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OPPORTUNITIES FOR UTILITY INVOLVEMENT WITH SOLAR DOMESTIC HOT WATER

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ABSTRACT

Solar water heating is one of a number of options that can be considered under utility demand-side management (DSM) programs. Utilities perceive a range of potential benefits for solar water heating in terms of customer service, energy conservation, load management, environmental enhancement, and public relations. The solar industry may benefit from utility marketing efforts, economies of scale, added credibility, financing options, and long-term maintenance arrangements. This paper covers three topics: (1) the energy and demand impacts of solar water heating on utility load profiles based on the results of four studies in the literature, (2) the results of workshops sponsored by the National Renewable Energy Laboratory (NREL) to identify key issues faced by utilities in considering residential solar water heating as a DSM option, (3) several current or planned utility programs to promote solar water heating.

1. INTRODUCTION

Electric utilities are increasingly looking to energy efficiency as an alternative to capacity additions (i.e., constructing new electric generation plants). Renewable energy resources in general and solar water heating in particular have potential to help achieve projected savings in energy and demand. Utilities show a renewed interest in solar water heating.

For the solar industry, utility water heating programs offer a good market opportunity. By encouraging the use of solar water heating, utilities will promote product sales, which can lead to economies of scale in manufacturing, marketing, and installation. Utility involvement may also provide added credibility for the solar industry and alternative approaches to financing and long-term maintenance. A solar industry/utility partnership could be advantageous to both parties.

The U.S. Department of Energy (DOE) and NREL initiated an effort with utilities to: (1) explore barriers/opportunities for the use of solar domestic hot water (SDHW) as a DSM measure, (2) facilitate early utility SDHW programs by providing technology transfer and technical support, and (3) encourage full-scale utility programs using renewable technologies as DSM measures.

This effort began with two NREL-sponsored utility workshops involving 20 DSM professionals to explore the problems and opportunities for utility involvement with solar water heating as a DSM measure. NREL is currently providing technical assistance to "early adopter" utilities in the development of solar water heating programs or pilot projects. DOE and NREL are working with the Solar Energy Industries Association on a large-scale initiative to develop and implement solar DHW within utility DSM programs.

The purposes of this paper are to present issues related to utility use of residential solar water heating as a DSM measure and to describe current utility projects.

2. BACKGROUND

Many utilities are spending more than 5% of their revenues on energy efficiency programs (1) with a few of the larger utilities allocating more than $100 million per year to such programs. These developments have grown in concert with adoption by utilities of integrated resource planning (IRP). IRP aims to achieve a mix of supply- and demand-side resources that satisfies energy needs at the lowest possible cost to utilities and consumers. The term "integrated resource planning" is now used interchangeably with the term "least-cost planning" (LCP). A central feature of integrated resource planning is demand-side management (DSM), which refers to actions on the customer side of the electric meter stimulated by the electric utility. DSM is expected to meet approximately 30% of the forecast growth in demand for new capacity over the next decade (1).

Based on a 1991 study (1), 31 states have IRP requirements in place. This is a 35% increase over the number of states requiring IRP only 2½ years ago. Utility regulators in these states have adopted some form of financial incentives to support investment in DSM. The incentives generally fall into three categories (1):

- Cost recovery - This allows utilities to recover capital and administrative costs involved in implementing DSM programs.
- Lost-revenue recovery - This allows utilities to recover revenues lost through efficiency programs.
- Pure Incentive - This offers bonuses to utilities that go beyond offsetting costs associated with DSM programs.

The Clean Air Act Amendments of 1990 include an incentive for utilities to invest in DSM programs to promote the increased use of efficient technologies. The law specifies that in order for utilities to qualify for the incentive, their state commissions must have IRP requirements in place and a mechanism to ensure that the utilities will not lose money from their efficiency programs (1).

3. SOLAR DHW IMPACT ON ELECTRIC UTILITY LOADS AND DEMAND

Water heating is an important energy end-use, consuming 2 to 3 quads of primary energy. Nationally, approximately 8% of the energy used in residential and commercial buildings is used to heat water. While the majority (54%) of water heating in U.S. households is provided with natural gas, electric water heating holds a significant and growing market share. Electricity currently provides water heating in 35% of existing U.S. households, and almost half of all new water heaters sold are electric.

