# SMUD SHADE TREE PROGRAM: A UNIQUE APPLICATION OF EVALUATION TOOLS

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## ABSTRACT

This paper examines how results of program evaluation tools were used to achieve continuous improvements and refinements in program design, operation and achievement. The nation's largest shade tree program, sponsored by the Sacramento Municipal Utility District (SMUD) in collaboration with the Sacramento Tree Foundation (STF), is used as a case study. Results of impact and process evaluation studies as well as market research analysis and quality assurance inspection results are presented, along with program modifications that were implemented to improve program effectiveness.

## INTRODUCTION

The SMUD's Shade Tree program offers an excellent example of how results of program evaluation tools have been used to achieve continuous improvements and refinements in program design, operation and achievement. The effect has been to transform an already innovative program into one of SMUD's most successful Demand-Side Management (DSM) programs today. This paper will also examine key issues involved in evaluating benefits (avoided cost of energy and capacity) of a tree planting program from the perspective of an electric utility, as well as from a wider perspective of public and private entities that may benefit from such programs.

## BACKGROUND AND PROGRAM DESCRIPTION

In 1990, SMUD in conjunction with the STF initiated the nation's largest organized shade tree program to reduce building cooling loads. The program's primary objective was to plant shade trees that directly shade air-conditioned building structures. A secondary objective of the program was to create an urban forest that would help mitigate the *urban heat island* effect-- the increase in summer outdoor temperatures caused by urban development. Potential non-energy benefits of the program include improving the region's air quality, enhancing esthetics and quality of life in the region, and improving property values of program participants.

The Shade Tree program provides a comprehensive and long-term program in tree planting, management, education, and citizen participation. The program is implemented in collaboration with the STF, a non-profit community based organization whose goal is to improve the quality of life in the Sacramento area by inspiring and motivating the community to plant and perpetuate a healthy urban forest. SMUD believed that the involvement of a community non-profit group would be an important ingredient in the success of the program.

Utility customers expressing interest in participating in the Shade Tree program contact SMUD, which schedules the customer to attend a neighborhood meeting with a Community Forester who is a member of STF staff. Program participants then attend a neighborhood meeting at a local

school, library, park facility, or church. During the meeting, customers watch a tree planting demonstration video in order to learn about proper planting and maintenance of shade trees. If there is an interest and need for shade trees, customers will schedule an appointment for a site visit by one of the Community Foresters. During site visits, Community Foresters and customers mutually select appropriate tree species and locate specific sites for each tree planting. Shortly thereafter, STF staff delivers to customers the requested trees in five-gallon containers free-of-charge. Customers are then responsible for planting and caring for the trees they received.

From SMUD's perspective, the tree-planting program represents a type of DSM program that has a tangible economic value to the utility. This value can be quantified based on avoided supply costs of energy and capacity during high cost of summer peak load periods, or the decrease in supply costs to the utility due to reduced building electrical loads. SMUD's total investment in the program since 1990 has been about 20 million dollars, or approximately two million dollars per year. Through 1998, over 250,000 trees have been planted through the program. However, under SMUD's strategic plan for 1996-2000, the goal of the Shade Tree program has shifted. The program performance measurement had shifted from planting a specified number of trees per year to measuring directly the kWh and kW savings resulting from shading homes to reduce summer cooling loads.

## PROCESS EVALUATION

In August of 1993 SMUD contracted with a private consulting firm to perform a process evaluation of the program. SMUD management believed that an outside consultant would provide an objective unbiased view of the program delivery mechanism and evaluate the structural relationship between the SMUD and STF.

From program inception, SMUD staff perceived a divergence of objectives between SMUD and STF. SMUD viewed the Shade Tree program as a DSM resource program that was competing internally against supply side options (i.e. power generation), and thus the emphasis was on the overall energy saving potential (i.e. kWh and kW saved). SMUD was building an energy conservation "power plant", and thus each shade tree was viewed as a DSM measure that was providing energy and capacity savings.

On the other hand, STF viewed the program as a way to expand the Sacramento urban forest, and thus the STF and the program goal was to maximize the number of trees planted. STF sited and homeowners planted large numbers of small decorative trees all over homeowners' properties with little regard to the energy saving potential of the tree-siting location.

