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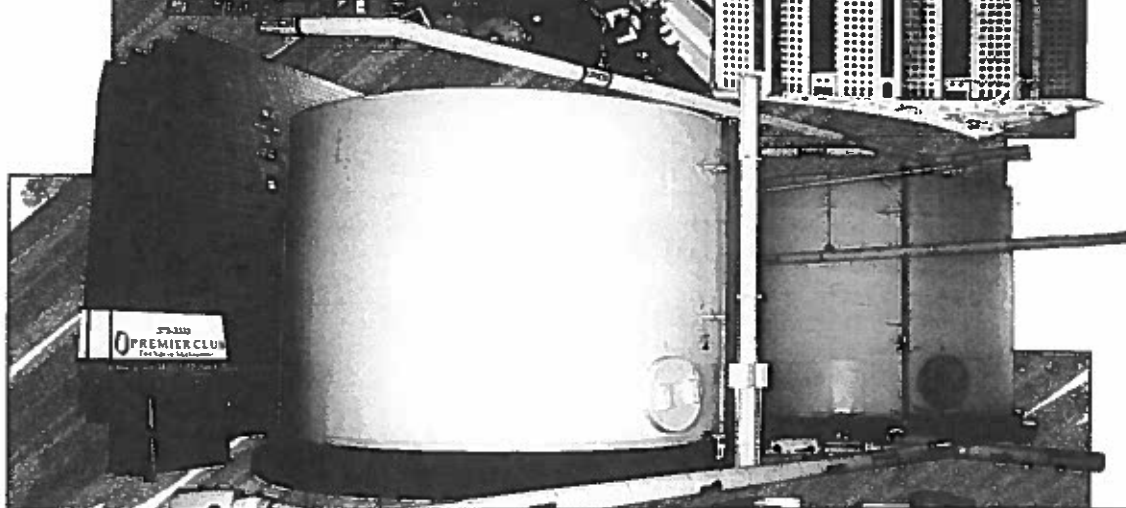
**ENGINEERED
SYSTEMS**

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THERMAL STORAGE

'MOVIN' ON UP' IN DALLAS



From its humble beginnings as a means of leveling the air conditioning load in churches, thermal storage has moved uptown to the high-rise skyline of Dallas.

In the true spirit of Texas hospitality, those uptown building owners accepted this new resident with open arms. Nine buildings, some with more than a million sq ft of space, currently are utilizing some form of energy storage. Another six projects are under construction, and three more are in the planning stages.

All this activity aroused the curiosity of the editors of Engineered Systems and its sister publication, Air Conditioning, Heating and Refrigeration News. We decided to travel to Dallas, put together a panel of experts, and get to the bottom of this phenomenon. Our purpose was not only to find out what was happening in Dallas and why, but to discover what the Texas experience might mean to the highly competitive commercial market everywhere.

Dallas certainly isn't the only place where thermal storage has gained a foothold, but we believe the experiences of the real estate development

and construction community there have significance for other areas considering this technology.

The panel of experts included a mechanical systems designer, mechanical contractors, a utility representative, owners' representatives, and an academician.

The panel was moderated by ES Contributing Editor Thomas A. Mahoney (executive editor of The News) and ES Editor Robert L. Schwed. Participants were: Building owners/users — Billy Hines, operations manager, Raymond D. Nasher Co., and Bill Hunsucker, director of engineering, Lincoln Property Co., Inc.; Consulting Engineer — James Purdy, president, P.M.I., Inc.; Mechanical Contractors — Ben Houston, president, TD Mechanical, Larry Lewis, senior project manager, Emde Mechanical Co., and W.P. Dickson, vice president, sales, Brandt Engineering Co., Inc.; Utility Representative — Jeff Herring, supervising engineer, Dallas Power and Light Co.; and Educator — Warren M. Heffington, Ph.D., associate professor and assistant department head, Mechanical Engineering Department, Texas A&M University.

Editor: To determine what the future prospects for thermal storage might be in Dallas, Mahoney asked the mechanical contractors on our panel to provide an overview of the local construction market.

While the boom times are over and much of the Texas market has gone flat, the three contractors remain optimistic about the prospects for the north Texas city.

According to Houston, the city has 40 million sq ft of vacant space which is filling slowly. This, he said, has happened in the past, but the overbuilt situation always seems to attract new people and business to the area.

The contractors said there seem to be more competent mechanical contractors in the Dallas area than anywhere else they've done business.

The apparently-temporary overbuilt situation in Dallas has caused a number of major projects to be put on hold, but the contractors have an attitude of (what they term) 'pessimistic optimism.' A demonstration of this is that one of them is still hiring people and another is building a 90,000-sq-ft addition to his facilities in the city.

Comments by Professor Heffington on his observations of the energy management and, in particular, the thermal storage situation in Texas opened the thermal storage round-

table discussion.

Heffington: In the 1970's, energy was cheap for commercial customers in Texas. Natural gas averaged about \$.44/MBtu, and some contracts were at much lower prices. Electricity was \$.018/kWh. With energy prices such as these, there was very little incentive to reduce fuel bills.

The cost of operating a one-million-sq-ft office building may have been only \$500,000 or less per year. Conservation was something folks considered to protect the environment for altruistic reasons. But look at things today. Energy is no longer cheap for commercial customers in Texas.

- Natural gas is about \$4.50/MBtu (about 10 times what it was in 1970).
- Electricity is \$.06 or \$.07/kWh.
- And it now costs \$2 million to \$4 million per year to operate that same one-million-sq-ft office building.

Today, conservation is done to save energy, and to reduce day-to-day operational costs.

Many improvements have been made by building designers and equipment manufacturers, such as better building orientation, higher SEER's, and variable speed drives.

Thermal storage can expect to undergo similar improvements. Its main development occurred some 30 to 40 years ago. It was designed to meet high peak loads of short duration in the dairy industry. It also found employment in churches and breweries.

Types of thermal storage are chilled or hot water, phase change (primarily ice), and mass (bricks, blocks, rock walls). In 1981, the Department of Energy did a survey on the status of thermal storage in the U.S., which was published by ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) in 1984. The survey uncovered 300 thermal storage installations. Researchers obtained useful data on 110 hot storage, 40 cold storage, and 42 dual storage installations. Most of these were located in the northeast where electricity prices were high and the winters long. From Texas to the eastern seaboard (the hot and humid

area) there were five cool storage and three dual storage installations. There were no large operative thermal storage installations in Texas in 1981.