To date, the most prevalent nonsolar residential DSM programs for water heating include simple timers, low-flow shower heads, direct load control, water heater insulation wraps, and the use of high-efficiency water heaters. Factors of interest to utilities in evaluating solar DHW as a DSM strategy include determining the impact that solar water heating has on peak demand and comparing the merits of solar DHW with competing technologies including direct load control, and high-efficiency water heaters such as heat pump and heat recovery units.

Several studies over the last 10 years have used measured performance to assess the influence of residential solar water heaters on electric utility peak demand. The results of three of these studies are presented in Figure 1 (2-4).

The first study was conducted in North Carolina through cooperative efforts of the North Carolina Alternative Energy Corporation, Carolina Power and Light, and the North Carolina Solar Energy Association. The Florida Solar Energy Center (FSEC) analyzed the data. The study involved monitoring 24 solar DHW systems in the Raleigh-Research Triangle area from December 1984 through November 1985. The systems were metered to determine the economic benefit to the consumer and the peak load impact on the utility resulting from residential solar water heating operating under direct utility load control. No conventional systems were monitored in North Carolina. The comparison in Figure 1 represents the North Carolina sites versus a sample of 55 conventional water heaters measured at a later date.

In the second study, conducted in Austin, Texas, Askey and Vliet (3) analyzed one year of data from 15 homes with solar water heating with electric auxiliary and a similar set of 15 homes with conventional electric water heaters. The essential requirement in selecting the homes was that each home with a conventional system was paired with a home using solar water heating that had a similar family size and age distribution. The results presented in Figure 1 represent the average peak demand for the 10 highest peak-demand days in the summer. The impact on energy use from this study is shown in Figure 2.

In the third study, conducted in Florida, FSEC (4) monitored 76 homes for 2 years to collect data on water heating electrical energy consumption, efficiency, and time-of-day demand. The homes were divided into samples of four different water heating systems: conventional electric resistance, heat pump, heat recovery, and solar water heaters. Eighteen conventional electric water heaters and 20 solar water heaters were monitored. The coincident winter and summer peaks are shown in Figure 1. Of the 4 systems tested, the solar systems had the highest coincident peak demand reduction.

In all three of these studies, the greatest coincident demand savings, which equaled approximately 0.4 kW in 2 studies and 0.7 kW in the third, occurred in the winter. This is because hot water use is a strong component of the utility's early morning winter peak but is not as critical during the summer peak period, which is typically in the afternoon.

In a more recent computer simulation study by the Canada Center for Mineral and Energy Technology (5), researchers assessed the supply and demand-side benefits of a conventional solar water heating system. A solar system with a programmable thermostat that allows for multistage off-peak charging, referred to as the "advanced" solar system, was included in the evaluation. The programmable thermostat was set to 45°C during peak hours and 64°C during off-peak periods. Off-peak periods were defined as always being between midnight and 4:00 a.m. In the advanced scenario, a reduced amount of auxiliary (1 kW) was made available on demand. This strategy attempts to shift a significant amount of load but doesn't affect the systems ability to continually provide hot water. The advanced solar water heater provided a net capacity displacement of 0.86 kW per system during a 16-hour period on the winter peak day in Ontario Hydro service territory. The maximum power demanded by the advanced solar water heater during the off-peak hours never exceeded the daily maximum