The purpose of the Shade Tree program process evaluation was to document the program implementation and to make specific recommendations for program optimization. The process evaluation included the following: in-person interviews with SMUD and STF program staff, a focus group discussion with STF Community Foresters, telephone surveys of program participants, telephone interviews of tree vendors, and a field review of the implementation of the program.

SMUD staff prepared the customer satisfaction survey instruments, and then contracted with a marketing research firm to perform the telephone interviews. Overall, customers were very satisfied with the Shade Tree program. Customers liked that trees were free and they liked the educational value of the program (i.e. tree care and maintenance). The process evaluation report was issued in 1994 and the following were the recommendations and the subsequently implemented outcomes:

(1) Recommendation: Establish a Steering Committee that would include equally selected SMUD and STF staff with the hands-on responsibility for the day-to-day planning, monitoring, evaluation, and

operation of the program. The recommendations of the Steering Committee were subject to approval by SMUD management before they were implemented. The objective of this recommendation was to foster cooperation between the SMUD and STF.

Implemented outcome: The Steering Committee was created in 1994 and is still in existence today. It has been instrumental in creating a sense of partnership between the two distinctly different entities: electric utility and non-profit community organization.

(2) Recommendation: Perform a market potential study and impact evaluation that would specifically provide recommendations for tree-siting guidelines, which would emphasize the optimal mix of the program goals.

Implemented outcome: An impact evaluation study commenced immediately after the process evaluation study was completed, and it resulted in significant revisions of the program's tree-siting guidelines.

(3) Recommendation: Develop annual marketing plan and joint advertising campaigns

Implemented outcome: A member of the SMUD Marketing department joined the Steering Committee and with the STF representative took the responsibility of developing a cohesive and effective marketing plan.

(4) Recommendation: Improve the customer appointment scheduling process for the STF Community Foresters' on-site visits.

Implemented outcome: SMUD installed new scheduling software for the Shade Tree program which automatically assigned appointments between the STF Community Foresters and SMUD customers.

The overall benefit of the process evaluation study recommendations was to improve the lines of communication between SMUD and STF staff, and to clarify the respective roles of SMUD and STF in the design and implementation of the Shade Tree Program.

## IMPACT ANALYSIS

SMUD and the U.S. Department of Agriculture Forest Service's (USDAFS) Western Center for Urban Forest Research and Education collaborated on an impact evaluation study. Pursuant to the process evaluation recommendation, the study was designed to develop more accurate methods for assessing the energy and capacity saving impacts and cost-effectiveness of SMUD's Shade Tree program. In 1994, SMUD and STF staff performed on-site surveys on a random sample of 326 residential sites at which trees had been planted through the program from 1991 to 1993. Staff collected detailed information on tree mortality rates, tree location (i.e. tree size, orientation, & distance to the building) and building characteristics (i.e. square footage, vintage, number of building stories, type of cooling system, orientation, number and size of the windows).

USDAFS used the data collected through the on-site visits to perform shade and building simulation modeling. As part of this study, the impacts of individual trees on utility electric loads (energy and peak capacity) were estimated for 72 different shading scenarios. These scenarios represented mature trees of three different sizes (Small, Medium, and Large), eight cardinal orientations (N, NE, E, SE, S, SW, W, and NW), and three distances (Adjacent 0-15ft, Near 16-30ft, and Far 31-50ft) from a typical post-1990 home in Sacramento.

The simulation model used for estimating electric load impacts from trees planted through the Shade Tree Program was calibrated to statistical estimates of average Unit Energy Consumption (UECs) and demand load shapes for homes with central electric cooling. These UEC estimates were developed by SMUD for use in utility program planning and load forecasting. Additional adjustments were made based on the percentage of program participants that were estimated to have central air conditioning or other types of electric cooling equipment.

The impact evaluation report was issued internally in 1995. The results revealed that the average cooling energy and demand savings per mature tree for central air & heat pumps homes (88% of all homes in the program) was 106 kWh and .041 kW. However, 4.2% of program participants reported having only room/wall air conditioners, and 1.7% reported having evaporative coolers. These cooling systems were assumed to use only 25% and 33% respectively of the cooling energy used by customers with central air conditioning systems. The remaining 6% of the program participants reported having no electric cooling system. After the adjustments, the SMUD weighted average energy and demand saving impacts per tree were lowered to 95 kWh and .038 kW.

