Creating a Sustainable Solar Water Heating Market in California

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ABSTRACT

Solar water heating has significant potential to contribute to meeting California's greenhouse gas emission reduction goals, as well as other benefits. However, the rate of adoption of solar water heaters in California has been slower than other states, such as Florida and Hawaii, which share similar solar resources. The primary difference is that 89 percent of single-family homes in California heat their water with natural gas, and displacing natural gas costs for heating water results in a longer payback period than displacing electricity costs for heating water. This paper provides detail regarding the market potential in California, as well as preliminary estimates of cost-effectiveness of SWH as derived from data from the Solar Water Heating Pilot Program in San Diego. The evaluation of the costs and benefits related to SWH are still evolving which may impact the final value for cost-effectiveness. The paper also provides recommendations for regulators, utilities and industry participants which may help to achieve market transformation. Developing a sustainable solar water heating market in California will reduce natural gas imports to California, will strengthen the California economy, and will help California reach its greenhouse gas emission reduction goals. A successful market transformation of the SWH industry in California could act as an example that could be replicated throughout the United States.

Introduction

On January 12, 2006, the California Public Utilities Commission (CPUC) issued Decision 06-01-024 which directed the California Center for Sustainable Energy (CCSE) to administer a pilot program for solar water heating incentives for San Diego Gas and Electric (SDG&E) customers. The Solar Water Heating Pilot Program (SWHPP) began in July 2007 and offers incentives through 2009 to electric customers from commercial, residential, and new construction sectors for natural gas, electricity, and propane-displacing solar water heating installations. The results of this program will be used to evaluate the cost-effectiveness and the current state of the SWH market in California. This information will aid the CPUC in deciding if a statewide solar water heater incentive program should be offered for natural gas customers and, if so, how it should be designed.

Two pieces of legislation were passed in California which have been influential in revitalizing the solar water heating (SWH) discussion. These were Assembly Bill 1470 (AB 1470) and Assembly Bill 32 (AB 32). AB 1470, enacted in 2007, states that "It is the intent of the Legislature to build a mainstream market for solar water heating systems that directly reduces demand for natural gas in homes, businesses, and government buildings. Toward that end, it is the goal of this article to install at least 200,000 solar water heating systems on homes, businesses, and government buildings throughout the state by 2017, thereby lowering prices and creating a self-sufficient market that will sustain itself beyond the life of the program." However, the bill also states that prior to establishing a statewide incentive program, the cost-effectiveness of SWH and the state of the current SWH market in California needs to be evaluated. The Solar Water

Heating Pilot Program was established as part of the California Solar Initiative in January 2006.

AB 32 was enacted in 2006, and requires greenhouse gas (GHG) emissions to be reduced to 1990 levels by 2020. The California Air Resources Board *Climate Change Proposed Scoping Plan* (*Scoping Plan*) estimates a potential reduction of 0.1 $MMTCO_2E$ from SWH installed as a result of AB 1470 by 2020 (CARB 2008, 44).

Current SWH Market in California

The 2003 Residential Appliance Saturation Study (KEMA-XENERGY, Itron, & RoperASW 2004, 95) found that 0.3 percent of households in California have installed a solar water heater (SWH), equivalent to approximately 34,500 systems (0.3 percent multiplied by 11.5 million households (Simmons & O'Neill 2001, 2). In 2007, California represented nine percent of the SWH collector area installed in the U.S. that applied for the federal investment tax credit (ITC). In comparison, Hawaii residents installed 49 percent of the total collector area and Florida residents installed 11 percent of the total collector area (Tomlinson 2008). With California being one of the most populated states and having one of the best solar resources in the U.S., this indicates that the California SWH market is much less developed than in Florida or Hawaii. However, unlike Florida and Hawaii, the majority of households in California heat their water with natural gas, and displacing natural gas costs for heating water results in a longer payback period than displacing electricity costs for heating water. In addition, Hawaii and Florida have notable state tax incentives and/or utility incentive programs in addition to the federal incentive, while the majority of California residents do not have access to an additional state or utility incentive.