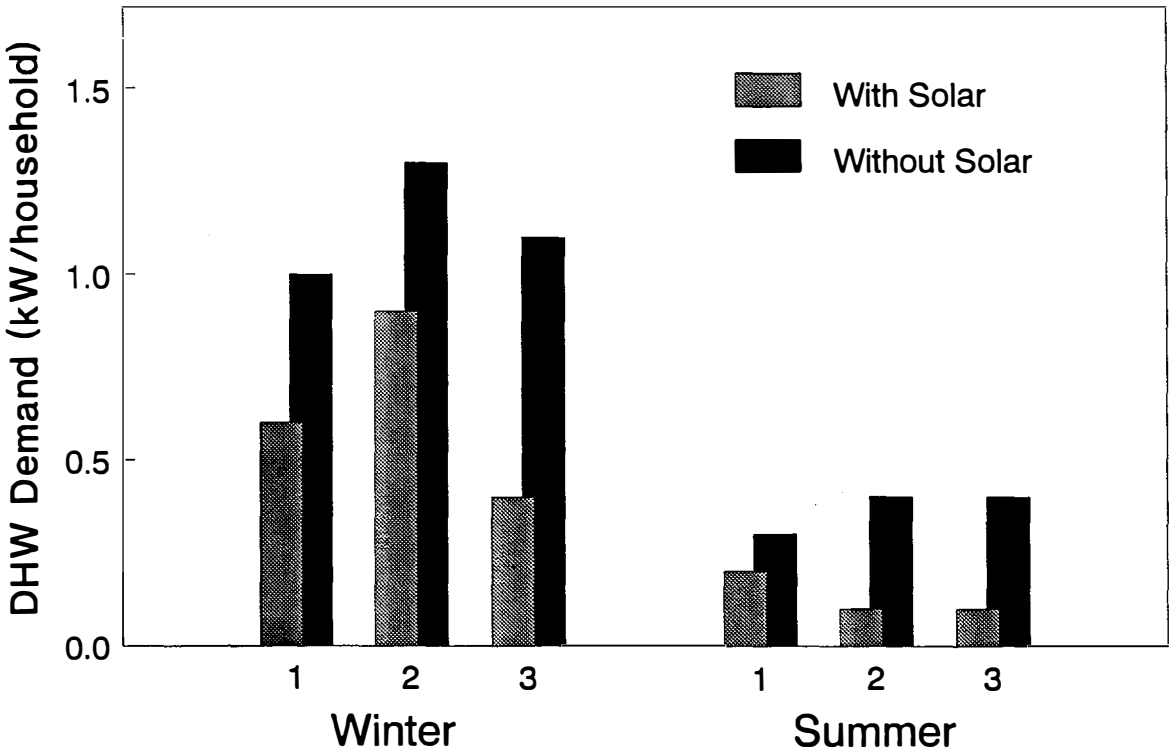

Fig. 1. Coincident Diversified Demand Impact of Residential Solar DHW Systems on Electric Utilities. (Study 1 was conducted in North Carolina with a sample of 55 electric and 24 solar customers (2); Study 2 was conducted in Texas with a sample of 15 electric and 15 solar customers (3); Study 3 was conducted in Florida with a sample of 19 electric and 19 solar customers (4).)

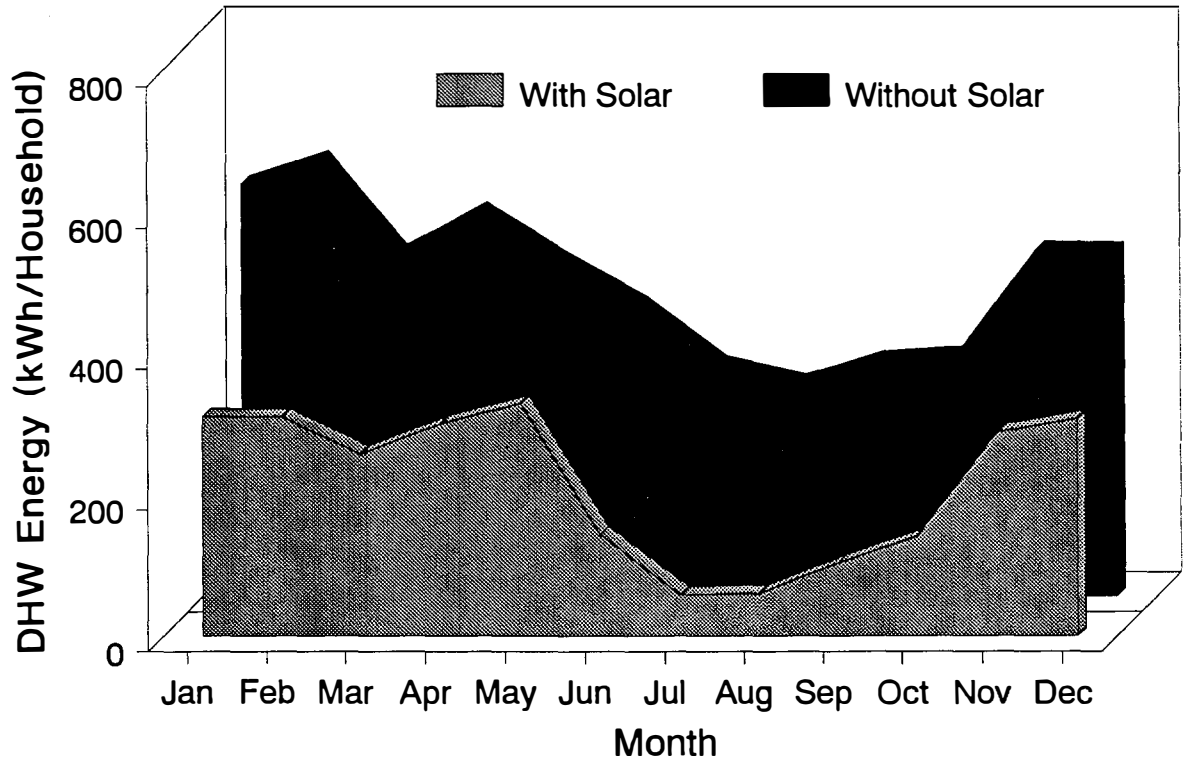

Fig. 2. Energy Savings from Residental Solar DHW Systems in Austin, Texas (3)

power demanded by the conventional all-electric system. Therefore the creation of new utility peaks was avoided.