The load impact estimates were also combined with data collected in on-site visits to estimate additional savings from shading of adjacent neighbor homes. Results of this analysis indicated that up to 23 percent of trees planted might provide benefits from direct shading of adjacent buildings. Overall, the analysis estimated that the additional reduction in electric load resulting from shading of adjacent buildings equaled about 15 percent of that from direct shading of participants' homes.

Finally, the impact evaluation resulted in a standardized economic value for the estimated reduction in energy and capacity attributable to shade trees. This value, which incorporated the impact from shading both a participant's home and an adjacent home, was converted to a dollar value of avoided supply cost per tree. Load impacts over the life of a shade tree were given a dollar value by using the SMUD's avoided cost of power in discounted present value format (i.e. based on SMUD's marginal energy and capacity cost of advanced renewable technologies and a discount rate of 6.6%) over a 30-year planning horizon. This dollar value will be referred to hereafter as "Present Value Benefit" or "PVB".

Figure 1 summarizes estimates of the average per tree program PVBs for trees planted during the 1991-1993 program period. The average estimated program PVBs for each tree planted to the west of participants' homes ($120) was estimated to be three times as large as the average benefits for all trees planted through the entire program ($39). In eastern and southern orientations (east, southeast, south, and southwest), average estimated program benefits from shading of participant homes ranged from about $19 to $35 per tree. Figure 1 illustrates the relative values of various tree-siting orientations. These values gave the program implementers a strong message of the relative importance of strategic tree-siting.

Figure 2 provides another perspective on the importance of orientation in tree planting. The figure compares the percentage of total number of trees planted in each orientation during 1991-1993 to the percentage of total estimated program benefits attributable to trees planted in each of these locations. As Figure 2 shows, trees planted on the west accounted for only 18 percent of trees planted through the program, but provided nearly one-half (47 percent) of program benefits. Trees planted on the north, northeast, and northwest of participants' homes represented 21 percent of all trees planted, but contributed only about eight percent of total program benefits.

**Figure 1**
**Total Average Present Value of Benefits (PVB) per Tree by Tree Orientation**

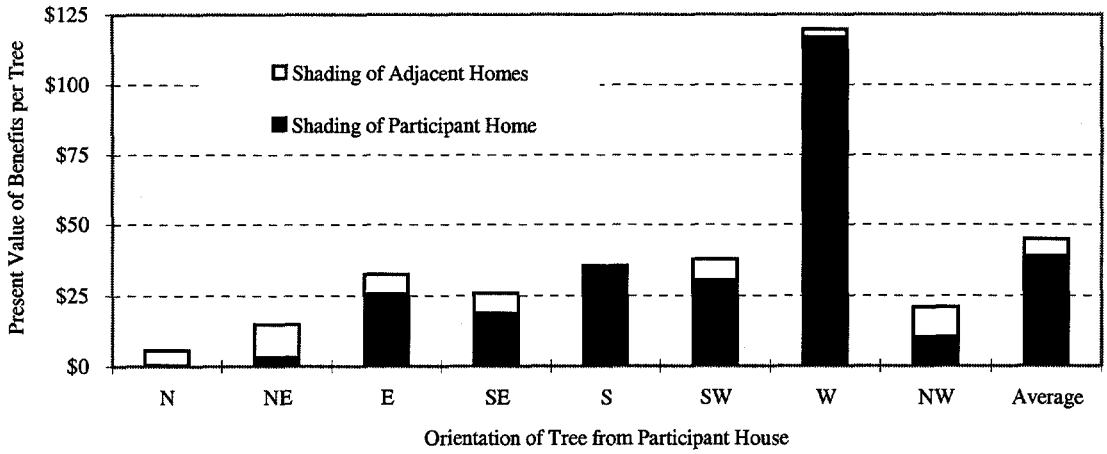
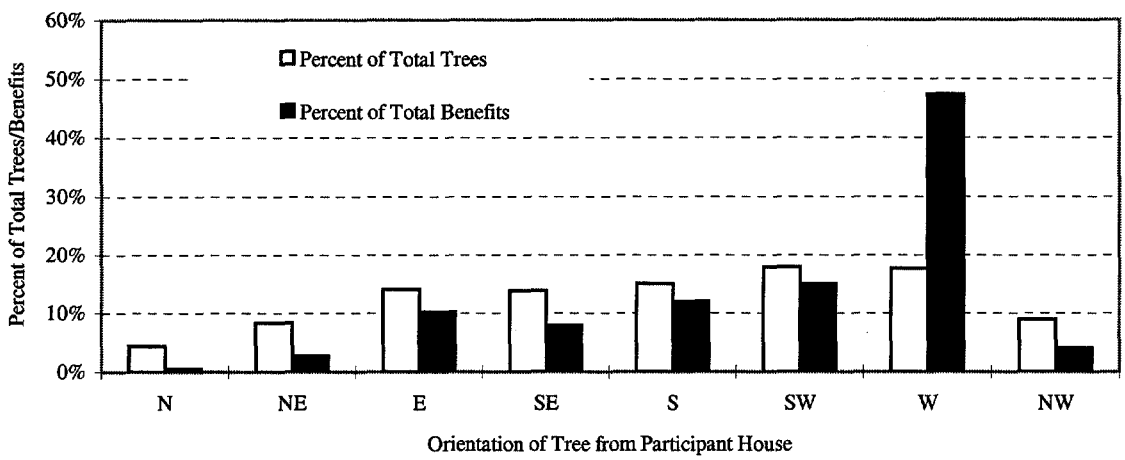



