DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.

PUB-432

Lawrence Berkeley Laboratory
Applied Science Division

NEWSLETTER

MAY 1984

RECEIVED
JUN 14 1984
PUB FILE
LBL LIBRARY

For Reference
Not to be taken from this room

FEATURED PUBLICATION

Journal of Solar Energy Engineering, Vol. 105: 217-223 (May 1983)

METHODOLOGY TO DETERMINE COST AND PERFORMANCE GOALS FOR ACTIVE SOLAR COOLING SYSTEMS

M.L. Warren and M. Wahlig

ABSTRACT: Economic and thermal performance analysis of typical residential and commercial active solar cooling systems are used to determine cost goals for systems to be installed between the years 1986 and 2000. Market penetration for heating, ventilating, and air conditioning systems depends on payback period, which is related to the expected real return on investment. Postulating a market share for solar cooling systems increasing to 20 percent by the year 2000, payback and return on investment goals as a function of year of purchase are established. The incremental solar system cost goal must be equal to or less than the 20-year present value of future energy savings, based on thermal performance analysis, at the desired return on investment. Methods for achieving these cost goals and expected solar cooling system costs will be discussed.

The following is from a discussion with Mashuri Warren:

AS: What are active solar cooling systems and how do they work?

Mashuri: Basically, an active solar cooling system is a heat-driven device that uses thermal energy from the sun to run either an absorption cycle or a Rankine cycle. You can either run a heat engine which generates mechanical power to drive a compressor or you can drive a chemical thermodynamic cycle to produce a refrigerant which upon expansion gives rise to a cooling effect.

PUB-432

AS: In the paper you mention that market penetration for heating, ventilation, and air conditioning systems depends on payback period, which is related to the expected real return on investment. What is meant by real return on investment?

Mashuri: A real return on investment means an estimated financial return using constant dollars. The economist, as I understand it, deals with inflation by making a distinction between nominal dollars and real dollars. Nominal dollars are the greenback dollars that we all spend. When this paper was written, we were just coming out of a period where the inflation rates were very high and were very much on peoples' minds. We wanted to remove the effect of variable inflation rates from the analysis. When we talk about real rates of return, we are talking about the rate of return on investment after you have factored out the effect of inflation.

AS: You say that: "The return on investment goals are used to calculate the 20-year present value of energy savings of the solar energy systems. To be cost-effective, the incremental solar system cost must be equal to or less than the present value of the energy savings. This establishes the link between incremental solar system cost and the return on investment goal and determines the system cost goals as a function of year of purchase." Could you clarify this?

Mashuri: There are a couple of key phrases here: "present value of energy savings" and "incremental solar system cost". If you go out and buy an air conditioning system, you spend a certain amount of money to purchase it, but you also pay the energy bill for the rest of your life. With a solar system, one makes a capital investment out front so that, hopefully, the ongoing expenses will be much smaller. We trade off present money for future money. This is something the economists know how to do. You have to calculate how much you think the system will save, keeping in mind that a dollar saved today is worth more than a dollar saved tomorrow. The incremental solar system cost is the extra cost for the solar system over that of a conventional cooling system. The crucial element for our analysis is to quantify what the energy cost savings are for one of these systems; if you don't save any money then the cost goal goes to zero and it's not worth doing it. In fact, my principal interest in this has been in the technical evaluation of system performance; that is, the systems analysis necessary to estimate the energy savings from these systems.

AS: You focus on the methodology used to establish cost goals, and mention that it is not limited to active solar cooling applications. What is novel about the methodology that you are using, and in which way could it be extended to other areas?

Mashuri: We do focus principally on the methodology because we are trying to establish a technique for setting goals for the solar

cooling technology; that is, how it could become economically viable. What is special about this particular methodology is that it describes how we get from the present, where active solar systems are not cost-effective, to some future in the year 2000 when they would be cost-effective by placing tighter economic requirements on the systems as time progresses. We focus on the methodology because the actual projected energy savings and projected system cost goals in this paper were very tentative (based on some early simulation work) and so we didn't particularly want to say that these were definitive goals. In general, solar cooling systems are not economically attractive today. Collectors are too expensive, the overall system is too expensive, and energy savings are too small. However, we are in the business of research and development. We are in the business of applying new concepts, new ideas, to solve these technical problems, and we need a way of measuring what would be required of these future systems. It is clear that there is a necessity to improve the performance of these chiller systems and to greatly reduce the cost of collector arrays. These are two important elements in the R&D program of the active solar program of the Department of Energy.

