Journal of Heat Island Institute International Vol.7-2 (2012)

SMUD SHADE TREE AND COOL ROOF PROGRAMS: CASE STUDY IN MITIGATING THE URBAN HEAT ISLAND EFFECTS

Misha Sarkovich, Ph.D.

Sacramento Municipal Utility District, Sacramento, California

ABSTRACT

The primary purpose of the Sacramento Municipal Utility District's (SMUD) Shade Tree and Cool Roof Programs is to save energy and capacity for the district. A secondary and long-term objective is to create an urban environment in Sacramento with a healthy urban forest and highly reflective rooftops that could mitigate the summer urban heat island (UHI) effect. The summer UHI effect is a phenomenon whereby urban areas have an ambient air temperature 5° to 10° F warmer than that of the surrounding rural areas. In addition, other long-term objectives include improving the region's air quality and enhancing the quality of life in the region.

This paper examines how a utility-sponsored urban tree-planting program evolved to achieve continuous improvements and refinements in program design, operation, and energy savings since the program's inception in 1990. The nation's largest and longest running shade-tree planting program, sponsored by SMUD in collaboration with the Sacramento Tree Foundation (STF), is used as a case study. Results of impact evaluation studies, as well as a market research analysis and quality-assurance inspection results, are presented, along with modifications that were implemented to improve the program's effectiveness. This paper also examines key issues involved in evaluating the benefits (e.g., avoided cost of energy and capacity and carbon sequestration) of an urban tree-planting program from the perspective of an electric utility, as well as from the wider perspective of public and private entities that may benefit from such programs.

In addition, this paper examines how a utility-sponsored cool-roof rebate program evolved since January 2001 to achieve continuous improvements in program design and operation, especially in light of changes in the California government's building code standards for commercial roofs in 2005 (Title 24). SMUD's Cool Roof Program started on January 1, 2001, and was the nation's first utility rebate program for cool-roof technologies. On January 1, 2006, the Cool Roof Program expanded to include rebates the residential roofs for the first time in the nation.

SHADE TREE PROGRAM: BACKGROUND AND PROGRAM DESCRIPTION

In 1990, Sacramento Municipal Utility District (SMUD), in conjunction with the Sacramento Tree Foundation (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 (UHI) effect (i.e., the increase in summer outdoor temperatures caused by urban development). Potential non-energy benefits of the program included improving the region's air quality, enhancing aesthetics and quality of life in the region, and improving the 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 STF, a nonprofit 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 the involvement of a community nonprofit 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 scheduled a site visit by one of the STF community foresters. During the site visit, customers received tree-planting demonstration DVDs to learn about proper planting and maintenance of shade trees. During site visits, community foresters and customers together selected appropriate tree species and located specific sites for each tree planting. Shortly thereafter, STF staff delivered to the customers the requested trees in five-gallon containers, free of charge.

Customers were then responsible for planting and caring for the trees they received.

From SMUD's perspective, the tree-planting program represents a type of demand-side management (DSM) program with a tangible economic value to the utility. This value can be quantified based on avoided supply costs for energy and capacity during expensive summer peak-load periods, and on decreased supply costs to the utility due to reduced electrical loads. SMUD's total investment in the program since its inception in 1990 has been about $30 million, with approximately $1.5 million for 2008. As of the end of 2008, more than 450,000 trees had been planted through the program.

SHADE TREE PROGRAM IMPACT ANALYSIS

In 1995, SMUD and the U.S. Department of Agriculture Forest Service's (USDAFS) Western Center for Urban Forest Research and Education collaborated closely 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 impact and cost-effectiveness of SMUD's Shade Tree Program. In 1994, SMUD staff performed onsite surveys with a random sample of 326 residential sites, at which trees had been planted through the program from 1991 to 1993. Staff collected detailed information about tree mortality rates; tree location (i.e., tree size, orientation, and distance to the building); and building characteristics (i.e., square footage, vintage, number of building stories, type of cooling system, orientation, and number and size of windows).