**Figure 2**
**Percent of Total Trees Planted and Total Program Benefits by Tree Orientation**




## Recommendation: Revise the Program Tree-Siting Guidelines to Improve Overall Program Cost-Effectiveness

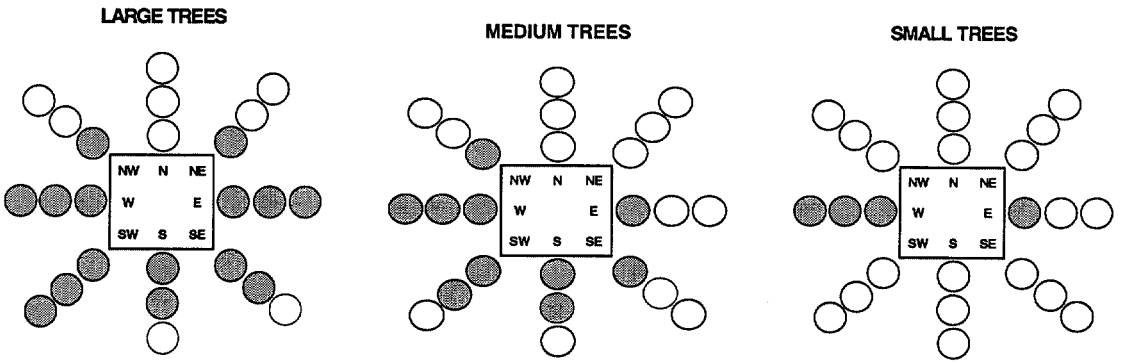
The most important contribution of the impact evaluation was a change in the program focus. Instead of tracking program performance in terms of the number of trees planted, the program is now evaluated in terms of estimated Present Value Benefit (PVB) of each planted tree (as expressed in dollar terms). STF staff refers to this program modification as the "paradigm shift". Community Forester job performance is now partially measured in terms of the achieved weekly and monthly PVB. The new tree-siting guidelines resulted in STF staff planting fewer shade trees, while the overall energy and capacity savings have increased.

These new tree-siting criteria have been expressed in terms of the72 tree shading scenarios identified in the impact evaluation. The72 tree shading scenarios pertain to the tree's size, orientation

to, and distance from the home it is shading. The tree shading scenarios are used to direct tree planting into orientations, distances, and appropriate tree sizes that represent cost-effective tree-sitings. The 72 tree shading scenarios also provide a "scorecard" used by Community Foresters in the field to maximize the benefits of shade tree planting on a site-by-site basis. Table 1 and Figure 3 illustrate the PVBs for the 72 tree shading scenarios. The shaded scenarios indicate the tree-sitings that are considered to be cost-effective and allowed in the program.

**Figure 3**

**What is Allowed Under the New Tree-Siting Guidelines**




*Shaded sites have higher than the minimum $11 per tree PVB.*

Previous tree-siting guidelines addressed minimum distances from buildings and other structures for safety reasons, but did not address maximum distances or orientation relative to buildings to be shaded. To establish minimum PVB criteria for correctly siting cost-effective trees, the siting guidelines were modified to require that the incremental program benefit of each additional tree planted at each site exceed $11, which is SMUD's incremental cost to plant that additional tree. In addition to indicating the minimum cost-effectiveness threshold (>$11), the PVBs for the 72 individual tree shading scenarios may be used to maximize the benefits at each tree planting site.

