A SUCCESSFUL COOL STORAGE RATE

A. C. Ahrens
Houston Lighting & Power Company
6700 West Loop South
Bellaire, Texas 77401

T. M. Sobey
Houston Lighting & Power Company
6700 West Loop South
Bellaire, Texas 77401

ABSTRACT

Houston Lighting & Power (HL&P) initiated design and development of its commercial cool storage program as part of an integrated resource planning process with a targeted 225 MW of demand reduction through DSM. Houston's extensive commercial air conditioning load, which is highly coincident with HL&P's system peak, provided a large market for cool storage technologies. Initial market research made it very clear that a special cool storage rate was required to successfully market the technology.

Development of the rate required an integrated, multi-

integrated resource planning model. An experimental version of the rate was initially implemented as part of the initial phase of the cool storage program. A permanent rate, incorporating lessons learned from the experimental rate, was then developed for the long term implementation of the program. The permanent rate went through a lengthy regulatory approval process which included intervention by a local natural gas distribution company. The end result is a very successful cool storage program with 52 projects and 31 megawatts of demand reduction in the first three and one-half years of program implementation.

INTRODUCTION

In the late 1980's the Houston economy was recovering from a severe economic recession caused by the precipitous decline of the price of oil. This economic recovery was in large part the result of a diversification away from the energy industry and towards the medical, aerospace, manufacturing, and service sectors. Demand for electricity, which had been very flat in the mid-80's, was now increasing at the rate of approximately 2% per year. HL&P was beginning to emerge from a period of surplus

the 1996 to 2000 timeframe.

To meet this need for new capacity, HL&P pursued an integrated resource planning approach in which demand-side management (DSM) resources were evaluated along with traditional supply-side resources. Consultants were brought in to quantify overall DSM potential in the HL&P service area and to identify conservation and load management technologies which passed cost-benefit screens. Through this process, a total of 225 megawatts of cost-effective DSM was identified and incorporated into the HL&P resource plan. The 225

Proceedings of the Ninth Symposium on Improving Building Systems in Hot and Humid Climates, Arlington, TX, May 19-20, 1994

megawatts represents about 20% of the demand growth on the HL&P system through the year 1995.

One of the key commercial sector DSM technologies identified was cool storage, also called thermal energy storage. Houston's extensive commercial air conditioning load, which is highly coincident with HL&P's system peak, provided a large market for cool storage technologies. As a result, cool storage was incorporated as a load management program into the company's overall DSM plan. The design and development of a commercial cool storage program was initiated in 1989. Integral to the development of a cool storage program would be the design, development, and implementation of a successful cool storage rate.

COOL STORAGE OVERVIEW

Cool storage involves the use of standard HVAC equipment and a storage medium, typically ice or water, that allows commercial building owners to shift the operation of chillers from peak to off-peak hours of the day. The utility benefits through reduced peak demand and increased utilization efficiency of existing plants. Commercial customers using cool storage technologies enjoy reduced electric bills, increased HVAC operating flexibility, and enhanced building value.

Cool storage is a well established technology, having been first introduced commercially in the 1930's. Houston was, in fact, one of the birthplaces of the technology with three downtown movie theaters installing cool storage systems in the early 1930's. There has been a resurgence in the application of cool storage in the last 10 years as electric utilities have promoted the technology through DSM initiatives. According to an EPRI survey of commercial sector DSM programs, there are 78 utilities which offer a cool storage program. EPRI has also played a large role in the recent success of cool storage, having produced and distributed over 10,000 cool storage design guides and played a leading role in the research and development of the technology. Well over 2000 systems are in operation across the country serving a wide variety of commercial customers.

HL&P COOL STORAGE PROGRAM DESIGN/DEVELOPMENT

Cool Storage program design and development efforts were initiated in early 1989. These efforts centered around market research studies and economic analyses.

The market research was a three pronged effort consisting of a commercial building survey, interviews with customer and trade ally groups, and research of other utility cool storage program experience. The building survey identified specific commercial buildings within the HL&P service area that were considered good cool storage candidates. Interviews with architects, engineers, developers, owners, and property management companies indicated a general awareness of cool storage technology and a strong, favorable reaction to the concept of a utility-sponsored cool storage program. These groups also indicated that economics and favorable payback would drive decision making, and that there were some doubts about the performance and reliability of cool storage technology. Research of other utilities demonstrated there were many successful cool storage programs throughout the country.