AS: As far as you are concerned, what were the major findings in this paper?

Mashuri: From my point of view, I am primarily interested in the technical issues associated with active solar cooling. As I mentioned, I think that improvement of the performance of the solar chiller systems is imperative. We have to improve the amount of cooling delivered for the amount of solar energy collected. We also have to improve the electrical performance of these chillers because they have pumps and fans that can eat up a lot of your energy savings. The cost of collector arrays has got to come down, and new methods of collecting solar energy have to be developed. The cost of solar energy systems has been the chief obstacle all along to the implementation of solar energy. This is particularly important for active solar cooling systems where one needs to collect energy at 160° F or higher temperatures.

I think the other major focus of this work was to put active solar cooling in a systems context. Much of the research in the solar program has focused on components, such as making a better chiller or making a better collector. One really has to put these together in terms of a system that is serving a need, namely, a specific cooling load in a specific city, to see what the actual system requirements are. My interest all along has been in systems analysis, and economics is one important part of that.

AS: Where do you think you go from here?

Mashuri: Presently, we have a more detailed paper, which has been accepted for publication, on cost and performance goals for

commercial active solar absorption cooling systems. We looked at more recent simulation results in greater detail to try to sharpen and better define what the economic goals will be. Also, over the last two years I have been very much involved in a nation-wide project to assess the research requirements for the Solar Program. In this work we have applied a somewhat simplified version of the methodology mentioned above: we simply say that in the year 2000 these systems should have a 5- or 7-year payback. We can then look at a broad range of technologies, including Rankine systems, desiccant systems, and absorption systems to try to do cross-technology comparisons to find out what are the most promising solar technologies on the horizon. I have also been involved in writing two book chapters (now in draft form) on the economics of active solar systems. One is on cost requirements for active solar heating and cooling, and the other is on comparison of cost and performance for solar cooling systems. This work has been broadened to include the full range of active solar technologies.

AS: On the practical side, which areas in this country do you think would have a cost-effective use for active solar cooling systems?

Mashuri: The focus of our work has been primarily on systems which provide only cooling. Phoenix is a great place for active solar cooling systems. The detailed simulation analyses have shown that if you have a dry climate, it is relatively easy to get cooling by evaporating water. If you have a dry climate that has a lot of sunshine, it is easy to produce solar cooling. Miami, with its large cooling load, also has a good climate for solar cooling. Probably the whole sunbelt would be a suitable area. Atlanta and Fort Worth, for example, have reasonable solar resources and significant cooling loads. The whole issue as to whether solar cooling systems would be cost-effective in a climate that has both a heating and cooling load is a subject of some controversy.

AS: To end this interview, maybe you can describe some of the general directions in which the Solar Program and yourself are working at the moment?

Mashuri: All along, I have been primarily interested in the technical issues relating to active solar cooling systems. The ongoing thrust of our work here in the Solar Program is both the development of advanced solar cooling concepts through the work of Kim Dao and Mike Wahlig, and my own work in system simulation and economic analysis of advanced concepts in active solar cooling. We are continuing to use the computer program TRNSYS for detailed simulations of the performance of some advanced systems and advanced storage strategies. I have basically completed my work on the economics of active solar cooling, but I am continuing to work on technical evaluation and to use TRNSYS as a computer simulation tool.

WHERE HAVE ALL THE ADMINISTRATORS GONE?

Mark Alper has now phased out of the Division Administrator position in Applied Science and phased into the comparable position in CAM (Center for Advanced Materials). The search committee (Don Grether, Wayne Place, Henry Ruderman, Nancy Schorn, Robert Sonderegger) has been diligently plowing through resumes and plans to start interviewing in the near future.

Linda Maio, the Program Administrator for the Environmental Program and, more recently, the Solar Program, has taken a higher level position in (where else?) CAM. Most of Linda's duties for the Environmental Program have been taken over by Gloria Gill. A job opening has been posted for a new Solar Administrator.

Maya Osowitt, the Division Office Administrator for programmatic matters (annual report, technology transfer, space management, institutional plan, press releases, budget and salary plots, nominations for scientific awards, the Division's brochure, and the like) will be joining (no not CAM) the San Francisco office of Arthur D. Little. Maya recently completed an MBA program at St. Mary's and will be using her new skills in a consultant's role. Susan Petersen will be taking over most of Maya's duties.

ASEAN CONFERENCE ON ENERGY CONSERVATION IN BUILDINGS

Mark Levine and Isaac Turiel of the Energy Analysis Program and Dick Curtis from the Energy Efficient Buildings Program will be the main speakers at a conference sponsored by the United States Agency for International Development (AID) and organized by the Ministry of National Development of the Republic of Singapore.