In addition to the tree-siting guidelines, the impact evaluation resulted in development of a new program database that was designed specifically to track the achieved tree PVBs. Also, tree-siting guidelines were relaxed to allow for the first time to plant trees to shade adjacent neighbor homes, as long as the PVB is greater than minimum of $11. In order to maximize the optimum shading by each individual tree along a building wall, the Shade Tree program instituted for the first time guidelines regarding the proper spacing between shade trees, and disallowing "redundant tree shading" practices.

**Table 1**
**Present Value of Avoided Cost Benefits (PVB) per Tree**

*NORTHWEST*

| Tree Size | Distance | PVB |
|---|---|---|
| LARGE | Adjacent | $44.41 |
| MEDIUM | Adjacent | $12.08 |
| LARGE | Near | $5.62 |
| SMALL | Adjacent | $5.06 |
| MEDIUM | Near | $3.37 |
| LARGE | Far | $2.81 |
| SMALL | Near | $1.69 |
| MEDIUM | Far | $1.40 |
| SMALL | Far | $1.12 |

*NORTH*

| Tree Size | Distance | PVB |
|---|---|---|
| LARGE | Adjacent | $3.65 |
| MEDIUM | Adjacent | $2.25 |
| LARGE | Near | $.84 |
| LARGE | Far | $.00 |
| MEDIUM | Far | $.00 |
| MEDIUM | Near | $.00 |
| SMALL | Adjacent | $.00 |
| SMALL | Far | $.00 |
| SMALL | Near | $.00 |

*NORTHEAST*

| Tree Size | Distance | PVB |
|---|---|---|
| LARGE | Adjacent | $30.23 |
| SMALL | Adjacent | $.00 |
| SMALL | Near | $.00 |
| SMALL | Far | $.00 |
| MEDIUM | Near | $.00 |
| MEDIUM | Far | $.00 |
| LARGE | Near | $.00 |
| LARGE | Far | $.00 |
| MEDIUM | Adjacent | $.00 |

*WEST*

| | | |
|---|---|---|
| LARGE | Near | $184.43 |
| LARGE | Adjacent | $170.60 |
| LARGE | Far | $154.69 |
| MEDIUM | Adjacent | $134.33 |
| MEDIUM | Near | $130.96 |
| MEDIUM | Far | $88.69 |
| SMALL | Adjacent | $65.90 |
| SMALL | Near | $38.13 |
| SMALL | Far | $22.89 |

*EAST*

| | | |
|---|---|---|
| LARGE | Adjacent | $69.26 |
| LARGE | Near | $61.96 |
| MEDIUM | Adjacent | $49.32 |
| LARGE | Far | $32.58 |
| SMALL | Adjacent | $14.32 |
| MEDIUM | Near | $2.81 |
| SMALL | Near | $2.81 |
| MEDIUM | Far | $.28 |
| SMALL | Far | $.28 |

*SOUTHWEST*

| | | |
|---|---|---|
| LARGE | Adjacent | $88.37 |
| MEDIUM | Adjacent | $53.58 |
| LARGE | Near | $47.50 |
| LARGE | Far | $14.60 |
| MEDIUM | Near | $13.76 |
| SMALL | Adjacent | $6.46 |
| MEDIUM | Far | $3.93 |
| SMALL | Near | $1.40 |
| SMALL | Far | $.28 |

*SOUTH*

| | | |
|---|---|---|
| LARGE | Adjacent | $105.78 |
| MEDIUM | Adjacent | $74.92 |
| LARGE | Near | $58.28 |
| MEDIUM | Near | $11.51 |
| SMALL | Adjacent | $7.58 |
| LARGE | Far | $6.74 |
| MEDIUM | Far | $.28 |
| SMALL | Far | $.00 |
| SMALL | Near | $.00 |

*SOUTHEAST*

| | | |
|---|---|---|
| LARGE | Adjacent | $80.82 |
| MEDIUM | Adjacent | $31.35 |
| LARGE | Near | $20.50 |
| MEDIUM | Near | $6.46 |
| LARGE | Far | $6.18 |
| SMALL | Adjacent | $2.81 |
| MEDIUM | Far | $.84 |
| SMALL | Near | $.28 |
| SMALL | Far | $.00 |

