Florida on Ice: Seniors Keep Cool With

Thermal Energy Storage

Centralization and thermal energy/ice storage meet super-sized chilled-water demand at Gulf Coast retirement community

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Staying cool in Florida never has been easy—or cheap. The task of cooling more than a million square feet of space on Florida's hot, humid Gulf Coast is daunting to say the least. But this was reality for Shell Point Retirement Community in Fort Myers, Fla., in 1997. The stakes were about to get much higher, as the property would embark on a 20-year, multistage expansion of its grounds and facilities that eventually will increase the existing 1.25 million sq ft of conditioned floor space by as much as 4.5 million sq ft. The challenge was to design a high-efficiency cooling system that would take advantage of Florida Power & Light's (FPL) power rate structure while building the system in stages at the most effective installed cost and still achieve optimum long-term energy savings.

Shell Point's needs and goals, though larger in scale than most, were not unlike those of any other institutional facility facing ongoing expansion. Long-term efficiency, sustainability, maintainability, and occupant satisfaction formed the framework of the design. A centralized chiller-plant system with thermal ice storage, a type of thermal energy storage (TES), provided the means to achieve these goals.

OPTING FOR TES

Once confined to a 75-acre island off the mainland of western Florida, Shell Point, a resort-like retirement community, reached its maximum zoning density in 1997. With a waiting list of tenants, the owner decided to purchase adjacent mainland property.

This enabled Shell Point to expand its facilities, which already provided every level of elderly care from independent and assisted living to 24-hr

Aerial view of Shell Point Retirement Community.

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The Decision to Centralize

Although several chilled-water plans, including multiple satellite chiller plants, were considered for Shell Point's mainland expansion it was decided that a centralized chiller plant more effectively and efficiently would serve The Island and mainland properties. This decision was based on a number of factors:

• *Maintaining peak operating performance.* The design team realized Shell Point did not have the additional staff needed to support multiple equipment locations. A centralized plant with a central energy-management system would allow for more consistent monitoring of equipment, cooling loads, and maintenance schedules—hence, greater sustainability.

• *Minimization of noise.* Because tenant satisfaction ranks high at Shell Point, the owners were concerned about noise coming from the satellite plants that served various Island facilities. A centralized plant could be located farther from occupied facilities and, therefore, be less of a noise nuisance.

• *Aesthetics.* Shell Point has strived to maintain a resort-like appearance and preferred to keep large HVAC equipment out of the sight of its residents. A central plant, separately located from Shell Point's other facilities, would be less invasive to residents and staff.

• *Long-term efficiency and equipment life cycle.* Based on specific data gathered from The Island satellite plants and comparative manufacturers' data, the larger industrial-grade equipment that would be used in a centralized plant was almost twice as efficient as the equipment that would be used for satellite plants. It also had more than twice the nominal life expectancy.

• *Diversity.* A central plant would require fewer total tons of refrigeration than would multiple satellite plants. Satellite plants have to supply the design peak load for each system and still have capacity left over to allow for routine maintenance and emergency backup. A central facility has the advantage of a lower combined peak load because individual building loads—at least in the case of Shell Point—peak at different times. This built-in diversity reduces the extra capacity needed for maintenance and emergency backup.

• *Payback.* Although at buildout the centralized plant was projected to cost approximately $1.5 million more than satellite plants, the operational savings would yield a net payback in two years or less. This primarily was because of the high-efficiency equipment that could be selected with a centralized plant. Based on comparative manufacturers' data, the centrifugal chillers selected for the project could produce a ton of refrigeration for approximately 50 percent of the energy costs of an individual satellite plant with air- or water-cooled screw chillers (including fan and pump horsepower.)

• *Life cycle.* The life-cycle savings of the central plant were calculated, as were the associated service and replacement costs. Calculations were based on 10, 20, and 25 years of operation, which would bring Shell Point to a complete build-out of its properties. At 25 years, the centralized system (not including the TES) was projected to yield a total net savings of $20.6 million. As a result of this analysis, 80 percent of The Island load and all future loads associated with the expansion are to be included under one roof and one control system. This allowed Shell Point to rid The Island of nearly all of the noisy, unsightly air-cooled equipment that had served its facilities while reaping the benefits of longer-lasting, more efficient industrial-grade equipment.

• *Other savings.* Centralization also allowed Shell Point to avoid the cost of additional landscaping and architectural enhancements that would be required to disguise individual satellite plants.

• *Maximization of TES.* Centralization allowed Shell Point to realize the full benefit of TES. Full load shifting would not have been practical—or even feasible—with so many separately located plants. It would not have been as efficient to handle or maintain separately located ice-storage systems that had to grow continuously to keep up with Shell Point's long-term expansion plans.

skilled nursing care.

