Demand Shifting Will Boost Thermal Energy Storage (TES)

Klaus Schiess, P.E., CEM
KSE Engineers

Thermal Energy Storage (TES) or off-peak cooling as the technology is also called may be ready to take off. Deregulation will bring dramatic changes to electrical rate structures that will impact TES more than any other load management technology. Predictions from crystal ball gazers vary from one extreme to the other. Some say that the industry is going to slow down. Others expect a rapid takeoff. Generally, most experts predict that deregulation will bring higher on-peak costs and lower off-peak costs. If this is true then TES is not only going to survive but it will prosper.

The progress and popularity of TES has been much slower than expected. Although the technology is not new and is uncomplicated, it is surprising how many problems have clouded the success stories. In this article we postulate that with a paradigm shift in the pricing of electricity from the "off-peak"/"on-peak" universe to a real time one, the stage is set for TES to finally pay off through demand shifting, resulting in significant cost savings.

TES CHALLENGES

The focus of most industry research in recent years has been on operating strategies and in designing control sequences. For instance, in the "Background" paragraph of the work statement for 1054-TRP of ASHRAE's Technical Committee TC 6.9 the following statement appears:

> "THE REAL NEED IS TO DEVELOP A COMPREHENSIVE SYSTEM FOR ACCURATELY DESCRIBING AND PROPERLY SELECTING AN OPERATING STRATEGY FOR A GIVEN SYSTEM."

This statement by industry leaders in this technology brings to our attention the fact that we are in need of more information. The root cause of the problem is a lack of communications between various entities to implement TES solutions. Each party has its own agenda and along the way they often lose sight of the fundamental objective.

TES Playing Fields

There are many variables which affect TES systems. Each TES system is an entirely separate entity due to its size, type of equipment, load characteristics, discharge characteristics and rate schedule.

Rate Schedule

The "first commandment" for TES systems: Thou shall have a rate schedule that allows you to save energy costs by using TES. Without a rate schedule that differentiates between on-peak and off-peak rates, whether it be in the form of energy costs or demand costs, a mixture of the two, or just plain real time pricing, there is seldom justification for making plant operation more difficult with additional equipment and a multitude of control sequences.

Utilities have created rate schedules that compensate them for the actual costs to produce electricity under the watchful eyes of some commission representing the public. The utilities overall electrical load profile will dictate the rules and rates under which TES operates to achieve savings that benefit the user. Therefore, TES systems are subjected to on-peak windows ranging from 4 hours to 14 hours to suit the requirements of the utility. There are on-peak, mid-peak and off-peak hours, demand charges and even maximum or non-time demand charges. To complicate matters even more there are ratchets and tier systems.

Load Profiles

In most TES applications the load profile varies considerably from season to season and usually on a daily basis as well. The load shape also varies from project to project. As mentioned above, the customary approach has been to satisfy peak conditions and the job is done. TES has to adjust to every variable for optimal performance, resulting in more complex control strategies. Partial storage systems need closer attention to ensure that the storage capacity is not depleted too early, i.e. before the end of the on-peak demand period.

TES Team Players

HVAC engineers design for peak conditions and assume that the system will function at any load lower than that. It is considered to be the problem of the operator to tweak out maximum efficiency from the system. Therefore, engineers think their job is done.

Manufacturers deliver the product. If it satisfies design conditions, their job is done.

The Automatic Control Contractor makes sure that the system functions according to the control modes that were specified. The control contractors are often in a tough situation, because they are expected to "fix" the system if there are any problems, commission it as they go along, and smooth over any problems that may occur whether it is of their making or not. Control contractors know what to deliver and how to control, but they need to be told why. In other words they speak controls but do not necessarily "speak TES." If the three or four modes that were specified work, hopefully, then they consider their job done.

The Contractor considers his job done once all the equipment is installed.

