EM&V Report for San Diego Cool Communities Shade Tree Program (1306-04)

CALMAC Study ID CCS000X.XX

Prepared for
California Center for Sustainable Energy
San Diego, California

Prepared by
Zebedee & Associates
Canton, New York

April 2009

SAN DIEGO COOL COMMUNITIES PROGRAM

Executive Summary

The San Diego Cool Communities Shade Tree Program is an incentive program designed to promote tree planting among residential customers in an effort to reduce long-term energy consumption and peak demand. The target market segments are the residential market (single family and multi-family) and small non-residential comprehensive retrofit market (K-12 schools, public agencies, and non-profit agencies). The San Diego Cool Communities Shade Tree Program (CPUC1306-04) was supported through funds made available during the 2004-05 program cycle. While the program was not accepted during the 2007-08 program cycle, the California Center for Sustainable Energy petitioned and received approval from the California Public Utilities Commission to use money allocated to the 2004-05 program cycle to continue the Cool Trees Program. Therefore the program funded by the 2004-05 program cycle includes program participants between June 2004 and November 2008 with two distinct phases of program participants. The first phase covers program participants between January 2005 and June 2006 while the second phase covers program participants between September 2006 and November 2008.

This report represents the second evaluation of the San Diego Cool Communities Shade Tree Program (CPUC1306-04). In November 2006, Zebedee & Associates completed a process evaluation of the program focusing on program participants in the first phase of the program (January 22, 2005 to June 21, 2006). The current report focuses on quantifying the energy impact of the program relying on program participants in the second phase of the program (September 5, 2006 to November 15, 2008) and provides an overall estimate of gross and net energy savings for the complete 2004-05 program cycle.

The specific program goals for the second phase of the program were to plant approximately 16,000 trees by the end of 2008, reducing energy consumption by approximately 156 kWh per tree and peak demand by 0.18 kW per tree for single-family homes and 113.8 kWh per tree and peak demand by 0.1314 per tree for multi-family homes. The program has allocated approximately 15,000 trees for single-family homes/school properties and 1,100 for multi-family properties.

The program's primary achievements in this second phase were:

- planting 17,062 trees;
- providing a service to program participants that resulted in extremely high customer satisfaction; and,

- generating significant societal benefits.

However, several problems remain apparent. These include:

- the number of trees that will ultimately provide energy savings, which is dependent on planting location (within San Diego County, vis-à-vis the home, etc.), tree survival, and other factors, is significantly fewer than the number of trees planted (see Table ES-1 below);
- there seems to be significant free-ridership, which further limits the potential energy savings, in that individuals who would have planted trees in the absence of the program are planting a fairly large portion of the trees (see Table ES-1 below);
- the program participants seem to be non-representative of the overall San Diego county population in that they are wealthier, older, less ethnically diverse, and more educated; and,
- marketing/outreach has not been able to attract participation of the traditional hard-to-reach population groups.

Table ES-1 presents a summary of the trees planted through the San Diego Cool Communities Program during the 2004-05 program cycle. Phase 1 (January 22, 2005 to June 21, 2006) and Phase 2 (September 5, 2006 to December 31, 2008) are presented separately as well as in aggregate. The first two rows of the table show the actual planting level. An examination of the program database provides information on the location of tree plantings within San Diego County (coastal, inland, mountain), and the proximity and relation to the residential structure (east, west, south and distance). From this information, we can create an estimate of the number of trees that are either unlikely or likely to provide energy savings (see Section 9). These estimates are provided in the second, third, and fourth rows of the table. We also adjust for tree mortality and free-ridership, which is defined in this study using self-reported participant data vetted using several independent methods (see Sections 4 – 6). Given all these adjustments, we derive an estimate of the trees that are likely to produce energy savings.

Therefore, our bottom-line conclusions regarding the program are: (1) individuals receiving trees highly value the program; (2) program participants recognize the benefits of the program beyond pure energy savings (e.g., education on proper tree planting and care, more livable communities, carbon dioxide reduction, etc.); and (3) the number of trees that will ultimately provide energy savings is a fraction of the trees actually planted. Our conclusions point to elimination of the program as a resource program or a substantial re-design of some aspects of the program in order to increase the relative proportion of energy saving trees. For example, the program needs to implement additional free-rider screening and more explicit requirements for planting trees in locations that provide the intended effect. Of course, these measures will increase the cost of planting each tree and this trade-off must be considered in any re-design. We consider these program design issues in more detail below.

Table ES-1
Estimate of Potential Energy Saving Trees

Tree Planting Issue	Phase 1	Phase 2	Cumulative
Trees Planted	16,191	17,062	33,253
Non-Energy Saving Plantings	-5,921	-3,630	-9,551
Coastal Tree Adjustment	-1,520	-808	-2,328
Eastern Tree Adjustment	-1,053	-831	-1,884
Potential Energy Saving Plantings	7,697	11,793	19,490
Tree Mortality	-185	-955	-1,140
Free-Rider Plantings	-2,136	-3,273	-5,409
Net Energy Saving Plantings			
Number	5,376	7,565	12,941
% of Plantings	33.2	44.3	38.9

Using the number of net energy savings planting we derive the expected kWh and peak kW savings using information from building simulations (see Section 8). In terms of program impacts for the full 2004-05 program cycle the estimated net annual program impact for electricity is 1,829,210 kWh with a peak demand reduction of 2,925 kW based on the engineering simulations. These savings are expected to start five years after being planted and extend for 15 years consistent with California Public Utilities' protocols. However the energy savings are likely to extend much further into the future as most trees will continue to survive for 15 or 30 more years (McPherson and Simpson, 2001b (pp.20)). The verified program impacts are summarized in the energy reporting table below. Overall, the program fell short of its energy and coincident peak demand reduction goals with an energy realization ratio of approximately 35 percent.

Table ES-2
Verified Net Energy and Demand Saving

	Electricity	
	Energy Savings (kWh)	**Demand Reduction (kW)**
Program Goal	5,187,468	5,986
Verified Savings	1,829,210	2,925

1. Introduction

The San Diego Cool Communities Shade Tree Program is an incentive program designed to promote tree planting among residential customers in an effort to reduce long-term energy consumption and peak demand. The target market segments are the residential market (single family and multi-family) and small non-residential comprehensive retrofit market (K-12 schools, public agencies, and non-profit agencies). The San Diego Cool Communities Shade Tree Program (CPUC1306-04) was supported through funds made available during the 2004-05 program cycle. While the program was not accepted during the 2007-08 program cycle, the California Center for Sustainable Energy petitioned and received approval from the California Public Utilities Commission to use money allocated to the 2004-05 program cycle to continue the Cool Trees Program. Therefore the program funded by the 2004-05 program cycle includes program participants between January 2005 and November 2008 with two distinct phases of program participants. The first phase covers program participants between January 2005 and June 2006 while the second phase covers program participants between September 2006 and November 2008.

This report represents the second evaluation of the San Diego Cool Communities Shade Tree Program (CPUC1306-04). In November 2006, Zebedee & Associates completed a process evaluation of the program focusing on program participants in the first phase of the program (January 2005 and June 2006). The current report focuses on quantifying the energy impact of the program relying on program participants in the second phase of the program (September 2006 and November 2008) and provides an overall estimate of gross and net energy savings for the complete 2004-05 program cycle.

The specific goals for the second phase of the program were to plant approximately 16,000 trees by the end of 2008, reducing energy consumption by approximately 156 kWh per tree and peak demand by 0.18 kW per tree for single-family homes and 113.8 kWh per tree and peak demand by 0.1314 per tree for multi-family homes. The program has allocated approximately 15,000 trees for single-family homes/school properties and 1,100 for multi-family properties.

Given the program goals, the primary objective of the EM&V analysis was to evaluate the energy and demand savings associated with the program. The evaluation relies on building simulations, telephone surveys, and site visits to generate net and gross energy and demand savings. The EM&V activity for this program was designed to address the following CPUC goals (see page 26 of the Energy Efficiency Policy Manual).

- *Energy and peak demand savings.* Both annual and lifetime savings impacts are provided. This analysis is provided in two sections. In Section 7, we provide a detailed review of the ex ante estimates used by the program to estimate energy saving. This review yields information on the validity of the program planning protocols and helps to identify key assumptions used in these protocols that are not consistent with realized program characteristics. In Section 8, we report on building simulations using DOE2 and specific program participant characteristics to measure the ex post energy and peak demand savings.
- *Cost-effectiveness.* The program implementation plan uses 0.8 as the underlying net-to-gross ratio. This figure is evaluated and adjusted through the use of survey information to estimate free-ridership, or program participants who would have undertaken the activity in the absence of the program (see Section 4 and 5).
- *An assessment of whether there is a continuing need for the program.* The final section provides an overall impact evaluation. We also provide specific recommendations on how the program should be changed to be more effective to maximize future net energy savings. Finally, we make a recommendation on continuance of the program.