Prior to expansion, the facilities known as "The Island" relied on an assortment of cooling means, including direct-expansion cooling, air-cooled chillers, and three TES systems, which provided a total of 5,400 ton-hours of cooling. These ice systems had exceeded projected cost savings, making TES a natural consideration for the expanded properties. However, various mechanical systems on The Island did not expand easily to accommodate Shell Point's growth, and the resulting change in operations deteriorated gains from the TES in a matter of years. It was a lesson that prompted the engineering team to re-evaluate how it could optimize TES more effectively for the expanded property. At the same time, the pending expansion provided an opportunity to investigate more efficient and sustainable options for The Island. Ultimately, TES was incorporated into one large centralized chiller plant that would serve both The Island and mainland properties (see sidebar).

To maximize long-term energy savings and provide cooling backup for Shell Point, a TES design was proposed. A full-load-shift design was selected because of the relatively short utility on-peak period. A full load shift of cooling to off-peak would allow Shell Point not only to minimize on-peak utility charges, but to take advantage of FPL's attractive rebate incentives.

Full-load-shifting TES would enable Shell Point to more easily and economically utilize the diverse and combined loads of the connected Island and Woodlands communities (Figure 1). Based on projected and monitored design loads and design-load profiles for Shell Point's central plant, it was determined that by 2003 the maximum off-peak summer load would be 3,684 tons and the maximum on-peak summer load would be 6,039 tons. Shell Point, with a conventional design, would have required five 1,200-ton centrifugal chillers to provide this maximum on-peak cooling capacity, allowing for little cooling capacity in reserve.

With TES, three 1,200-ton centrifugal chillers are required to provide chilled water during off-peak hours and three 1,200/920-ton ice-making chillers are provided for use during off-peak hours. (Ice-making chillers are rated nominally at 1,200 tons, but produce only 920 tons when making ice at 26 F.) No chillers operate during on-peak hours, except as backup or in emergency situations.

Therefore, the inclusion of full storage and the reserve capacity necessitated the purchase of only one extra chiller. If a chiller is off line with the conventional design on a peak cooling day, available cooling capacity cannot meet the load unless a sixth conventional chiller is added. With the TES design, there is enough reserve capacity to meet the load.

By incorporating TES, Shell Point was able to sustain a greener design. An off-peak kilowatt-hour uses less fuel than an on-peak kilowatt-hour. Less fuel means fewer emissions. One study by the California Energy Commission indicates that it takes 10 to 30 percent less energy to create and deliver power off peak.[1] This is attributed to lower heat rates typical for off-peak base-load plants, fewer line losses during nighttime transmission, and the elimination of some energy waste associated with maintaining reserves at night to meet the following day's peak load. (Heat rate is defined as the amount of fossil energy needed to produce each kilowatt hour of electricity.) Emissions are reduced further because the last plants to come online during the peak demand period often are the dirtiest.[1] If the utility can minimize the use of these peaking power plants, there is less negative impact on the environment.

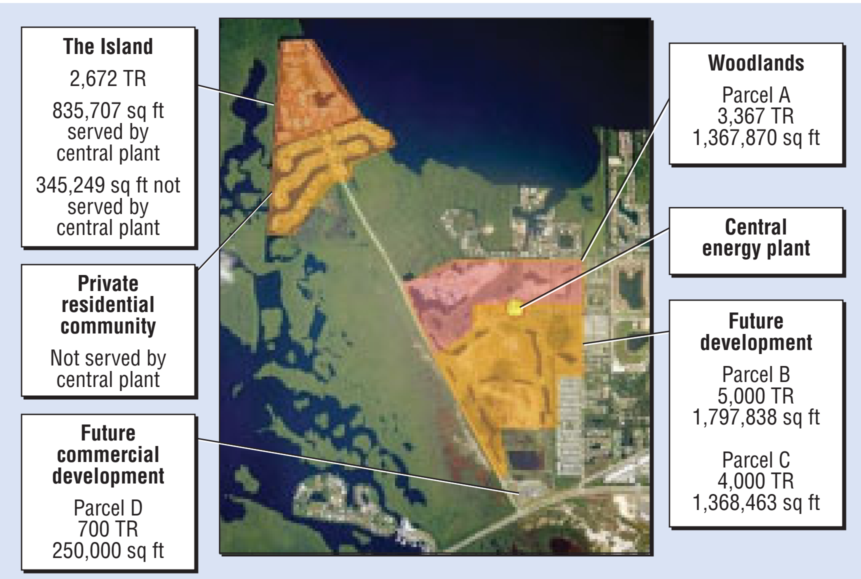

FIGURE 1. Current and future areas of conditioned space and associated tons of refrigeration (TR) at Shell Point Retirement Community.

