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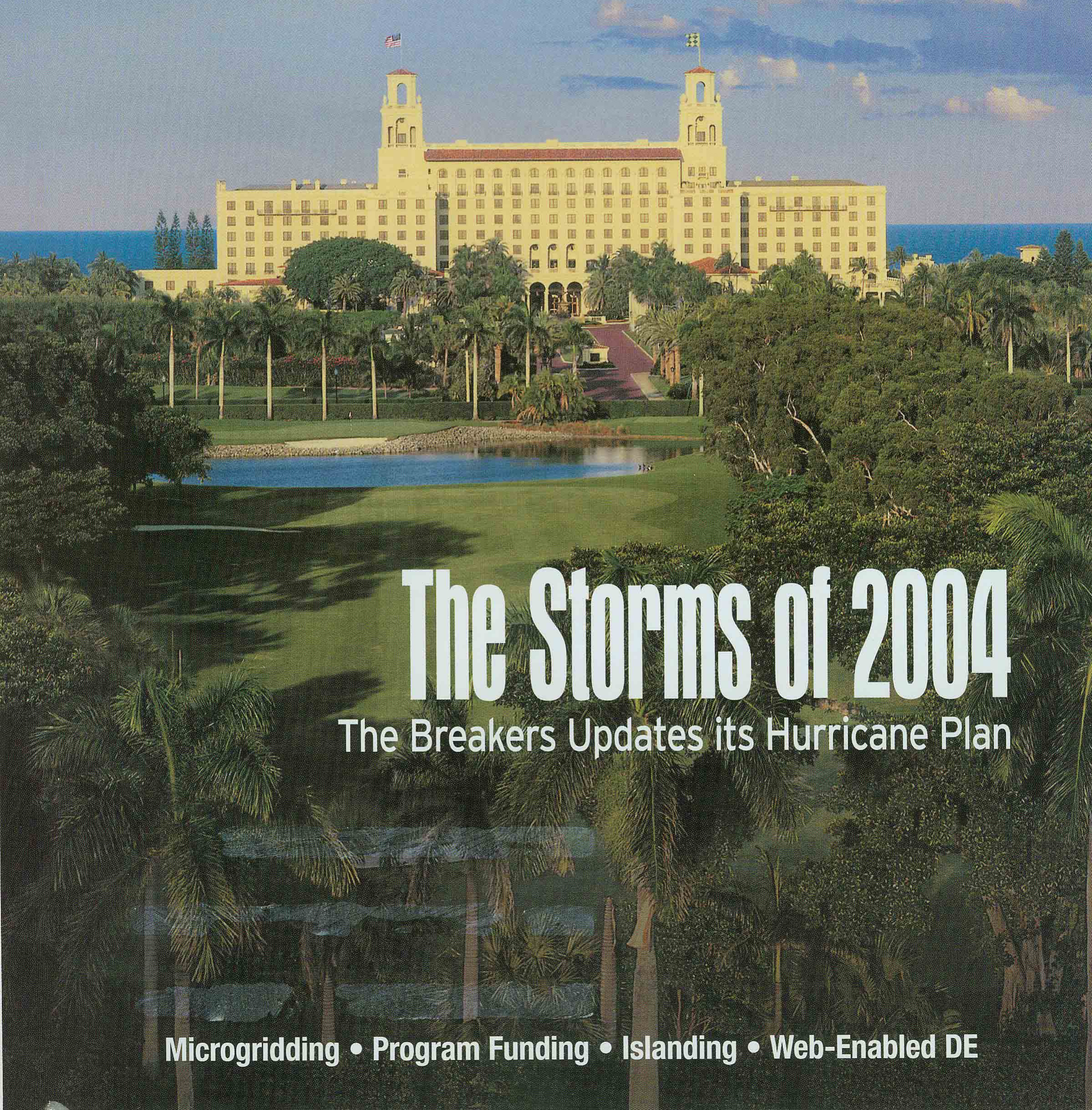

The Storms of 2004

The Breakers Updates its Hurricane Plan

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Miracle Cure for Utility-Rate Headaches

Sprawling health facility saves millions with CHP trigeneration.