The Canadian study also documents the synergistic effects of combining solar water heating with load control of water heating. Several U.S. utilities use direct load control as a DSM strategy. One problem with direct load control is that customers may run out of hot water. The Canadian study demonstrated that when the off-peak control strategy is used with solar, the reliability of providing hot water is greater for the solar system than it would be for an all-electric system operating under the same conditions.

4. NREL SOLAR WATER HEATING WORKSHOPS

NREL sponsored two workshops for DSM professionals to explore the problems of and the opportunities for residential solar water heating as a DSM measure. Each workshop was planned for a limited number of selected utilities with an active interest in DSM and a current or potential interest in solar water heating. The utility DSM professionals were drawn from various disciplines including program planning, program design, implementation and marketing, customer service, and program evaluation. The utilities that were represented covered all regions of the country and ranged in size from small municipal utilities to large investor-owned companies. The results of the workshops are described in detail in Reference 6.

The workshops involved 20 utility participants from 17 utilities and two power marketing authorities. The workshops began with overview presentations from NREL and utilities currently operating solar water heating programs (including the City of Santa Clara and the Sacramento Municipal Utility District). The format for the workshops was a focus group in which the participants discussed the benefits and problems of solar water heating as perceived by utilities and possible solutions and the next steps for utilities and NREL. The perceived benefits are identified in Table 1. Table 2 provides a listing of the perceived problems and solutions that were discussed.

TABLE 1. BENEFITS OF SOLAR WATER HEATING AS PERCEIVED BY UTILITIES

Customer Service	Supplying customers with choices to reduce monthly energy bills
Public Relations	Creating good will with customers, legislators, and regulators
Load Management	Reducing peak demand in summer
Conservation	Reducing fuel usage
Environment	Improving air quality
Market Share	Retaining electric water heating load versus natural gas
Profitability	Improving net income based on regulatory incentives
Technology	Developing innovative technologies

TABLE 2. PERCEIVED PROBLEMS AND SUGGESTED SOLUTIONS

Problem	Description	Solution
System Costs	Low benefit/cost ratio relative to other DSM options	Utility bulk purchases and technology development
Reliability	Poor performance if not properly installed and maintained	Extended warranties and performance contracting
Infrastructure	Lack of dealer network to effectively deliver and maintain equipment	Utility, industry, and government partnership and collaboration
Reputation	Past overzealous marketing and questionable business practices	Rating/certification and utility involvement
Information	Lack of credible, unbiased information	Utility involvement in advertising and promotion
Lack of incentives	Negative utility revenue impacts unless PUCs provide incentives	Regulatory reform to provide incentives to utilities
Risk	Utility reputation at stake, liability issues	Pilot projects, monitoring, and performance contracting
Aesthetics	Unattractive to some consumers and communities	Increased acceptance for solar based on successful programs

Based on the workshops, it appears that some utilities are more receptive than others to consider solar water heating as a DSM strategy. We have identified several factors which may influence a utility decision to consider solar water heating.

- Load Management - Demand reduction (kW) was the initial basis for utility interest in DSM.

- Regulatory Reform - In a number of states, regulatory reform has decoupled sales from revenues so that energy savings (kWh) have become attractive to utilities based on provisions for cost recovery, lost-revenue recovery, and incentives.

- Environmental Externalities - Utility operations are increasingly impacted by air pollution regulations. The issues may be local (air quality), (Clean Air Act), or potentially international (agreements on acid rain or atmospheric warning).

- Incremental Growth - Modular capacity additions can better track uncertain market growth.

- Transmission and Distribution (T&D) - Decentralized resources can lead to reduced utility T&D system requirements.

- Public Relations Benefits - Renewable energy programs can help to offset public concerns regarding coal or nuclear power generation.