Since then, at least nine have been completed in the Dallas area, and another six or more are scheduled for completion this year.

Why has this happened? Demand reduction is the reason cited by 70% of the companies using thermal storage. The other 30% cite off-peak rates as their reason for turning to

Despite its apparent popularity, there are still some issues surrounding thermal storage that have to be addressed, such as, how well do these systems perform? Building owners want their money's worth, and utilities want to defer building new capacity. Monitoring the existing systems might help answer questions.

Also, use strategies need to be better defined. Can we get a better handle on the optimal strategy for a particular site? What fraction of the air conditioning load should the thermal storage system meet to be the optimal trade-off in first cost, energy cost, and demand costs?

Utilities also need to get a firm handle on what price structure they should offer to induce building owners to install thermal storage systems.

Herring: There was a tremendous



"Utilities also need to get a firm handle on what price structure they should offer to induce building owners to install thermal storage systems." — Heffington



"If we can encourage our customers to reduce their demand for electric power during our own peak periods, then we can defer the need to build new generating plants." — Herring

influx of population to the southwest between 1970 and 1980. It was obvious we were going to have to build quite a bit of generating capacity. We had experienced tremendous estimates of what this would cost. We were building gas-fired generating stations in the early 1970's for about \$125/kW. We then began to build large central-station lignite-fired plants and the cost began to rise on those dramatically.

Today, we're looking at costs of maybe \$1,000/kW for a coal-fired generating station.

We've got a large nuclear power station under construction and the

"It turns out that thermal storage falls very well into this type of rate structure, because storage systems can use the higher-demand-consuming equipment, such as chillers, during off-peak periods, and then turn them off during our peak periods, relying on the storage system for cooling."
— Herring

cost of building it can easily be more than \$2,000/kW. The estimated completion date of that plant is uncertain now due to regulatory concerns. So, all these factors of cost and construction delays have led us to the conclusion that, if we can encourage our customers to reduce their demand for electric power during our own peak periods, then we can defer the need to build new generating plants.

We've even found that it's economical for us to actually make a cash investment in those installations and pay customers financial incentives to build them.

By reducing our need for additional generating capacity and providing a financial incentive to our customers, it turns out to be a mutual benefit situation.

Editor: Could you summarize the peak demand rate you use to encourage participation?

Herring: We have adopted a time-of-day structure. (By we, I mean Dallas Power & Light Co. [DP&L] and Texas Electric Service Co. They are part of the Texas Utilities Electric Co. which serves approximately one-third of the state. So we're talk-

ing about a very big commitment.)

Our rate G, a standard commercial rate applied to most customers, incorporates an optional provision in which a customer can elect to try to control his demand between noon and 8 p.m., Monday through Friday, June through September, which is our peak period.

If they can reduce their demand during this time, they can achieve very significant operating cost savings. It turns out that thermal storage falls very well into this type of rate structure, because storage systems can use the higher-demand-consuming equipment, such as chillers, during off-peak periods, and then turn them off during our peak periods, relying on the storage system for cooling.

Editor: Jim (Purdy), how do you view thermal storage in the overall mix of systems?

Purdy: With the energy crunch we've come through and the projected cost of energy, we're all going to see more thermal storage systems where the rate structure is such that it makes it economically feasible.

Certainly the rate structures here in Dallas are conducive to thermal storage systems.

We just had the formal opening of



"With the energy crunch we've come through and the projected cost of energy, we're all going to see more thermal storage systems where the rate structure is such that it makes it economically feasible." — Purdy

Interfirst Plaza. It's the tallest building in Dallas, 72 stories, and we have a little more than two million gallons of chilled water storage serving that building.

We did an in-depth study of storage there, and with the economic incentive offered up-front by DP&L for reduction of connected demand, plus the time-of-day rate structure they have, the payoff period was something in the neighborhood of 23 months.

We are also looking at some thermal storage systems in other parts of the country.

Amazingly enough, we found one rate structure that has time-of-day usage, but it actually penalizes the customer for having off-peak loading. We're going to have to sit down with that power company and see if we can't work out a new rate structure. While the company is pushing thermal storage, its rate structure is not conducive to an adequate payout. Indications are the

"If careful thought and planning are put into the system design so you can take care of intermittent loads through the week, you can serve any project from a thermal storage system satisfactorily." — Purdy

payback on that job would be somewhere between 12 and 15 years. As we all recognize, that's not attractive to any investor or developer.

I think we're going to be faced with thermal storage systems on all our projects. Our firm has several of them in the design stage now. We only have two in operation in Dallas now, one being Interfirst Plaza and the other a small church with an ice storage system.

Thirty or 40 years ago, all churches and theaters had ice systems, but they were not adequately designed to handle varying loads caused by fluctuating occupancies. The theory was to put in a 5-hp compressor and let it run six days so you could use the church on Sunday. That didn't work when the ladies' Bible class and the Boy Scouts started meeting in the church. So, thermal storage, as it was then, sort of got a bad name.

If careful thought and planning are put into the system design so you can take care of intermittent loads

through the week, you can serve any project from a thermal storage system satisfactorily.

Editor: Down the road, for your clients, is that the way buildings are going to be designed? Is it a settled matter for most commercial buildings?

Purdy: We are looking at thermal storage on every commercial project we have in-house.

I think that not only are these



"The system was designed so chillers don't have to be run to provide after-hours cooling. A pump can be run instead to provide cooling for individual floors." — Lewis

systems economically justifiable, but in the commercial market, I think that a builder almost has to be thinking about thermal storage to compete with his neighbor across the street who is using the sales pitch, 'We've got thermal storage here so your electrical costs are going to be lower than the guy's across the street.'

Lewis: The thermal storage system has helped Interfirst Plaza lease space because of after-hours costs.

Most of the tenants there are attorneys and accountants whose staffs often work late into the night.

The system was designed so chillers don't have to be run to provide after-hours cooling. A pump can be run instead to provide cooling for individual floors.

This makes after-hours costs much less than for a conventional building where the owner has to start a chiller when tenants stay late. The leasing people are happier about the thermal storage system than they are

about anything else on that particular project.

Purdy: That's very true. There are a lot of computer installations in almost every building today, and many of these are 24-hour, seven-day-a-week operations. A thermal storage system allows you to serve these continuous loads at a much lower cost than if you had to run a chiller plant constantly.