SWH Market Potential in California

The potential for SWH to reduce natural gas use in California is great. Forty-four percent of the natural gas used in the residential sector is for heating water (KEMA-XENERGY, Itron & RoperASW 2004, 22). Opportunities for reducing natural gas use exist in the lodging, restaurant, and health sectors as well. Additionally, solar thermal systems which combine water heating and space heating, could further reduce natural gas usage as 54 percent of natural gas use in the residential sector is for space heating (KEMA-XENERGY, Itron, & RoperASW 2004, 22) and 36 percent of natural gas use in the commercial sector is for space heating (Itron 2006, 150).

Table 1: Natural gas use for water heating and space heating in California by sector.

Sector	Water Heating	Space Heating
Single Family	1,861.8 Mtherms (206 therms/HOME) (41 % of total for sector)	2,187.1 Mtherms (242 therms/HOME) (48 % of total for sector)
Multifamily	777.7 Mtherms (188 therms/UNIT) (70 % of total for sector)	421.9 Mtherms (102 therms/UNIT) (38 % of total for sector)
Lodging	78.2 Mtherms (68 % of total for sector)	19.7 Mtherms (17 % of total for sector)
Restaurant	72.4 Mtherms (23 % of total for sector)	11.5 Mtherms (4 % of total for sector)
Health	73.0 Mtherms (42 % of total for sector)	76.1 Mtherms (43 % of total for sector)

* (Itron 2006, KEMA-XENERGY, Itron, RoperASW 2004, U.S. Census Bureau 2000 and 2006)

Therefore just a 5 percent reduction in natural gas use for water heating from the combination of these sectors could result in 0.76 million metric tons of CO_2eq emission reduction. If an additional 5 percent reduction in space heating occurred, this could result in 0.72 million additional metric tons of CO_2eq emission reduction. The *Scoping Plan* estimates that if AB1470 resulted in the installation of 200,000 systems, the result would be a potential reduction of 0.1 million metric tons of CO_2E from SWH installed by 2020, this assumes that each system saves on average 130 therms. As can be seen, even with a low adoption rate or increased efficiency, California could easily surpass the current estimated potential to reduce greenhouse gases if SWH systems become cost-effective.

The potential for reducing natural gas through implementing solar thermal is great, however, at this time it is not currently cost-effective from a society's perspective, particularly when compared to the alternative of using natural gas. The payback period for a residential retrofit SWH system displacing natural gas is currently around 15 years, and homeowners are seeing an upfront installed cost of around $6,500[1] before incentives or tax credits are applied. In addition to the high out-of-pocket cost, the general public is not aware of the technology. In order to facilitate a larger market adoption of SWH in California, many steps will need to be taken to encourage and inform the public. California Public Utilities Commission (CPUC) Decision 08-06-029 (CPUC 2008) specifically addresses the issue of the extent to which "market intervention" is needed to increase adoption of SWH technologies. As such, the cost-effectiveness of SWH can be viewed from the perspective of a market transformation program. Under this perspective, the extent of needed market intervention is identified by evaluating the cost-effectiveness and ratepayer benefits in 2008 and then at the end of the market transformation period in 2017.[2] Scenario analyses are then performed to determine what factors would have the most impact on improving cost-effectiveness. The scenario analysis establishes general conditions by which the SWH market can possibly be transformed, and as such identifies possible pathways for achieving a transformed SWH market that is cost-effective.

[1] This is the average cost seen from applications to the SWHPP.
[2] AB 1470 calls for any statewide incentive program for SWH to be completed by 2017.