The Owner buys a complete system and expects that it will produce the savings as predicted or promised. Understandably the owner expects TES to work, just as replacing a light bulb with an energy efficient one does.

Operators are usually suspicious of something that makes their work more complex but they have to go along because it is expected of them. If they are lucky they get a few hours of training from the control contractor. This is equivalent to learning to drive a car. After a few starts and stops you get your driver's license. The job is done.

With all these variables and players it is not surprising that after so many years of TES experience, industry societies are still attempting to *"develop a framework for describing and characterizing cool storage operating and control strategies'*. We have not yet even managed to clearly define "full storage." To some it means full shift of the whole daily load. To others, it means shift of all load during the on-peak demand period. Obviously with the on-peak windows varying from 4 hours to 14 hours these definitions can become blurred.

So what went wrong? Once you have a drivers license you are surely not considered a professional driver with experience in fuel

economy and good road sense. In other words, I would like to plagiarize a well known proverb about happiness and change it to:

TES IS NOT A DESTINATION, BUT A WAY OF TRAVELING

DEREGULATION

Effect on TES

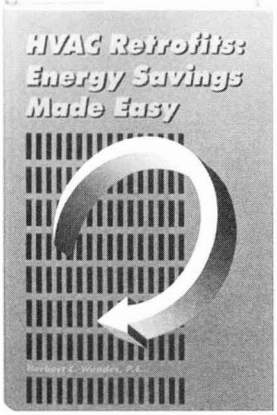
With deregulation it is inevitable that the concept of REAL TIME PRICING (RTP) is entering the electricity market. After having completed a TES study comparing time-of-use and real time pricing rate schedules this author presented a paper "The Effect of Real Time Pricing on TES Systems" at AEE and IDEA conventions. This article was also published in "Strategic Planning for Energy and the Environment" and was also accepted as a poster presentation at the MEGASTOCK conference in Sapporo, Japan, in June 1997.

For the TES study with RTP I soon realized that calculations ideally have to be done on an hourly basis for each and every day. This is obviously a cumbersome approach with 8,760 hours a year and possibly the same number of hourly prices.

Since the study however, I have come to realize that RTP and deregulation could be a blessing in disguise for TES. The dark clouds on the horizon promise even more rate schedules created by the new ESCO, ESP companies who will now create new rate schedules to convince any potential client into believing that they are getting electricity at a better price than before or from their competitor. How is TES going to adjust to this flood of rate schedules and the new ground rules that complicate things even more?

Current Software is Inadequate

The HVAC industry has been geared to designing the chiller capacity to satisfy peak conditions. All software programs in the HVAC field were developed to find the peak cooling load. Later on, when energy conservation became more important, computer programs were upgraded to include conditions on an hourly basis all year round. These programs have become quite sophisticated and thus more difficult to use. In my personal opinion the results are often too theoretical and



HVAC RETROFITS: ENERGY SAVINGS MADE EASY

By Herbert C. We ndes, P.E.

Covering the entire process of retrofitting HVAC systems to achieve energy savings, this straightforward guide takes you step by step from the initial walk-through audit through the monitoring of results after the retrofit project is complete. You'll learn how to estimate labor and material costs for all types of HVAC equipment and systems. You'll find out how to convert constant volume systems to variable air volume, along with how to calculate the costs of doing so. Methods for calculating, analyzing and projecting energy consumption in terms of BTU and KW as well as in cost terms are detailed. Sample energy retrofit estimates are included, along with many time-saving reference lists.

