SOLAR WATER HEATING FOR UNIVERSITIES AND COLLEGES: MEETING A NEED FOR COST-EFFECTIVE GREEN TECHNOLOGIES

Darrell Blakeway
Saif Islam
Munjed Murad
Perennial Energy Consulting, Inc
608 5th Street, N.E.
Washington, DC 20002
dblakeway@perenrgy.com
sislam@perenrgy.com
munjedm@perenrgy.com

Peter Lowenthal
Consultant to Perennial Energy Consulting
4707 Elmhirst Lane
Bethesda, MD 20814
pslowenthal@gmail.com

Paul Skorochod
Consultant to Perennial Energy Consulting
1410 Hamlin Street, NE
Washington, DC 20017
paulskorochod@gmail.com

ABSTRACT

Educational institutions are showing interest in the application of Solar Water Heating (SWH) systems for dormitories and general HVAC as part of their strategy for reducing their carbon fuel consumption. Perennial Energy Consulting, Inc. (PEC) interviewed several educational institutions in the DC/MD/VA area over the past year concerning their efforts to demonstrate SWH and their plans for expanded implementation. There is an interest in installing SWH systems by some universities, but also unfamiliarity with the financial aspects of SWH system applications. PEC is developing a methodology to provide efficient ways of evaluating the costs of SWH and comparisons with sole reliance on electric and natural gas heating.

1. METHODOLOGY

A consultant to PEC became aware of a demonstration project for SWH at George Washington University in the District of Columbia and interviewed a university staff member familiar with the project. Then we researched trade press and general news media for information about any other such projects at DC/Baltimore area universities. We found references to such a project at American University in Washington, DC, and plans for implementing SWH together with a campus air conditioning plant at John Hopkins University in Baltimore. PEC decided to make inquiries about SWH projects at other area universities. We limited our area of research to DC, Maryland and Northern Virginia because PEC is based in Washington, D.C.

We contacted all of the universities that participated in the College and University Sustainability Pledge (explained later in this paper) for interviews, as well as others in the DC/MD/VA area. Those contacted were either part of an office of sustainability on campus or the university's facilities management team. The sustainability office (if there is one) or the facilities management office, or both, usually oversees the environmentally sustainable initiatives of the university. We sent our questionnaire and requests for interviews to the director of the office of sustainability or someone designated by the university to specifically oversee its energy-related and environmental operations. We indentified these individuals from the university's newspaper articles on environmental or sustainable initiatives. Where no specific person could be identified, we contacted the general office of sustainability or facilities management.

Each of the university representatives was asked to answer a questionnaire by email or to participate in a phone interview using the questionnaire as a guideline for discussion. Most of the university representatives we contacted responded. They either chose to conduct a phone interview or provided a brief response about the university's overall approach to the subject of SWH systems. A copy of the questionnaire is in the Appendix.

2. INTRODUCTION

Our natural environment is being fouled and many natural resources are being rapidly depleted by our efforts to secure energy. As conventional fossil fuel resources are being depleted, human consumption of energy is increasing. An impending crisis looms ahead of us, and may have already begun,[1] which requires a timely transition away from fossil fuel use to renewable energy resources.

As public awareness of the threat of the collapse of our natural resource base and the environment grows, many individuals, institutions, and communities have taken it upon themselves to lessen their negative environmental impact. Moreover, eco-friendly means of operating companies and communities are often more economical. In university and college communities, especially, there is great concern over the adverse effects of global climate change. This encourages administrations of academic institutions to search for economical investments in energy technologies that reduce or avoid carbon emissions.

Whatever the impetus for individuals and entities to act, the result is a search for different, more economic and more environmentally friendly supplies of natural resources for energy use and other forms of consumption. In the DC/MD/VA area, our focus of interest in this study, there is also a growing environmental awareness in local and state governments. Thus, the government of Washington, D.C., under the administration of Mayor Vincent C. Gray, has taken a leading role in developing the College and University Sustainability Pledge, signed in February of 2012, in which nine presidents of universities in the District of Columbia pledged to diminish their universities' adverse environmental impacts and contribute towards making D.C. the most environmentally sustainable city in the country. Although this public/private partnership claims to be the first of its kind, it meshes with the generally perceived need of academic institutions and governmental entities to adopt means of operation that are more eco-friendly and economic.