The conference, which will be held in Singapore May 29-31, 1984, will be attended by officials from ASEAN (Association of Southeast Asian Nations) member countries. It is also open to the private sector of the ASEAN countries, and architects, engineers and developers interested in incorporating energy efficient systems into their buildings will also be participating.

Topics to be discussed at the conference include the following: Description of the DOE-2 Computer Code; Overview & Policy Results; Windows and Daylighting; Building Equipment Maintenance Standards; Assessment of Indoor Environment; Analysis of Singapore Commercial Building/Energy Use & Conservation Measures. In addition, there will be a presentation on simulation studies carried out in Singapore, and country papers by the ASEAN nations on the status of energy conservation programs in their respective countries.

SUPPLYING ENERGY THROUGH GREATER EFFICIENCY
THE POTENTIAL FOR CONSERVATION IN CALIFORNIA'S RESIDENTIAL SECTOR

[Alan Meier, Janice Wright, and A.H. Rosenfeld]

There have been many studies on energy conservation, but Supplying Energy Through Greater Efficiency is probably the most carefully researched and documented assessment of conservation's potential. The authors show in a clear way exactly how they estimated the potential for conservation. They specifically exclude conservation measures that lead to a lower quality of life, often called "belt-tightening". Instead, they examine conservation measures that provide the same services with less energy. For example, there are technologies available which can reduce the standard refrigerator's electricity use by over 40 percent. The refrigerator still provides the same volume, automatic defrost, and other features to which we are accustomed. The cost of conserving a kilowatt-hour through these conservation measures is often much less than the cost of producing a kilowatt-hour at the power plant.

In order to save energy, you almost always have to invest some money. To establish the unit cost of the conserved energy, such as cents per kWh, the annual investment in conservation (for materials and labor) is divided by the annual energy savings. The "cost of conserved energy" statistic is independent of the energy price and thus is not affected by the sometimes large fluctuations in energy prices.

Because conserved energy is a novel source, the techniques used to estimate its reserves are almost as important as the estimates themselves. The authors express the potential for conservation in terms of supply curves instead of tables or equations. A supply curve of conserved energy is the same as a supply curve for reserves of gas, coal, or other tangible energy resources - the curve slopes upward since more conserved energy becomes available at increasing costs. To develop a regional supply curve of conserved energy, two coordinates must be found for each measure. The vertical coordinate (y-value) of a conservation measure is the cost of the energy conserved by that measure; the horizontal coordinate (x-value) is the cumulative energy saved annually by that measure and all measures preceding it in the supply curve. The authors conclude that by investing in a "cost of conserved energy" equal to today's average energy prices, we can reduce the residential sector's consumption of electricity 33 percent and natural gas 34 percent.

The supply curves can also be used as a planning tool to consider conservation as an alternative to a conventional energy supply. For example, we can compare the price of electricity from a planned power plant with the cost of conserving electricity. This book shows, through use of supply curves of conserved energy, that conservation is not a one-shot activity, but a necessary element of the continuing response to energy shortages and rising prices.

The study of potential for conservation in California's residential sector was funded by the California Policy Seminar, and the researchers were helped considerably by the well-organized data on energy use which

had been compiled by the California Energy Commission. This book was published by the University of California Press in December 1983, and you may contact the authors for information on purchasing the book.

ASHRAE COMES TO LBL

On the evening of May 3, ASD hosted a group from the Bay Area Chapter of ASHRAE (the American Society of Heating, Refrigerating, and Air Conditioning Engineers) who were interested in touring some of the Lab's facilities. Maya Osowitt worked with Mike Jayko, LBL tour director, to arrange the tour for 50 engineers.

After arriving at 6:30 p.m., the visitors were divided into two groups and traveled, by shuttle bus, to the Bevatron, the electron microscope, the solar absorption air conditioner, and the Mobile Window Thermal Test facility (MoWiTT). Joseph Rasson and Jean-Marc Bouchez explained the solar air conditioner and the MoWiTT to the group. The ASHRAE Bay Area Chapter President, who requested the visit, said that the tour was extremely interesting and considered a great success by all who attended.

RECENT REFEREED JOURNAL ARTICLES

R.R. Miksch and D.W. Anthon, "A Recommendation for Combining the Standard Analytical Methods for the Determinations of Formaldehyde and Total Aldehydes in Air," Am.Ind.Hyg.Assoc.J.(43), 362-365 (May 1982).