ISBN: 0-88173-161-7

ORDER CODE: 0312

6 x 9, 470 pp., Illus.
Hardcover, $84.00

CONTENTS

BOOK ORDER FORM

① Complete quantity, book title, order code, price and amount due for each book you wish to order:

QUANTITY	BOOK TITLE	ORDER CODE	PRICE*	AMOUNT DUE

② Indicate shipping address: **CODE: Journal 99**

NAME (Please print) BUSINESS PHONE

SIGNATURE (Required to process order)

COMPANY

STREET ADDRESS ONLY (No P.O. Box)

CITY, STATE, ZIP

Applicable Discount	
Georgia Residents add 6% Sales Tax	
Shipping Fees*	**6.50**
TOTAL	

MEMBER DISCOUNTS
A 15% discount is allowed to AEE members.
☐ AEE Member (Member No._____)

③ Select method of payment:
☐ **CHECK ENCLOSED**
☐ **CHARGE TO MY CREDIT CARD**
☐ *VISA* ☐ *MASTERCARD* ☐ *AMERICAN EXPRESS*

CARD NO.

Expiration date *Signature*

Make check payable in U.S. funds to:
AEE ENERGY BOOKS

④ Send your order to:
AEE BOOKS
P.O. Box 1026
Lilburn, GA 30048

INTERNET ORDERING
www.aeecenter.org

TO ORDER BY PHONE
Use your credit card and call :
(770) 925-9558

TO ORDER BY FAX
Complete and Fax to:
(770) 381-9865

INTERNATIONAL ORDERS
Must be prepaid in U.S. dollars and must include an additional charge of $10.00 per book plus 15% for shipping and handling by surface mail.

Here's your complete guide to today's automated temperature control systems for HVAC, covering optimizing the performance of new DDC systems, upgrading existing controls and more...

HVAC CONTROLS: OPERATION & MAINTENANCE

SECOND EDITION

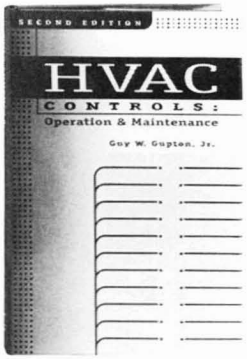
By Guy W. Gupton, Jr.

In the eight years since the publication of the first edition of this book, there have been quantum changes in the automated temperature control (ATC) industry due to the widespread and growing use of direct digital control (DDC) systems. The fully updated second edition fully addresses these technology changes, from equipment characteristics and operation, to troubleshooting and maintenance, to training of operating and maintenance personnel. The full range of topics pertinent to the effective operation of all types of HVAC control systems currently in use today are explored, including equipment-to-control interactions, control system set-up and functions, local loop to building automation system interfaces, performance prediction and assessment, operational parameters, and maintenance and testing.

ISBN: 0-88173-221-4

ORDER CODE: 0383

6 x 9, 327 pp., Illus.
Hardcover, $84.00



CONTENTS

BOOK ORDER FORM

① Complete quantity, book title, order code, price and amount due for each book you wish to order:

QUANTITY	BOOK TITLE	ORDER CODE	PRICE*	AMOUNT DUE

② Indicate shipping address: **CODE: Journal 99**

NAME (Please print) BUSINESS PHONE

SIGNATURE (Required to process order)

COMPANY

STREET ADDRESS ONLY (No P.O. Box)

CITY, STATE, ZIP

Applicable Discount	
Georgia Residents add 6% Sales Tax	
Shipping Fees*	**6.50**
TOTAL	

MEMBER DISCOUNTS
A 15% discount is allowed to AEE members.
☐ AEE Member (Member No._____)

③ Select method of payment:
☐ **CHECK ENCLOSED**
☐ **CHARGE TO MY CREDIT CARD**
☐ *VISA* ☐ *MASTERCARD* ☐ *AMERICAN EXPRESS*

CARD NO.

Expiration date *Signature*

Make check payable in U.S. funds to:
AEE ENERGY BOOKS

④ Send your order to:
AEE BOOKS
P.O. Box 1026
Lilburn, GA 30048

INTERNET ORDERING
www.aeecenter.org

TO ORDER BY PHONE
Use your credit card and call:
(770) 925-9558

TO ORDER BY FAX
Complete and Fax to:
(770) 381-9865

INTERNATIONAL ORDERS
Must be prepaid in U.S. dollars and must include an additional charge of $10.00 per book plus 15% for shipping and handling by surface mail.

sometimes when one studies the results more closely, old Hollywood comes to mind: "Any similarity with real life is purely coincidental."