[1] [T]he twelve hottest years on record have all come in the last fifteen. Heat waves, droughts, wildfires, floods—all are now more frequent and more intense. We can choose to believe that superstorm Sandy, and the most severe drought in decades, and the worst wildfires some states have ever seen were all just a freak coincidence. Or we can choose to believe in the overwhelming judgment of science—and act before it's too late. (President Obama, State of the Union address, February 12, 2013)

Institutions have responded to this need for action in various ways. They generally seek to implement some forms of renewable energy, such as solar energy, wind energy, and energy efficient designs of buildings. Solar energy can be utilized in different ways. One is the use of solar photovoltaic panels and another is that of solar thermal systems, which capture and concentrate the sun's heat. Solar water heating equipment is a simple form of solar thermal usage, which has been used for many years in many parts of the world.

3. UNIVERSITIES PURSUING AND DEMONSTRATING SWH SYSTEMS

Each of the three universities in this section has an official office of sustainability that overlooks or supports the university's efforts to make its campus more environmentally friendly, as well as increases on-campus awareness of sustainable practices. Not all of the universities we surveyed are part of the College and University Sustainability Pledge.

3.1 Case 1 — American University (Washington, D.C.)

Currently, SWH is installed on four buildings. Three of these are residential halls and one is a dining hall. The types of buildings were chosen based on volumes of hot water consumption— higher volumes being the more suitable for an SWH system. American University (AU) also has photovoltaic (PV) solar panels installed on an academic building to service a coffee shop within the building.

AU chose to use SWH due to its cost-effectiveness. It is committed to being carbon neutral by 2020, as outlined in a climate action plan it published in May 2010. Its provider is Skyline Innovations (SI), a Northern Virginia-based solar thermal financing company, which offers to own and maintain SWH systems and offers a power purchase agreement (PPA) to its customers. Solar Energy Services, a Maryland-based solar energy servicing company, was hired to do the installation at AU.

The implementation process reportedly was easy. There were no roof penetrations on the residential dormitories selected and there was adequate space for the heat solar collection and storage tanks. However, at one point the system overheated due to a change in load profile while students were away. A heat sink was installed—as a means of channeling the surplus heat to prevent boiling the

antifreeze within the system. Installing this bypass and additional heat rejection solved the overheating problem. SI currently owns the equipment and the solar renewable energy credits (SRECs). According to its agreement with SI, the university will own the equipment after 10 years of usage. For now, SI provides competitively priced hot water to the university. AU was not responsible for capital costs or ongoing maintenance, both of which are SI's responsibility. The university's insurance costs did not increase, and its roof warranty was not impaired by the SWH installation.

The university has five other residence halls. It is considering adding SWH to them. It expects to solicit multiple bids, and might do a PPA again or directly purchase the equipment. It intends to take into consideration the availability of SRECs and tax-incentives and thinks the prospects of owning the systems may be attractive due to the expected financial benefits over time.

3.2 Case 2 — John Hopkins University

John Hopkins University (JHU) is currently exploring the use of SWH technology at its main campus. This effort is being led by the University's Sustainability Office in conjunction with its Facilities Maintenance Staff. SWH is expected to fit into its long-term goal of energy self-reliance.

Although food services would seem to be a fitting application for SWH technology, JHU decided it was not an appropriate application at the main campus because the dining halls are in historic buildings that have slope and slate-clad roofs. The university is concerned with preserving the historic fabric and look of its campus. It is, however, considering SWH for its newer high-density residential buildings —specifically, three dormitories that are outside the most historic parts of its campus.
The primary benefits of installing SWH systems are carbon neutrality, energy independence, and cost savings. It expects to receive solar renewable energy credits (SRECs) from its use of SWH under the provisions of Maryland's Renewable Portfolio Standard, which should significantly reduce the costs. Currently, the university has a natural gas-fired power plant on campus. However, with natural gas prices being currently so low, and the high efficiencies of its gas-fired boilers, natural gas seems to be a less costly option for the university. Therefore, JHU will probably closely scrutinize the economics of its investment in SWH and its costs over its useable life.