Frank Robben, "Coal-Fueled Diesel Engines," SAE Technical Paper Series (831747), presented at Fuels and Lubricants Meeting, San Francisco, Calif., October 31-November 3, 1983.

W. Alvarez, L.W. Alvarez. F. Asaro, and H.V. Michel, "The End of the Cretaceous: Sharp Boundary or Gradual Transition?", Science, Vol. 223, 1183-1186 (16 March 1984).

E. Lam, I. Fry, L. Packer, and Y. Mukohata, "Comparison of the O_{640} Photo-intermediate and Acid-induced Species in Membrane Patches from Halobacterium halobium S_9 and R_1mW Strains," FEBS Letters, Vol.146, No. 1, 106-110 (1982).

W. Alvarez, E. Kauffman, F. Surlyk, L.W. Alvarez, F. Asaro, and H. Michel, "Impact Theory of Mass Extinctions and the Invertebrate Fossil Record," Science, Vol. 223, 1135-1141, (16 March 1984).

ASD GOES TO THE ENERGY FAIR

The Applied Science Division represented LBL at the Energy Pavilion of the Berkeley City Fair, May 4 through 6. The Pavilion, located in a tent on the PG&E parking lot in downtown Berkeley, attracted thousands of visitors. On the opening day alone, 1,100 Berkeley elementary school children swept through the Pavilion, escorted by their teachers.

The ASD/LBL booth portrayed various energy-efficient and solar technologies. The efficient fluorescent light bulbs, CIRA (Computerized, Instrumented Residential Audit), and aerogel window insulation material were among the most intriguing displays at the Fair, and received many positive comments from the viewers.

Maya Osowitt coordinated the display, and she was assisted by the following volunteers who spent part of the weekend staffing the booth and answering the deluge of questions: Steve Byrne, Darryl Dickerhoff, Bruce Dickinson, Diane Douglas, Joe Eto, Jeff Harris, Pat Hull, Bud Offerman, Phila Rogers, Peter Rumsey, Michael Siminovitch, and Tony Usibelli.

INVITED TALKS AND FOREIGN TRAVEL

April

- Tica Novakov attended the Planning Meeting of the International Heterogeneous Atmospheric Chemistry Project in Vienna, Austria.

May

- Nabil Amer and Nancy Brown were invited speakers at the DOE/OHER Workshop on Chemical Measurement Needs in Energy Related Health & Environmental Research in Seattle, Washington. Nabil's presentation was entitled "Energy Related Measurement Science: A Physicist's Perspective", and Nancy's talk was entitled "The Importance of Measuring Reactive Intermediates".

- Dick Fish is in Bordeaux, France, where he will be a Visiting Professor for two months at the University of Bordeaux. He will be teaching a course on Organometallic Chemistry.

- Dave Grimsrud was an invited speaker at the EPRI Seminar in Denver, Colorado. His talk was entitled "Indoor Air Pollutants: General Overview and Discussion of the EPRI Manual".

UPDATE ON THE CRAIG HOLLOWELL LECTURE SERIES

Somewhat over a year ago, the Craig Hollowell Lecture Series on Energy and the Environment was established as a memorial to Craig and as a way of providing recognition to outstanding scientists in the energy and environment fields. The first lecture, given by Jan Stolwijk of Yale, was held on October 25, 1983, and provided an excellent start for the series. Planning for the second lecture, to be held in the fall of 1984, is now underway. For the purpose of selecting a candidate and otherwise making the necessary arrangements, Elton has reconstituted the lecture committee as follows:

David Grimsrud, Energy Efficient Buildings Program, Chairperson
Frank McLarnon, Chemical Process R&D Program
Marlo Martin, Solar Program
Nancy Brown, Environmental Program
Edward Kahn, Energy Analysis Program
James McMahon, ex-officio, Seminar Co-coordinator
Alex Quintanilha, ex-officio, Assistant Division Head
Susan Petersen, staff

We would like to thank Nancy Brown for chairing the first committee; and Mort Denn, Sam Berman, Rolf Mehlhorn, and Mark Alper for serving on that committee.

The committee for the second lecture has started to meet already, as a considerable lead time is needed to properly arrange for such a lecture. Anyone having recommendations for either lecture candidates or arrangements for the lecture should contact one of the committee members.

PUB-432 5/84-350 This work was supported by the U.S. Department of Energy under Contract Number DE-AC03-76SF00098.
Lawrence Berkeley Laboratory, University of California
Berkeley, California 94720
An Equal Opportunity Employer