Economic evaluations were carried out which looked at customer investment economics as well as the traditional DSM cost-benefit analyses. These evaluations utilized EPRI's DSManager software and the California Standard Practice Methodology in which the participant, rate impact, utility, and total resource perspectives were analyzed.

Based on the results of the market research and financial analyses, the program was designed around three key elements - a cash incentive, technical assistance, and a special rate. The cash incentive, designed to help offset the increased capital cost of cool storage systems, was set at $300 per kilowatt shifted. Technical assistance, in the form of cool storage screening analysis, was designed to provide customers with the information needed to make the initial decision to pursue application of cool storage. HL&P in-house staff performs the analysis at no cost to the customer. An example of the results of this analysis are shown in Figure 1. The special cool storage rate provides ongoing electric bill savings and insures that the cool storage system will be operated over the long term. The combination of the rate

BUILDING: HIGH SCHOOL

ADDRESS: HOUSTON, TEXAS

APPLICATION: FULL STORAGE - ICE

ASSUMPTIONS:	COOLING EFFICIENCY:	1.2 KW/TON
	CHARGING EFFICIENCY:	1.5 KW/TON
	COOLING LOAD:	500 TONS
	INSTALLED COOLING CAPACITY:	500 TONS
	AVAILABLE CHARGE TIME:	10 HOURS
	CFC CAPACITY DERATE FACTOR:	N/A
	CFC EFFICIENCY DERATE FACTOR:	N/A
	ICE CONVERSION CAPACITY DERATE FACTOR:	35%
RESULTS:	kW SHIFT:	582 kW
	INCENTIVE PAYMENT:	$174,600
	ANNUAL SAVINGS:	
	1ST THREE YEARS:	38,438/YR
	REMAINING YEARS:	20,525/YR
	TON-HOURS REQUIRED:	2275 T-H
	TON-HOURS AVAILABLE:	3250 T-H
	TON-HOUR SHORTAGE:	3250 T-H
	ADDITIONAL TONNAGE REQUIRED TO MAKE UP SHORTAGE:	0 TONS
	TIME REQUIRED TO CHARGE:	7.0 HOURS
	PAYBACK:	
	@ $100/TON-HOUR:	1.4 YEARS
	@ $150/TON-HOUR:	5.5 YEARS
	@ $200/TON-HOUR:	11.0 YEARS

Figure 1. Cool Storage Screening Analysis

and the incentive are designed to provide the customer with sufficient payback to justify investment in the cool storage system.

COOL STORAGE RATE DESIGN

Essential to the success of the overall cool storage program is the design of an effective cool storage rate which achieves an acceptable balance between participant and utility economic perspectives. HL&P established the following objectives in the design of the rate:

* Provide participants with adequate savings to justify investment
* Balance participant and utility costs/benefits
* Keep the rate simple
* Promote a load shifting design approach

The development of the rate required an integrated, multi-departmental effort which included the Corporate Planning, Rate, Regulatory, Marketing, and Legal departments. The key elements of the initial cool storage rate can be summarized as follows:

* The cool storage rate, referred to as the CSB rate, was initially implemented in June of 1990 as an experimental tariff. The experimental status enabled quicker implementation of the rate due to minimal regulatory review, but had a participation limit.

* The CSB rate is designed as a supplement to the existing HL&P small commercial (MGS) and large commercial (LGS) rates. It is not a stand alone rate but simply modifies the on-peak billing demand period of the MGS and LGS rates. The energy and demand charges and the basic structure of the existing commercial rates are maintained which reduces complexity.

* For both the MGS and LGS rates, the CSB rate redefines the on-peak billing demand period as noon to 7:00 p.m., weekdays, 12 months per year. The year round on-peak period is designed to encourage operation of the cool storage system the full year, allowing customers to achieve bill savings each month of the year. The seven hour daily on-peak period promotes a load shifting approach and provides adequate off-peak hours for recharging the storage system. Sufficient savings can be obtained through billing demand reduction. This also reduces rate complexity.