USDAFS used the data collected through the onsite visits to perform shade and building simulation modeling. As part of this study, the impact of individual trees on utility electric loads (energy and peak capacity) was estimated for 72 shading scenarios. These scenarios represented mature trees of three sizes (small, medium, and large); eight cardinal orientations (N, NE, E, SE, S, SW, W, and NW); and three distances (adjacent 0–15 ft, near 16–30 ft, and far 31–50 ft) at a typical post-1990 home in Sacramento.

The simulation model used for estimating the electric-load impact 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 who were estimated to have central air conditioning (AC) 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 and heat-pump homes (88% of all homes in the program) was 153 KWh and 0.056 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 AC systems. The remaining 6% of the program participants reported having no electric cooling system. After the adjustments, he SMUD's 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 during onsite visits to estimate additional savings from shading of adjacent homes. Results of this analysis indicated that up to 23% 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% 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 impact over the life of a shade tree were given a dollar value by using SMUD's avoided cost of power in discounted present-value format (i.e., based on SMUD's marginal energy cost of 4 cents per KWh at that point in time, the capacity cost of advanced renewable technologies, and a discount rate of 6.6%) over a 30-year planning horizon. This dollar value is referred to hereafter as present-value benefit (PVB).

Figure 1 summarizes estimates of the average per tree program PVBs for trees planted during the 1991–1993 period. The average program PVB 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 $19 to $35 per tree. Figure 1 illustrates the relative value of various tree-siting orientations. These values gave the program implementers a strong message about 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 with 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% of trees planted through the program, but provided nearly half (47%) of program benefits. Trees planted on the north, northeast, and northwest of participants' homes represented 21% of all trees planted, but contributed only about 8% of total program benefits.