2. Evaluation Background

This report constitutes the third separate evaluation by Zebedee and Associates of the San Diego Region Cool Communities Shade Tree Program. While these previous evaluations (Thayer and Zebedee, 2004; Thayer and Zebedee, 2006) principally examined the program process as well as program participant satisfaction the following conclusions provide important reference to the current impact evaluation.

- The level of participation, as measured by number of trees planted, met expectations. The program did not achieve exactly 100% of the program goal but over the previous two program cycles (2003 – 2004, 2004 – 2005 (Phase 1)) approximately 25,000 trees were planted.

- The level of customer satisfaction was overwhelmingly positive. This result extends to all aspects of the program. For example, approximately 90 percent of respondents were "very satisfied" with the planting event/workshop. Also, approximately 90 percent of respondents had an "increase in knowledge of "energy/environmental issues" and over 90 percent felt that the newly planted trees "enhanced their neighborhood." In excess 95 percent of respondents indicated they were "very satisfied" with the Cool Communities Shade Tree program. Finally, more than 99 percent of respondents indicated that they would "participate again" in the program.

- There were significant programmatic issues related to potential free riding, the location of tree plantings, the representativeness of the program participants, and the difficulty in reaching the traditionally hard-to-reach population groups. The most important considerations were planting location and free-ridership, both of which decrease the number of "energy saving' tree plantings. For example, in Thayer and Zebedee (2006) only 11 percent of the plantings were considered to have satisfied the criteria for energy saving status. Several portions of our previous research point to inappropriate tree planting, significant free riding behavior, and increased free-riding as the program becomes better known (see Thayer and Zebedee, 2004; Thayer and Zebedee, 2006).
- There are potentially large education benefits of the program (e.g., appropriate tree selection, enhanced maintenance, reduced tree mortality, more livable communities, carbon dioxide reduction, reduced storm runoff, etc.) that could potentially offset some of the effects of any free-ridership and inappropriate tree plantings.
- Finally, we considered the issue of whether there is a continuing need for the Cool Communities Shade Tree Program. On the one hand the program was well designed from the customer's perspective, seemed to fulfill a market niche, almost met planting goals, and altered the awareness and subsequent decisions of the participants. On the other hand, there is evidence consistent with free-ridership and inappropriate planting procedures. Therefore, our overall assessment was marginally positive. We also recommended that the program be re-designed to prevent, to the greatest degree possible, inappropriate planting and free-ridership and to generate the expected energy savings on a consistent basis.

Given these previous findings, we designed this EM&V exercise to focus on the identified problem areas, tree planting location, free-ridership, and overall energy savings. This report is organized as follows. In the next section, we summarize program performance during the period from September 2006 through December 2008. The results from our participant survey, non-participant survey, and site visits are described in

Section 4 – 6. In Sections 7 – 9, we consider the issues of ex ante savings estimates, building simulations, and energy saving plantings. Conclusions and recommendations for future shade tree programs are offered in the final section.

3. Program Performance, September 2006 – November 2008

The San Diego Cool Communities Shade Tree Program continues to perform exceptionally in terms of the number of trees planted (note this measure of success does not address energy savings). Zebedee & Associates has received a database of program participation through December 31, 2008. As of this date, there were 2,367 unique individuals/sites in the database and 17,062 trees planted. This converts to approximately 7.23 trees per unique individual/site. The program participants are predominantly homeowners (96.57 percent), with English being there first language (99.86 percent).

Table 1 summarizes the tree planting by variety. Over 30 different varieties have been delivered through the program but the most popular varieties are the Crape Myrtle, Jacaranda, and the Coastal Live Oak, accounting for approximately 34.8 percent of all trees planted. The tree size is noted in parentheses following the tree name with “s” representing small trees, “m” medium trees, and “l” large trees. Of course, long-term energy savings/tree is a function of both size and planting location vis-à-vis the home. That is, smaller trees have to be planted nearer the home to have the intended savings.

Table 1
Trees by Tree Variety

Tree Type	Trees Planted	Percentage
African Sumac (m)	459	2.69
Bradford Pear (s)	202	1.18
Bronze Loquat (s)	594	3.48
Camphor (l)	411	2.41
Canary Island Pine (l)	218	1.28
Carolina Laurel Cherry (m)	85	0.50
Chinese Flame (m)	866	5.08
Chinese Pistache (m)	831	4.87
Coastal Live Oak (l)	1,227	7.19
Crape Myrtle (s)	3,489	20.45
Fern Pine (l)	547	3.21
Flame Bottle Tree (m)	106	0.62
Fruitless Mulberry (m)	676	3.96
Golden Medallion (m)	763	4.47
Goldenrain (m)	136	0.80
Jacaranda (l)	1,217	7.13
London Plane (l)	494	2.90
Long-Leafed Yellow Wood	166	0.97
Los Angeles Silk (m)	65	0.38
Mimosa Silk Tree (m)	589	3.45
New Zealand Christmas Tree (m)	137	0.80
Purple Orchid (m)	468	2.74
Purple Robe/Locust (m)	409	2.40
Purple-Leaf Plum (s)	817	4.79
Southern Magnolia (l)	907	5.32
Southern Magnolia Little Gem (m)	84	0.49
Stone Pine (l)	164	0.96
Strawberry Madrone (s)	486	2.85
Sweetgum (l)	342	0
Weeping Peppermint (m)	97	0.57
Unknown	10	0.06
Total	17,062	100.0

Tables 2 and 3 provide additional aggregate information about the trees being chosen by program participants. Across tree types, deciduous trees are the most popular accounting for approximately 58.3 percent of all trees, followed by evergreen trees (36.8 percent), and semi-evergreen trees (4.9 percent). Note that significantly less than one percent of the trees do not have attached types in the program database. Finally, there seems to be a very small preference for medium tree types.

Table 2
Trees Planted by Tree Type

General Type	Trees Planted
Deciduous	9,947
Evergreen	6,277
Semi-Evergreen	828
Unknown	10

Table 3
Trees Planted by Size

Tree Size	Trees Planted
Large	5,693
Medium	5,771
Small	5,588
Unknown	10

Table 4 provides summary information on the location of tree planting as reported by individual homeowners. Most homeowners report planting to the south (42.0 percent)[1] or west (27.7 percent) of their housing structure in order to provide shading, while planting to the north and east accounts for 10.3 percent and 18.2 percent of locations, respectively. Participants were also asked to identify the expected distance from their home that the trees would be planted. These results are summarized in Table 5. At this juncture there seems to be a strong trend emerging planting distance – on a relative scale trees are being planted nearer to the home compared to previous evaluations. Additional information is available from the site visits (see Section 6 below).

[1] Note that this group includes southwest and southeast.

Table 4

Trees Planted by Installation Area

Installation Area	Trees Planted
East	3,098
Northeast	814
Northwest	951
South	3,127
Southeast	1,826
Southwest	2,207
West	4,718
Unknown	321

Table 5
Trees Planted by Distance from House

Installation Distance	Trees Planted
Within 15 Feet	6,590
Between 15 – 25 Feet	6,187
Between 25 – 50 Feet	3,964
Unknown	321

In Table 6, tree plantings are summarized by geographical region or climatic zones. These zones are characterized as coastal, inland, and mountain as determined by the zip code of the program participant. The region with the greatest activity by far is the inland region with approximately 79.5 percent of all program participants followed by coastal (11.7%) and finally mountain 6.25%). This pattern ultimately bodes well for long-term energy savings, especially those related to air conditioning. However, expected energy savings will likely be smaller than projected since location related plantings do not satisfy the 85 percent Inland Empire and 15 percent High Desert assumption of McPherson and Simpson (2001a). In addition, the "coastal" plantings violate the qualifications for participation in the program (see Application Form and Applicant Agreement page of program brochure) and may demonstrate a lack of enforcement.

Table 6
Trees Planted by Climatic Zone

Climate Zone	Trees Planted
Coastal	1,997
Inland	13,572
Mountain	1,068
Unknown	425

Since we do not have knowledge of all the individual participant characteristics, we examined program participant characteristics based upon zip codes to assess the representativeness of the participants. For example, we computed a weighted average (using planted trees as the weights) across zip codes for three specific census variables: percent with a college degree, percent white, and median household income. The values for these variables were 26.8 percent, 66.0 percent, and $52,978, respectively for the zip codes where there was tree-planting activity. In comparison, the values for San Diego County, weighted by population, are 28.7 percent, 58.5 percent, and $49,150, respectively. Thus, it seems (based on the zip codes level analysis) that participants in the San Diego Cool Communities Shade Tree Program are being drawn from zip codes are fairly representative of the surrounding county, although the program seems to attract slightly fewer non-white residents who have higher than average income and lower educational attainment than the county-wide averages.

One final aspect of program performance deals with year the single family home was built. The participant agreement stipulates that the home must have been built prior to 1994. In order to test conformance with the requirement, we surveyed a random sample 200 individuals from the population of program participants (see Section 4 below). The survey results indicated that only 78.6 percent of the participants satisfied the pre-1994 requirement. This finding, together with the approximate 11.7 percent of trees that were planted in the coastal region, may point to a lack of enforcement of the program rules.