* The savings that a typical MGS customer with a 40% or greater load factor can achieve is approximately $14 per kilowatt shifted. For the LGS customer with a 40% or greater load factor, savings amount to about $12 per kilowatt shifted. Savings are reduced if customer load factor falls below 40%. A detailed summary of demand and energy charges for the MGS

and LGS rates is shown in Figures 2 and 3.

* The CSB rate effectively removes the ratchet clause for cool storage customers. The basis for this is to prevent cool storage system failures from reducing or eliminating bill savings for an entire year. The HL&P approach is to keep savings reductions caused by system failures confined to a one month period. This approach also avoids constant customer demands for forgiveness when a ratchet clause is in place.

The typical annual bill savings that a customer can achieve on the CSB rate is approximately $100 per kilowatt shifted. This savings level, combined with a typical cool storage capital cost of $600 per kilowatt shifted and a rebate of $300 per kilowatt, produces a payback of about 3 years.

PERMANENT COOL STORAGE RATE

Work was initiated in 1992 to convert the CSB experimental rate to a permanent rate. The design of the permanent rate focused on the level of rate discount over the life of the program. Between 1990 and 1992, the company's avoided capacity costs had decreased. This decrease meant that, to maintain acceptable utility and rate impact cost-benefit ratios, the rate discounting had to be decreased. The rate design challenge was achieving this decrease while maintaining acceptable customer investment economics.

Load Factor (Lf) Range	KWH/KVA Ratio	Season	Effective Demand Charge $ / KVA	Effective Energy Charge $ / KWH
0.00 < Lf <= 0.17	< 125	May-Oct	$3.400	$0.07738
0.17 < Lf <= 0.40	125 - 295	May-Oct	$6.357	$0.05373
Lf > 0.40	> 295	May-Oct	$14.017	$0.02776
0.00 < Lf <= 0.17	< 125	Nov-Apr	$3.400	$0.07373
0.17 < Lf <= 0.40	125 - 295	Nov-Apr	$5.900	$0.05373
Lf > 0.40	> 295	Nov-Apr	$13.560	$0.02776

Rate Factors

Demand		$3.40	/KVA for all KVA greater than 10.
Energy	(May-Oct)	0.056937	/KWH for first 1250 KWH or 125 KWH/KVA.
	(Nov-Apr)	0.053281	/KWH for first 1250 KWH or 125 KWH/KVA.
	All	0.033279	/KWH for next 1700 KWH or 170 KWH/KVA.
	All	0.007313	/KWh for all remaining KWH.
Fuel Cost		0.019924	/KWH
PCRF		0.000523	/KWH

Notes

(1) These effective charges do not include a facilities charge, taxes or other charges which may be applicable and should be used for evaluating the relative impacts of DSM strategies only.

(2) The Rate Factors are those from rates effective 1-1-93.

(3) Load Factor is defined as KWH/(KVA*Hrs) where KWH is monthly energy consumption, KVA is monthly billing demand and Hrs represents the number of hours in the billing period.

Figure 2. MGS Effective Demand and Energy Charges

Load Factor (Lf) Range	KWH/KVA Ratio	Season	Effective Demand Charge $ / KVA	Effective Energy Charge $ / KWH
<= 0.40	<= 295	All	$6.820	$0.04611
> 0.40	> 295	All	$12.187	$0.02791

Rate Factors

Demand	$6.82	/ KVA of Primary Demand
Energy	0.025734	/ KWH for first 295 KWH / Primary KVA
	0.007540	/ KWH for all remaining KWH
Fuel Cost	0.019924	/ KWH
PCRF	0.000449	/ KWH

Notes

(1) These effective charges do not include a Facility Charge, taxes or other charges which may be applicable and should be used for evaluating the relative impacts of DSM strategies only.

(2) The Demand Charge rate ($/KVA) applies to all primary KVA. The minimum Primary Demand for the LGS rate is 600 KVA.

(3) The effect of the demand "Ratchet" and Secondary Demand has been neglected. The effective rates indicated only consider Primary Demand and total KWH.

(4) The Rate Factors are those from rates effective 1-1-93.

(5) Load Factor is defined as KWH/(KVA*Hrs) where KWH is monthly energy consumption, KVA is monthly billing demand, and Hrs represents the number of hours in the billing period.