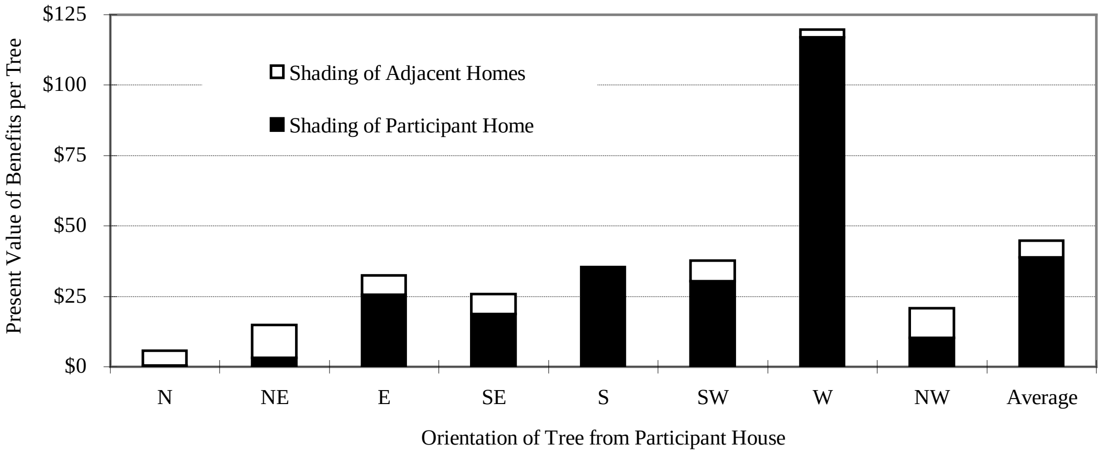

Figure 1. Total average PVB per tree, by tree orientation

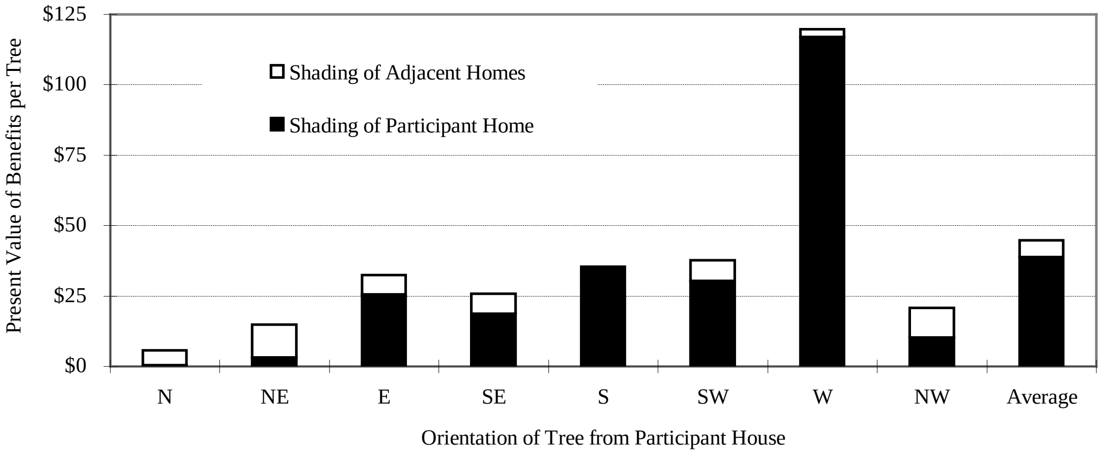

Figure 2. Percentage of total trees planted and total program benefits, by tree orientation

The most important contribution of the impact evaluation was a change in the program's focus. Instead of tracking program performance in terms of the number of trees planted, the program is now evaluated in terms of the estimated PVB of each planted tree (as expressed in dollar terms). STF staff refer to this program modification as a "paradigm shift." Community forester job performance is now measured in terms of 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 the 72 tree-shading scenarios identified in the impact evaluation. The 72 tree-shading scenarios pertain to the tree's size and its orientation to, and distance from, the home it is shading. The tree-shading scenarios are used to direct tree planting toward the 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 tree sitings that are considered cost-effective and allowed in the program.

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 the 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 $20, which is SMUD's incremental cost to plant that additional tree. In addition to indicating the minimum cost-effectiveness threshold (>$20), the PVBs for the 72 individual tree-shading scenarios may be used to maximize 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, the tree-siting guidelines were relaxed to allow for first-time opportunities to plant trees to shade adjacent homes, as long as the PVB was greater than $20. 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 disallowed "redundant tree shading" practices.

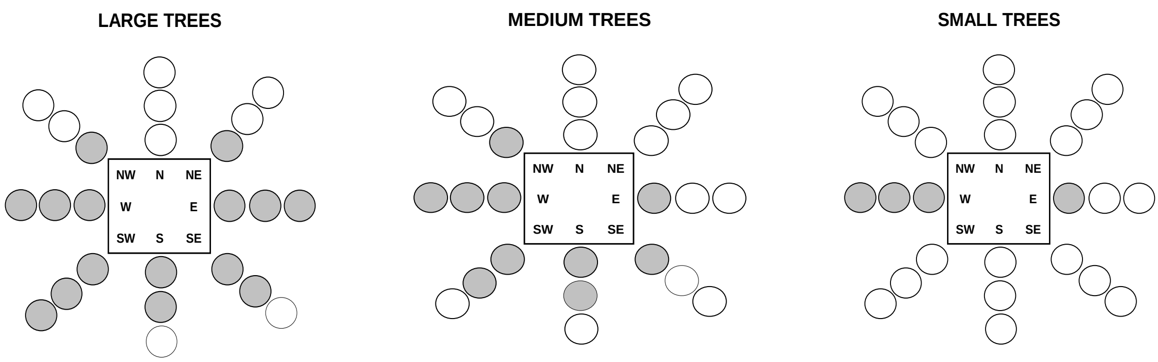

Figure 3. What is allowed under the new tree-siting guidelines

Shaded sites have higher than the minimum $20 per tree PVB. The distance of tree from building is based on the following categories: adjacent or closest to the structure (0–18 ft), near (18-30), and far or farthest from the structure (30–50 ft).

In 2008, researchers Geoffrey H. Donovan and David T. Butry from the USDAFS's Pacific Northwest Research Station analyzed the monthly electricity-usage billing data of 460 single-family homes in one randomly selected Sacramento zip code. The Pacific Northwest Research Station had high-definition aerial photos of that particular zip code and was able to extract tree-canopy shading coefficients for those 460 homes. That was the first large-scale statistical regression study to use utility billing data to show that trees can reduce electric-energy consumption. The study found that the average amount of east-, south-, and west-side tree canopy combined cover reduced summertime electricity use by 5.2%, or 185 KWh. Under SMUD's electricity pricing system, the combined east-, south-, and west-side tree cover reduced summertime electricity bills by an average of $25.16. These results are very much in line with the results of the earlier energy simulation study.