Editor: Let's hear from the building owners/users.

Hunsucker: I go back a long way to the ice pack systems. I put in many of them when I worked for Dallas Air Conditioning, many years ago.

I've always believed in it. Yes, most of the churches experienced problems when they began to have functions at all hours. It worked very well for auditoriums.

The biggest problem I see today is training people to operate these systems. It's like getting an energy management computer. You can buy a computer, and it will do a very good job, but someone has to program it, somebody has to understand how to get the benefits out of it.

Beyond energy, thermal storage has benefits you may not have thought of — for example, in maintenance.

If I lose a chiller now, with two buildings on thermal storage, I can afford to overhaul one during the day, which I never had the luxury of doing before. We always worked all night before, and we never had time to do the job right.

So, from a maintenance standpoint, I'm getting a big boost from thermal storage.

From an operations standpoint, it's no more difficult to operate than a conventional system, once the engineers are trained. It does take certain training, and someone has to be with the system at all times.

Thermal storage is the answer of the future. In the next few years these systems are going to become even more technologically advanced. Forty years ago, we didn't have the control of systems nor the people to operate them that we do now.

I intend to make very good use of

these controls and better educated people. In demand reduction alone, I estimate a 29% savings. I'm going to be doing 1,200,000 sq ft with our thermal storage system, which is approximately 1.5 million gallons of chilled water.

We don't have a real history of the system yet, since this is the first month we've been totally on it, but we have not had any major problems yet. We had a lot of little things, but



"Beyond energy, thermal storage has benefits you may not have thought of — for example, in maintenance." — Hunsucker

we anticipate those. We have an energy management system that controls the whole thing.

Editor: What building are you talking about?

Hunsucker: Lincoln Center II and III. III is a new building with thermal storage included in the original construction and II is a retrofit. The two are side-by-side so we didn't have to run five blocks of piping.

We anticipate a 3-to 3½-year payback. If it had been five or seven years, I would have started to worry. With those kinds of paybacks, I'd think we missed something technologically.

There are three buildings on the property which vary in space from 500,000 to 688,000 sq ft.

These office buildings normally shut down at 5 p.m., and do not come back on line until 6 a.m. the next day. We let the building sit dormant. We're closed on Saturday afternoon until Monday morning. That doesn't mean we don't have air conditioning during these off-hours, because there are many, many users today who want after-hours cooling.

The biggest problem owners have today, particularly with vav (variable air volume) systems where you have large fan units in the basement and large chillers, is when after-hours users come in, it is impossible to do per-floor usage with that type of system.

Editor: Per-floor usage?

Hunsucker: I cannot supply cooling floor-by-floor with that type of

"If I lose a chiller now, with two buildings on thermal storage, I can afford to overhaul one during the day, which I never had the luxury of doing before." — Hunsucker

system. I've got to run a 680-ton chiller, which is the smallest thing I've got in some cases, and I've got to run a minimum of one 125-hp Flakt fan, 50-hp chilled water pumps, and 40-hp condenser water pumps.

I've got to do four or five floors on one side of the building. If I have to do both sides, it's even worse, because I'm caught with a vav system wherein I cannot do individual spaces.

This is very hard to explain to tenants, because they say, 'What's it going to cost me?' and I say, 'Between \$100 and \$150 an hour.' Well, that sounds terrible, but that's what it costs. Our thermal storage system is going to allow us to run overtime air conditioning for much less, even though I insist on having an operator on duty to watch the system.

Editor: When you were first considering thermal storage, was there any apprehension on the part of management?

Hunsucker: Definitely. When engineers approach management with these concepts, they're faced with these questions: How do we build it cheaper? Will we be able to hire people to run it? And will it work as advertised?

With our system I intend to have an extremely low utility bill, just to prove I can do it. I think I'm going to be down in the \$.60/sq ft range. It will take a lot of work, but I'm going to do it, and I'm going to have to work on more than just the thermal

storage.

Editor: When you were soliciting tenants for the new building, Lincoln III, was thermal storage a factor in your solicitation?

Hunsucker: Very much so.

Editor: Billy (Hines), may I ask what your experience has been with thermal storage? How do you feel about it? Has it been a positive experience for you?

Hines: I think thermal storage is just good common sense now. We have one million sq ft in one office development. From a marketing and property management standpoint,



"We have to watch it very closely because we could lose the benefits of the rate structure in just a matter of hours." — Hines

thermal storage systems definitely give us an edge. We're 100% occupied in a 500,000-sq-ft building. The after-hour incentives, the DP&L incentive with off-peak demand, creates a class A building that has to be defined as state-of-the-art. State-of-the-art today is an energy efficient building.

When I negotiate with prospective tenants, one of their first questions is, 'What is my cost?' They want to know not just the cost per sq ft for minimum rent, but the operational costs as well. Energy is our biggest expense, compared with taxes and other operating expenses.

We had a thermal storage system in our IV NorthPark East building, sometimes known as the Exploration Building, before DP&L's incentive

program.

We were forced to look at our energy costs in the 1970's.

We took a nuts-and-bolts approach first. We went in and fine-tuned our operations. Then we examined the types of systems we had. We had everything from a Texas multizone to variable air volume systems to compare.

We were one of the first three in the city to try thermal storage, so we felt like we were pioneering this system. Some of the considerations and concerns that developed out of these early systems we had to address as we occupied the building, because the day the building was completed, we were 65% occupied. We were at \$1.06 a sq ft for that 500,000-sq-ft building and that was inclusive of all after-hours operations.

We found that in the evenings, when we were in the production cycle of chilled water, we had some of the same concerns that Bill mentioned. We do have to have an operator to watch this much more sophisticated system. There are tremendous penalties when you qualify for the off-rate from DP&L if you have to go to individual operation for tenant comfort.

In the first year we've had a building in operation under this rate structure, we haven't had any particular problems. The system does have to be supervised, and we had to put in special systems to monitor it 24 hours a day, seven days a week, where excess head pressure sounds an alarm, for example, which we respond to immediately.

Editor: Does your staff monitor that or is it an outside contractor?

Hines: We monitor internally. We have security consoles that monitor all the equipment, as well as having an engineer on the project. We have to watch it very closely because we could lose the benefits of the rate structure in just a matter of hours.

Editor: How do these systems affect the marketability of your building?