4. Participant Survey

Zebedee & Associates, with the assistance of our subcontractor Social Science Research Laboratory (SSRL) at San Diego State University, conducted a telephone survey of program participants to help assess post-participation customer satisfaction, tree retention, appropriateness of tree planting, and free ridership. The participant survey instrument is provided in the appendix. The survey was conducted in May/June 2008

4.1 *Sampling Plan*

The survey sample was developed from the list of participants in the Cool Communities Shade Tree Program. The initial step in our sampling procedure was to obtain the participant list from the CCSE. In conducting the survey, Zebedee & Associates began with a list of individual names, addresses, and contact and tree choice information for 2006 – 2007 program participants. Our next step was to remove duplication and problem telephone numbers (incomplete contact information), thereby leaving 1,076 unique individuals. We used this value to represent the relevant population.

In order to determine the appropriate sample size, we began with the following formula:

$n = \frac{\{Z_{\alpha/2}\}^2 pq}{E^2}$, where n is the sample size, Z is the normal distribution Z-score, 1-α is the degree of confidence, p is the population proportion, q = 1-p, and E is the margin of error. Since the population was not infinite we corrected the formula above by the finite correction factor. This produced the following equation: $n = \frac{Npq\{Z_{\alpha/2}\}^2}{pq\{Z_{\alpha/2}\}^2 + (N-1)E^2}$,

where N is the population size and all other variables are defined above (see Triola, 2001). In addition, we used a 90 - 10 sample model, consistent with CALMAC procedures, implying Z = 1.645 and E = 0.10. Finally, we did not use knowledge gained from our previous work to provide an *a priori* estimate of p. Rather, we used p = 0.5. Thus, our target sample size was 68 individuals. In fact, we made 506 phone calls and completed surveys with 200 individuals.

4.2 *Survey Implementation*

Each individual on the final participant list was telephoned to ascertain his/her willingness to participate in the survey. This initial inquiry resulted in one of the following outcomes:

(1) unknown eligibility (e.g., busy signal, answering machine, left message, unqualified refusal, etc.);
(2) ineligible (e.g., incorrect contact information, fax number, etc.);
(3) unwillingness to participate; and,
(4) completed survey.

In Table 7, we present the complete attrition analysis, including both sampling and survey implementation. As illustrated in the table, 200 surveys were completed. This value converts to a response rate of 39.5 percent of the phone calls attempted. Alternatively, one can calculate the following rates as (all values taken from Table 7):

- Eligibility Rate = E* = Eligible/(Eligible + Ineligible) = 212/(212 + 91) = 69.97%.
- Response Rate = R* = Completes/(Eligible + Unknown Eligibility) = 200/(212 + 203) = 48.19%.
- Cooperation Rate = C* = Completes/Eligible = 200/212 = 94.33%.

As is evident, the survey implementation can be characterized as quite successful in both response rate and cooperation of the respondents.

Table 7
Attrition Analysis

Sampling/Survey Step	Number of (Potential) Respondents
Initial Survey List	1,076
Remove Excess Names	570
Remove Unknown Eligibility	203
Remove Ineligible Records	91
Remove Terminated Surveys	12
Completed Surveys	200

Another measure of the survey coverage is the percentage of trees that are accounted for by the survey respondents. In this case, survey respondents accounted for 7.6% (1,275 out of a population of 16,870) of trees planted.

4.3 Respondent Characteristics

There were 200 completed surveys in the two survey phases, with 126 male respondents and 74 female respondents. The socio-demographic characteristics of the survey respondents are presented in Table 8. As is illustrated the survey respondent values, relative to San Diego County residents, suggest that the survey respondent group is significantly older, less ethnically diverse, more educated, and has higher income.

Table 8
Summary Characteristics of Program Participants

Characteristic	Units of Measure	Survey Value (n=200)	San Diego County
Age	Percent Greater than 45	66.5	30.8
Household Size	Mean	2.92	2.7
Income	Percent Greater than $75,000	56.0	27.2
Membership in Environmental Organization	Percent Yes	23.5	NA
Employment Status	Percent Working Full or Part-Time	72.0	74.0
Ethnicity	Percent White, Not Hispanic	73.0	54.9
Education	Percent Bachelor's Degree or Greater	57.5	29.5
Have Central Air Conditioning	Percent Yes	64.0	NA
Use other equipment such as portable air conditioning units	Percent Yes	88.5	NA

Table 8 also presents data on the saturation of air conditioning among surveyed program participants. Of the 200 surveyed program participants, 128 or 64 percent indicated they have central air conditioning, while 89 percent indicated they use other equipment such as portable air conditioning units. If we examine program participants without central air conditioning separately we find 66 of the 72 program participants without central air conditioning use other equipment to cool their homes. Therefore of the 200 surveyed program participants, 128 plus 66 or 194 program participants (97 percent) cool their homes using either central or portable air conditioning units.

4.4 General Observations

The average respondent to the survey received 6.38 trees, slightly less than the overall average of 7.23 trees[2]. In fact, 35.5 percent received the maximum allowable number of ten trees. Approximately 41.5 percent first heard about the tree program via "word-of-mouth," whereas very few learned of the program through the usual media outlets (flyers, newspapers, and the CCSE website accounted for approximately 9.5% combined, with newspapers being the most important information source (7.5%)). The most important reason for program participation (51.0% indicated this reason "contributed greatly" to participation decision) was to help the environment. Improving landscaping/property value (45% indicated "contributed greatly") and reducing energy bills (35% indicated "contributed greatly") were secondary concerns. Approximately 89.0 percent of the respondents indicated that they or another household member was responsible for deciding on the planting locations.

4.5 Customer Satisfaction

In previous evaluations of the Cool Communities Shade Tree program Thayer and Zebedee (2004, 2006) examined five different aspects of the program (planting location, the *DigAlert* program, the planting event/workshop, primary organization of neighborhood planting, and overall) to the test level of customer satisfaction. In this evaluation we focus on the overall level of participant satisfaction.

When queried about their overall program satisfaction with the Cool Communities Shade Tree program, 94.5 percent of the survey respondents selected "very satisfied." In addition, 99.0 percent of respondents indicated that they would willingly participate in this program again. These are extremely high satisfaction values and suggest that, for the participants, the program has little room for improvement. Approximately 89 percent of respondents referred others to the program. According to the respondents estimates these referrals resulted in 264 additional participants. In addition, most respondents (92%) felt that the program increased their knowledge of ecological, energy and/or environmental issues "somewhat" or "a great deal." Finally, the majority of respondents could not state a suggestion for improving the program. Of those participants that did offer suggestions,

[2] The test statistic under the null hypothesis of equality of means is t = 3.045.

providing more trees, doing more advertising, and getting more participants were the dominate answers.

4.6 Program Effects

The Cool Communities Shade Tree program is primarily designed to provide house structures with shade and corresponding energy savings. It has also been suggested that there are indirect program benefits related to home and/or neighborhood appearance, knowledge of environmental and energy issues, and sense of community (e.g., see John Balzar, *Los Angeles Times*, March 8, 2004). In Table 9, we provide a summary of survey responses for these program effects. Somewhat inconsistent with expectations, program participants perceive that the newly planted trees already provide shade and associated energy savings. In addition, as the trees mature we would expect the appropriately planted trees to capture significant benefits from both shade and energy savings (see discussion below for an estimate of the proportion of trees that are potentially energy savers). In terms of indirect benefits it seems that the program has enhanced neighborhoods and provided information to participants.

Table 9
Program Effects

Program Effect	"Yes" (%)
Trees Shade Portion of Home	34.5
Trees Expected to Provide Shade in Future	95.5
Trees Shade Air Conditioner	5.5
Trees Reduce Energy Bill	4.5
Altered Summer Thermostat Settings	7.5
Use Supplemental Cooling Units Less Often	2.5

4.7 Tree Survival or Retention

Tree survival is an important impact parameter and is being assessed both through the telephone survey instrument but also on-site verification (see Section 5 below). The telephone survey results indicate that approximately 87 of the 1,275 trees planted (6.8%) have not survived, indicating a persistence factor of 93.2 percent for net-to-gross adjustments. Of course, tree survival will change over time, especially during the first few years after planting. In Section 6, below, we report on site visits to locations that planted trees in previous program cycles.

4.8 Planting/Participation Motivation

In Table 10, we list the reasons individuals chose to plant trees. As is evident, providing shade and capturing the associated energy benefits was the most common answer. Of course, this does not affect the overall program benefits – energy savings are energy savings regardless of the motivation for planting the tree(s).

Approximately 86.5 percent of the respondents were already focused on tree planting before hearing about the Cool Communities Shade Tree program. This value is the sum of those individuals who: (1) were already thinking about purchasing trees (38%), (2) were already collecting information about trees (16%), (3) already decided to purchase trees (9%), and (4) already planted trees (23.5%). Many of these individuals could be classified as free riders in the energy efficiency literature and they have an impact on the resulting energy savings from the program.[3] However, free ridership must also consider other program influences such as the placement of the tree from an energy efficiency standpoint, how long had the participant been planning to plant new trees, etc. We turn to this issue in the next section.