SHADE TREE PROGRAM'S TREE BENEFITS ESTIMATOR

A web-based application was designed and developed by SMUD staff to help other utilities in the United States quantify and track the benefits of planting shade trees. It estimates the amount of energy savings (KWh saved), capacity savings (KW saved), and carbon and CO2 sequestration (lbs), resulting from trees planted in urban and suburban settings. The Tree Benefits Estimator can be used by those who have no formal background in urban forestry or DSM utility practices. The tool is free and posted at www.SMUD.org.

One of the greatest challenges facing public power today is environmental stewardship. It is increasingly important that public power utilities not only take steps toward local environmental improvements, but measure the effectiveness of their efforts. The measurements are important to local communities in understanding how they can control their environmental future and the cost of doing so. It is also important for utilities to be able to measure environmental impacts that in the future may be reported to state and federal governments on a voluntary or mandatory basis.

The Tree Benefit Estimator was based on the experience of SMUD's Shade Tree Program. In developing this simplified and easy-to-use method for estimating tree-planting benefits, broad assumptions were made regarding the trees' impact on direct shading benefits and on indirect or evapotranspiration effects, heating penalty in winter months, tree growth rates, and tree survival rates. As a result, this method may yield less precise results than a more tailored approach. In addition, staff from the USDAFS's Center for Urban Forest Research located at the University of California, Davis, reviewed the Tree Benefits Estimator.

The following input items about trees are needed:

1. Average cost of electricity in summer and winter months (cost of KWh)
2. Tree species (common OR botanical name)
3. Age of the tree from the tree planting date OR tree diameter at breast height (DBH)
4. Number of trees planted (1 or more)
5. Location in the United States, which determines the climate zone
6. Direction the tree faces (for trees planted next to buildings)
7. Distance between the tree and the building being shaded

To take into account different climate zones, information about the standardized climate zones or regions in the United States must be entered, and then the Tree Benefit Estimator can calculate the impact of ambient temperature and relative humidity on the summer cooling-load and winter-heating requirements, using cooling and heating degree days and latent enthalpy hours data. The summer cooling-load requirements and winter-heating penalty are essentially a function of the cooling and heating degree days and direct shading impact. The KWh impact of the tree's evapotranspiration effect (or indirect effects) is essentially a function of latent enthalpy hours. However, regardless of whether a tree is planted for its energy-saving

Table 1 PVB of avoided cost 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 PVBs over the minimum allowed $20, and thus those tree-siting scenarios are allowed in the program. The distance of the tree from a building is based on the following categories: adjacent (0030–18 ft), near (18–30 ft), and far (30–50 ft).

benefits, the method will estimate carbon and CO2 sequestration values for the specified tree species.

The methodology is based on the standard nursery-raised trees that are typically sold in 5-gallon containers, and that are usually 1 inch in diameter at the tree base (1 foot above ground). (SMUD’s Shade Tree Program has found that 5-gallon container trees will grow quickly and catch up with larger, 15-gallon container trees within two years, and thus the methodology applies for both 5- and 15-gallon container trees.) This methodology assumes that the standard (5-gallon) trees are "0" age when planted. The Tree Benefit Estimator can provide estimates for the large selection of common species of deciduous, broadleaf, evergreen, and conifer trees in the United States.

The age of the tree from the planting date or DBH can then be used to determine the tree’s growth rate factor, which in turn determines the level of energy and carbon sequestration benefits for any year. For the program’s trees or the trees planted by the utility, the age of the tree from the planting date or the DBH and the tree survival rate factor in that year then determine together the program tree factor, which then determines the level of energy and carbon sequestration benefits for the program’s trees in any year. In other words, the combination of the tree growth rate and the tree survival rate determine the final multiplier factor that is used to estimate the appropriate level of the program's tree benefits for any year. Given the age of the program's tree from the tree planting date, the estimator will automatically multiply the energy, capacity, and carbon sequestration benefit values of mature trees with the appropriate tree growth and survival rate factor.