Hines: The design of the building's mechanical system was very much a part of their consideration to rent in that building.

The marketability of your project

is not just in its aesthetic or architectural value or its location. It becomes your responsibility to educate the prospective tenants about their final energy costs, and, more importantly, the annual escalation of those energy costs you anticipate over the next five or 10 years.

Editor: I would like to shift the focus a bit, to the equipment side. What are the consequences to large chiller manufacturers of thermal storage? Smaller chillers? Smaller pumps? Are the big equipment manufacturers getting on the thermal storage bandwagon at all?

Purdy: I don't think thermal storage has impacted the equipment manufacturers at all. They've all been striving for more efficient chillers, of course. That today can have a big part in the overall energy cost picture.

Our firm is looking at several options that might affect additional economies of operation. For instance, a few years ago most of the design engineers were looking at water temperature differences of 10°F, pumping 3 gal/min/ton, and today nobody uses a 10° rise. Most people are using at least 12° to 16°F and we're looking at 20° to 24°F. Obviously, the economies are quite great in that you pump a heck of a lot less water. We're looking at the possibility of going with super-cold air, as well as pumping less water. It lets us pump less air. We really can't dump 45°F air down somebody's neck, so we're going to have to do some mixing of that cold air; but we think there are some definite possibilities for savings in both initial cost and in the life of the system.

If we have colder air, obviously we don't have to have as much of it, so the duct systems are going to be smaller; transportation equipment is going to be smaller, and the horsepower to run it is going to be less; so it should affect an overall savings, both initially and for the life of the system.

Back to your original question: I think that all of the equipment on the market is easily adaptable to thermal storage, so I don't think the manufacturers really have to do anything to get on the thermal storage

bandwagon.

Dickson: Do you think ice tanks have more of an impact than just water storage?

Purdy: We're going to see a lot of ice systems, but I don't know if they're going to be a major factor. We haven't felt that that's the answer to every job, but we are looking at it on some projects. I still believe that the operating people are going to have an easier time with chilled water storage than ice storage.

The maintenance factor for an ice system is going to be considerably higher than for chilled water.

Dickson: I meant specifically that



"There is more of an impact on manufacturers' equipment with ice than with water. When you start building 24°F glycol systems, you're restricted in chiller selection. . . ." — Dickson

there is more of an impact on manufacturers' equipment with ice than with water. When you start building 24°F glycol systems, you're restricted in chiller selection, as far as brand is concerned.

Houston: So far, our water-storage systems have installed tonnages that are about 75% to 80% of the total installed capacity for conventional systems (that is, on larger jobs), so the equipment manufacturers have not seen significant impact on the amount of product they're selling.

Purdy: That's true. As Dick mentioned, the selection of refrigeration equipment to go with ice storage systems is somewhat limited because not everybody's into low-temp compressors. There might be enough ice

storage system design in the next few years to force some other manufacturers to begin looking at building that sort of equipment. But, as I said, I'm not sure that ice storage systems are going to be that much of a factor.

Editor: Jim, you were at the grand opening of a new building with thermal storage last night. Is that correct? You are now poised to see how well that system works?

Purdy: Yes, but actually, the Interfirst Plaza has been in operation since last October — we had early occupancy in October of 1984 and the thermal storage system has been on-line since that time. Last night was just the official opening ceremony.

Editor: How has the system performed this summer? Any lost days, any tenant complaints?

Purdy: To my knowledge there has not been a single down hour.

The building is probably 72% occupied. It has about 2 million sq ft of space, and we've been operating off the thermal storage system since the first tenant moved in.

The storage system itself is a tank farm, with concrete tanks. We had some sloughing off of some plaster material from the inside of the tanks and it got through the pumps and piping system. We had some clogging of chillers and the plate/fin heat exchangers, but it didn't cause any down time. Everything was cleaned and we've installed some additional filtering capability, so we don't expect that problem to recur.

The system is controlled by a building automation system which monitors water levels in the tanks, monitors temperatures, and optimizes chiller operation.

We generate chilled water at 38°F through the use of three centrifugals in series, and if we had it to do over, we'd be generating 36°F instead of 38°F water to get a little more of a temperature difference available.

Editor: What is the total refrigeration capacity of the building?

Purdy: We've got three 1,300-ton machines for a total of about 4,000 tons.

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Editor: Do you typically design systems so if there is down time, you can go back to a closed loop system? Is that a question owners ask you when you're designing a system?

Purdy: Yes, everybody wants to know, 'What if we lost the thermal storage system?' In the multiple tank farm, it's almost impossible to lose the entire storage system.

At Interfirst Plaza, for instance, we have eight cold storage tanks, so we could lose one-eighth of our storage capacity if something went haywire with one of our tanks. The likelihood of losing more than one is

see 'X' amount of kW.

Houston: We've seen some systems designed where you couldn't pump through. As a contractor, we've always given that as an add option. The cheapest way to run is 'off,' but tenants don't like that.

In most cases with all the chillers on line, we tend to have enough to get by.

Herring: I would like to address the concern about reliability. There is some concern in the minds of owners about reliability. They say, 'What if my system craters, and I've got this smaller chiller in place, and I don't

to limp along on two chillers, running them as much as they possibly could, and relying on a tremendous reserve of chilled water. They were able to maintain space temperature in that building with one of their chillers completely down, and this was on 100°F days.

The chillers were smaller than what would normally be required for that building — it wasn't that they were greatly oversized.

Heffington: Is there any forgiving policy in the DP&L rate structure that will allow a person a one-time spike in demand as a result of a thermal storage system being out? Or maybe even more than that, during startup, for example? That's been suggested as a way to encourage thermal storage.

Herring: This question is asked by a number of developers. Is there a forgiving clause? Well, the rate structure is very specific. It does not provide a so-called forgiving clause, such that if you do run the chiller on-peak during the time we've defined, it won't be ignored.

Let me tell you how we respond to both situations — during startup and during later occupancy.

It's not necessary to sign up on the time-of-day option right away when the building is being commissioned. So when the building is going through shakedown, it can be on our normal rate structure. Then, when it is felt the building is pretty well up to speed and operating properly, it can be put on the time-of-day option. At that point, we would ignore previous demands that were hit and begin from there measuring on-peak demands.