BY DAVID ENGLE

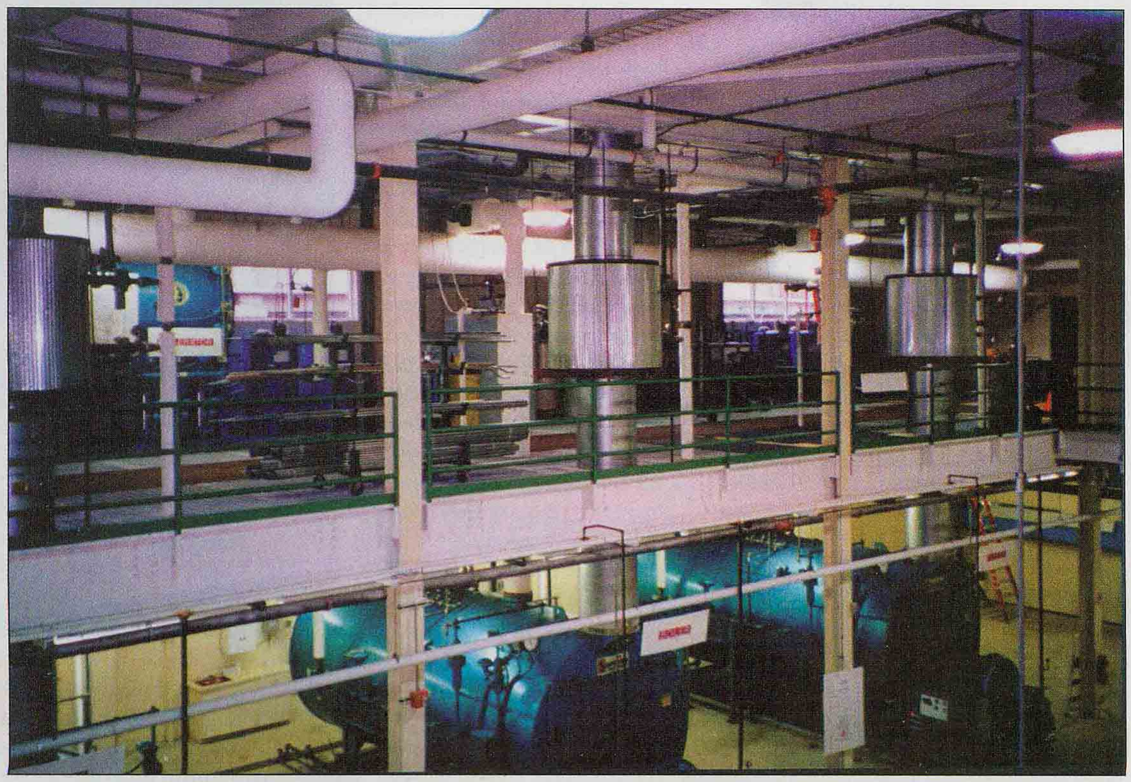
Fixed or sluggish revenues, rising costs, slashed budgets. Not exactly an unheard-of scenario, and, perhaps surprisingly, sometimes occurring simultaneously with growth and expansion. More than a few hospital plant-and-facilities departments in the 1990s were probably experiencing this kind of chronic—well, sort of squeezing—pain "right here in my budget." As Charlie Stevenson, head of the plant operations at Northwest Community Hospital (NCH) near Chicago, IL, describes it, "My predicament here is that, year after year, our income keeps going down because insurance reimbursements are being reduced"; hence, the only real way he can stay within cost parameters, as he labors to energize and climate control a 563-bed, million-square-foot facility, is with judicious investments "in operational cost savings."

Above all, the critical triage patient here, he explains, is his utility meter. NCH's gas and electric bills typically account for better than 50% of the annual operations budget (currently $4.3 million). Of that figure, natural gas is now taking $1.7 million, and electricity $600,000. "Those are my big dollars," Stevenson says, and thus he routinely pulls out the scalpel to pare them down. Conserving energy is a key. So too is wringing out maximum efficiency from his fuel and energy expenditures: "That's the big bang for my dollar."