Table 10
Rationale for Planting Trees

Program Effect	"Yes" (%)
Replace Trees that Died	9.0
Replace Trees that Were Living	4.0
Add to Existing Landscape	10.5
Achieve Energy Benefits/Shade	27.0
Beauty of Trees	8.5

4.9 Self Reported Free Ridership

Estimating free ridership from self-reported data is somewhat complicated. For example, individuals who indicate that they had "already decided to purchase trees" seem like obvious free riders. However, the program might alter the number or quantity of plantings, the timing of plantings, the type and corresponding efficiency of plantings, etc. Therefore, a comprehensive evaluation of free ridership requires a battery of questions

[3] The magnitude of free riding is somewhat offset by the educational component of the program. Specifically, individuals who plant trees without participating in the program are more likely to select an inappropriate tree type and/or to have significantly more tree mortality.

designed to ascertain all possible impacts of the program (see questions 17 through 23 in the participant survey instrument in the appendix). This methodology is outlined in the draft document authored by the CPUC Residential NTG Team and entitled "Proposed Method for Estimating the Net-to-Gross Ratio for Residential and Small Commercial Customers" (January 2008).

We attempted to precisely follow the methodology to calculate free ridership directly (see questions 17 and 22 in participant survey) and to calculate efficiency, quantity, and timing factors (see questions 18 – 21, 23 in participant survey) to determine free ridership indirectly. Both yes/no and 1 – 10 scale questions were used to ensure consistency. The end result is the calculation of a free ridership propensity for each individual. This propensity or likelihood ranges from zero (no tendency to free ride) to one (total free rider).

In order to demonstrate the methodology, consider the two individuals described in Table 11. As is evident, individual A is a classic free rider in that he/she would have purchased and planted the same trees at the same time with or without the program. This individual would receive the maximum free rider propensity (0.98)[4]. On the other hand, the program was essential in getting individual B to undertake energy efficiency and would receive the minimum free ridership value of zero.

This methodology generates an average propensity to free ride equal to 0.302, with a standard deviation of 0.2535. The minimum (zero) and maximum (0.98) values correspond to the actual respondents portrayed in Table 11. Therefore, the self-reported free ridership adjustment is 0.698.

[4] The maximum in our analysis is 0.98 since we used scales ranging from 1 – 10 rather that the suggested range of 0 – 10.

Table 11
Free Ridership Examples

Question	Individual A	Individual B
At the time you first heard of the Cool Communities Shade Tree Program	Already planted trees	Had not considered planting trees
In absence of program would	Plant the same quantity of trees	Not plant trees
In absence of program would	Plant the same type of trees	Not plant trees
In absence of program would	Plant trees at the same time	Not plant trees
On a scale of 1 (not likely) – 10 (likely) would have purchased the same trees in absence of program	10	1
On a scale of 1 (disagree) – 10 (agree) would have paid to purchase trees on my own in absence of program	10	1
On a scale of 1 (disagree) – 10 (agree) the free trees were critical factor in decision to plant trees	1	10
On a scale of 1 (disagree) – 10 (agree) would have planted trees with one year with or without program	10	1
On a scale of 1 (disagree) – 10 (agree) the free trees from the program were not necessary to cause planting	10	1
Free Ridership Value	0.98	0.0

5. *Non-Participant Survey*

Zebedee & Associates, with the assistance of our subcontractor Social Science Research Laboratory (SSRL) at San Diego State University, also conducted a telephone survey of program non-participants to help assess the importance of the program for improving planting practices, tree retention, and free ridership. The non-participant survey instrument is provided in the appendix. The survey was conducted in September/October 2008

5.1 Sampling Plan

The survey sample was randomly selected from the homeowner population in San Diego County. Selected individuals were required to have the following characteristics: (1) live in an inland or mountain area (i.e., those living in the coastal area did not qualify); (2) reside in a home built prior to 1994; and (3) reside in an owner-occupied single family residence.

In order to determine the appropriate sample size, we utilize the standard formula for estimating a population proportion: $n = \frac{\{Z_{\alpha/2}\}^2 pq}{E^2}$, where n is the sample size, Z is the normal distribution Z-score, 1-α is the degree of confidence, p is the population proportion, q = 1-p, and E is the margin of error. The population is essentially infinite so there was no need to adjust the formula by the finite correction factor. We used a 90 - 10 sample model, consistent with CALMAC procedures, implying Z = 1.645 and E = 0.10. Finally, we did not use knowledge gained from our previous work to provide an *a priori* estimate of p. Rather, we used p = 0.5. Thus, our target sample size was 68 individuals. In fact, we made 1,025 phone calls and completed surveys with 101 individuals.

5.2 Survey Implementation

Each individual on the final participant list was telephoned to ascertain his/her willingness to participate in the survey. This initial inquiry resulted in one of the following outcomes:

(5) unknown eligibility (e.g., busy signal, answering machine, left message, unqualified refusal, etc.);
(6) ineligible (e.g., incorrect contact information, fax number, etc.);
(7) unwillingness to participate; and,
(8) completed survey.

In Table 12, we present the complete attrition analysis, including both sampling and survey implementation. As illustrated in the table, 101 surveys were completed. This value converts to a response rate of 39.5 percent of the phone calls attempted. Alternatively, one can calculate the following rates as (all values taken from Table 7):

- Eligibility Rate = E* = Eligible/(Eligible + Ineligible) = 115/(115 + 261) = 30.6%.

- Response Rate = R* = Completes/(Eligible + Unknown Eligibility) = 101/(115 + 649) = 13.2%.
- Cooperation Rate = C* = Completes/Eligible = 101/115 = 87.8%.

As is evident, the survey implementation can be characterized as quite successful, especially the cooperation of the respondents.

Table 12
Attrition Analysis

Sampling/Survey Step	Number of (Potential) Respondents
Attempted Calls	1,025
Remove Unknown Eligibility	649
Remove Ineligible Records	261
Remove Terminated Surveys	14
Completed Surveys	101

5.3 Respondent Characteristics

There were 101 completed surveys, with 38 male respondents and 63 female respondents. The socio-demographic characteristics of the survey respondents are presented in Table 13. As is illustrated, the non-participant survey respondents, relative to the program participants (see Table 8 above) are significantly older, less ethnically diverse, less educated, and have lower income.

Table 13
Summary Characteristics of Non-Participants

Characteristic	Units of Measure	Survey Value (n=101)
Age	Percent Greater than 45	83.2
Household Size	Mean	2.65
Income	Percent Greater than $75,000	45.5
Membership in Environmental Organization	Percent Yes	21.8
Employment Status	Percent Working Full or Part-Time	54.6
Ethnicity	Percent White, Not Hispanic	88.1
Education	Percent Bachelor's Degree or Greater	40.6
Have Central Air Conditioning	Percent Yes	63.4

5.4 General Observations from Non-Participant Survey

Conditional on having planted trees, the average respondent to the non-participant survey planted 4.45 trees/home. Tree attrition was 0.45 trees/home which is almost identical to the 0.435 trees/home from the participant survey.[5] However, on a relative basis the nonparticipants self-report an attrition rate of 10.1% compared to 6.8% from the participant survey. This difference suggests the quality of plantings and hence the survival rate is greater due to program participation. The primary reason for planting was to improve landscaping (47.5% gave this reason a maximum value of "10") whereas energy savings was relatively unimportant (77.8% gave this reason a minimum value of "1").

Some indicators of program success/failure are presented in Table 14. As is illustrated participants in the program received/planted larger trees, closer to the home, and on the correct side of the home (not north side). In addition, both immediate and longer term

[5] The test statistic under the null hypothesis of equality of means is t = 0.72, indicating failure to reject the null hypothesis.

shade benefits are greater for program participants. On the basis of the measures listed the program is achieving its goals of appropriate energy saving plantings, relative to plantings completed by program non-participants.

Table 14
Program Effects

Program Effect	Program Participant	Non-Participant who planted trees
Average Size of Tree (Gallons)	15	7.71
Trees Planted on North (%)	1.4	25.5
Average Distance from House (Feet)	21.4	30.6
Trees Shade Portion of Home (% "Yes")	34.5	22.5
Trees Expected to Provide Shade in Future (% "Yes")	95.5	40.0
Trees Reduce Energy Bill (% "Yes")	4.5	1.0
Trees Reduced Air Conditioner Use (% "Yes")	4.5	10.7
Use Supplemental Cooling Units Less Often	2.5	0.0

5.6 Free Ridership

The results of the non-participant survey can also be used to create an alternative estimate of free ridership. These estimates are used to vet the free-ridership estimates derived from the participant survey data. In total, three separate approaches are employed.