As far as any special problems, like the bearing burnout I mentioned earlier: We, as an electric utility, want to encourage thermal storage systems. We feel so confident in their ability to perform for us and the customer that we pay incentives. If the customer notifies us immediately of a problem and we see he's making a legitimate effort to correct the problem, and it's not a continuing problem, we will attempt to waive the demand on the building



To discover why thermal storage has made such a hit in the greater Dallas metropolitan area, ES editors recently asked this panel of experts to meet and discuss the phenomenon. Included in the discussion were: an engineer, an educator, contractors, and representatives of building owners.

quite remote, so we don't think there's any problem. However, if we came in on Monday morning and discovered that the machines hadn't run all weekend and we've got 2 million gallons of nice lukewarm water, we can operate the building directly off of the chillers by pumping through the tank farm. You can create what would amount to a conventional system.

Editor: The chillers have been sized to handle the building load?

Purdy: No. We have a 16-hour window to provide cooling capacity for the occupied hours of the day, so we wouldn't be able to serve the building on a design day with the 4,000-ton capacity. Part of the reason for the incentive was to reduce the size of the refrigeration plant so DP&L would never have to

have the secondary ability to pump directly through the building?

Actually, they've got a huge storage battery that acts as a backup to their mechanical equipment. The mechanical component is the thing that's most likely to fail. In fact, in one of our existing thermal storage projects, there was a failure in a mechanical component. A bearing burned up on an 800-ton chiller, which was about a third of the building's chiller capacity.

The incident happened on Sunday night, and in a conventional building, when Monday morning came around (and Tuesday, Wednesday, and Thursday), they would not have been able to maintain space temperature.

But because of the building's thermal storage system, they were able

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for some period of time. But it has to be during a period when we're not experiencing a short supply.

We're going to work with our customers; we want to make thermal storage a good deal for them; we don't want them to lose a year's savings because of a mechanical failure.

Lewis: A lot of these concerns may have been designed out of later systems. The system Jim's talking about at Interfirst can tolerate a lot of mechanical loss, such as loss of a chiller when you don't have a redundant chiller.

When they shut a machine down, the worst that can happen, if the building is fully occupied on a design day, is that they'll have to reset their space temperatures.

The commissioning of these systems can be done completely on off hours. Interfirst never went into demand and hasn't yet. The only problem on that project was that Trane was told it had to start the machines after-hours and the salesman knew it but the service people didn't.

Editor: Do you have 'what if' scenarios?

Purdy: Well, on Interfirst we did have quite a 'what if' session — rather, sessions. The owners were aware that this was a new thing in the Dallas area and they played the devil's advocate with every conceivable sort of disaster taking place.

As Larry said, while we don't have a standby chiller and an extra cooling tower, etc., we collectively agreed that the system had the flexibility and built-in redundancy, because of the thermal storage system, and that unless an incredible combination of circumstances occurred, they wouldn't have any problem taking care of tenants.

Editor: Could you share with us some specific examples of scenarios you considered?

Purdy: We asked questions like, what if you lose a chiller? Well, if you lose a chiller, you valve it off and go to work on it, and you run the other two chillers; and unless it is a design day, you probably didn't use all 2 million gallons of water anyway. So, you only have to

regenerate 1 million gallons and the two remaining chillers can do that quite adequately in 16 hours.

What if we lose two chillers? Well, again, if it was a design day and you used up all your chilled water, you're only going to be able to recover a third of it during the window available. You're going to suffer either by resetting the space temperature or by closing some offices. It's the same thing that happens with a conventional system, but you're in better shape because you do have some storage.

We also played, what if you lose the entire thermal storage system? But we decided that just wasn't going to happen.

The final consensus of the owner, Emde Co., PMI, and everybody involved was that with thermal storage, you've got the most reliable system you can possibly have.



"Every major project in the Dallas area we've done or looked at in the last three or four years has considered thermal storage." — Houston

Hunsucker: As a experiment, we ran both buildings one day without any chiller running, and it worked. One building is 688,000 sq ft and is 100% occupied, and the other has 523,000 sq ft and had 50% occupancy. However, history has shown me there's not a lot of difference between an occupied and partially occupied building.

Houston: We've done six thermal storage systems. The largest is 5 million gallons with 8,100 tons of

chiller capacity. I have to share the feelings that everything is a plus. There are no minuses in terms of reliability. And I agree with Bill that the danger isn't in the storage or the chillers or the pumps or the condenser water tower; the danger is in the control system. The attention to making it sophisticated enough so that you can get the data you need, but uncomplicated enough so it doesn't become a weak link, is the key element.

We also haven't had any problems with leakage. In the Crescent we installed a gigantic eight-story steel tank; the others are concrete tanks, and we haven't had any problems, other than at initial start-up, on any of those.

Hunsucker: Overdesign might be a problem. Those tanks cost a lot of money. They cost me more than any other part of the system.

Editor: We're talking about concrete tanks?

Hunsucker: I have three concrete tanks.

Houston: We've installed steel tanks on three of the jobs we've done. I'm talking about gigantic tanks — 1.7 million gallons. When the tanks are fully assembled it looks like a petroleum tank farm, only underground and insulated.

Editor: What kind of insulation, Ben?

Houston: They use standard fiberglass insulation.

Editor: How do you view the market for thermal storage?

Houston: Every major project in the Dallas area we've done or looked at in the last three or four years has considered thermal storage. All the giants have gone that way unless they're restricted by the footprints of the building. We do have a 60-story building that we can't get thermal storage into because of its footprint.



EDITOR'S NOTE: In the next issue of ES, our panel of experts continues the thermal storage discussion as they take a closer look at ice storage systems, tank insulation, heating methods, and retrofit possibilities.

Part II

Thermal storage

'Movin' on up' in Dallas

EDITOR'S NOTE: In the last issue of *Engineered Systems*, we began this two-part series on the thermal storage phenomenon taking place in Dallas.

This Texas community has embraced the technology with open arms, and the editors of *ES* and its sister publication, *Air Conditioning, Heating, & Refrigeration News*, wanted to know why. To get the answer, the publications assembled a panel of local experts to discuss why thermal storage has been so well received by building owners, and the potential of the technology in Dallas.

In bringing the results of that roundtable discussion to our readers, we hope they will help those considering the application of thermal storage in other areas of the country.