Cost-Effectiveness Methodology

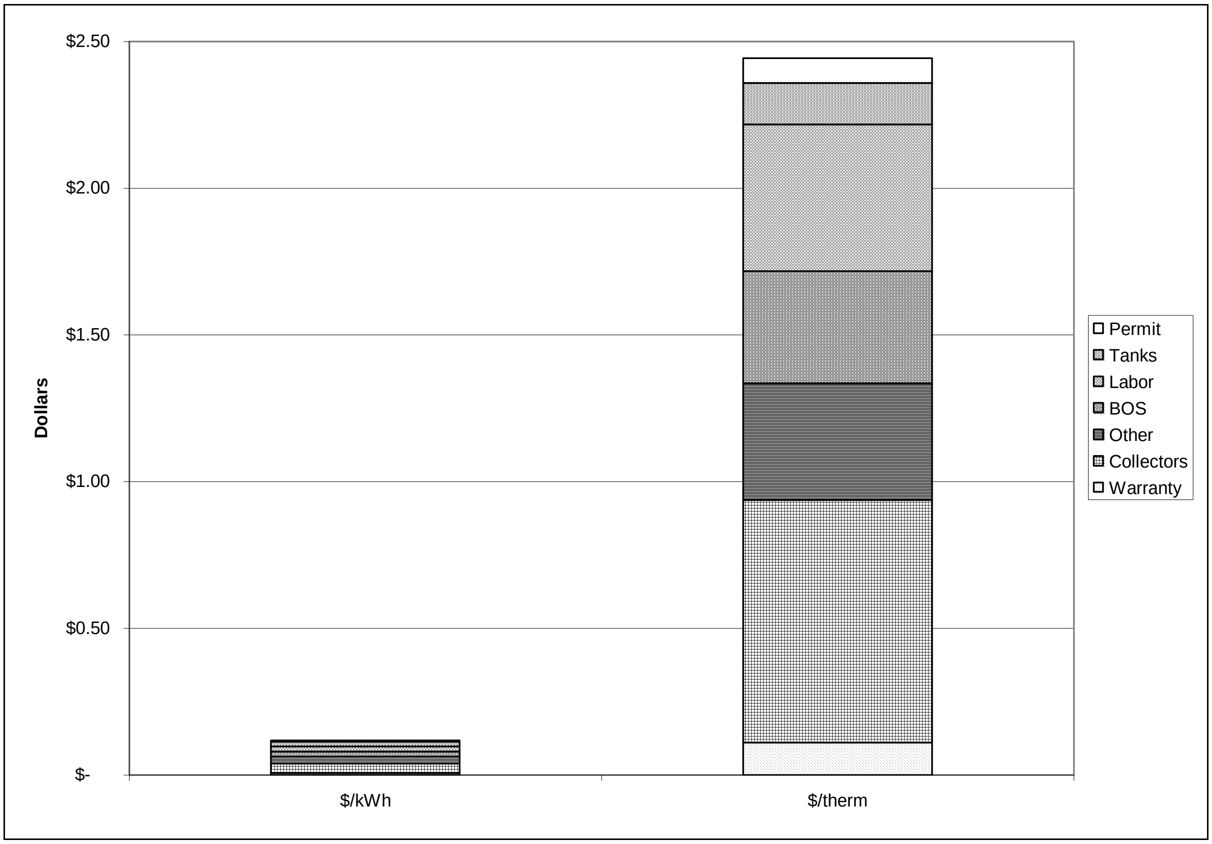
The methodology was based on a framework used to evaluate the cost-effectiveness of distributed generation (DG) technologies deployed under the CPUC's Self-Generation Incentive Program (SGIP). The SGIP cost-effectiveness methodology is based on a modified approach to the SPM and is described in detail in the *CPUC Self-Generation Incentive Program Preliminary Cost-Effectiveness Evaluation Report* (Itron 2005). The SGIP cost-effectiveness methodology was modified to reflect the specific needs and aspects of DG technologies and markets. In a similar manner, the cost-effectiveness model proposed for SWH analysis will be modified to reflect the unique aspects of SWH technology and SWH markets.

The use of a modified SPM approach allows for the quantification of the various costs and benefits associated with SWH systems. Using the identified benefits and costs, a benefit-cost ratio is calculated for a SWH program at the present time (e.g., 2008) and at the end of a market transformation period (e.g., 2017). As the magnitude of market transformation and subsequent effects is unknown at this time, the societal benefit-cost ratio is set at 1.0 at the end of the transformation period (e.g., 2017). Setting the societal benefit-cost ratio to 1.0 captures the idea that by the definition of a transformed market, a SWH program should be cost-effective at the end of the transformation period. Using the benefit-cost ratio of 1.0 as a goal, the individual costs and benefits which can most affect market transformation can be identified and the magnitude of the effect from changes in the costs and benefits can be explored. One manner in which the reasonableness of changes in benefits and costs can be assessed is through the use of levelized cost of energy (LCOE).