Design engineers who had the courage to take TES more seriously prepared their own spreadsheet type of software to assist them in calculating energy and cost savings. From my personal experience it was the software this author developed that gave him the versatility to be effective in the application of TES. Some of these ideas were subsequently integrated into the COOLAID program developed by EPRI.

COOLAID was developed to assist utilities in analyzing and developing sufficient information to interest their clients to consider TES seriously. It is not known how many engineers used it eventually as their design tool. The input allows for hot days, workdays, cold days and nonwork days. The operational sequence is only defined by the peak condition. For more accurate calculations it should be possible to input operational sequences for the other loads as well.

COOLAID is DOS based and may have become somewhat outdated in today's window-based computer world. Some manufacturers developed their own software which, of course, is equipment and proprietary orientated.

The Department of Energy has developed various versions of DOE energy conservation programs. TES eventually found its way into the later versions but fails to adequately address TES application needs.

GREAT OPPORTUNITY

Deregulation forces new rules into the TES game. It is, therefore, time for a fundamentally new approach. What is the driving force that dominates studies, cost savings calculations, design and control sequences of TES? *MONEY*, of course. TES must reduce operating costs. By using a totally new approach it is possible to reform TES strategies to be ready for the worst case scenario (given by RTP) and thus cater to any rate schedule that has thus far been developed.

If we accept the challenges which operators are facing, we must look at TES operating strategies on a daily basis with hourly increments (or even less if the rates so dictate) and everything will start to take on a new look. If we can develop a tool that allows us to calculate optimum performance on an hourly basis, every other rate schedule will fall into

this mold. Actually, "conventional" rate schedules will then simplify calculations by being repetitive to some degree.

SOFTWARE BASED ON PRACTICALITY AND SIMPLICITY

If we have software that calculates the optimum method of producing the required cooling under given constraints of a load profile and rate structure, we can then derive the operational strategy for optimum savings for that day. The TES industry needs a software package that can be used by operators and engineers alike. Operators must be able to get a control sequence on a daily basis if RTP is involved.

KSEngineers intends to fill this gap and create an Off-peak Cooling Software for the 21st century. Deregulation provides the opportunity for us to define a new approach which satisfies future requirements and which at the same time corrects the deficiencies of the past. The intent is to develop a simple computer program for the TES industry that gives optimal control sequences for operators and at the same time provides the tool for the designers and engineers to evaluate TES projects. The program will be spreadsheet-based which allows any control software to interface with control sequences input.

The basic concepts are not that difficult. Every system initially has certain inputs like chiller sizes, efficiencies, pumps etc. basically to define what it costs to produce one ton-hour of cooling. Part of this input is also the peak discharge performance of the TES system. This basic input will then be used to determine the cost to satisfy the cooling load at a given hour.

The program can be simply used on a daily basis or weekly or whichever is desired. For TES plants with RTP, the calculations will be done on a daily basis. For large TES systems on time-of-use rate schedules, it will also be done on a daily basis, especially if partial storage is involved.

For smaller systems the program should allow the operator to establish the best simple time clock type of controls. If the available controls are sophisticated enough, control sequences can then be based on whatever the existing controls can work with.

The program will facilitate simplification to allow reducing the 8,760 "hour-values" to the accuracy that is desired. Design engineers can

use the program to predict savings to any degree they wish to input. One can still do it on a monthly basis with four different typical daily load curves (as in COOLAID). The program will then automatically optimize the non-peak load profiles.

Time-of-use rate schedules with a window of on-peak demand charges will automatically develop a control sequence that will use the tank fully during the on-peak period because of the high cost per ton-hour during the on-peak period. If there is surplus capacity the program will automatically select the most cost effective shift of mid-peak load fully discharging the tank.