For the past eight years, the biggest bang by far has come from onsite combined cooling, heating, and power (CCHP). Commissioned in 1997, the integrated system paid for itself in the first four years. Since 2001 it's all been gravy. In terms of net impact, for the two most recent accounting periods, Stevenson's department has saved an estimated $600,000 to $700,000 respectively on total energy costs (i.e., reduced electric billings and multiplied heating efficiency). Extend these figures over the equipment investment's full lifespan of roughly two decades and multiple millions of dollars will be lopped off from assorted utility billings. And, given the income pressures Stevenson describes, it's money the hospital urgently needs to pay for repairs that otherwise might be hard to do.

Assessing Options

Back in 1995, NCH's administrators undertook a basic risk assessment and building survey of the hospital's plant. They were contemplating a $112 million capital investment for expansion. Would the campus's aging stock of boilers, chillers, and piping be able to support more development? And what were its reliability, energy efficiency, and maintainability?



Alas, bad news. The engineering prognosis wasn't good. Over the years, urban sprawl (hospital style) had tacked on new wings and additions piecemeal. Mismatched and scatter-shot heating and cooling elements were "over-burdened, undersized, and environmentally unfriendly," a report stated. Steam loops were incompatible; chilled-water hydronic flows were problematic; and the equipment rooms lacked space for more hardware—all while the community's demand for health care services continued to grow.

The engineers' recommendation: Basically, NCH's entire mechanical plant badly needed an overhaul.

Administrators sought proposals on what to do, and received a half-dozen replies. Three alternatives emerged:

- Option one was to remain decentralized and try to swap out and upgrade the old equipment in place.
- Option two would entail buying state-of-the-art boilers, chillers, and pumps, and centralizing them within a new plant building; this approach would shorten maintenance response times and achieve other efficiencies.
- Option three took this centralization concept one step further, as Stevenson recalls. "We said, 'Well, if we're going to centralize it all, doesn't it make sense to do a CHP—and generate our own electricity, to reduce our demand load, and then capture the heat of those engines and utilize all that for heating and/or cooling?' "

Smart logic, and a formal assessment easily confirmed that this would be tantalizingly cost-effective and potentially very remunerative. By contrast, taking the more conservative and seemingly affordable approach of upgrading boilers and chillers in place turned out to be surprisingly costlier. Far better—both for meeting long-term growth and solving immediate infrastructure shortcomings—would be to "start again from scratch" by designing high-efficiency CCHP, all under one roof.

One of the six engineering proposals actually laid out this scenario in some detail, including making the attractive business case for a cogen investment; this was the design-build plan offered by Ballard Engineering Inc. of Rockford, IL. Ballard also noted its requisite experience: onsite power installations (as of today, a combined total of 80 MW developed, in the 1- to 10-MW range). The firm's prospectus also documented for NCH some of the hospital's actual utility usage data of recent years. Clearly, an onsite power plant would drastically cut energy billings; the equipment payback would arrive in about three years. "Bottom line was," recalls Stevenson, "the incremental cost to add three engines to our already centralized plant was going to be just $2,057,000. That would give us a payback of 2.85 years, and, from our perspective, you just have to do that."

Sizing the Plant

How big should this new power train be? Ballard partner Joe Sinclair advised his client that the generators should approximate the daily peak load, as the driver. "Electrical rates here are fairly high," he says, referring to regulated utility Commonwealth Edison (ComEd), serving Chicago. Sinclair calculates current average peak energy cost at about $0.12 to $0.14 per kilowatt-hour, when factoring in unusually hefty demand charges (aka "rate 18"). Even eight years ago, when Sinclair did the original analysis, about 70% of the hospital's utility costs were for electricity, and the balance for thermal.

By comparison, in many other successful CHP projects nationwide, it's perhaps more typical that the engine sizing be based on the heat load and especially natural gas usage, the generators being sized and run to provide the necessary heat output relying on engine exhaust—thus multiplying the energy efficiency. Here, though, Ballard's strategy differed by aiming directly at electricity peak load shaving. Sinclair advised knocking down ComEd's extremely high rate 18. In 1997 this was the critical driver so Ballard specified a configuration that would meet most of the hospital's load for nine hours daily.

Next, as for specific gensets, Ballard recommended three 1.1-MW Waukesha VHP rich-burn engines, which would yield a total megawattage of 3.45. Other drivetrains were also carefully considered, with their respective pros and cons compared to reliability, anticipated maintenance costs, first-time cost, operational profiles, and control issues. As Stevenson recalls, the Waukeshas looked particularly good for their initial price and low maintenance, offering a strong prospect of rapid payback and long-term savings.