In the initial approach, we utilize the telephone disposition data from the non-participant survey to estimate the probability that an individual will plant a tree independent of the program. Specifically, we use the number of number of tree planters relative to the number of completed telephone calls. As is indicated in Table 12 above 1,025 telephone calls were made by the survey firm SSRL to obtain 101 non-participant surveys. Of these 101 complete surveys of non-participants 40 (39.6%) individuals planted trees on their own. Thus, we conclude that approximately 39.6% of participants would have planted trees in the absence of the program. Since the calls were made using random digit dialing procedures without any additional constraints (e.g., a pre-determined or required number of tree planters) then if 1,025 calls were made again we would expect the same rate of tree planters. This estimate is fairly close to the 30.2% rate of free ridership obtained using self-reported data from the participant survey.

The second approach uses a two-step procedure. In the first step, we use the non-participant data only to estimate a regression equation which relates whether or not an individual planted at least one tree versus a set of characteristics. In the second step, we use this estimated relationship and apply it to the participant data to produce an estimate of participants would have planted at least one tree in the absence of the program. Consider the first step in more detail. Table 15 lists the titles and corresponding definitions of the variables used in the analysis of free ridership. Two alternative specifications, the linear probability model and logistic regression, are presented. Thus, the dependent variable takes two possible forms. In the linear probability model, the dependent variable is a dichotomous variable with values of zero and one. The logistic regression model employs a conversion of the dichotomous variable. The estimation results, which are quite similar across the models, are presented in Table 16.[6] Education and a couple of house characteristics (number of bathrooms, presence of a pool) are the only statistically significant variables although participation in an environmental group is almost statistically significant.

In the second step, the regression equations are applied to the participant data to estimate the number (or probability) that participants would have planted trees, in the absence of the program. This represents an indirect measure of free ridership. Using the linear probability model our free ridership estimate is 0.368 whereas in the logistic model we obtain an estimate of 0.421. These estimates are relatively close to those obtained from the self-reported data or the evaluation of telephone call disposition. The advantage of the two-step regression approach is that there is an explicit modeling of the probability that an individual will plant at least one tree in the absence of the Cool Communities Shade Tree program. The disadvantages are two-fold. First, we are applying a relationship estimated from one group to another group. Second, this approach does not address the number of trees planted. We turn to this issue in our third approach below.

[6] Note that the coefficients in the logistic regression are not directly comparable to those in the linear probability model. If the former coefficients are converted to marginal effects the impact of any specific variable is very close to the effect of a variable as estimated in the linear probability model.

Table 15
Variables Used in Free Ridership Analysis

Variable/Definition	Variable Categories
Full Participation in Program	Yes, No
Education Level	High School, Some college, Bachelors Degree, Some Graduate School
Employment Status	Full-time or Part-time, Not working
Ethnicity	White, Black, Hispanic, Asian/Pacific Islander, Native American, Other
Income Status	< \$25000, \$25000 – \$49999, \$50000 – \$74999, \$75000 – \$99999, > \$99999
Family Size	Number of Family Members
Age	18 – 24, 25 – 34, 35 – 44, 45 – 54, 55 – 64, > 64
Environmental Group Status	Yes, No
Bedrooms	Number
Bathrooms	Number
Fireplaces	Number
Pool	Yes, No

Table 16
Empirical Analysis
Dependent Variable: 1 if Planted Tree

Variable	Linear Probability Parameter Estimate (Standard Error)	Logistic Regression Parameter Estimate (Standard Error)
Intercept	0.09	-1.89
	(0.39)	(2.06)
Education Level	0.15*	0.78*
	(0.07)	(0.12)
Employment Status	0.03	0.10
	(0.12)	(0.58)
Ethnicity	-0.02	-0.12
	(0.05)	(0.27)
Income Status	-0.06	-0.27
	(0.05)	(0.24)
Family Size	-0.01	-0.05
	(0.05)	(0.24)
Age	0.0003	-0.01
	(0.05)	(0.28)
Environmental Group	0.16	0.68
	(0.13)	(0.58)
Bedrooms	-0.06	-0.38
	(0.08)	(0.42)
Bathrooms	0.14*	0.72*
	(0.09)	(0.46)
Fireplaces	-0.06	-0.27
	(0.09)	(0.46)
Pool	0.16*	0.80*
	(0.09)	(0.42)
R-Square	0.17	
Number of Observations	101	101

In order to examine the effect of the program on the number of trees planted participant and non-participant data are combined to estimate an empirical relationship between the number of trees a set of household characteristics, including participation in the program. The variables used in the analysis are defined in Table 15. The results of the estimation are presented in Table 17. As is evident, the estimated relationship accounts for approximately 39 percent of the variation in the dependent variable and the coefficients on ethnicity, family size, environmental group membership, number of bathrooms, and program participation are significantly different from zero. Note that the coefficient on participation in this relationship is interpreted as the marginal effect of the program. Thus, participation increases average plantings by 4.38 trees/home.

In this approach the free ridership rate is defined as (trees – 4.38)/trees) where free ridership is bounded on the lower end by 0.0; that is all homes that plant less than 4.38 trees are by definition not free riders. This approach produces a free ridership estimate of 0.275, which is in line with all other estimates. The advantage of this approach is that it considers the number of trees planted. However, the disadvantage is that any individual that plants more than the participation coefficient is deemed to be free riding.

Table 17
Variables Used in Empirical Analysis
Dependent Variable: Number of Trees Planted

Variable	Parameter Estimate	Standard Error
Intercept	1.67	1.83
Program Participation	4.38*	0.42
Education Level	-0.15	0.22
Sex	-0.17	0.41
Employment Status	0.25	0.47
Ethnicity	0.47*	0.15
Income Status	-0.03	0.17
Family Size	-0.24*	0.19
Age	-0.15	0.19
Environmental Group	0.80*	0.47
Bedrooms	-0.26	0.29
Bathrooms	0.83*	0.31
Fireplaces	0.01	0.33
Pool	0.51	0.35
R-Square	0.39	
Number of Observations	301	

* Significantly different from zero at 10 percent level.

In conclusion, the free ridership estimates derived from the nonparticipant survey data are consistent with the estimate derived from based on self reported participant data. For the final calculation of energy savings we therefore rely on the participant data as the more reliable estimates for net to gross calculations.

6. Site Visits

In order to further investigate tree retention, Zebedee & Associates completed site visits to a sample of individual locations that had received trees.

6.1 Sampling Plan

The on-site sample was developed from the list of participants in the Cool Communities Shade Tree Program, which during the June 2006 – December 2007 period included 1,076 unique individuals. In order to determine the appropriate sample size, we began with the following formula: $n = \frac{\{Z_{\alpha/2}\}^2 pq}{E^2}$, where n is the sample size, Z is the normal distribution Z-score, 1-α is the degree of confidence, p is the population proportion, q = 1-p, and E is the margin of error. Since the population was not infinite we corrected the formula above by the finite correction factor. This produced the following equation: $n = \frac{Npq\{Z_{\alpha/2}\}^2}{pq\{Z_{\alpha/2}\}^2 + (N-1)E^2}$, where N is the population size (1,076) and all other variables are defined above (see Triola, 2001). In addition, we used a 99 - 10 sample model, which is significantly better than CALMAC recommended procedures (90 – 10 model). The interpretation of our choices is that we are 99% confident that our estimate falls within 0.10 of the true value. These parameters imply Z = 2.575 and E = 0.10. Finally, since we were most interested in the proportion of trees still alive, we used knowledge gained from both the telephone survey and our previous work to provide an *a priori* estimate of p equal to 0.90 (see Thayer and Zebedee, 2004). Thus, our target sample size was 57 sites for this round of site visits. In fact, we visited 62 independent locations.

We utilized cluster sampling procedures and further restricted our target sample to five specific cities: Alpine, El Cajon, Escondido, La Mesa, and Valley Center. These zip codes were concentrated in the inland climate zone and are representative of the overall population of Cool Communities Shade Tree program participants.

6.2 On-site Visit Implementation

Each individual on the participant list that lived in one of the selected communities was telephoned to ascertain his/her willingness to allow a site visit. In Table 15, we present the attrition analysis by community for the effort to contact participants.

Table 18
Attrition Analysis for On-Site Visits

Location	Telephone Calls Attempted	Unknown Eligibility	Refused	Visits
Alpine	31	21 (67.7%)	1 (3.2%)	9 (29.0%)
El Cajon	33	22 (66.7%)	2 (6.1%)	9 (27.3%)
Escondido	48	25 (52.1%)	2 (4.2%)	21 (43.8%)
La Mesa	18	9 (50%)	0 (0%)	9 (50%)
Valley Center	45	26 (57.8%)	5 (11.1%)	14 (31.1%)
Total	175	103 (58.9%)	10 (5.7%)	62 (35.4%)

The 175 telephone calls yielded 62 visits for an overall response rate of 35.4%. Seven individuals who agreed to a visit indicated that they would not be available during the stated visitation period, which was within 1 – 2 hours of the telephone call. These individuals provided precise directions to the tree locations (e.g., front yard right hand side of lot) and the visit was conducted without the owner being present. After obtaining site visit approval from the homeowner, we then mapped the locations using the *Google Maps* mapping software program, identified the least cost route, and visited the sites.