ON-PEAK/OFF-PEAK OPERATION

During off-peak hours, the three dedicated TES chillers work to cool 48,000 gal. of a glycol/water mixture that circulates from the chillers to the TES tanks. This solution (or brine) circulates through modular, insulated, polyethylene TES tanks containing a spiral-wound plastic-tube heat exchanger surrounded by water. This circulation continues until the water in the tanks is 95 to 98 percent frozen. During ice making, the other three chillers are working to provide off-peak cooling to the connected loads.

During off-peak hours, the plate-and-frame heat exchangers become inactive, and the glycol mixture circulates from the ice tanks to the dedicated TES chillers to rebuild the ice used during the previous on-peak cycle.

At the start of on-peak operation, valves reposition, allowing the glycol mixture to flow from the ice tanks through one side of the plate and frame heat exchangers, using a combination of dedicated variable-flow ice-melting pumps and primary chilled-water pumps to extract heat from the system load's return water. (The glycol remains cool because it is recirculated through the ice tanks.) The main-system return water bypasses the off-peak chillers (typically turned off during on-peak periods) and is recirculated back into the system after being cooled by the plate-and-frame heat exchangers.

CONTROLLING THE SYSTEM

Control and monitoring are critical to Shell Point and are the property's best means of sustaining efficiencies. The selected control system includes an energy-management system (EMS), which is supplemented by a power logic system that provides "real-time" monitoring and recording of electrical-power-systems performance.

Connected buildings are installed with direct digital controls that use BACnet and BACtalk to communicate with the