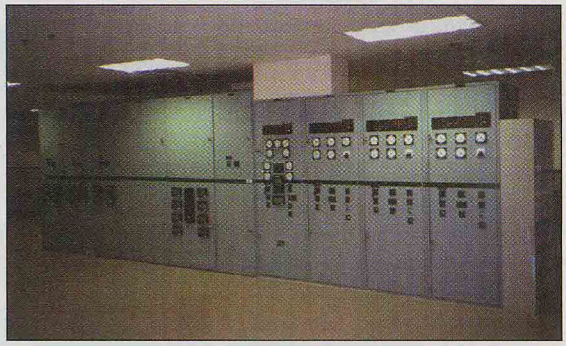
And, indeed, after nearly a decade in service, those Waukeshas and the initial expectations about them have panned out nicely. Payback on the three units came in 2001. The system has been delivering pure savings ever since. Avoided costs naturally fluctuate year to year, but, to take 2003 as an example, NCH'S electric bill savings alone, attributed to onsite power, came in at $563,000. This figure accurately reflects, says Stevenson, "all costs," including "fuel, maintenance, expenses from breakdowns, replacement parts, and repair." A midsize-figure net is now "the bottom-line saving to running those engines." (More details follow.)

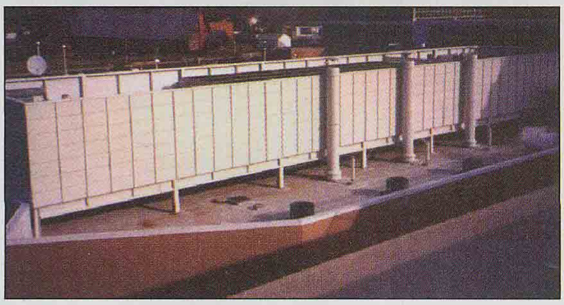
Boilers and Chillers

Don't forget, either, that other heat-recovery benefits come on top of this. The Waukeshas each exhaust around 1,600°F, which is captured by Cain heat-recovery units for reduction to between 700°F and 800°F, notes Stevenson. Resulting output is translated into domestic hot water and steam, at the rate of around 2,000 Btu/kW of electricity produced, or around 2,000 pounds of heat per hour. Those figures reflect recent years' performances, but actual operation can vary considerably year to year, depending on a cost-optimization strategy, which is pegged to the often volatile price of natural gas purchased for heating.

On that score, also installed in 1997 were three brand-new, high-efficiency natural gas–fired Cleaverbrook boilers, capable of producing 600 bhp apiece, and supplementing the CHP heat as required. Steam is maintained at 150 psi, yielding 6,000 lb/hr at this pressure. To increase heat efficiency even more, the Cleaverbrooks are equipped with heat recovery on the blowdown, and with stack economizers. All comfort heating, hot water, and even steam for the autoclaves and sterilizers is thus supplied and piped from this central plant.

When the need for comfort cooling arrives, two high-efficiency, 1,300-ton centrifugal York chillers carry the main burden. They're supplemented by an 850-ton York absorption chiller (which is heat fired by the "free" generator exhaust during the summer). For light cooling loads, says Stevenson, "There's what we call our baby chiller," a 240-ton York that's also exhaust heat–fired. Again, all are centralized and balanced for differential pressure controls.





Full Recovery With Healthy ROI

Totaling up costs and benefits of this vastly more efficient and environmentally friendly equipment inventory, the combined outlay in 1997 came to about $8 million. Another $2.5 million was incurred for its installation and for construction of the new central plant building to house it all. Ample extra space was included to provide for future expansion. Removal and retirement of the old boilers and chillers opened up even more space for other uses. Add to these expenses another $1.5 million for landscaping, annual maintenance, and plumbing for the hospital's new chemical and medical gas systems. Total investment: $12 million. And again, the portion of that spent on cogen machinery—proceeds from which are pay-

ing for the entire freight here—came to just over $2 million.

Moreover, energy projects often receive public subsidies, and in this case, a generous low-interest loan came in from the State of Illinois, underwriting the Waukeshas.