Levelized Cost of Energy

The LCOE is a means of representing the cost of a system, in this case a solar water heater, over the life of the system. The total costs are distributed over the life of the system for the amount of energy that is either displaced or generated. LCOE models are helpful as they provide a single value which can be compared to the costs of conventional fuels as a threshold that must be met. An LCOE model that identifies the individual cost components can be used in scenario analyses to determine the areas with the largest proportion of costs and those that would have the largest impact on decreasing the LCOE. For example, one scenario may require SWH technologies displacing natural gas water heating to achieve a specific LCOE value by 2017. However, if LCOE models show the value can be obtained only with heroic improvements in costs or performance during the transformation period, then the costs and benefits associated with those SWH technologies under those conditions would not be considered appropriate changes. Cost-effectiveness will be evaluated under a business as usual model and a market transformation model. The LCOE shown in Figure 1 is based on average actual costs and energy savings from the SWHPP, with no subsidies. Some SWH systems may have higher or lower LCOE values depending upon the total cost of the system and the performance of the system.

Figure 1: LCOE of SWH Displacing Electricity vs. Displacing Natural Gas



Business as Usual (BAU) Scenario

This scenario assumes that there is little improvement in cost or performance of SWH technology, little change in business approaches, and little change in market conditions. Under this scenario, 0.2 percent of households install a SWH each year through 2017 resulting in an overall adoption rate of 2.0 percent by the end of the market transformation period. Lower cost systems exist, but have limited freeze protection and are much less efficient than the higher cost systems. Natural gas prices will increase at a rate of 7.2 percent, which is based on the historic average annual growth rate for residential rates (California Energy Commission 2008c).

Market Transformation Scenario

In this scenario the benefit-cost ratio is set to 1 to represent the fact that market transformation has occurred. Then the necessary cost reductions and increases in benefits are considered which would allow the benefit-cost ratio to be equal to 1. Only those cost reductions and benefit improvements that are realistic are considered in this scenario analysis. Examples include improvements in technology costs and performance; streamlining of business operations; and changes in governmental policies.
Additionally, natural gas prices are modeled as increasing at an annual rate of 10 percent and that the value of environmental attributes increases as a result of increased reliance on natural gas in an economy that is focused on climate change.

Cost-Effectiveness Results

The cost-effectiveness values shown below are very preliminary. The identification and quantification of the benefits and costs associated with the installation of a SWH system is evolving. The authors are in the process of receiving stakeholder input which is necessary for the finalization of the cost-effectiveness results.

Business as Usual Scenario

The Business As Usual scenario sets a baseline for SWH. The benefit-cost ratio results are very preliminary and may not incorporate all of the benefits and costs attributable to a SWH incentive program. The benefit-cost ratio is calculated assuming the 200,000 systems have been installed, but that there have been no changes in the market. As can be seen in Table 2, the benefit-cost ratio is greater than one for the participant. However, the benefit-cost ratio for society is 0.53. As GHG emission reduction becomes increasingly important, the cost-effectiveness of technologies which provide a positive external benefit to society becomes increasingly important. This would be reflected in an increase in value of the environmental attributes associated with SWH>

Table 2: Benefit-Cost ratios under the Business As Usual Scenario

	Participant	Society
Benefit-Cost Ratio	> 1	0.53

Market Transformation scenario

Achieving a benefit-cost ratio of 1.0 for society is rather daunting as the primary benefits of SWH are received by the participant in the form of energy savings and additional revenue from the monetization of the environmental attributes. To have a positive impact on society, there need to be benefits which accrue to society, such as less volatile natural gas prices as a result of lower demand, increase in jobs in the local economy which leads to more spending by consumers and a higher income for all of California, or the economic value of health benefits from the reduction in GHG emissions.