On the panel were: building owners/operators — Billy Hines, Raymond D. Nasher Co., and Bill Hunsucker, Lincoln Property Co., Inc.; consulting engineer — James Purdy, PMI Engineers; mechanical contractors — Ben Houston, TD Mechanical, Larry Lewis, Emde Mechanical Co., and W.P. Dickson, Brandt Engineering; educator — Warren M. Heffington, Ph.D., Mechanical Engineering Department, Texas A&M University; and utility representative — Jeffrey Herring, Dallas Power & Light Co.

The discussion was moderated by *ES* contributing editor Thomas A. Mahoney and *ES* editor Robert L. Schwed.

The conversation reopens with a look at ice-based thermal storage sys-

tems.

Editor: Are there any ice storage systems in Dallas?

Purdy: Previously I said we had only two ice systems in operation here, but I neglected to point out that Dallas Power & Light (DP&L) feels that, if thermal storage systems are good for their customers, they're also good for DP&L.

They have an ice storage system that uses three 250-hp screw compressors. The system has been in operation since last summer.

They practice what they preach. That was a retrofit installation. The main reason for going to ice was that there wasn't enough space for water storage. The ice system was installed in the existing basement without any



structural modifications. I believe it was installed without interrupting the operations of the totally occupied building.

Dickson: We have a job under contract now involving a 565,000-sq-ft building. It will use two nominal 475-ton machines and a 25% glycol solution to produce ice for a system with about 9,000-ton-hours of storage.

Lewis: There's another project in Dallas, a 165,000-sq ft office building, where ice storage is being considered, but we don't know what they're going to do yet.

Dickson: There's a breaking point at about 500,000 sq ft, below which thermal storage may be impractical. But each building has to be individually analyzed.

Houston: Do you think ice might have a lower break-even point?

Dickson: Possibly. I know of one 75,000-sq-ft building that couldn't afford it, but I think ice storage would have a lower break-even point than water.

Purdy: We sort of feel that the break point for water is about 300,000 sq ft. And, if ice is chosen, you can get down to something even smaller than that and still have a feasible design.

Lewis: Would you have felt the same way five years ago, Jim?

Purdy: No. Five years ago I would have thought the break point to be much larger.

Also, concerning the discussion about projects that have considered thermal storage and decided against

it, the only major building we've done in the last few years where storage wasn't installed was LTV Center. We did a study there that proved storage was justifiable, but they had a time constraint.

The building footprint covered the entire piece of real estate, which meant the only place for thermal storage was at the bottom of a parking structure under the building. The parking facility already was six-stories below grade and we were going to have to excavate for another two levels. The contractor said this would take another six months, but the developer did not have that much time before his lead tenant was scheduled to move in.

Hunsucker: I'm not sure, but I think



Ben Houston



W. P. Dickson



Jeffrey Herring



Bill Hunsucker



Warren M. Heffington



Larry Lewis



Bill Hines



James Purdy

there is an ice bank at University Park Methodist Church. I'm told that system was installed in the 1940's.

Purdy: There are a number of small churches in Dallas using it. The church I was married in has an ice bank that has been running for 30 years. It has been a very satisfactory system. They've got pieces of wood over the tank and they store lawnmowers and buckets and brooms on it. It's very crude, but it works.

Editor: What about the insulation of these tanks? You don't have 20 years of experience to call on, so this is a leap of faith, isn't it?

Purdy: With the concrete tanks we have at Interfirst Plaza, the bottoms of the tanks are 25 to 30 ft below grade. The surrounding earth temperature is pretty constant, so we didn't have to insulate the sides of the tanks. The tops of the tanks and the sides above the normal water level are insulated with from 4 to 6 in. of "Styrofoam."

The steel tanks at the Crescent, which were mentioned earlier, are not buried. They're in a basement space. I don't know what the factors were, but there are tables published by insulation manufacturers telling you that if you're transporting water at such and such a temperature in a pipe of a given size, you need so much insulation to lose this many Btu's per linear foot of pipe. That information would just have to be studied to determine what the insula-

tion thickness requirement of a tank should be.

I don't think you can really say a storage tank needs to be insulated with a material that has an R-factor of X. You need to look at the size of the tank and the temperature of the water you're going to be storing in it. Then you get some insulation data which would allow you to calculate how much heat gain you would have through insulation of a given thickness. Then the economics involved would determine how much insulation you should have.

Editor: Is there a standard? A design manual? Is there a procedure some technical or trade association has published?

Purdy: Not that I'm aware of.

Houston: There is a minimum of 4 in. of insulation on those tanks (at the Crescent). Of course, they're in a very deep basement area where it naturally tends to be cooler to begin with — it's like a cave. Figuring the insulation is part of the analysis you have to make when deciding whether thermal storage will pay back.

Purdy: Tell us approximately the size of those tanks, Ben.

Houston: My recollection is they're approaching 70 ft tall and they're probably 30 to 40 ft in diameter.

Editor: That's in a basement?

Herring: It's a deep basement. This is part of the subsurface parking garage at the Crescent. At the corner of McKinney and Pearl the land

comes to a sharp point, and my understanding is that this was not very usable space anyway because of the building's shape. They could arrange those cylindrical tanks within that triangular space so it was not as much wasted space as you might think.

Hunsucker: Our tanks are 85 ft long, 37 ft wide, and 27 ft deep. There are three of them. They're monstrous. I thought I was in the hold of an aircraft carrier when we went down into them.

Editor: These are not subterranean?

Hunsucker: They're buried, but part of them is exposed in the basement.

If we have a ruptured tank, we'll lose an engine room. We won't have to worry about our two chillers any more.

We also have a morning warm-up cycle for winter, which I failed to mention previously.

One of the biggest problems in an office building in the winter, when it's been shut down for a weekend and you have electric strip heat, is the long period of time it takes to warm the building back up. You don't get the same heat transfer or temperature rise you do with a hydronic system.

We put in a warm-up cycle that would allow us to use the double-bundle condenser for heat. We also use electric heat to boost the temperature even further. This system is only good for the first blast of warm air on cold mornings. It's not good for anything else because we have to

IV North Park East

Walnut Green

Crescent

Lincoln Center



generate chilled water to make heat. Our building has 100% outside air capabilities, which means I don't need the chilled water on those cold days.

At first I didn't like the warm-up cycle, because it produced chilled water when we didn't need it. But I think the theory of just using it for that blast of warm air on the first morning of the week works well.