As this financing began to gel, what Sinclair remembers best was the look of delight from a hospital's accountant, upon realizing what the power plant would mean. "The beauty of this CHP to him," Sinclair recalls, "was not simply the return for the cogen system, but the fact that these savings would pay for the central energy plant too [i.e., for the entire $12 million centralization and mechanical upgrade]. "The whole theme of it was, basically, 'We can get this built, we can get all the equipment in it—and it will pay for itself,' " all thanks to cogeneration. The accountant was overjoyed because the hospital had already committed itself to the $112 million campus expansion before it had fully appreciated the inadequacy of the heating and cooling infrastructure, for which, Sinclair says, "They hadn't really allocated funds." Thus, the cogen plant savings "provided them a nice way out."

Moreover, one year after the plant's commissioning, NCH received an ASHRAE Excellence in Engineering Award for its innovative energy-saving investment. Notable from a technical standpoint was the fact that this was true co- or tri-generation, using well-integrated, high-efficiency components assembled from the ground up, making the gains even more dramatic.

Strategies to Maximize Benefit

As had been planned from the outset, the Waukeshas began running 9 a.m. to 6 p.m. daily for peak shaving, and have largely continued that schedule ever since. At day's end Stevenson idles them, and ComEd power takes over. During the winter months the engines' nine-hour work shift adds up to 98%-plus of the daily electrical load. Summer heat increases the load considerably so that the Waukesha's, at full throttle, can contribute about 72%.

What's the most cost-effective energy delivery point, you may ask? There's a tradeoff here, in that a fourth engine would enable 100% daytime load-following, but idling during winter and nighttime would increase, too. Thus, as Stevenson explains, "You have to find the right balance. You don't want to buy too much generating capacity so that the payback isn't there."

After-hours rates from ComEd are actually quite low, at only $0.02 or $0.03 per kilowatt, Sinclair points out. During the daytime this jumps a few cents higher at the peak, but is still far from exorbitant. The real "killer," in this particular rate structure, is the per-kilowatt demand charge. It's calculated by taking the average of the three highest-demand excursions during a billing period, then multiplying this by either $13 or $14, depending on the season. Tacking this surcharge on to the base rate makes ComEd's effective hourly rate more like $0.12 or $0.14 per kilowatt (of which the actual energy charge is only about $0.52). Incidentally, utilities argue that the huge demand charge is justified by the expense in having to maintain a ready reserve of power on demand. From a customer standpoint, though, gripes Stevenson, "It's almost like a penalty."

At any rate, compared to $0.12 or $0.14, NCH's in-house power production cost comes to about $0.10 per kilowatt; and again, that's including fuel, maintenance, hardware, etc.

How many thousands of dollars does a few cents' differential add up to in savings? Actually, Sinclair is able to track usage precisely, in real time, via Ballard's SCADA (for supervisory control and data acquisition) serial connection. Incremental shifts in load can be flagged; and making appropriate, timely adjustments results in bigger savings. So, says Sinclair, "It pays to keep close watch" on your power generators via SCADA (which has been widely used by utilities and power managers for decades).

Also, to share this monitoring benefit with NCH, Ballard installed graphical monitoring tools there. Stevenson's operators "can pull up on the displays the actual loading that the system took care of the previous day, right up to the hour," notes Sinclair. Assorted other logs are accessible, as is real-time monitoring of machine temperatures, pressures, and assorted metrics.

Equipment Care and Feeding

Daily operation of the three generators, for long hours, year after year, demands unusually good regular maintenance, Sinclair emphasizes. This may actually go well beyond what one might be used to from experiences with less-critical systems. At NCH the highly specialized task of machine health care has been outsourced from day one. Stevenson and Sinclair alike recommend this approach, both for quality results and the fact that it will probably be cheaper and more efficient. Considering the almost punitive impact of downtime and the resulting demand charges, the money you might spend for top-flight maintenance is well worth it. Stevenson even suggests obtaining a contractual guarantee ensuring timely repair response.

Waukesha's local vendor, Charles Equipment Co., provides NCH's preventive maintenance and all other servicing. Charles' techs visit at least weekly for inspections and testing. Billings vary year to year, depending on operational hours logged and whether a top-end or major overhaul is required. (Ballard initially assisted Stevenson in doing an extended 10-year estimate for these expenses.) In 2003, NCH's maintenance tab came to around $50,000, but in 2004 that figure doubled, due to the need for two costly overhauls.