Table 3: Benefit-Cost ratios under the Market Transformation Scenario

	Participant	Society
Benefit-Cost Ratio	4.17	1.0[3]

Market Transformation Recommendations

In order to create a sustainable SWH market in California that does not rely upon a subsidy, the market barriers need to be addressed. This section makes recommendations for goals in removing the market barriers by implementing a statewide incentive program aimed at creating a sustainable SWH market over 10 years. In addition to providing incentives, the program should develop goals for the regulators, the utilities, and the industry to meet in order to transform the market.

[3] As described in the methodology, this value is assumed to be 1.0, such that market transformation is achieved by 2017.

Regulator Goals

California is a leader in energy efficiency, renewable energy, and greenhouse gas reduction goals. In the last 10 years, many policies have been developed which encourage increased investment in energy efficiency and renewable energy and, more recently, in reducing greenhouse gas emissions. Many of the energy efficiency, renewable energy, and greenhouse gas reduction targets are already in place, and regulators should place more emphasis on the role of SWH in meeting these goals. SWH has been considered both an energy efficiency technology and a renewable energy technology by the state energy regulators, and, therefore, both applications will be discussed here.

Energy Efficiency. The *2008 Building Energy Efficiency Standards Residential Compliance Manual* (California Energy Commission 2008b) requires that all low-rise residential buildings that are constructed by the State (California) have SWH. In this way, SWH can be used as an energy efficiency measure to help meet the targets established by the California Energy Commission (CEC) and the CPUC.

In the *Integrated Energy Policy Report Update* (California Energy Commission 2008a), the energy policy agencies recommend that all new residential buildings be net-zero energy by 2020, and all new commercial buildings be net-zero energy by 2030.

Renewable Energy. In 2002, Senate Bill (SB) 1078 established the Renewables Portfolio Standard (RPS) which required the electric investor-owned utilities (IOUs) to generate a minimum percentage of electricity (kWh) using renewable energy resources. The RPS goals are to meet 20 percent of their electricity generation with renewable energy by 2010, and 33 percent by 2020.[4] It is recommended that similar goals be applied to the natural gas utilities, to which solar thermal technologies could contribute by offsetting natural gas used for both water heating and space heating or cooling.

Climate Change Policies. Assembly Bill 32 (AB 32) requires California to reduce greenhouse gas emissions to 1990 levels by 2020. SWH had been identified as a means for reducing greenhouse gas emissions in the *Scoping Plan* and the California Air Resources Board estimates that achieving the AB 1470 goal of 200,000 SWH systems would result in a potential reduction of 0.1 million metric tons of CO2eq by 2020 (California Air Resources Board 2008, 44). The California Air Resources Board recommends that California agencies work together with stakeholders to incorporate SWH into local green building codes and eventually into the CEC's building codes in order to surpass the AB 1470 goal and add further support to the SWH market in California.

Building Permits. In addition to the legislative mandates and policies that are currently in effect in California for energy efficiency, renewable energy, and greenhouse gas emission reductions, there is one other recommendation for a regulator goal which could help advance the adoption of SWH. Building permits for SWH have been difficult and sometimes expensive to obtain, and requirements differ between local permitting offices. Some contractors have said that they will not install systems in certain areas because of the difficult permitting processes. It is recommended that permits for SWH be standardized at a state level so that requirements and costs are consistent in all cities and counties throughout California.

It is also recommended that regulatory agencies work with local permitting agencies to provide training and education regarding the design and installation of SWH systems in order to reduce the amount

[4] The goal of 33 percent by 2020 is a goal established by the Governor's office and state energy agencies and is not a legislative mandate.

of time needed to inspect the system and avoid the need for multiple inspections. Once local permitting agencies are trained, it is recommended that the incentive program allow the local permitting inspection to suffice and not duplicate efforts by also performing the program's own quality control inspection. This would decrease the cost of administering the program and could lead to a decrease in the cost of the SWH system.

Regulatory changes could have a very large impact on the ability of SWH to be cost-effective. Allowing the energy displaced by SWH to be eligible for either renewable energy policy goals (such as an RPS or natural gas equivalent) or energy efficiency goals (Efficiency Portfolio Standards) would provide increased value to the installation of solar water heaters. Regardless of whether value is monetized (i.e. SWH system creates carbon credits which could be sold), being able to count SWH towards meeting certain goals will help increase the value of SWH and also increase awareness of the benefits provided.