- Timing - Utilities at various stages in the LCP/IRP process will have different positions on new DSM measures. A utility that has just completed extensive LCP/IRP efforts may be less receptive, while a utility that is beginning a first (or second) round of evaluations may be more receptive.

5. EARLY ADOPTER UTILITIES

The workshop participants identified the need for utilities to conduct pilot projects or full-scale programs as the next step for utilities interested in evaluating solar water heating as a DSM strategy. NREL staff members are providing technical assistance to several utilities, and we are aware of other utilities that are either operating or planning solar water heating programs. The following is a description of several of these utility programs. These descriptions are provided to illustrate the range of programs currently planned or operating.

- **Santa Clara Municipal Utility**

The City of Santa Clara, California has been operating municipal solar utility programs for residential SDHW and pool heating since 1975. The program provides for the design, installation, and ongoing maintenance of SDHW and pool heating systems. Each user, typically a home or apartment owner, pays an initial installation fee to cover the value of labor and permanent materials required to install a solar heating system. The recoverable components, including panels and automatic controls, are rented; the monthly fees are set by the City Council as a "Solar Utility Rate." Each user and the city enter into a contract that defines the responsibilities of each party and sets the monthly utility fee proportional to the size of the solar energy system. Fees are designed to repay installation costs as though repaying an amortization loan for a term equal to the expected life of the equipment. The program has made its greatest impact serving multifamily residential buildings with central water heaters. Over 400 residential units receive solar hot water from equipment rented from the city. In addition, more than 300 pools—from a total of 800 pools in the city—are heated by the city's solar program (7).

- **Eugene Water and Electric Board**

The Eugene, Oregon, Water and Electric Board initiated a solar rebate program in May 1990. The rebate, which is based on predicted system performance, ranges from $100 to $400. The rebate can be combined with the Oregon state tax credit for alternate energy systems. The tax credit is equivalent to $0.60 per kWh of predicted annual savings based on an F-chart analysis. Assuming a 15 year system life and a 4% real discount rate, this is equivalent to $0.05/kWh/yr. The credit is a one-time credit up to a maximum of $1500. A homeowner is required to obtain a building permit to install a system, and the building department inspects the installation. The Eugene Water and Electric Board has worked closely with the city building department and local installers to ensure that the installations meet certain standards. To date, 120 residential systems have been installed through the program. The Water and Electric Board staff is planning to evaluate the cost effectiveness of the program from the utility perspective and is interested in exploring alternative means of program delivery.

- **Central Vermont Public Service (CVPS)**

CVPS personnel are conducting a solar domestic hot water test project in which they plan to install and monitor the performance of 16 SDHW systems throughout their service region, aimed at different load groups. The systems will come from several manufacturers. CVPS plans to monitor the systems for 2 to 3 years to determine the effectiveness of the systems in reducing the consumers' electricity usage.

- **Sacramento Municipal Utility District (SMUD)**

SMUD is establishing an ambitious program to accelerate the adoption of solar domestic water heating systems in SMUD service territory. The program has three major elements:

Solar DHW Rebate Program

The SDHW Rebate Program is scheduled to begin in mid-1992. The program institutes a performance-based rebate and adopts nationally accepted standards adapted to the Sacramento area. The rebate is up to $1000, based on predicted system performance. An added freeze protection bonus of $225 is available for certain system types that have enhanced freeze protection. Also, as a marketing strategy, a $300 campaign bonus will also be offered for a limited time. The goal of the program in 1992 is the installation of 800 SDHW systems.

Solar Utility Program

The Solar Utility Program will be developed during 1992 to be implemented in the summer of 1993. It will involve bulk purchases by the utility of solar hardware.

SDHW Test Facility

SMUD is proposing to construct an SDHW testing facility to provide side-by-side testing and performance monitoring of 10 to 12 different SDHW systems that may be installed in the district.

- **New England Electric System (NEES)**

NEES is currently planning a pilot project on solar water heating for single family, multifamily, and small commercial applications. The purpose of the program is to collect cost and kW and kWh savings data in order to evaluate the cost effectiveness of a large-scale solar program.

6. CONCLUSIONS

Utilities, through their IRP programs, offer good opportunities for the promotion of solar DHW. Several studies have been done that show that solar DHW can positively impact a utility's peak demand in both cold and hot climates. Solar DHW offers a wide range of advantages to utilities, and solutions appear to be available to overcome utility-perceived problems. Several utilities are currently operating solar DHW programs. If these programs prove to be successful over time, additional utility programs should follow.

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