in bbl/day, or BPD) and post fluid level:

> Annual energy savings (kWh/yr) = (kWh/bbl/1000'$_{pre}$ – kWh/bbl/1000'$_{post}$) x Gross BPD $_{post}$ x Fluid level depth $_{post}$/1000' x 365 days/yr

Discussion

Table 1 summarizes the key inputs and data for two wells analyzed so far.[16] The fluid depth is the depth at the fluid surface. Mid-perf depth is the average of the upper and lower perforations. For these wells, the fluid depth decreased

[16] Note that data for the C well were available, but not all pre and post values were recorded so we could not analyze this well consistently with the others.

and both the gross and oil production rates increased after project implementation. The pumping efficiency, as measured by the PM (kWh/bbl/1000'), decreased for both wells, as expected.

Table 1: Well Data

Characteristic	A	B
Fluid Depth, Pre (ft)	4,568	5,723
Fluid Depth, Post (ft)	5,765	6,000
Mid-perf Depth (ft)	6,884	7,523
Gross Production Rate, Pre (bbl/day)	1,258	1,451
Gross Production Rate, Post (bbl/day)	1,889	1,729
Oil Production Rate, Pre (bbl/day)	20	29.8
Oil Production Rate, Post (bbl/day)	60.5	41.5
kWh/bbl/1000', Using All Pre Conditions, Fluid Depth, and Gross bbl	0.386	0.385
kWh/bbl/1000', Using All Post Conditions, Fluid Depth, and Gross bbl	0.221	0.239
Change in kWh/bbl/1000', Post – Pre	0.165	0.146

From the cases analyzed so far, there are three factors that we believe should be reviewed that can greatly impact the energy savings calculation:

- Fluid surface depth - pre, post, or mid-perf
- Production rate - pre or post
- Production measure - bbl oil v. bbl gross

We investigated the impact of each of these factors on the energy savings calculation in more detail. The results are presented as sensitivity analyses where only one variable is changed at a time, starting with the basic methodology used by Global.

Fluid Surface Depth

Energy savings are currently estimated by using the pre and post fluid surface depths to calculate the pre and post pumping PMs and then using the post fluid depth in the energy savings calculation. There are three questions that we believe this raises.

First, does the fluid surface depth accurately reflect the amount of pumping energy required? Because the fluid is distributed over a substantial depth from which it is being pumped, the top level may not be the most accurate estimate of the energy required to lift the fluid from different levels.

Second, should a change that increases fluid depth alone be treated as an efficiency improvement? A change in fluid depth enters the current savings calculation in two ways. It is reflected in the change in the PM, kWh/bbl/1000', and in the depth multiplied by this value. For example, if a change results in a 20% increase in fluid depth, but no change in the kWh required to lift a bbl of fluid, this calculation would suggest that the energy consumption per bbl/1000' has declined by 17% (1 – (1/1.20)), and total pumping energy per bbl extracted has fallen by 20%. However, since neither the kWh nor production rate has decreased in this simple example, the energy required to produce a barrel has not actually changed.

One alternative to using the fluid depth in the performance calculation is to use the mid-perf elevation. This depth is the average of the top and bottom levels of the region between which oil is extracted from the well; this depth is constant between pre and post conditions in most configurations. Table 2 compares the energy savings estimates using the original methodology to the estimates using the mid-perf depths in all calculations. Note that since the depth does not change, the calculation can be simplified to pumping energy per bbl. The following equation is used to calculate this revised estimate of energy savings:

$$\text{Total Annual Savings} = (\text{kWh/bbl}_{pre} - \text{kWh/bbl}_{post}) \times \text{Gross BPD}_{post} \times 365 \text{ day/yr}$$

Table 2: Energy Savings Calculations using Different Depths, kWh/yr

Depth Used in Savings Calculation	A	B
Pre/Post Fluid Depths in PM and Post Fluid Depth Multiplier	657,839	549,249
Mid-perf Depth in All	339,113	481,956
Change	-48%	-12%

In these two cases, the estimated energy savings are less using the mid-perf depths.

As noted above, using the same depth in the pre and post calculations effectively eliminates depth from the PM calculation and a more straightforward calculation of energy use per bbl extracted can be applied. This is attractive because the energy required to pump a given fluid amount is the economic test that is most important. The PM based on depth, however, remains the preferred metric for comparison of pumping efficiency between wells and identification of candidates for efficiency improvements.

Production Rate

The second parameter that has a large impact on the results of the energy savings calculation is the production rate. By making efficiency improvements, the gross production rate can increase, decrease, or remain the same, depending on interactions with other changes in well characteristics.

This raises the question of what production rate should be used in the energy savings calculation.