Service date	Relative month	Days	Total kwh	On-peak kwh	Percent on-peak kwh	kwh per day	Actual kwd (maximum)	On-peak kwd	Percent load factor	Electric amount	Bill-comparison amount	Monthly savings
1/25/2005	1	35	614,000	41,788	6.81	17,543	1,936	396	37.8	$34,314	$50,406	$16,092
12/21/2004	12	33	710,400	44,179	6.22	21,527	3,179	279	28.2	$35,409	$63,473	$28,064
11/18/2004	11	29	819,600	133,558	13.86	28,262	3,569	842	33.0	$67,920	$88,047	$20,127
10/20/2004	10	29	1,010,400	191,205	18.92	34,841	4,490	3,652	32.3	$80,628	$89,942	$9,314
9/21/2004	9	32	1,279,200	66,571	5.20	39,975	4,488	842	37.1	$66,209	$88,047	$21,838
8/20/2004	8	29	927,200	87,032	9.39	31,972	3,808	926	35.0	$51,581	$79,943	$28,362
7/22/2004	7	30	1,068,800	55,367	5.18	35,627	3,693	1,019	40.2	$58,026	$86,242	$28,216
6/22/2004	6	32	1,044,800	56,159	5.38	32,650	3,750	416	36.3	$51,872	$85,492	$33,620
5/21/2004	5	29	717,600	51,248	7.14	24,745	4,213	349	24.5	$36,494	$72,601	$36,107
4/22/2004	4	29	542,000	47,467	8.76	18,690	3,591	686	21.7	$31,355	$58,308	$26,953
3/24/2004	3	29	596,800	44,329	7.43	20,579	3,083	556	27.8	$32,649	$56,831	$24,182
2/24/2004	2	32	580,800	44,316	7.63	18,150	2,974	316	25.4	$29,904	$55,089	$25,186
Annual totals			**9,911,600**	**843,219**						**$576,361**	**$874,421**	**$298,060**
1/23/2004	1	35	540,000	41,969	7.77	15,429	2,570	591	25.0	$30,341	$49,584	$19,243
12/19/2003	12	31	546,400	38,232	7.00	17,626	2,432	1,057	30.2	$34,662	$48,778	$14,116
11/18/2003	11	29	770,000	43,429	5.64	26,552	3,413	1,057	32.4	$44,906	$68,552	$23,645
10/20/2003	10	31	951,200	49,184	5.17	30,684	4,434	510	28.8	$48,615	$86,486	$37,871
9/19/2003	9	30	1,051,600	63,839	6.07	35,053	4,350	842	33.6	$56,277	$90,931	$34,654
8/20/2003	8	29	993,600	60,589	6.10	34,262	3,500	926	40.8	$54,290	$80,767	$26,477
7/22/2003	7	32	1,064,400	59,253	5.57	33,263	3,661	728	37.9	$50,224	$80,189	$29,965
6/20/2003	6	30	997,600	128,032	12.83	33,253	2,462	758	56.3	$49,223	$66,972	$17,749
5/21/2003	5	29	829,600	80,996	9.76	28,607	2,700	757	44.1	$41,505	$61,239	$19,734
4/22/2003	4	29	549,600	39,953	7.27	18,952	2,400	933	32.9	$30,918	$45,796	$14,878
3/24/2003	3	31	737,200	42,372	5.75	23,781	2,538	890	39.0	$34,542	$52,028	$17,486
2/21/2003	2	30	459,600	49,175	10.70	15,320	1,589	354	40.2	$20,370	$32,555	$12,185
Annual totals			**9,490,800**	**697,023**						**$495,872**	**$763,876**	**$268,004**
1/22/2003	1	35	466,000	40,979	8.79	13,314	1,684	336	32.9	$20,273	$33,622	$13,349
12/18/2002	12	30	453,200	44,387	9.79	15,107	1,768	515	35.6	$20,804	$33,362	$12,558
11/18/2002	11	31	668,800	90,274	13.50	21,574	1,890	893	47.6	$32,287	$43,023	$10,736
10/18/2002	10	29	787,600	145,140	18.43	27,159	1,926	866	58.8	$37,241	$48,080	$10,839
9/19/2002	9	30	784,000	140,564	17.93	26,133	1,944	967	56.0	$37,883	$48,090	$10,207
8/20/2002	8	29	746,000	130,065	17.43	25,724	2,137	1,129	50.2	$37,757	$48,216	$10,459
7/22/2002	7	32	666,400	128,029	19.21	20,825	1,485	880	58.4	$32,903	$39,473	$6,571
6/20/2002	6	30	499,200	39,062	7.82	16,640	2,643	1,007	26.2	$26,439	$42,663	$16,224
5/21/2002	5	29	454,000	40,166	8.85	15,655	1,732	1,091	37.7	$25,653	$33,087	$7,434
4/22/2002	4	31	398,800	37,103	9.30	12,865	1,464	300	36.6	$16,979	$28,595	$11,616
3/22/2002	3	29	354,000	49,822	14.07	12,207	2,067	817	24.6	$21,618	$34,051	$12,434
2/21/2002	2	29	421,200	79,070	18.77	14,524	1,320	993	45.8	$26,392	$30,273	$3,880
Annual totals			**6,699,200**	**964,661**						**$336,229**	**$462,536**	**$126,307**
1/23/2002	1	35	345,000	63,713	18.41	9,866	610	427	67.5	$18,161	$20,603	$2,442
12/19/2001	12	33	358,800	77,388	21.57	10,873	1,028	530	44.1	$20,247	$25,042	$4,795
11/16/2001	11	29	305,600	69,800	22.84	10,538	949	677	46.3	$19,241	$21,956	$2,715
10/18/2001	10	29	327,600	87,368	26.67	11,297	979	858	48.1	$22,005	$23,209	$1,205
9/19/2001	9	30	364,400	96,582	26.50	12,147	741	741	68.3	$25,029	$25,245	$216

TABLE 1. Shell Point central-energy-plant output and costs.

EMS. This combination of management tools provides instant 24/7 operational status of components, as well as trend and data reports of both current conditions and historical data needed to efficiently operate all system components.

Normal operating parameters are programmed into the system software.

Date online	Location	Design cooling load (tons of refrigeration)	Cummulative total (tons of refrigeration)	Nine-hour window (tons of refrigeration)	Cummulative total (tons of refrigeration)	Max off peak (tons of refrigeration)	Building square feet of air conditioning
Island loads transferred to the central plant, 2002 and 2003	Island loads:						
	Pavilion and addition	490	490	3,136	3,136	299	92,172
	Kings Crown	320	810	2,102	5,238	494	75,707
	Sun Dial and facilities	208	1,018	1,367	6,605	621	66,000
	Harbor Court	250	1,268	1,641	8,246	774	110,600
	Bible Conference Center and addition	217	1,485	1,426	9,672	906	67,104
	Administration complex	550	2,035	3,614	13,286	1,241	95,000
	Motel and office	45	2,080	296	13,582	1,269	18,632
	Medical clinic	42	2,122	276	13,858	1,294	16,800
	Mid-rise	550	2,672	3,614	17,472	1,630	291,692
Online 2001	Commons/Oakmont	460	3,132	3,022	20,494	1,910	224,033
Online 2001	Rosemont	396	3,528	2,602	23,096	2,152	189,710
Online 2002	Lakewood	396	3,924	2,602	25,698	2,394	155,957
Online 2004	Parkwood	396	4,320	2,602	28,300	2,635	155,957
Online 2006	Eagle Preserve	602	4,922	3,290	31,590	2,986	225,000
Online 2005	Arbors	567	5,489	3,725	35,315	3,348	219,713
Online—to be determined	Woodlands Activities and Hurricane Shelter	200	5,689	1,314	36,629	3,470	70,000
Online—to be determined	Golf club house	200	5,889	1,314	37,943	3,592	70,000
Online—to be determined	Chapel	50	5,939	325	38,268	3,623	17,500
Online—to be determined	New facilities	100	6,039	657	38,925	3,684	40,000