Utility Business Model Recommendations for Meeting the Regulatory Goals

The regulator goals and policies outlined in the section above specify certain targets that the utilities must meet in terms of renewable energy, energy efficiency, and greenhouse gas emission reductions. There are many examples of how utilities can encourage the adoption of SWH, which could contribute to meeting renewable energy, energy efficiency, and/or greenhouse gas emission goals. There are two types of business models proposed: 1) the utility provides incentives for residential and commercial customers to purchase SWH and the customer owns the system; and 2) the utility purchases and owns the system that is installed on the customer's home or business, based on voluntary participation.

Customer Ownership Model. Many utility programs provide incentives for SWH either as a lump sum that decreases the upfront cost or as a performance-based incentive (PBI), which could be paid as a credit to the customer on their monthly bill. By providing an incentive, the utility may be able to claim any energy efficiency, renewable energy, or greenhouse gas emission reduction benefits from the system in order to meet regulatory goals. Most of the utility programs that provide a financial incentive are mandated by legislation and are funded through a surcharge on ratepayers. The system owner still bears the burden of the upfront cost as well as maintenance costs, which may slow the adoption of SWH. PBIs have typically only been used for commercial installations; however, making this incentive type available to homeowners could be a good tool in assuring system reliability and performance. Homeowners would be able to monitor their system to ensure that it is working properly, and they would have more motivation to maintain and repair the system when needed. Similar to time-of-use metering of electricity, if homeowners can monitor the hot water production by the SWH, they will be able to choose to change their behavior in order to optimize their energy savings. In the event that monitoring is too expensive, a valid alternative would be to use the estimated annual performance ratings provided by the Solar Rating and Certification Corporation (SRCC) which provide detailed reports of estimated energy savings for 16 climate zones in California for the OG-300 Certified Systems.

Utility Ownership Models. Lakeland Electric Utility had a SWH leasing program in 1997 which proved to be very successful and provides the basis for the utility ownership model. In this model, the utility purchases and installs SWH systems on its residential and/or commercial customer's roofs, along with metering equipment. The meter measures the amount of energy that is displaced by the SWH system, which allows the utility to bill the customer separately for that portion of the bill. The metering for SWH systems that use electricity as the backup fuel are typically less expensive and less invasive than for systems that use natural gas. The benefit to the customer is that the water heating portion of the bill is charged at a fixed rate, which will not increase despite any increases in the standard electricity gas rate. The utility ownership model means that the utility, as the owner of the system, has the property rights to any environmental attributes that are applicable to the SWH system.5 Additionally, the utility has more direct control over the adoption rate of the technology and can invest more funds if it finds the technology to be cost-effective or if certain targets need to be achieved. One further advantage is that the utility could purchase systems in bulk at a discount and could also receive a lower rate on installation costs, resulting in a lower per system cost. One drawback to the utility is that the utility would be responsible for the maintenance of the system and there may be more perceived risk of investing funds in SWH.

Regardless of which model is adopted, the key to encouraging more interest in SWH from utilities is to coordinate regulatory activity and to increase the programs for which SWH energy displacement is eligible as described under the Regulator Goals section. The ownership model which prevails will depend on the costs and benefits associated with each type. If SWHs that displace electricity are eligible for an RPS, such as is trying to be accomplished in Florida, there is more incentive to pursue the utility ownership model where there will be no question of the property rights to the associated environmental attributes.

Industry goals for SWH

In addition to the regulatory and utility goals for SWH, the SWH industry should also assist in transforming the market and increasing the adoption of SWH. With funding and support from outside sources, changes have already been made in the industry; however, further advances can still be made. This section discusses how reducing costs, increasing marketing, and seeking partnership opportunities can address two of the primary market barriers: high initial cost and lack of public awareness.