To illustrate, a change that doubles gross production rate, but does not affect well depth or energy consumption, decreases the energy used per barrel of fluid by 50%. However, the calculated energy savings differ by a factor of two depending on whether they are based on the original or new production rate. In most program evaluations where production changes, the usual approach is to evaluate the savings using the post production rates. The current energy savings methodology does use the new gross production rate to estimate energy savings.

Table 3 shows the effect of production rates on the energy savings calculation. The calculation is exactly the same as that used by Global except the production rate used to multiply the PM is the pre-project rate in one case and the post-project rate in the other. Since the production rate increased for both projects after the efficiency measures were implemented, energy savings calculated using the post production rates are higher.

Table 3: Energy Savings Calculations using Different Gross Production Rates, kWh/yr

Production Rate Used in Savings Calculation	A	B
Post Production Rate	657,839	549,249
Pre Production Rate	438,095	461,150
Change	-33%	-16%

Using the pre production rate at post fluid level gives conservative estimates by not accounting for the increased production. Using the post production rate at post fluid level assumes that production could have been increased somehow to the final production rate without changing the efficiency level (kWh/bbl/1000’). In addition, it assumes that production can be continued at the new conditions at least as long as production at the original rate.

Oil Production Rate

In all the previous calculations, the production rate used was based on gross production. However, barrels of oil, not total fluid, are the key output. The producer makes economic decisions based on the costs of producing oil since oil output generates revenues. From the data available for these two projects, it appears that the mix of oil and water can change, along with production rate, fluid depth, and energy consumption. Consequently, we examined the effects of basing the calculation on oil production instead of gross production. The results are shown in Table 4.

For the two wells analyzed, the effect of using oil production in the savings calculation is to increase the estimated energy savings significantly. For the well with a tripling of oil production, this method increases the savings estimate by more than 200%.

Table 4: Energy Savings Calculations using Gross and Oil Production Rates, kWh/yr

Fluid Used in Savings Calculation	A	B
Gross (Oil + Water)	657,839	549,249
Oil	2,215,194	798,449
Change	+237%	+45%

Using the oil production rates in the energy savings calculation assumes that the original oil production could have been increased to the post level without changing the original PM and that oil production at the post level is sustainable indefinitely. Whether this is achievable is an open question.

Conclusions

Our analyses illustrate the importance that key assumptions have in the calculation of energy savings. Because so many parameters can change between the pre and post conditions and the parameters are linked in complex ways, there is no simple approach to estimate the "correct" energy savings values.

Ideally, monitoring data would be available that would allow us to determine the effect of individual parameters on energy use. Long-term monitoring and monitoring done at conditions that were identical between the pre and post conditions would help control for the parameters that change. It would be desirable to do a research project that addressed these parameters. Without more extensive data, however, we have used the available information to draw some conclusions and propose a consistent approach for estimating savings.

We believe that kWh/bbl is a key variable because it measures the energy required to lift a barrel of fluid (whether gross or oil). A decrease in this variable indicates how much less energy is required to produce one unit of output. In the PM calculation, using a constant depth midway between the upper and lower perf depth (as long as there is no change between pre and post conditions) and multiplying by the average perf depth removes depth from the savings calculation and we propose taking this step.

This leaves two questions for the energy savings calculation:

1) Should barrels of oil or gross barrels be used?

2) What production rate should be used?

Because oil is the critical output, we propose using barrels of oil in the calculation. Since it appears the oil production rate can change dramatically between the pre and post conditions, but there are likely to be uncertainties about maintaining large increases in the oil production rate, we propose using the average of the pre and post oil production rates in the calculation. Our proposed revised equation for calculating energy savings is shown below:

$$\text{Annual energy savings (kWh/yr)} = (\text{kWh/bbl}_{\text{oil, pre}} - \text{kWh/bbl}_{\text{oil, post}}) \times (\text{bbl}_{\text{oil, pre}} + \text{bbl}_{\text{oil, post}})/2 \times 365 \text{ days/yr}$$

A comparison of the energy savings from this calculation with the original savings estimates is shown in Table 5.

Table 5: Savings Estimates from Original and Proposed Method, kWh/yr

Method	A	B
Original	657,839	549,249
Proposed	1,046,574	617,759
Change	+59%	+13%

For both these projects, the energy savings estimated using our proposed method are higher than the original estimates. There is no certainty, however, that this will be the case with other projects. It would be desirable to settle on a consistent approach before many additional projects are in the pipeline.

We would appreciate your feedback on the information and proposals presented in this memo. In particular, we would appreciate your comments and Dr. Ershaghi's on the following:

- Is the mid-perf depth likely to be constant between pre and post conditions for the remaining projects?
- Is it reasonable to use the oil production, instead of gross production, as the factor most closely linked to energy use?
- Is it reasonable to base the savings estimates on the average of the pre and post oil production rates?

- Are the post production conditions likely to remain relatively constant for an extended period of time?
- What lifetime is most reasonable to assume in the cost-effectiveness analysis?