6.2 On-Site Visit Results

The sixty-two sites we visited had planted 393 trees (6.34/home) and 356 trees were still alive (90.6%). The trees/home value is not significantly different from the value found in the telephone survey (6.38)[7]. However, the visit-determined level of tree attrition (9.4%) is significantly higher than we found in the household telephone survey (approximately 6.8). The finding suggests the measurement error from self-reports exceed 38 percent and is most likely related to the lack of respondent knowledge or deceit[8]. This finding is consistent with earlier evaluations of the program.

[7] The test statistic under the null hypothesis of equality of means is t = 0.087.

[8] The relevant null hypothesis is equality of the two proportions. The relevant test statistic is z = 1.71, which implies that the null hypothesis is rejected at the 10 percent significance level.

Of the surviving trees, 244 (or 62.1% of the total 393 planted) were planted so that they would eventually provide shade to the structure. Of the 62 homes, 43 (69.4%) had a central air conditioning unit outside their home. However, most individuals also indicated that they hardly ever used their air conditioning systems. This could have significant implications for the ultimate level of savings from the tree program. The newly planted trees would eventually shade the air conditioning unit in two (4.6%) of this latter group (homes with air conditioning).

6.3 Overall Evaluation from On-site Visits

In summary, our on-site visits discovered that in general individuals planted and cared for the trees as directed and that the level of tree attrition is small and in line with our previous analysis (see Thayer and Zebedee, 2004). In addition, the people we met with were very appreciative of the program, very friendly, wanted to discuss the program, and very cooperative. Many expressed interest in obtaining additional trees. However, tree survival was significantly smaller than that suggested by the telephone survey.

Our on-site visits also uncovered three potential problems. First, many of the trees were planted on the property's borders. Thus, potential shade benefits were minimal for these trees. This problem increased with lot size[9]. This has continued to be a problem in spite of more explicit directions in the program materials. Second, most of the homes with air conditioning units had placed these units on the north side of the home since that is the cooler, shadier side. However, these same individuals were directed to not plant their trees on the north side. Therefore, it is not surprising that few trees shade air conditioning units. Third, five of the homes we visited had not planted all of their trees, even though they had received them many months before. This type of procrastination may signal a longer term concern about the trees ultimate well being.

Finally, we came across an interesting situation in which individuals had received trees even though they were unaware the program, the required workshops, etc. In fact, one individual had permanently moved outside the state (Oregon) and had received trees at her previous home (she still owned it) post-departure and without her knowledge. In this

[9] To explore this relationship we estimated a regression between the proportion of trees that would eventually provide shade (range = 0 – 1) and lot size, where lot size was characterized as a set of dummy variables for small, average, and large. The estimated equation (Proportion = 0.397 - 0.238*Average – 0.46*Large), with Small the omitted category, demonstrated that the relationship between lot size and the proportion was as expected and that all variables were significantly different from zero (t-values were 11.77, -2.26, and -4.61 for the variables Intercept, Average, and Large, respectively).

situation the officers of a homeowners association obtained the trees (47) and had their landscape company install them on common property. The positive attributes of the program associated with education on tree installation and maintenance for program participants were certainly missing in this case. However, having the landscape company responsible resulted in correctly installed and maintained trees, planted in such a way to maximize energy savings. The association had lost only two trees (4.3% death rate) and it was our assessment that 40 of the 45 (88.9%) living trees would eventually provide shade to nearby residences. This finding suggests that, if energy savings is the ultimate objective, the future renditions of the program might want to explore alternative installation/maintenance procedures. For example, a possible alternative procedure is to add shade trees to an existing program such as a direct install or home audit program.

6.4 Site Visits – Trees Sites from Previous Program Years

The evaluation of the 2006 – 2008 program represents an assessment at one point in time and does not enable us to comment on the longer term impacts of tree plantings. In an effort to close this gap we also conducted site visits to residences that had received trees in previous program years. We utilized the same procedure as that used for the current program visits; that is, we selected specific geographic areas, called individual homeowners to set up a visit, mapped the least cost route, and visited the residences. The results of the telephone effort were quite similar to those presented in Table 15 above. Specifically, of the 75 phone calls attempted, there were 50 (66.7%) with unknown eligibility, one refusal (1.3%), and 24 visits (32.0%). The 24 sites had originally planted 89 trees or 3.71/home. This figure is significantly smaller than the corresponding value for this program cycle (6.38/home). Of course, the program rules have changed over time (e.g., the maximum number of trees one was allowed to receive in previous program cycles was five whereas the maximum is now ten).

These visits produced two important results. First, tree attrition continues. Worms, wind and rain storms, lack of care and maintenance, etc. all take their toll. The retention rate dropped to 0.809 for trees planted in previous program cycles. The attrition rate has approximately doubled (9.4% in this cycle so far) over the intervening years. Second, as the remaining trees have grown we are now able to better assess the likelihood that they will eventually provide energy saving shade to the residence. Of the 72 trees still alive we estimate that 59 (or approximately 82%) will provide shade. This value (66.3% of the original 89 trees planted) is slightly larger than we estimate for the current program (62.1%).

7. *Review of Ex ante Estimates of Energy Savings*

The Cool Communities Shade Tree Program relies on an energy and demand savings algorithm adopted from McPherson and Simpson (2001a). McPherson and Simpson considers climate effects, air conditioner saturations, relative energy consumption of room air conditioning and evaporative cooling, shade from neighboring buildings as well as expected mortality of the planted trees. In adopting McPherson and Simpson's findings to San Diego, the California Center for Sustainable Energy (CCSE) has assumed two climate zones with relative weightings of 85% Inland Empire and 15% High Desert. Additional assumptions include the tree is planted on the west side of a single family dwelling with air conditioning and the attrition rate for new tree plantings is 25 percent. To the extent that the trees are properly planted and maintained, the program is expected to generate average annual gross savings of 155.9 kWh/tree and 133.9/tree kWh for single family and multi-family residences, respectively. In addition, it is expected that the program will reduce the coincident peak by 0.17 kW. While Zebedee & Associates was unable to replicate these finding due to data limitations in the reporting by McPherson and Simpson (2001a), we were able to closely approximate these finding assuming the gross energy savings are based on shade effects only.

8. *Building Simulations*

In this section, we describe our effort to determine the impact of the planting trees through the use of calibrated building simulations. The simulations are calibrated using pre-planting billing data. We then calculate the difference in the energy use expected with and without the plantings to determine the gross programmatic impact. In other words, we compute the electricity and gas savings through a comparison of the home that was built to what will be given the tree plantings.

8.1. Home Selected for Building Simulations

Three specific homes were selected as representative of the types of homes that were received trees during the 2006 – 2007 Cool Communities Shade Tree Program. Table 19 provides basic information about each home. As is evident, the three homes include a relatively small home (Home #1), an average home (Home #2), and a home slightly larger than average (Home #3). We also selected two suburban homes and one relatively rural home. All homes are in climate zone 10, although the rural home is very close to the border for climate zone 14.

8.2. Building Simulation Model Description

The tool used to model the homes was *EnergyGauge USA*, an hourly building simulation software based on the DOE 2.1-E engine. It was developed at the University of Central Florida specifically for use in residential applications, and is accredited for HERS (Home Energy Rating System) Rating analysis.

The goal of the simulation activity was to estimate the energy impact of adding trees. To make this estimate, we developed a baseline model for each home, without trees installed, and calibrated to twelve months of pre-installation utility bills. The baseline models were developed using a minimum set of descriptive data for each home collected from the program participant on-site visits. These data included floor space, number of floors, aspect ratio (length of home v. width), home orientation, type of roof, size of garage, heating fuel, and whether or not there was a pool pump. Note that Home #1 and Home #2 both used propane rather than natural gas.

In terms of shading the homes are characterized as follows:

- Home #1: Trees planted on west (5 trees) and south (2 trees) sides of house with a shade pattern on the West that will be “dense” (trees will be relatively tall and are approximately 20-25 feet from house) and a shade pattern on the South that will be “light” (trees will be relatively tall and are approximately 25-30 feet from house).
- Home #2: Trees planted on west (4 trees), east (1 tree), and south (2 trees) sides of house with a shade pattern on the West that will be “dense” (trees will be relatively tall and are approximately 20-25 feet from house), a shade pattern on east that will be light (tree is tall but only one tree 20 feet from house), and a shade pattern on the South that will be “light” (trees will be relatively tall and are approximately 25-30 feet from house).
- Home #3: Trees planted on west (5 trees) and south (5 trees) sides of house with a shade Pattern on the West that will be “dense” (trees will be relatively tall and are approximately 20-25 feet from house) and a shade pattern on the South that

will be "dense" (trees will be relatively tall and are approximately 15-20 feet from house).

Since detailed data regarding construction and lighting types, occupancy patterns, appliance use, and other aspects of each home were not available, certain gross assumptions were made as a first step in developing the baselines. Internal loads, thermostat settings, hot water usage, and other parameters were then adjusted in an iterative process until the monthly results from the simulation closely approximated the utility bills.