Dickson: Speaking of heating, two of the projects we're installing now each have a chiller with a double-bundle condenser. We can generate hot water and make ice (on one) and chilled water (on the other) at the same time. We can use that heat during off hours and not use electric strip heating. It helped the paybacks.

Houston: We have one installation that has both hot and cold water storage. It has hot water heat, which also cuts winter electric demand.

Herring: You might think offhand that this is not good for us, but our winter load has been growing extremely fast. It's growing at such a rapid rate that, sometime in the future, it might get very close to our maximum. In fact, that's not too far off. We're doing some investigation into winter load management concepts using hot water thermal storage. From the standpoint of the electric utility company, there are things to look forward to.

Editor: Are there any multifamily structures that are candidates for

thermal storage? Is there anything on the boards now in the way of multifamily projects?

Herring: Normally, 24-hour-a-day occupancy situations are not the best candidates for thermal storage. Not only do you have to meet the instantaneous load during off-peak hours, but you've also got to be generating the tonhours for the next day, which might produce a penalty in equipment sizing for the project.

Editor: So we're mostly talking about conventional office buildings?

Herring: Not just office buildings. The Dallas Concert Hall is going to have a heating and cooling thermal storage system. That's going to be the best application of all. It will generate more savings than any of the other projects.

Editor: Are these greater savings because that facility can produce either chilled or hot water with smaller equipment, rather than having to do it in a much shorter time span as in an office building?

Herring: You have to remember that each project has to be considered separately to see if it warrants thermal storage.

This concert hall has a tremendous amount of single-pane, clear glass. Therefore, it has a tremendous heat loss. The building also needs a lot of humidification in the winter to provide proper relative humidity for the instruments. So the air is carrying a lot of humidity, which means they'll

have to have defoggers on the windows to keep them from steaming up.

There is a tremendous heating requirement. Because the building was going to use chilled water storage, it was only natural to also use a double-bundle condenser to produce hot water for storage.

Not only do they produce demand savings both winter and summer because of the chilled water storage, but they also achieve tremendous energy savings. It's a multifaceted concept that can be used for structures other than office buildings. It just so happens that Dallas is heavily oriented toward offices.

Purdy: Peak loading and off-hour loading impact the viability of a thermal storage system immensely.

One project we're looking at now is a mixed-use occupancy (condominiums, offices, and retail space all in one large building). Because the condos constitute a larger area than the office building itself, the 24-hour loading is what's setting the size of the refrigeration plant, rather than the peak-day load. We're not going to be able to downsize the refrigeration equipment (or very little, at any rate) because of the off-hours requirement.

Herring: I don't think it means that thermal storage is absolutely out of the question. But the advantage of downsizing the chiller plant cannot be taken advantage of if you have a large percentage of 24-hour-a-day usage taken up with condominiums or

Premier Place

Premier Place

Tanks for the Crescent

Allied Bank Tower



apartments.

Editor: Jeff, can you tell us what it is in the Dallas market that caused thermal storage to come on so strong in contrast to, say, Houston where, evidently, the concept hasn't taken hold?

Herring: It's hard for me to respond to that because I don't know what's on the minds of the people at the Houston utility. But, I do know that Dallas is fortunate in having had the Raymond D. Nasher Co. develop two downtown buildings with more than 2 million sq ft of space served by thermal storage systems before there were any incentives.

We saw this happening at about the same time we were setting load management goals to reduce our summer on-peak demand.

When we saw these buildings going up, we were very interested in the fact that they were reapplying an old technology in those modern structures.

It finally clicked that this was going to be a concept that would be advantageous to us in our load management plans, and that it could help reduce the need for additional generating capacity.

I have to credit a lot of what's happened to them (Nasher Co.) for their foresight in designing these buildings. We felt we wanted to encourage other building developers to use it.

Houston: I believe there's another reason but, even so, I believe the management of our Texas utilities is exceptional.

They have always provided incentives for energy conservation and energy-conserving equipment. They've supported anything that makes good sense in terms of energy conservation.

Dickson: I think it's safe to go a step further. DP&L has been more aggressive in this area than some of its sister companies within Texas. They've been very aggressive.

Herring: I appreciate your comments.

Lewis: There is another reason. When you're not building new buildings, it's hard to sell a whole lot of thermal storage.

Herring: That's a very big point. Thermal storage does lend itself to new construction. We encouraged people to use thermal storage but we couldn't get people to consider it.

We couldn't figure out what we

were doing wrong, or if there were something wrong with the system. Finally, we decided that, because we were paying incentives for high-efficiency residential equipment, maybe we should consider incentives for thermal storage because of its tremendous potential.

So we developed a time-of-day rate structure. Through negotiations with Jim Purdy, we also developed an incentive program. He was one of the pioneers, along with the Interfirst Plaza people. That was the first project for which we paid an incentive. We met with an enthusiastic consulting engineer and an enthusiastic owner and, through a melding of ideas, we developed our incentive program. That program now is our standard.

Editor: As you were going around pitching thermal storage, what were the major objections owners had?

Herring: First cost was probably the biggest. They said, 'I'm going to have to spend more money for this system than for a conventional system?' In speculative office building construction, that's always going to be the first negative response you're going to get.

Dallas Thermal Storage Systems

Thermal Storage Systems in Operation

Name	Size (Sq. Ft.)	Comp. Date	Type	KW Peak Shift
Main Center	1,813,000	11/84	Water	2,650
Thanksgiving Tower	1,500,000	02/82	Water	2,600
IV NorthPark East	530,000	07/82	Water	1,190
Haggar Company	73,000	07/83	Water	166
Episcopal Church	23,772	1983	Ice	65
Southland Corp. (Exist-Retrofit)	—	1984	Ice	180 ±
Dallas Pwr. & Lgt. (Exist-Retrofit)	180,000	1984	Ice	600
Walnut Green	167,740	01/85	Water	354
Lincoln Centre II & III	1,231,500	07/85	Water	2,741
Total	5,519,012			10,516 kW

Source: Dallas Power & Light

These are the existing thermal storage systems in the Dallas metropolitan area. Another six projects are under construction representing some 9 million sq ft of space, and another three are on the drawing boards.

Editor: Do they render that in terms of a percentage? Say, X% higher first cost?

Herring: No, just basic discussion and understanding of how the systems are designed. If you go with full-shifting water thermal storage, there's strong potential for it to cost more than a conventional system.