The size of the SWH system is a chief concern when optimizing the return of an investment in such a system, especially when SWH is compared to natural gas water heating. The demand for hot water typically decreases in the summer, while a solar thermal system's production increases. Sizing a SWH system appropriately for all seasonal usages and production is the biggest challenge in attaining economical performance of the system. This dilemma is compounded in academic residential applications where an even lower hot water demand is experienced due to students' leaving the campus during school-year breaks and the reduced student populations in the summer.

The university also uses hot water for air-conditioning systems. It does so through a district hot and chilled water system on campus. The chillers for its air-conditioning units are powered by electricity. Adsorption chillers can also run on hot water heated from solar collectors. If the university installs an adsorption chiller system that can provide some of the cooling load of the building as a by-product it will create enough hot water to meet its load and operate at a higher efficiency due to the double application of cooling and hot water. This application matches the high hot-water production, low hot-water demand, and high AC demand of the summer months.

The university is conducting informational interviews with companies that specialize in SWH systems and adsorption cooling. They expect the expertise gained from such interviews will help them develop their plans for more effective use of solar thermal technology year round. The university expects it will require extensive external engineering and financial analysis of their plan before implementation.

3.3 Case 3 — The George Washington University

The university's sustainability office conceived the idea to install and utilize SWH because of awareness of its efficiency, and expected it to be a perfect application for the high demand for hot water in the university's residences. It preferred solar water heating technology for the rooftops of its residence halls to photovoltaic panels to generate electricity. An in-house cost-benefit analysis was performed and the results were compelling enough that a Request for Proposals (RFP) was tendered.

Although the RFP process is not the sole procurement procedure for the university, it seemed an obvious choice for this project. There are constant improvements in SWH,

and new rosters of vendors. The university staff recognized their lack of expertise in the subject and saw the RFP process as the best way to gain the greatest body of evidence. It yielded many proposals that were narrowed down to three competitive finalists. The original intention was for the university to own the system and merely procure construction services. However, Skyline Innovations (SI), the company that was awarded the contract, proposed a model whereby it would build and own the system, financing it through a monthly utility charge to GWU. This option was selected because the up-front costs in outright ownership were more expensive than expected. The only other procurement requirement was that equipment be made in the U.S.

SI built, owns, and maintains the SWH systems. A baseline hot water usage rate was determined by analyzing past utility bills and data collected from flow meters. It calculated the amount of natural gas costs that could be avoided by installation of the SWH systems. The university pays SI 70% of the natural gas cost avoided by supplementing existing water heaters with SWH for ten years after the system is commissioned. According to the terms of the agreement, as natural gas rates fluctuate, so will the price paid by the university, but the 70% rate remains constant for the duration of the contract.

Once commissioned, it became evident that the system built was oversized for the application because the demand for hot water varies so much with the seasons. The university and SI are trying to capitalize on this condition by piping surplus hot water to additional buildings. This effort is currently in the engineering stage. In the interim, SI keeps the system from overheating by turning parts of the system off at key times and by purging hot water. On one occasion, the system created too much hot water and surplus hot water was dumped onto the roof of one dormitory. The hot water made contact with the sprinkler system on the floor below through a crack in the roof. This triggered the sprinkler system and caused substantial water damage. The university was successful in collecting on its insurance claim to cover the water damage.

At the end of ten years, the university will own the system. At that time, both parties will assess the equipment and consider entering into a maintenance contract. All warranties remain with the equipment, regardless of who owns it. Both parties are expected to carefully monitor equipment performance and maintenance requirements, as well as look for ways to improve the system. SI can offer a multi-year maintenance fee or a rate-based ($/Therm) fuel offset cost. The university will have the option to execute a maintenance contract or service the equipment with in-house maintenance staff. It is likely that the cost of natural gas will increase in future years, and therefore affect any new contract terms. The parties also expect that advances will be made in SWH technology that will influence the economics of an extension of the agreement. The flexibility of this end-of-term option played a large part in the university's selection of the SI model.