On that score, note this: Breakdowns happen! Despite the very best care, ailments come, and eventually all engines conk out. Human error also intervenes. In 2004, for instance, one of the Waukeshas threw a piston, reportedly because the operator hadn't followed a prescribed shutdown procedure. The machine was severely damaged, and, due to the mistake, its five-year extended warranty was invalidated. Recovery from this loss took about 21 days (a reasonable turnaround time for this kind of event) and impacted Stevenson's budget to the tune of tens of thousands of dollars, not to mention the expense of reverting to peak-demand power rates.

Apart from that one human failing, however, Stevenson reports that the Waukeshas have proven very reliable. He advises that, when budgeting for upkeep, one should calculate the cost of shutting down for occasional overhauls, and also for an unscheduled breakdown or two. In sizing the system in the first place, consider carefully the value of having reserve power, both to accommodate future load growth and to provide a backup when a unit goes offline. Similar estimates of projected downtime should be figured into your negotiation for purchased power. And, lastly, don't neglect operator training and oversight.

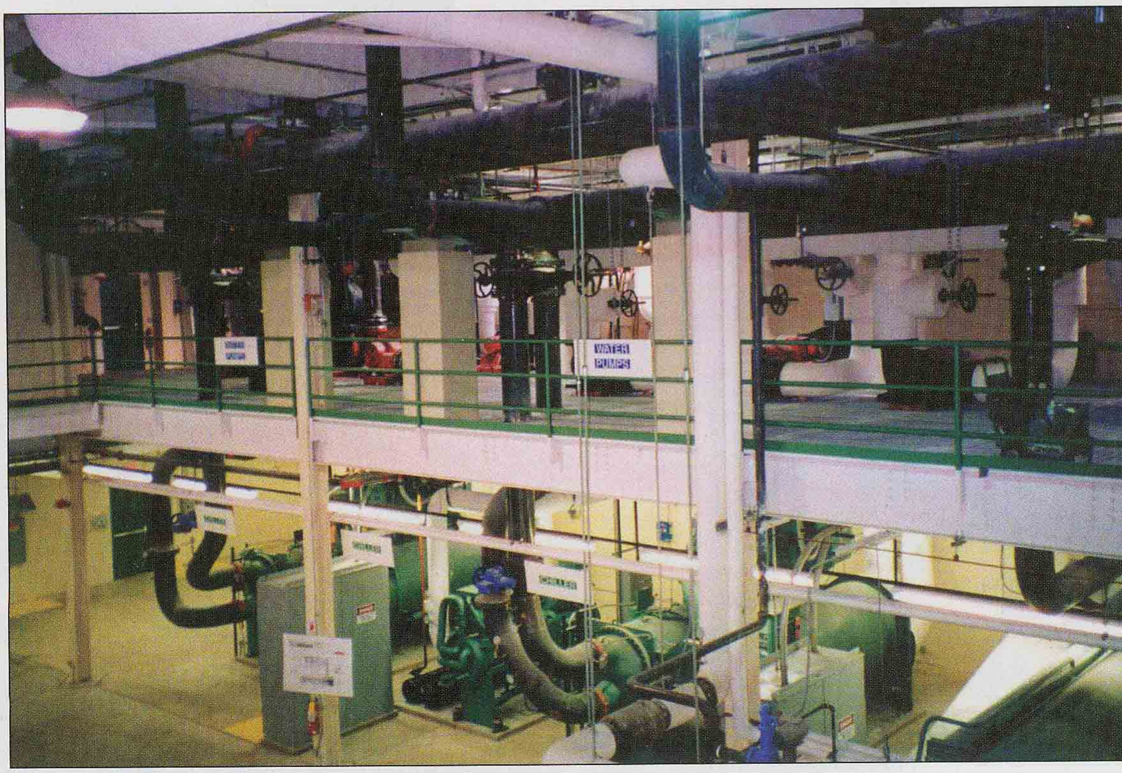
Sinclair characterizes this power train, CHP, and its maintainability as "a very sophisticated system, in that it is standalone. It almost operates itself. It has its own diagnostics. All the operator really has to do is basically check gauges and computer readings." As for the overall supervision, all that's needed is for someone "to make sure that somebody at least looks after the system to see it is still running and the 'roof is still on.' "