POSSIBILITY FOR ZERO COST ENERGY

At seminars on deregulation, zero cost energy during certain night hours is often discussed as a possibility. Even if this does not materialize, it certainly shows that very low cost electricity may be available for a few hours during the night.

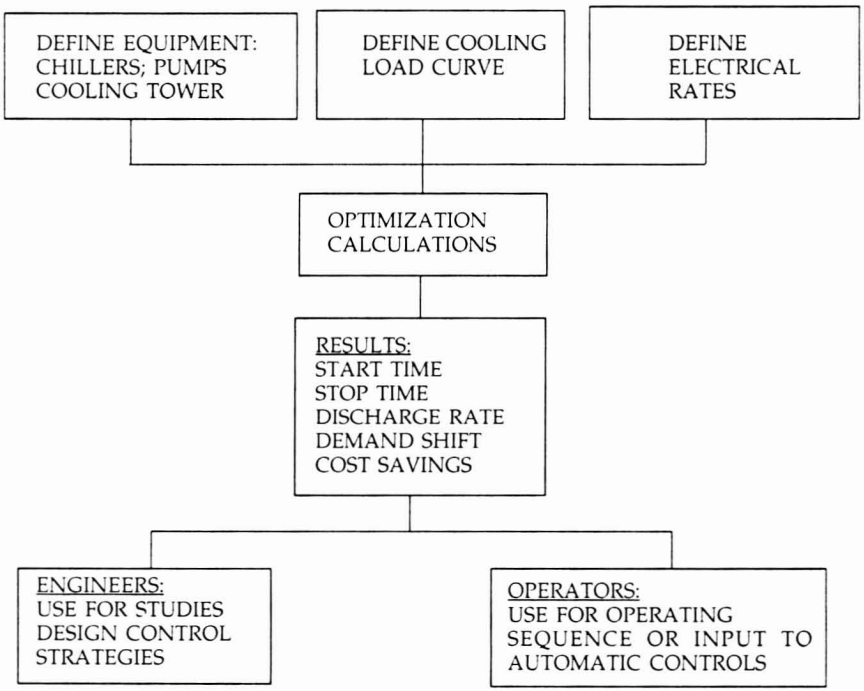
This opens up a whole new world for the charging cycle of TES systems that so far has not even been considered. Presently off-peak rates at night are constant. Chiller size was then selected to charge the system during the full off-peak period. With the possibility that another marked reduction could occur, say for five hours during the night, it may be economically feasible to increase chiller capacity to charge the system during those five hours instead of the customary use of the total off-peak period. In other words, the charging cycle can also be optimized to save energy cost using TES systems.

CONCLUSION

KSEngineers proposes to develop the tools for the TES industry that actually provides the operating strategy for operators in graphic form and, if needed, delivers system readable input for the automatic control system. Furthermore, the program will provide the designers and engineers with an analytical tool to estimate savings more accurately leading to better utilization of existing and future TES systems. With deregulation a reality in California and soon for the rest of the nation, it

is imperative that the TES industry has the sophisticated tools available to respond to the vast and forever changing rate changes that will inevitably result from deregulation. Our solution does not only allow us to cope with the challenges of the future, but also remedies the deficiencies of the past.

FLOW CHART OF COMPUTER PROGRAM



ABOUT THE AUTHOR

Klaus Schiess, P.E., CEM, holds a bachelor's degree in mechanical engineering from the Witwatersrand University in Johannesburg, South Africa. He worked in South Africa, Germany, and Switzerland before coming to America in 1968. Since 1987 he has been president of his own consulting firm, KSEngineers. The firm specializes in feasibility studies, design, specification and supervision of mainly energy-related HVAC projects and thermal energy storage.

KSEngineers, 8763 Caminito Sueno, La Jolla, CA 92037-1604; (619) 535-9819; mschiess@aol.com