Once the baselines were established, the models were modified by adding shade corresponding to the actual planting pattern for each home.

Table 19
Characteristics for Homes Simulated

Characteristic	Home #1	Home #2	Home #3
Living Area	2,400	2,000	1,600
Bedrooms	4	3	3
Bathrooms	2	2	2.5
Fireplaces	1	1	0
Pool	Yes	No	No
Stories	1	1	1
Orientation	North	South	South
Aspect Ratio	60 X 40	50 X 40	48 X 25, 20 X 20
Garage	Three-Car	Two-Car	One-Car
Roof Type	Concrete Tile	Concrete Tile	Asphalt Shingles

8.3. Building Simulation Model Results

Three significant results from the building simulations are presented in Table 20. First, the simulations for electricity are very close approximations to actual usage. In other words, our simulations appear to do a good job of capturing the characteristics of each sample home.

Second, in two of the three simulated homes there are significant programmatic effects for electricity. As is evident in Table 20, the impact of the tree planting on electricity use is approximately 4.7 percent and 6.7 percent of electricity use for Home #1 and Home #2, respectively. The average energy reduction across these two homes on a per-square-foot basis is 0.315 kWh per square foot. On a per tree basis Home #1 achieves annual savings of 104 kWh/tree whereas Home #2 achieves annual savings of approximately 78 kWh/tree. In addition, in these two homes the program also has a significant effect on peak electricity demand. The gross effect ranges from 0.21 – 0.86 kW per program participant, where the demand values are measured as one-hour averages.

The results for Home #3 are inconsistent with those reported for Homes #1 and #2. As indicated in Table 20, Home #3 has very small actual electricity use, less than 10 kWh per day. This billed usage represents approximately 20 – 40 percent of the usage of the other simulated homes and is significantly below the average electricity usage in the SDG&E service territory.[10] Given the relatively small electricity usage in Home #3, shade trees do not produce any significant savings. This result may point to an additional problem with the program, one that is related to free ridership. The specific home is inhabited by a single individual who is extremely energy and environment conscious. Before planting trees she had already taken most, if not all, available steps to minimize her energy use and environmental footprint (e.g., she recycles grey water for use in her garden). In discussion, this individual indicated that she had and would continue to plant trees in the absence of the program (classic free rider). But to exacerbate the problem, the tree shading does not reduce energy use since it has already been minimized.

Another potential issue with the program is that dense shading increases the use of heating in the winter months (i.e, a negative interactive effect). The simulations indicate that there is a potential for significant give-back of electricity savings in the winter months if the trees are evergreen (not deciduous). For example, evergreen trees planted on the south or west for Home #2 or Home #3 will result in very little overall net energy savings (possibly even negative savings) because the increased winter heating cost offsets the summer electricity savings. At Home #1 the give-back is generally small regardless of the density of shading and the side of the home the trees are planted on. The

[10] Information contained in SDG&E's Home Energy Comparison Tool indicates that average per day usage of electricity is 19.36 kWh for an average sized home of 1,727 square feet of living area. The relevant test statistic for equality of means ($t = 28.3$) is significantly different from zero at any significance level.

difference between the homes relates to the home's aspect ratio and local weather. But the overall message is that one must be careful about both the location and type of trees planted in order to produce maximum energy savings.

In order to investigate the relative importance of these interactive effects we conducted a large number of additional simulations. These simulations were based on a range of possible planting outcomes and did not correspond to the specific trees planted at each of the three homes analyzed above. Our analysis indicated that year-round dense or medium shading on the south or west results in significant negative interactive effects whereas light shading on the south or west does not produce these negative interactive effects. Also, shading from eastern trees has only minimal associated interactive effects. These conclusions imply that trees planted to the south or west of a home must be deciduous in order to capture the expected electricity savings without offsetting winter-related increases in heating fuel use. This design change should be included in any future version of the program.

Table 20
Building Simulation Results

	Home #1	Home #2	Home #3
Billed Electric Use (kWh)	17,096	9,231	3,609
Simulated Electric Use – As Built (kWh)	17,037	9,350	3,606
Simulated Electric Intensity – As Built (kWh/ft^2)	7.10	4.68	2.25
Simulated Electric Use – With Shading (kWh)	16,291	8,726	3,602
Simulated Electric Intensity – With Shading (kWh/ft^2)	6.79	4.36	2.25
kWh Saved	746	624	4
kWh % Saved	**4.71%**	**6.67%**	**0.01%**
Peak Day Demand – As Built (kW)	5.45	6.24	2.33
Peak Day Demand – Old Standards (kW)	5.24	5.38	2.02
Peak Day Demand Reduction (kW)	**0.21**	**0.86**	**0.31**

The gross program impacts range from 624 – 746 kWh with a 0.21 – 0.86 kW reduction in peak day demand.[11]

9. Estimate of Energy Saving Plantings

In this section, we consider the issue of how many trees will eventually provide energy savings. Given the relative immaturity of the trees, the program is not expected to create any energy savings in the near term. The purpose of this section of the report is to provide an estimate of the number of trees that may *eventually* provide energy savings. In this approach, we eliminate trees that will be unlikely to produce energy savings (e.g., trees planted too far from the home or on the South side of the home) or reduce the expected impact of trees (e.g., trees planted in coastal areas or on the East side of the home).

[11] Note that in this calculation and the analysis in Section 9 below we disregard the simulation results for Home #3 since this type of home would be identified and eliminated as a free rider household.

First, consider the distance trees are planted away from the house. The current program literature states small trees should be planted within 15 feet for energy savings, medium trees should be planted between 25 and 40 feet, and large trees 40 feet and up. As a part current program database, CCSE collects self-reported information about the planting location including the distance from the house. Our revised estimate eliminates trees that do not meet the programmatic conditions. Therefore, we eliminate:

- Any tree planted more than 50 feet from the house;
- Small trees planted more than 15 feet from the house; and
- Medium trees planted more than 35 feet from the house.

Second, consider the placement of the trees around the house. The current algorithm assumes a mix of trees planted to the west and east. McPherson and Simpson (2001b) report a reduction of energy and demand savings when the trees are planted to the east. Specifically they estimate energy savings resulting from trees planted to the east are 60 to 75 percent of the savings resulting from plantings to the west. Therefore, we adjust trees planted "East" by multiplying by 0.675. More importantly, McPherson and Simpson (2001b) report no energy saving for trees planted to the south, indicating trees in these locations are energy neutral. Using the self reported data for the placement of the trees around the house we have eliminated trees to the south as potential energy saving trees consistent with McPherson and Simpson (2001b).

The third issue of concern is trees planted in the coastal area since these trees do not correspond to the current algorithm assumptions. McPherson and Simpson (2001a) estimate the southern coastal area generates air conditioning saving between 40 and 60 kWh which is considerably less than the inland empire and high desert estimates currently used in the algorithm. Therefore, we adjust trees planted in the "Coastal" region, as determined by zip code, by multiplying by 0.50.

These calculations are summarized in Table 21. In total, after adjusting for trees planted too far from the house, to the South and East of the house and in coastal areas, Zebedee & Associates estimates that the original 17,062 trees planted yields approximately 11,793 trees available for potential energy savings. Thus, approximately 69 percent of the trees planted are designated potential energy saving trees. This value is further adjusted to the extent that there is tree mortality and trees were planted by free-riders[12]. We estimate approximately 8.1% tree mortality in the first year (average of the self-reported estimate of 6.8% and evidence from the visits – 9.4%). In addition, our self-reported estimate of free ridership is 0.302.

Given all these adjustments it seems that the Cool Communities Shade Tree Program produces approximately 44.3% of the expected energy saving tree plantings (7,565 trees). This figure can be converted into energy and demand savings using the building simulation results. Recall the gross program impacts range from 624 – 746 kWh with a 0.21 – 0.86 kW reduction in peak day demand. To make these numbers comparable we must first normalize the energy and demand saving based on potential energy saving plantings. Home # 1 has trees planted on the west (5 trees) and south (2 trees) sides or five energy saving plantings while home #2 has trees planted on the west (4 trees), east (1 tree), and south (2 trees) sides or 4.675 energy savings plantings based on the above methodology for calculating energy savings plantings. Therefore, the average gross program impacts per energy saving planting is 141.35 kWh with a 0.226 kW reduction in peak day demand.

In conclusion, it is evident that some program design changes would have to be implemented in order for the program to create additional energy saving trees. For example, expanded pre- and post-inspections could reduce the number of trees planted inappropriately (i.e., those that fail to achieve expected energy savings). Of course, these program changes have associated costs and would likely reduce the number of trees planted.

[12] Our current estimate of CCSE program tree mortality, which is based on the self-reported data, is consistent with the McPherson and Simpson (2001b) algorithm (25 percent mortality rate among trees by year 15).