Fourth Unit on the Way

After several years of tracking load growth, and in light of the rate 18 surcharges and assorted power reliability concerns, Stevenson and NCH have opted to purchase yet another generator, for a commissioning date in 2005. This fourth Waukesha will thus pick up some of the hospital's previously unserved building loads and will also help balance other loads (which, again, have been growing). Adding another 1.1 MW virtually ensures that the hospital can either eliminate outright or greatly curtail its remaining demand charges, at least apart from summer months. Matching virtually 100% of daytime loads, at times, there will also be some reserve left for future growth.

With this quartet of megawattage in place, NCH will attain energy self-sufficiency. And, whenever the grid goes down some evenings, the idling Waukeshas will power up automatically: The system now has sufficient redundancy for full standalone capability.

Better still, the new 2005 model Waukesha is a prototype design boasting 20% higher efficiency. NCH negotiated a sweet deal to serve as a pre-production test site for the engine maker, to run the new machine 24/7 for a full year, with the supplier footing much of the fuel bill. After



the field trial ends, Waukesha Co. will install a permanent high-efficiency version. Simple payback is projected in five years, and the amortized depreciation method will shorten this to three.

Bottom-Line Savings

Remember, too, that in NCH's pre-generator era, the facility department was forking over about 70% of its utility budget for purchased power and 30% for natural gas. Today those proportions are pretty much reversed. However, the real material difference comes in the fact that—whereas before millions of therms of gas were only heating water—today it's also firing 4.5 MW of energy. This output is sufficient to power virtually all of the daytime peak load for this million-square-foot facility. Total net budgetary impact varies year to year (engine-running being sensitive to fuel price). A figure noted above, $563,000, illustrates electricity bill savings for 2003 alone. However, notes Stevenson, add to this a realistic valuation of the assorted heat energy gains—such as from the exhaust heat–fired chiller and the more efficient CHP boiler output, etc., and the impressive figure easily increases by another $100,000. In terms of paying back the $12 million investment in 1997, the hospital is now probably beyond the halfway point, and Stevenson expects full cost recovery by 2010.

Fuel prices make or break the payback for cogen and dictate operation. Matters here suddenly looked bleak in 2001, when NCH's per-therm costs rocketed up to $1.10. Once-rosy expectation vanished. Nevertheless, the administrators opted to keep the power running, despite the marginal benefit, and focused on better purchasing. NCH hadn't been particularly adept here, but Stevenson (promoted to head of the plant department that year) began researching markets and shopping wholesale. Figuring that the 2001 price leap was temporary, he signed a cautious one-year commitment for gas at a much more affordable $0.55 per therm. When this expired, he determined that prices were probably bottomed out, and signed a three-year future commitment for delivery at $0.45. This is well below the current market. "We made out OK on that deal," Stevenson says with some satisfaction. It pays to study market forecasts, he says, then negotiate aggressively when you can.

NCH's glowing success with power overall, despite one or two snafus, has spurred confidence in developing new energy projects. There's that new experimental Waukesha test-drive coming in 2005, and Stevenson is also exploring a relatively novel technique for using cooling-tower water to supply off-season cooling indoors. From autumn until spring, indoor chilling loads are light, in the 100- to 260-ton range. During these times, Stevenson wants to see how much he can gain by using free, "pre-cooled" water residing in the water tower outside, for his supply side, relying less on the two York chillers.

NCH senior execs, he adds, "continue to support me in my effort to create an infrastructure that's reliable, that's state-of-the-art, and that's essentially giving us some cost savings" through leaner operations, new technologies, or staffing changes. Stevenson feels fortunate that NCH's leadership expresses a strong commitment to facility department needs. "Not all health care organizations are as healthy as we are," he observes. "Not all of them can say, 'We're willing to spend $12 or $14 million on a central utility plant.' " Even if the payback numbers do make sense, "That's a big expense," he says, "but, fortunately, we were able to do that." DE

La Mesa, CA–based writer **David Engle** *specializes in construction and energy topics.*