*NOTES: Shaded scenarios indicate trees with Present Value Benefits over the minimum allowed $11, and thus those tree siting scenarios are allowed in the program. Distance of tree from building is based on the following categories: adjacent (15 to 30 ft), near (30-50), and far (50 ft).*

## TECHNICAL POTENTIAL STUDY

Another recommendation of the process evaluation was to conduct a technical market potential study to quantify the remaining tree-planting potential in the SMUD service area. In 1994 SMUD contracted with the USDAFS to identify the number of energy-conserving planting sites in the SMUD service area. The study was designed to provide information beyond a count of tree sites. For example, because air conditioning savings are related to tree location, information regarding the distribution of tree sites with respect to building orientation can be indicative of potential savings. Also, information on the number of sites for trees of different sizes (small, medium, and large trees) could help gauge the future demand for different types of trees.

Using large-scale aerial photographs of residences within the urbanized portion of SMUD service territory, USDAFS classified existing trees and potential tree planting sites by tree size, cardinal direction, and distance from buildings (60-ft maximum distance). The estimated number of technical potential for tree planting was determined to be 844,192 trees. The overall mean was 3.2 trees per residence. Most sites were suitable for medium trees (44%) and small trees (39%). Seventy percent of these sites were located in directions from which the greatest air conditioning savings are usually obtained (i.e., east, southeast, southwest, and west).

The results of the technical potential study were used to reaffirm that planting several thousand shade trees annually is technically feasible. Also, the study was able to answer affirmatively the question of whether the STF could implement the new tree-siting guidelines without sacrificing its long-term tree planting goals.

## MARKET POTENTIAL STUDY

As a follow-up to the technical potential study, SMUD's next evaluation of the program was a market potential study. For this study SMUD in 1996 conducted two distinctly different telephone surveys of its residential customers regarding the Shade Tree program.

The first of the two surveys was a survey of program non-participants from the general population of 420,000 residential customers (minus 80,000 existing program participants) who had never called SMUD or STF regarding participation in the program. The objectives of the Non-Participants survey were to assess and quantify:

(1) the level of customers' awareness about the Shade Tree program,
(2) reasons for customers' non-participation,
(3) market barriers to customer participation,
(4) impact of potential program marketing messages, and
(5) any marketing leads among the survey respondents who expressed interest in the program participation.

The key findings of the non-participant survey were issued in 1997:

1. The two most common reasons that customers did not participate were a technical constraint "No Space in Yard"(34%) and a market constraint "Do Not Want Any More Trees"(25%). These results appeared to indicate that any program modifications instituted by the program would not influence participation of approximately 59% of the market.

2. Cross tabulation of non-participant customers revealed that only 29% of customers had both high technical potential and high market potential. In other words, 29% of customers had the Western side of their homes fully exposed to sun and stated that they would be somewhat likely or very likely to participate in the program.

The second element of the market potential study was a "Decline" survey. This survey contacted SMUD customers who had called SMUD or STF for free shade trees and subsequently received a visit by a community forester, but who missed the tree planting demonstration, and never received the shade trees. STF had a list of approximately 1,000 such customers who failed to continue their participation in the program. The objectives of the "Decline" survey were:

(1) assess and quantify market barriers to customer participation or quantify reasons why customers choose not to continue participation in the program,
(2) seek suggestions from the survey respondents on how to improve the program delivery, and
(3) seek any leads among the survey respondents who expressed interest in continuing their program participation.

The key findings of the "Decline" survey were published in 1997:

1. The two most common reasons why Decline Customers did not complete their participation in the program were "Conflict of Schedules" (35%) and "No Time for Tree Planting Demonstration" (6%).
2. For Decline customers who cited "Conflict of Schedules", 75% or 93 customers stated that they would like to be contacted again to attend another tree planting demonstration.
3. For Decline customers who did not have the time for the tree planting demonstration, 33% stated that they prefer Weekends as the more convenient time, and 14% stated they do not have *any* free time.