Table 21
Estimate of Potential Energy Saving Trees

Tree Planting Issue	Trees
Trees Planted	17,062
Non-Energy Saving Plantings	(3,630)
Coastal Tree Adjustment	(808)
Eastern Tree Adjustment	(831)
Potential Energy Saving Plantings	11,793
Tree Mortality	(955)
Free-Rider Plantings	(3,273)
Net Energy Saving Plantings	
Number	7,565
% of Plantings	44.3
Estimated Annual kWh Savings	1,069,313
Estimated Annual Peak kW Savings	1,710

10. Overall Evaluation of the Cool Communities Shade Tree Program

In our original scope of work we stated that we would develop a scoring system to be used to evaluate the long-term efficacy of the program. Our scoring system uses a 1-10 scale to evaluate the following components of the program: (1) the program theory and approach; (2) the success of program implementation; (3) the level of participation, relative to projections; (4) program success in raising awareness and affecting decisions of participants to implement the energy efficiency and demand reduction measures; and (5) any unanticipated outcomes/results. The overall scale value is then used to make conclusions regarding the program future.

The program theory and approach refers to both how the program is to operate in the field (implementation theory) and why the program is expected to lead to specific outcomes (program theory). The Cool Communities Shade Tree Program was designed to flow from initial contact to delivery of trees, to tree planting demonstration and tree planting, to tree retention, and ultimate energy savings. Thus, there are several linkages that affect the overall performance of the program. For example, ultimate program success requires that program effort directly lead to participant action and corresponding energy savings. On the contrary, a flawed program theory would have linkages that are poorly designed so that the program does not meet its stated objectives (e.g., difficulty finding potential participants, poorly planted trees, free-ridership, tree mortality).

Success of implementation refers to the quality of the program materials, the ability of the program to reach the intended audience, and the resulting energy savings action taken by participants. Success implies that program effort leads to participation and ultimate energy savings action on the part of participants.

Level of participation, relative to projections is simply an analysis of program activity compared to program goals. If the program satisfies its goals then it is considered successful, although the evaluation also allowed the program to receive extra credit for surpassing its stated goals.

Program success in raising awareness and affecting energy use decisions is dependent on the program participant's response to program initiatives. For example, for an information only program we would expect that a large majority of program participants felt that the program changed their knowledge of energy issues. A program designed to create energy savings would be evaluated according to the magnitude of actual savings.

Finally, Zebedee and Associates account for any unexpected developments by evaluating the occurrence of any unusual program results. For example, excessive free ridership, or tree planting in areas that do not create energy savings would be cause for downgrading the program effectiveness.

Our overall evaluation of the Cool Communities Shade Tree Program is presented in Table 22 below. As is illustrated, we found the program theory to contain several flaws. For example, there may be issues associated with potential free riding, the location of tree plantings, the representativeness of the program participants, and the difficulty in reaching the traditionally hard-to-reach population groups. In addition, the level of participation, as measured by number of trees planted per household is below our expectations.

The most important consideration concerns free-ridership, which is difficult to assess for the Cool Communities Shade Tree program. However, several portions of our research point to significant free riding behavior. Our overall estimate is that 30.2 percent of participants are free riders. This value is significant lower than previous estimates ranging from 67 to 79 percent (see Zebedee and Thayer, 2006). This difference is attributable to an improved methodology. While in previous studies we relied on responses asking if the program participants were "already planning to plant trees" the current study implemented a more rigorous approach consistent with the protocols developed by the California Public Utilities Commission for the 2007-08 program cycle. While there is still a significant amount of free-riding we believe the reduction in the estimate of freeriders is the result of an improved methodology and not a structural change in the program. This conclusion is further supported by the consistency of the freeridership estimates derived using several independent methodologies.

In addition to the freeridership issue, a significant number of individuals planted their free trees inappropriately (e.g., too far from home, incorrect side of house, etc.), thereby limiting the potential shade benefits. On the other hand, there are potentially large education benefits of the program (e.g., appropriate tree selection, enhanced maintenance, reduced tree mortality, etc.) that could potentially offset some of the effects of these inefficiencies.

Finally, consider the issue of whether there is a continuing need for the Cool Communities Shade Tree Program. On the one hand the program was well designed from the customer's perspective, seemed to fulfill a market niche, almost met planting goals, and altered the awareness and subsequent decisions of the participants. On the other hand, there is evidence consistent with free-ridership and inappropriate planting procedures. Therefore, our overall assessment is negative and we recommend that the program be discontinued and re-designed to prevent, to the greatest degree possible, inappropriate planting and free-ridership. In addition, interaction effects should be considered. The placement of the trees can significantly alter the heating needs for program participants and future may want to limit the availability of evergreen trees. Of course, this re-design, which might include pre and post inspections, will increase the cost of planting each tree. In effect, there is likely a trade-off between the number of trees planted and control of the appropriate planting and free-ridership.

The value of shade trees and the San Diego Cool Communities Shade Tree Program is far beyond energy savings. For example the program also results in education on proper tree planting and care, more livable communities, carbon dioxide reduction as well as reduced storm runoff. However as a resource program the expected energy savings are significantly below programs of comparable size.

Table 22
Overall Evaluation of the
Cool Communities Shade Tree Program

	Cool Communities Shade Tree Program Value	Comments
Program Theory and Approach	6	Tree planting important for energy savings. In addition, many potential side benefits. However, several design flaws since free-riding and inappropriate tree planting not prevented.
Success of Implementation	9	Program materials very informative and appropriate to pre-participation through care and maintenance. Usage of print and broadcast media helped to expand program.
Level of Participation	7	Achieved programmatic tree planting goals. However, as trees/home increased the number of participants has declined, limiting program's external benefits
Change in Awareness, Decisions	7	Most respondents to survey commented that the program upgraded their understanding of energy efficiency.
Unanticipated Outcomes	5	Potentially excessive free-ridership as most participants stated they would have planted trees in the absence of the program. Also, many plantings on borders of property, which could minimize energy savings.
Total	34	

11. References

Akbari, H., S. Davis, S. Dorsano, J, Huang, and S. Winnett, eds. 1992. "Cooling Our Communities: A Guidebook on Tree Planting and Light-Colored Surfacing." Washington, DC: U.S. Environmental Protection Agency.

Anderson, A. 1995. "Utilities Grow Energy Savings." *Home Energy* 12 (2): 14-15.

Balzar, John. 2004. "No Safe Arbor in the City." *Los Angeles Times*, March 8.

Dwyer, J.F., E.G. McPherson, H.W. Schroeder, and R.A. Rowntree, R.A. 1992. "Assessing the Benefits and Costs of the Urban Forest." *Journal of Arboriculture* 18(5): 227-234.

Heisler, G.M. 1986. "Energy Savings with Trees." *Journal of Arboriculture* 12 (5): 113-125.

Hildebrandt, E.W., R. Kallett, M. Sarkovich, and R. Sequest. 1996. "Maximizing the Energy Benefits of Urban Forestation." In the Proceedings of the ACEEE 1996 Summer Study on Energy Efficiency in Buildings, Volume 9. Washington DC: American Council for an Energy Efficient Economy; 121- 131.

McPherson, E.G. 1992a. "Accounting for Benefits and Costs of Urban Green-Space." *Landscape and Urban Planning* 22: 41-51.

McPherson, E.G. 1992b. "Evaluating the Cost Effectiveness of Shade Trees for Demand-Side Management." *The Electricity Journal* 6 (9): 57-65.

McPherson, E.G. and J.R. Simpson. 1995. "Shade Trees as a Demand-Side Resource. *Home Energy Magazine*, Online March/April.

McPherson, E.G., J.R. Simpson, P.J. Peper, and Q. Xiao. 1999. "Benefit-Cost Analysis of Modesto's Municipal Urban Forest." *Journal of Arboriculture* 25(5): 235-248.

McPherson, E.G., J.R. Simpson, P.J. Peper, K.I. Scott, and Q. Xiao. 2000. "Tree Guidelines for Coastal Southern California Communities." USDA Forest Service, Sacramento, CA.

McPherson, E.G. and J.R. Simpson. 2001a. "Benefit-Cost Analysis of LADWP's Trees for a Green LA Shade Program." USDA Forest Service, Davis, CA.

McPherson, E.G. and J.R. Simpson. 2001b. "Effects of California's Urban Forest on Energy Use and Potential Savings from Large-Scale Tree Planting." USDA Forest Service, Davis, CA.

Rosenfeld, A.H., H. Akbari, J.J. Romm, and M. Pomerantz. 1998. "Cool Communities: Strategies for Heat Island Mitigation and Smog Reduction." *Energy and Buildings*. 28: 51-62.

Simpson, J.R. and E.G. McPherson. 1996. "Potential of Tree Shade for Reducing Residential Energy Use in California." *Journal of Arboriculture* 22 (1): 10-18.

Thayer, M. and A. Zebedee, 2004. Final Report for Cool Communities Shade Tree Program, prepared for California Public Utilities Commission, Zebedee and Associates, San Diego, CA.

Thayer, M. and A. Zebedee, 2006. Final Report for Cool Communities Shade Tree Program, prepared for California Public Utilities Commission (1306.4), CALMAC Study ID: SDR0006.01, Zebedee and Associates, San Diego, CA.