COOL ROOF PROGRAM'S BACKGROUND AND PROGRAM DESCRIPTION

The residential Cool Roof Program follows SMUD's successful commercial Cool Roof Program, which began in 2001 and ended at the end of 2005. SMUD was the first utility in the nation to offer rebates for cool-roof technologies for commercial buildings (starting in January 2001). In 2005, the California Energy Commission adopted new Title 24 standards for energy efficiency for new commercial buildings in California, and cool-roof technology was part of the Title 24 standards for the first time. SMUD does not offer rebates for any measures that are considered "standard technology," and thus SMUD stopped offering rebates for commercial cool-roof applications. SMUD's experience with commercial cool-roof technology helped influence development of SMUD's residential Cool Roof Program. The new Title 24 standards for cool roofs do not apply to residential buildings, which was the impetus for SMUD to initiate the residential Cool Roof Program.

In 2006, SMUD expanded the program to provide similar services to residential customers, but only those with flat roofs. In 2007, the program was expanded to include cool-roof products for steep-slope roofs as well as flat roofs. SMUD provides incentives for installation of qualified roofing materials to residential property owners, including single-family homes, apartments, and mobile homes. New construction projects are excluded. The participating roofing contractors agree to install cool-roof products that meet minimum SMUD specifications, which include being listed on the qualifying Environmental Protection Agency (EPA) Energy Star product list and meeting the initial solar reflectance and initial thermal emittance standards, as rated by the Cool Roof Rating Council. Below are the specific technical requirements and incentive amounts for flat and steep roofs:

- Flat slope roofs: 20 cents per ft^2 rebate, reflectivity >75%, emissivity >75%
- Steep slope roofs: 10 cents per ft^2 rebate, reflectivity >40%, emissivity >75%

An additional program requirement is that all residential mobile homes and single-family and multi-family homes have an electrical central AC system. Customers whose homes have evaporative cooling systems or wall AC units are not eligible for rebates.

Cool roofs are highly reflective and have substantial thermal emittance, which helps block heat from being absorbed through the roof and into a building. Roof-surface temperatures can be reduced by up to 50°. Flat cool roofs are white, while steep-slope cool-roof applications are commonly light weight and light color tiles made from concrete or clay. The color of the tiles can be in any traditional rooftop color, as long the products meet the minimum solar reflectivity of 40%. In 2008, the program completed 119 residential cool-roof projects, with a total area of 189,000 ft^2. The average project was 1700 ft^2, with an incentive payment of $350.

COOL ROOF PROGRAM'S IMPACT ANALYSIS

Using the energy simulation modeling programs, SMUD staff estimated conservatively the following average energy and demand savings for commercial Cool Roof Program participants:

- Average energy cooling-load savings of 20%
- Average energy cooling-load savings are 0.15 kWh/year/ ft^2
- Average demand savings are 0.25 W/ ft^2

In August 2005, SMUD's consultant the ADM Associates prepared the impact evaluation analysis for the SMUD's commercial Cool Roof Program. The realized energy-use savings were estimated through statistical analysis of billing data for the program's participants. The analysis of billing data involved applying regression analysis to monthly billing data for a group of 125 commercial buildings participating in the

Table 2. Estimates for pre- and post-installation kWh usage per day and daily kWh savings for regression groups

Daily kWh Usage and Savings	*Regression Group*			
	Offices with Package AC	*Retail with Package AC*	*School with Package AC*	*Central AC*
Pre-installation	1,369.88	797.98	1,599.24	8,882.34
Post-installation	1,261.83	725.91	1,456.57	4,908.21
Savings	108.05	72.06	142.67	3,974.12
Savings %	7.9%	9.0%	8.9%	44.7%
Number of buildings	45	35	29	19

program, using regression analysis for billing data for periods before and after the installation of the cool-roof measures. From a statistical perspective, the statistical model fitted fairly well, the R2 values for buildings with central AC systems were reasonably high, and the coefficient estimates were generally statistically significant at the 5% level. The results are presented in Table 2. The savings percentages reported in Table 2 appear to be within a reasonable range, except for the group with central AC, for which the estimates are rather too high.