TABLE 2. Load summaries for Shell Point's central energy plant.

When these parameters are violated, the software generates several levels of alarm, including automatic alerts, so corrective actions can be taken promptly.

SAVINGS AND REBATES

The net effect of Shell Point's off-peak cooling is a substantial reduction in electrical energy cost because of the reduction in on-peak electrical charges. Based on an average $8.30-per-kilowatt demand charge and a 6.5-to-8.5-cents-per-kilowatt-hour on-peak charge vs. a 2.5-to-4-cents-per-kilowatt-hour off-peak charge, annual savings are $468,000. This savings applies to Shell Point's current load, which consists of 1,640,806 sq ft of conditioned space from both The Island and the new Woodlands facilities.

From September 2001, when Shell Point went online with centrally located TES units, to January 2005, when approximately 61 percent of the planned TES was online (Table 1), FPL documented savings in excess of $700,000.

These savings directly reflect the impact of full load shifting made possible with TES. Given Shell Point's ongoing expansion, these savings are expected to increase. Future load additions offer some perspective on these expected increases. These are indicated in Table 2, which shows the cumulative tons at various completion dates.

Not included in these savings is the extra stored cooling inherent in underground chilled-water lines. These lines contain approximately 500,000 gal. of chilled water and yield an additional 3,400 ton-hours of cooling, which is available to the plant manager at 10-F delta T. This extra capacity has been utilized fully during staged expansions and emergency situations, including hurricanes that left much of Fort Myers without power for several days in 2004.

Because part of Shell Point's total load includes health-care facilities on The Island, there is no room for failure in the system, as this would necessitate evacuation. Temperature and humidity must be maintained 24/7. Again, TES and the built-in diversity of the centralized plant have proven their value to Shell Point. When the central plant loses power, which has occurred only once (during a 2004 hurricane), there is enough onsite generating capacity to run pumps required to use stored ice for cooling for 24 hr. This can be extended by selectively eliminating loads that are not as critical as those of the medical facilities at Shell Point.

TES and the central plant have earned Shell Point one of the largest total demand-side-management rebates in FPL history. Based on a rebate schedule of $330 per ton of refrigeration shifted off peak, total rebates from FPL could be more than $2 million. Approximately 97 percent of the rebate money is attributed to TES.

FPL's aggressive rebate program was a notable advantage to Shell Point, but it is important to note that facilities need not be enormous or eligible for large rebates for TES and off-peak cooling to make good economic sense. For one North Carolina school district, the sizable energy savings alone were reason enough to standardize a school design featuring air-cooled chillers and ice-storage tanks. In fact, schools in Johnston County, N.C., and throughout the country have achieved simple TES project paybacks in as little as two years.[2]

For large facilities such as Shell Point, rebates can be an added incentive for investing in more efficient HVAC designs. Also it is less expensive for a utility to offer large customers financial incentives for installing more energy-efficient equipment than it is to build new power plants. Undoubtedly, the enormous demand created by the Shell Point expansion would have required FPL to install another distribution feeder. With TES and off-peak cooling, that was not necessary.

CONCLUSION

Shell Point is an excellent (albeit super-sized) example of a growing trend among institutions to actively pursue innovative and more sustainable designs that include energy-cost savings, right-sizing, managed growth, and operational flexibility. More and more, colleges, hospitals, and retirement facilities are proving they are willing to invest in long-term savings. The reasons are clear. Like Shell Point, most institutions constantly are evolving, making centralized systems with TES more appealing because they can be added onto incrementally at proportional cost. Also, they are more manageable—an important consideration, given that maintenance staffs rarely increase at the rate institutions expand. Finally, because institutions are under greater pressure to appeal to their residents and staff, aesthetics and noise control are critical concerns for the owners. With careful design, aesthetics and noise can be minimized with the use of TES and a centralized plant. Last but not least are the long-term savings these systems can provide—savings that are in keeping with institutions that must look not only years, but decades, ahead.

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