They want to minimize that first cost. Plus the fact that, in speculative office building construction, operating costs are passed on to the tenants. The owners and developers were looking at this and saying, 'Well, I like it, but a lot of these savings are really going to go to the tenants.'

There's also the fact that you have to put in these huge tanks and a lot of piping. They're used to just having a chiller installed. It's an offbeat kind of concept for them to get used to.

The reason it's become so acceptable here is because we've overcome those objections. The consultants and contractors also have gotten involved and have shown enthusiasm for these kinds of systems.

We've got systems out there working. When you show someone a building that's working, then you've got a success story to prove your point. We found that 38% of the

buildings 50,000 sq ft or larger started in 1984 were equipped with thermal storage.

Someone earlier said owners are in competition for tenants. If I've got a building that's more attractive from an energy standpoint, then I have the ability to attract more tenants because I can offer them a more attractive package.

Editor: I'm sure it helps when you don't have a developer's contractor or engineer walk in after you've given a presentation and say, 'Oh no, that won't work at all.'

Dickson: No, that doesn't help much. You have to have the cooperation of all parties.

Houston: Another thing that's being used as a sales tool, and I'll compliment Larry's group and Jim on this, is the way a building is being shown off.

At last night's grand opening, Interfirst's mechanical room was open to the public. You couldn't really see the storage tanks, but you could see the pumps, chillers, and the control center with all its flashing lights. It's a very good marketing tool.

Herring: It demonstrates an owner's commitment to the tenant by his providing an environment that is state-of-

the-art. That speaks highly of the owner.

Houston: These guys aren't the only ones doing this kind of selling, but they did an excellent job.

Dickson: Another consideration is that we were used to 2 cents/kWh or less for a number of years. Then suddenly, we were hit with a 500% increase. Even though our rates are still among the lowest in the country, action was taken when we saw this coming.

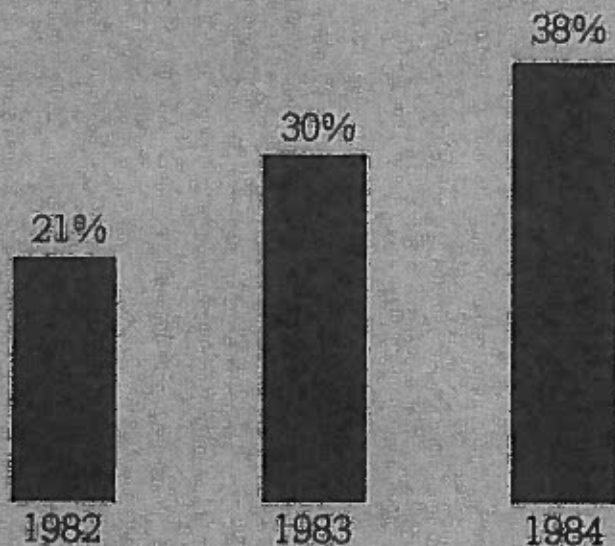
Editor: Do you see any potential for the retrofitting of existing buildings? Now that you've got these new buildings on stream, and they're out there for the whole world to see, are conventional building owners coming back to you and saying, 'Look, we want some of these features, too?'

Purdy: I think there is a great potential for retrofitting older buildings. A lot of the rehab work that's being done in our west-end historical district could utilize thermal storage to effectively turn old warehouses into Class A office space.

I think you'll see more and more projects being retrofitted with thermal storage, particularly as our rate structure continues to creep upward.

Herring: We've got a building in the

Thermal Storage Market Share for New Office Buildings in Dallas, Texas



This graph indicates the rapid acceptance of thermal storage for commercial office space in Dallas since it first began being installed about 1980.

west-end historical district that's being looked at for ice thermal storage now.

Lewis: We're seeing a lot of projects where they've completed the first phase, they're looking at the second phase, and are considering thermal storage for both buildings. This is similar to what Lincoln did with its buildings.

There are some manufacturers producing packaged systems for ice storage. I think that, for smaller building retrofits, ice systems are awfully attractive.

Editor: Any last thoughts on where thermal storage is going?

Herring: Nowhere but up. We are in the midst of expanding our involvement, not only in our particular service area, but throughout the system.

We have recently approved some long-term million dollar programs to continue our load management efforts.

In the next 10 years, we are expecting load growth on the Texas Utilities system of about 10,000 MW. That's a lot of capacity. Some 1,734 MW of that is expected to be met by load management.

In other words, 17% of our net load addition is going to be met through conservation and load management.

Dickson: How much money have you put out so far in this effort? Or is that

proprietary?

Herring: Dick, my checkbook is back on my chest of drawers.

However, I can tell you that we've entered into a contractual agreement with one customer to pay \$1.26 million on one project.

I don't have the exact tally, but my budget for next year, just in Dallas, is going to be in the million dollar range. We pay this money when construction begins and when the project is completed.

Lewis: Jeff, you touched on the heating aspect of storage. We don't see many heat storage systems, just as we didn't see many cooling storage systems before there were incentives. Do you see DP&L getting into the same kind of programs for hot water storage?

Herring: With the enthusiasm for load management I've seen within the Texas Utilities system and the resources that have been dedicated and approved, we're going to be looking at a lot of things. Thermal storage for winter heating purposes is going to be one of them.

Heating loads can be a big target for thermal storage. We haven't done nearly so much analysis of these types of systems as we have with cooling storage.

Editor: Are you getting into situations where your summer and winter loads

are balancing out?

Herring: Our winter load is approximately 91% of our summer load.

Editor: You don't have much comfort heating provided by boilers here, do you?

Herring: That's right. The vast majority of new buildings, particularly office buildings, use electric resistance heat. Practically all of the multifamily construction uses electric resistance heating. There are some heat pumps, but very little gas heating. We're developing a pretty heavy winter load.

Houston: However, there are an awful lot of our buildings that can almost be heated just by the lighting. With good thermal envelopes and good glass, those strip heaters hardly ever come on.

Hines: We're improving our auditing so much and whittling our bills down so much that we're almost killing ourselves in the winter. I had a store in San Antonio that used 586 500-watt light bulbs. I replaced them with fluorescent fixtures and that winter I had to turn on the boiler for the first time.

Herring: This incentive program for thermal storage is spreading throughout the country. It's being used in California, other areas of Texas, Arizona, Oklahoma, and a Florida utility is considering it. □

Cost of Power Plants Dollars per Kilowatt