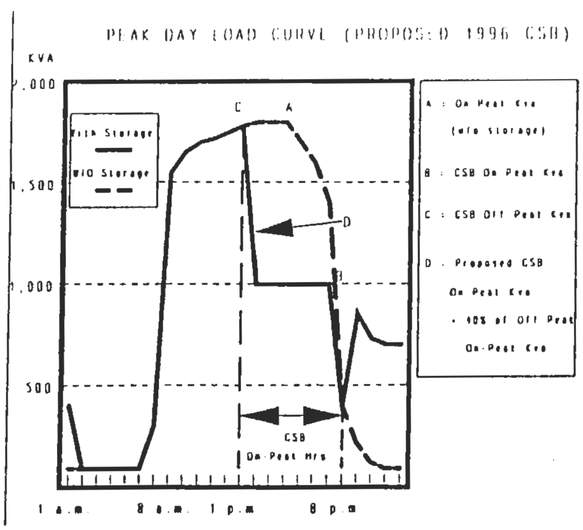
Figure 3. LGS Effective Demand and Energy Charges

The solution reached was an innovative two-tiered rate structure which maintained the basic approach and simplicity of the experimental tariff and provided an acceptable balance between participant and utility economics. The first tier of the rate covers the first 3 years of cool storage system operation and maintains the bill savings level of the CSB experimental rate. After the third year, the second tier of the rate takes effect and modifies the calculation of billing demand to effectively reduce bill savings by 40%. This savings reduction is carried out by adding to the on-peak billing demand an amount equal to 40% of the difference between on-peak and off-peak demand. The difference cannot be greater than the shifted chiller load. This design enables customers to achieve reasonable paybacks while at the same time enhancing utility and rate impact economics. The level of bill savings on the second tier of the rate is reduced but is still at a high enough level to insure continued load shift over the life of the cool storage system. Figure 4 displays an example of a CSB customer's load curve and bill calculation before cool storage, after cool storage on the first tier of the rate, and after cool storage on the second tier of the rate. The calculation shows the approximately 40% reduction in bill savings effected by the second tier of the rate.

The results of the cost-benefit analysis performed to support design of the permanent rate are shown in Figures 5 and 6. Figure 5 shows cost-benefit results assuming the CSB experimental rate is extended permanently. They indicate large net present value (NPV) for program participants and highly negative NPV for the rate impact measure. Figure 6 shows the cost-benefit results for the permanent, two-tiered rate.

The results show that rate impact NPV has been brought more in line with participant NPV.

An additional change was made to the permanent rate so that the on-peak period was advanced one hour from noon to 7:00 p.m. to 1:00 p.m. to 8:00 p.m. This change was made because the 1:00 p.m. to 8:00 p.m. on-peak window is more representative of HL&P's system peak period. The new on-peak window actually benefits customer economics by generally lowering the storage capacity required for the cool



Example
LGS
Customer (Proposed 1996 CSB Rate)

	Without Storage		With Storage			
			Current CSB Rate		Proposed 1996 CSB Rate	
	Billing Units	$	Billing Units	$	Billing Units	$
Demand: (Primary) 6.82/KVA	1,800	12,276	1,000	6,820	1,320	9,002
Energy: 295 Kwh/Kva @ 0.025734/Kwh	531,000	13,665	295,000	7,592	389,400	10,021
Additional Kwh @ 0.00754/Kwh	52,000	392	288,200	2,173	193,800	1,461
	583,200	14,057	583,200	9,765	583,200	11,482
Total		$ 26,333		$16,585		$20,484
	Monthly Savings:		$9,748/800 KVA = $12.19/KVA Shifted		$5,848/800 Kva = $7.31/KVA Shifted	

Figure 4. Sample Bill Calculations Showing Bill Amounts with and without Storage and for the CSB Experimental and Permanent Rates

Benefit-Cost Test	Net Present Value	Benefit/Cost Ratio
Rate Impact Measure	($30,107,000)	0.64
Participant	$58,028,000	3.55
Utility Cost	$38,304,000	3.46
Total Resource Cost	$27,906,000	2.08

Figure 5. Benefit-Cost Summary for CSB Experimental Rate

Benefit-Cost Test	Net Present Value($)	Benefit/Cost Ratio
Rate Impact Measure	($5,573,610)	0.91
Participant	$33,479,470	2.47
Utility Cost	$38,289,440	3.46
Total Resource Cost	$27,905,860	2.08

Figure 6. Benefit-Cost Summary for Permanent CSB Rate

storage system per kilowatt shifted. This results from the fact that the integrated cooling load for most commercial facilities is lower in the 1:00 p.m. to 8:00 p.m. period than the noon to 7:00 p.m. period.