For the residential buildings, SMUD's staff estimated the program weighted-average annual energy savings for both the low (5% of total residential roofs) and steep-slope roofs to be 505 kWh per year. These energy simulation estimates were weighted for the various housing vintage and HVAC equipment types for both steep and flat roofs. Customer savings were less, due to a heating penalty. The reflectance of the cool roof, while reducing cooling loads in summer, increases heating loads slightly in winter. Consequently, occupants experienced reduced AC bills but increased heating bills. Summer bill savings were greater than winter bill increases, resulting in a net annual energy-bill savings.

The weighted-average annual heating penalty reduction was estimated as -5.5 therms, or $6.13 in additional cost for a greater heating load. The weighted-average energy-bill savings, including the heating penalty, were estimated to be $88 per year. It is important to note that these are net savings. The annual net savings varied from $179 for homes with low-slope roofs to $17 for highly energy-efficient homes built recently, with the steep-slope roofs.

There is a dramatic difference in energy savings between the low and steep-slope cool-roof residential applications. In general, residential buildings with flat (or low-slope) roofs generated much higher levels of energy savings for this program than did buildings with other roof types. SMUD staff estimated that flat or low-slope cool roofs can generate, on average, annually 1,840 KWh in energy savings (based on a 1,539 ft^2 average home size). On the other hand, estimates for weighted-average energy savings for steep-slope roof applications (based on a 1,694 ft^2 average home size, and given the average building vintage mix) was 417 KWh annually.

The most important reason for this fact is that flat-roof installations use cool-roof technologies that have relatively high levels of solar reflectivity (e.g., single-ply membranes that have solar reflectivity > 80%). On the other hand, steep-slope roof installations use cool-roof technologies that have relatively low levels of solar reflectivity (e.g., light-colored tiles, which have reflectivity of 40% to 50%). In addition, the flat-roof residential buildings in SMUD's service territory are older, vintage-construction homes built in the 1950s and 1960s, which generally have much lower energy-efficiency, HVAC, and building code standards. Subsequently the energy-savings values from the cool-roof installations are much greater and more prominent for residential buildings that have flat roofs than for building with other roof types.

CONCLUSIONS

From the standpoint of energy efficiency, SMUD's evaluation found the planting of trees to directly shade buildings and rebating the installation of cool-roof products were cost-effective energy-efficiency strategies for SMUD and were highly valued by its customers. Although the energy-savings impact of the shade-tree plantings varied dramatically depending on tree orientation (West side was the best), tree size (large trees were the best), and distance to the building (the closer the better), the impact-evaluation studies revealed that the average cooling energy and demand savings per mature tree for central-air and heat-pump homes in the Sacramento climate zone (hot and dry summer) was 153 KWh and 0.056 KW. In addition, SMUD staff created a free Internet-based Tree Benefits Estimator tool, which is posted on the SMUD website (www.SMUD.org) and which takes into account all the different climate zones in the United States.

With respect to cool-roof technologies, SMUD staff had estimated conservatively the following average energy and demand savings for the commercial Cool Roof Program participants: average energy cooling load savings of 20%, average energy cooling load savings are 0.15 $kWh/year/ft^2$, and average demand savings are 0.25 $W/\ ft^2$. There is a dramatic difference in energy savings between the low- and steep-slope residential cool-roof applications. In general, residential buildings with flat (or low-slope) roofs generate much higher levels of energy savings for this program than do buildings with other types of roofs. SMUD staff estimated that flat or low-slope cool roofs can generate on average annually 1,840 KWh in energy savings (based on a 1,539 ft^2 average home size). On the other hand, the estimate for weighted-average energy savings for steep-slope roof applications (based on a 1,694 ft^2average home size, and given the average building vintage mix) was 417 KWh annually.

This successful outcome of the two programs (Shade Tree and Cool Roof) was the result of the fact that SMUD's board of directors and management made an enduring commitment to the long-term Shade Tree and Cool Roof Programs' goals. In addition, program monitoring and evaluation have been an important part of that commitment. The program management has been receptive to evaluation recommendations and committed to implementing them to improve the programs' delivery.

References

Geoffrey H Donovan and David T. Butry, 2009, The value of shade: Estimating the effect of urban trees on summertime electricity use, Energy and Buildings

SMUD, 1995, Shade Tree Program Impact Evaluation

(Received Feb 9, 2012, Accepted Oct 10, 2012)