The survey resulted in three (3) recommendations designed to make the process of receiving and planting trees more customer friendly, increase customer participation, and provide valuable public relations benefits to the District. These recommendations were derived from the options that survey respondents said might make them "much more likely" to start or complete program participation. Three program changes have been incorporated, as a result of these recommendations:

1. Over half of all survey respondents mentioned more convenient scheduling, such as being able to schedule a site visit on Saturdays and/or weekdays after 5 p.m. during summer months. This program modification was implemented quickly.
2. Almost half of the survey respondents mentioned being able to receive instructional material through the mail instead of attending a tree planting video demonstration. This option is being implemented.
3. Almost one third of the survey respondents mentioned the option of obtaining tree delivery and planting through youth organizations or professional contractors. STF now delivers free shade trees to the homeowner's door. If the homeowner is unable to dig a planting hole, STF has a list of volunteers who can help.

## QUALITY ASSURANCE INSPECTIONS

One of the impact evaluation recommendations was to conduct routine Quality Assurance (QA) inspections as an integral part of the program oversight. These QA efforts provide an ongoing opportunity to evaluate program performance by examining various measures of success such as the tree survival rate, realization rate of the reported PVB (a cost effectiveness measurement) and various customer satisfaction indicators. Through the middle of 1999, SMUD performed seven (7) QA inspections and Customer Satisfaction Surveys since the program impact evaluation report was issued in 1995. Each time a QA Inspection sample is selected, customers receive a letter notifying them that they should expect a visit from the SMUD QA staff. At the same time, SMUD staff mails to customers a copy of the Customer Satisfaction Survey. Survey results have consistently shown an overwhelming majority of participants to be extremely satisfied with the program.

Table 2 summarizes results of the 7 QA inspections conducted thus far.

**Table 2**
**Shade Tree Program Quality Assurance Inspection Results**

| | 1st QA | 2nd QA | 3rd QA | 4th QA | 5th QA | 6th QA | 7th QA |
|---|---|---|---|---|---|---|---|
| Inspection Date | 1/96 | 12/96 | 3/97 | 7/97 | 3/98 | 8/98 | 1/99 |
| Tree Planting Period Covered | Dec. 95 | Aug. - Oct. 96 | Nov. 96 - Jan. 97 | Feb. - Apr. 97 | Sep.- Dec.97 | Feb.- Apr. 98 | July- Oct. 98 |
| Trees in the Sample | 276 | 476 | 602 | 410 | 471 | 414 | 518 |
| Sites receiving trees in the Sample | 82 | 101 | 119 | 100 | 102 | 101 | 88 |
| Avg. Planted Trees per Site in the sample | 3.4 | 3.8 | 3.7 | 3.2 | 4.6 | 4 | 5.8 |
| Overall Realization Rate in the sample | 83% | 84% | 86% | 88% | 86% | 91% | 84% |
| Avg. Total Observed PVB per tree | $70 | $62.50 | $68.28 | $71.43 | $60.25 | $63.25 | $49.70 |
| % of trees Dead or Missing, | NA | 9% | 18% | 12% | 9.5% | 10.9% | 6.7% |
| % of trees still in containers | NA | 12% | 9% | 8% | 19% | 14% | 11% |
| % of trees with less than $11 PVB | 27% | 32% | 14% | 14% | 19% | 13% | 26% |
| % of trees violating spacing guidelines | NA | 22% | 13% | 2% | 15% | 7% | 5% |
| % of trees with redundant shading | NA | 5% | 7% | 0.3% | 2% | 2% | 0% |

As the results indicate, performance has varied over the period. Primarily, these indicators have provided an on-going feedback mechanism to program management to alert them to areas that require attention. The unique nature of the Shade Tree program leads to a list of highly specialized performance indicators. These are, for example, the overall realization rate and series of

measurements that calculate the proportion of trees that have failed to provide shading benefits for various reasons. Those measurements examine percentage of trees that are dead or missing, left in containers, have less than $11 of PVB, violate spacing guidelines between the trees, and have redundant shading effect.

## CONCLUSIONS

From the standpoint of energy efficiency, SMUD evaluation research has found that the planting of trees to directly shade buildings is a cost-effective strategy for SMUD and highly valued by its customers. In addition, the SMUD Shade Tree program offers an excellent example of how results of program evaluation efforts were used to achieve continuous improvements and refinements in program design, operation and achievement. The SMUD evaluation efforts have made the difference. This outcome is the result of three factors. SMUD Board of Directors and management made an enduring commitment to District's long-term DSM goals. Second, monitoring and evaluation has been an important part of that commitment. Finally, program management both at SMUD and STF has been receptive to evaluation recommendations and committed to implementing them to improve the program.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