The university reports that it is very satisfied with the SWH system and SI. The project experienced typical delays and cost overruns for SI in its installation, but nothing exceptional. Both parties learned lessons in building this system. Building selection proved to be a critical factor in minimizing project costs and maintaining deadlines. Buildings were selected based on the age and condition of their roofs. The consistency of the demand for hot water also makes athletic facilities, and especially indoor pools, good candidates for SWH. Structural enhancements were not necessary for any of the buildings.

4. UNIVERSITIES WITHOUT SWH SYSTEMS

Five other universities responded to our survey, but none had SWH systems, nor plans to pursue them in the near future. Three of them were located in the District of Columbia and were signatories to the D.C. Mayor's College and University Sustainability Pledge.

For one university, a major factor militating against its installation of SWH was its extremely low utility costs resulting from its centralized steam plant and cheap natural gas. The university already reaps significant cost savings through this centralized steam plant and district heating facilities. Thus, it did not expect to see major cost reduction benefits from the installation of SWH systems. It apparently would, however, reconsider if it were to obtain a donated or grant-funded system and had access to demonstration-scale technologies.

Another academic institution is not considering any changes to its method of energy consumption because of limited funding and the assignment of priorities to other areas. Another university is not considering such changes due to administrative issues, which include the elimination of many jobs and a change in administration, all of which contribute to an atmosphere not conducive to sustainability investments.

5. RESEARCH SUMMARY

Overall, the main factor discouraging universities from considering the use of SWH systems is their impression that the installation and maintenance of such systems would be costly, if only in the beginning of the process. Other factors include administrative issues, different priorities, and the use of other already efficient systems of energy.

Universities that have implemented SWH systems are satisfied with them as cost-efficient means of acquiring clean, renewable energy. The PPA format for acquiring SWH systems seems popular, especially for universities that have not used SWH systems in the past. Although one company has serviced many universities in the past, it seems RFP's and general tenders are increasing in popularity as methods of acquiring contracts for SWH systems.

6. CONCLUDING QUESTION AND ANSWER

Our study led us to ask: What is needed to motivate more universities and other institutional, commercial and residential customers to consider the possible advantages of installing SWH systems?

PEC is currently developing web-based tools to make the evaluation of SWH systems easier for all customer groups. We expect these tools, which will be provided through a Solar Water Heating "Portal"—a solar thermal informational and system-sizing center with links to industry practitioners—to motivate universities, as well as and other customer groups, to consider and evaluate the use of SWH systems by making such evaluations quick and easy. This can greatly simplify the process of assessing the suitability of sites, and acquiring, financing, installing and maintaining SWH systems. Such services can make purchasing SWH systems as easy as ordering a book on Amazon.com, after reading through the reader's reviews, or finding and purchasing a used car through Edmunds.com, Consumer Reports, and Cars.com. Examples of such website applications will include links to existing maps and aerial photographs to assess irradiance of a site, electronically accessible resources such as a price index database and an online interactive application for energy bill analysis. Through its resources, PEC expects to make the process of acquiring SWH systems easier, more informative, and more inviting for potential educational institutions, as well as other institutions (hospitals, hotels, prisons), and commercial, and residential customers. This will help manufacturers, distributors, vendors and installers to increase their volume of sales, and, could rapidly accelerate the scale-up in deployment of SWH systems that contribute to a lower carbon footprint for universities and colleges and a healthier environment and stabler climate for the world.

APPENDIX

Questionnaire

- Does your campus use solar water heating systems (SWH)?

  If so:

- For how many buildings do you use SWH, and what kind of buildings? (Academic, dormitories, cafeteria, etc….)
- What was the motivation behind your choice of SWH?
- What provider did you work with?
- What was the nature of the agreement? Do you own the equipment, have a power purchase agreement, or have some other arrangement?
- Did you experience difficulties in the implementation process?
- What do you do with excess hot water?
- Do you intend to expand your use of SWH?
- Is there a different approach to SWH that you plan to take in the future?
- Any advice to other colleges and universities contemplating pilot projects and/or full implementation of SWH?
- How do your SWH activities relate to the D.C. College and University Sustainability Pledge?
- Other comments?