Low-Cost Systems. The average total installed cost of a SWH installed through the SWHPP is roughly $6,500 before an incentive, which has averaged roughly $1,240, and the federal tax credit of 30 percent of system cost up to $2,000 which in this case would be $1,950 resulting in a net cost to the customer of $3,310. With an average energy savings of 130 therms per year and a lifetime of 20 years, the resulting LCOE would be $1.27 per therm if displacing natural gas. Contractors who were interviewed had mixed responses when asked their opinion on the maximum cost a customer would pay for a SWH. Some said the cost did not matter because customers were purchasing the SWH for environmental reasons. Most contractors, however, thought that the cost for a residential system should be $6,000 or less. At the very least, one would expect the customer to want to be able to have an LCOE that is less than what is currently being paid for natural gas.

The SWH industry should focus further on reducing equipment and labor costs. If material costs and fuel costs continue to rise, the out-of-pocket installation cost, even with an incentive, may be too high for many homeowners. One way to provide insulation against volatile material costs would be to manufacture SWH equipment using different types of materials, for example plastic instead of copper. There are currently in the market a few lower cost systems, however, these systems also produce less energy savings. The expected installed cost of the lower cost system is $3,000. With a lower energy savings, such as 60 therms per year, and assuming the same lifetime, the resulting LCOE would be $2.50, showing that the

[5] In a customer ownership model, there may be a question of who retains ownership of any environmental attributes which may have value in the market, as both the utility and the customer have contributed funds to install the SWH system.

lower initial cost does not necessarily result in a lower LCOE. However, some of the lower cost systems may have higher energy savings resulting in a lower LCOE.

Installation Improvements and Options. In addition to the lower cost of the systems, some of the newly developed SWH systems are easier to install than before. The increased ease in installation is a result of a movement towards plug-and-play technology where the system design and manufacturing incorporates more of the complicated aspects of SWH system, allowing for easier installation. These types of systems provide all the required parts in a kit and use the same installation methodology for each system. No system engineering is required by the installer. Kit systems can be purchased by homeowners to install themselves, or could be installed by a contractor.

Develop Low-Cost Metering Equipment. Wisconsin Public Service (WPS) and Public Energy Systems (PES) engaged in an effort to discover the number of SWH systems that had been "orphaned" in Wisconsin after the federal tax incentive was discontinued in 1986 and homeowners no longer had access to a contractor who could repair or perform routine maintenance on their system. DeLaune, Bircher and Lane (1995) found that 50 percent of individuals whose SWH was not functioning were satisfied with their system.

Basic metering equipment is relatively inexpensive, and is increasingly becoming a standard component in SWH systems. Metering equipment would enable homeowners to ensure that their system is working properly. In the event that a repair is needed, having access to the metered data could allow the contractor to diagnose the problem over the phone and save both time and expense in system maintenance costs. Additionally, if homeowners can monitor the energy produced by the SWH in real-time, they are able to make decisions about their hot water use that could optimize their energy savings.

Coordinated Efforts. In order to raise awareness regarding SWH technology, manufacturers and installers should start to explore opportunities for coordination and collaboration with other industries and technologies. SWH installers could establish networks with plumbers to provide additional education and ensure the customer is aware of all of the alternatives available when replacing a hot water heater. To the extent that SWH installers do not also install PV, establishing a coordinated effort between the two groups may prove beneficial to both parties. SWH, PV, and energy efficiency technologies should all be considered when designing a zero-energy home, as the most cost-effective approach is likely to occur when all three are used together.

Conclusions

Improving cost-effectiveness can be done either by decreasing costs or improving performance and increasing the benefits. Based on survey results with SWH installers, manufacturers and distributors, most felt that costs could not be decreased as prices for raw materials were increasing and few technological advances are expected to occur. However, changes in the materials used to create SWH systems, as well as the construction of the systems themselves (move towards plug-and-play) have allowed lower cost alternatives to enter the market. Depending upon the performance of the systems, these low-cost alternatives may or may not have a better LCOE. If greater energy savings are achieved, the lower cost system could result in a lower LCOE and become more cost competitive with conventional technologies.

Not incorporated into the LCOE values is the fact that under certain policy regimes, SWH system owners could receive more benefits beyond just energy savings. To the extent that the energy displaced by SWH results in environmental attributes which have economic value (such as carbon credits which could be sold in the voluntary market), the cost-effectiveness of SWH systems would begin to improve. These market changes will greatly support and improve SWH cost-effectiveness over time.

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