The permanent rate was filed for approval by the Public Utility Commission of Texas (PUCT) in January of 1993. The 180 day approval process included a discovery period, witness testimony, and hearing of merits if required. The single intervenor in the case was a local natural gas distribution company which intervened on the basis that HL&P's cool storage program and special rate represented unfair competition to commercial gas air conditioning technologies. Following the discovery period, which included an exchange of numerous interrogatories, the gas company withdrew from the case. Following the gas company's withdrawal, the PUCT and HL&P reached a stipulated agreement and the rate was approved on September 1, 1993.

PROGRAM RESULTS

Response to the program has been outstanding. Since program implementation in 1990, 52 cool storage projects are under contract representing a cumulative demand reduction of 30.9 megawatts. Approximately 70% of the 52 projects are operational, 20% are under construction, and 10% are currently in design. A detailed breakdown of participants in the program is shown in Figure 7. The predominant building types in the program are schools and office buildings. Additional building types include churches, retail facilities, hospitals, recreation/meeting facilities, manufacturing, and a museum.

The program has met its demand reduction goals in each of the four years it has been in operation. Figure 8 displays these results. Additionally, HL&P is working with a number of excellent cool storage prospects which represent potential demand reduction of over 30 megawatts. Goals for the program in 1994 and 1995, are 10 megawatts and 11 megawatts respectively.

CONCLUSION

An effective, well designed cool storage rate is essential to the success of a cool storage program. The key to a successful rate design is achieving an acceptable balance between participant and utility/rate impact economics. Participants must receive sufficient rate savings to justify their capital investment in cool storage while impact on rates is held to acceptable levels. Programs such as cool storage and the special rates which support them have become more important to electric utilities not only as a cost-effective DSM resource, but also in their ability to provide customers with more choices and more control over energy costs.

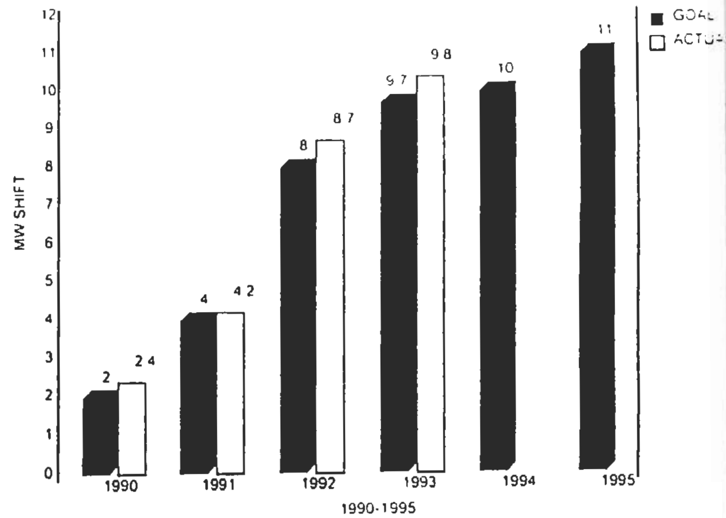


Figure 8. HL&P Commercial Cool Storage Program Goal Status

BUILDING TYPE	NUMBER OF PROJECTS	SHIFT RANGE (KW) LOW	SHIFT RANGE (KW) HIGH	TOTAL SHIFT (KW)	% OF TOTAL SHIFT
OFFICES	13	31	6,040	15,000	48%
SCHOOLS	24	139	1,303	9,473	31%
COLLEGES	3	569	789	2,118	7%
MANUFACTURING	3	270	654	1,329	4%
CHURCHES	3	68	631	840	3%
MEDICAL	1	930	930	930	3%
MUSEUM	1	618	618	618	2%
RETAIL	2	190	223	413	1%
MEETING/RECREATION	2	81	131	212	1%
TOTALS	52			30,933	100%

Figure 7. HL&P Commercial Cool Storage Program Participation